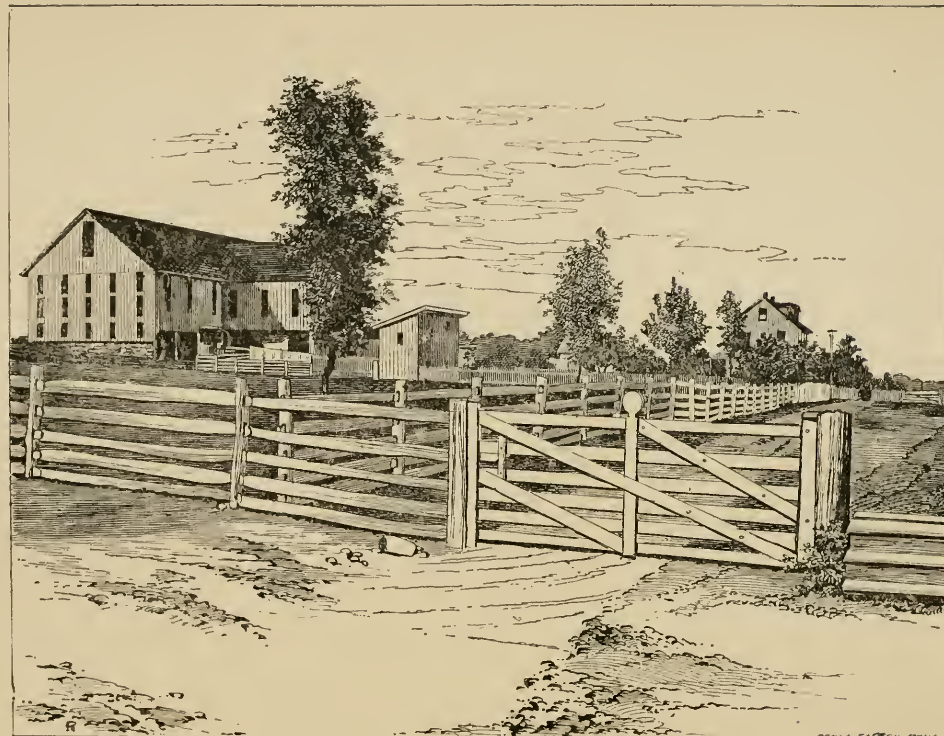

EXPERIMENTAL FARM BUILDINGS.

REPORT

OF THE

PENNSYLVANIA STATE COLLEGE.

AGRICULTURAL CHEMISTRY

AND

AGRICULTURAL EXPERIMENT WORK.

FOR THE YEAR 1886.

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VIRTUE LIBERTY AND INDEPENDENCE

AGRICULTURAL CHEMISTRY.

AND

AGRICULTURAL EXPERIMENT WORK.

THE PENNSYLVANIA STATE COLLEGE,
December 11, 1886.

To the President of the Pennsylvania State College:

SIR: I have the honor to make the following report for the department of agricultural chemistry for 1886:

During the past year, I have given instruction in the branches belonging to the senior and junior years of the advanced course in agriculture, and in those belonging to the second year of the general course in agricultural. In addition, I have taken charge of the instruction in Elementary Physiology in the "B" preparatory class. The classes in agriculture being small, it has been my aim in the practicums to devote the student's time to such work as each seemed to need most, with the object of securing a practical acquaintance on their part with the object of securing a practical acquaintance on especially to give them training which will fit them for the business of farm management.

On account of the small size of the classes in the agricultural courses, as well as by reason of the great importance of the work itself, I have devoted the major part of my time and attention to carrying on agricultural experiments. The aim has been, not so much to increase the number of lines of experiments, though that has been done to a considerable extent, as to study more fully and minutely the questions already under examination. The general series of experiments with fertilizers and on cattle-feeding, carried on under Prof. Jordan, have been continued, but the effort has been made to check the results of the field and stable experiments by the more accurate investigations of the laboratory. A full account of these and other experiments carried on is given in an appended report.

For the sake of more closely correlating the investigations on crops with the observations of a meteorological character, this latter work has, by arrangement with the department of physics, been transferred to my department. As part of the apparatus heretofore used for taking these observations belongs to the physical laboratory, and is essential in its current work, the equipment of the farm for meteorological observations is not complete. I desire, however, to perfect the equipment during the coming year, and to arrange for a more complete study of this very important side of agricultural experiment than it has before been possible to make.

In 1884, the chemists of the various State and National experiment stations associated themselves under the title of the "Association of Official Agricultural Chemists," for the purpose of checking and perfecting the analytical work of fertilizer control. Their work has resulted in securing a decided improvement in the methods and accuracy of fertilizer analysis, and more *uniformity* in method. As a corresponding member, I have, during the past year, made analyses and investigations similar to those made by full members of this association.

At the last annual convention, the constitution was changed so as to make the professors of agricultural chemistry in the State colleges eligible for membership, and, at the same time, the scope of the investigations was widened so as to include the work on feeding stuffs and dairy products. As the aim of this association is so commendable, and the results of its labors have already proven so useful and influential, I would suggest that measures be taken to secure for this college a full official representation.

In addition to the experimental work that will require some years of investigation before the full results can be known, I have attempted to make the present equipment available, as far as possible, for the purpose of lending more immediate aid to the general farming public. With this aim, analyses have been made of such different products sent here by various individuals as were deemed of general interest to the farmers of the State. With the same view, I announced in the last bulletin, after consultation with yourself, that we will make a free examination of the germinative power of such seeds as farmers may send, provided they are accompanied by sufficient information concerning their source, character, etc., to make the results of general value.

Another line of work has engaged my attention, and is of interest.

not only for the scientific results which may be obtained, but for the educational and economic benefits which ought to accrue from its extension. I refer to the effort to get farmers in different localities to make a systematic comparative test of the effect of certain general fertilizers on the soil of their farms. A few have already undertaken these tests, and express themselves as amply repaid for the small expense and labor required. It is my hope that this line of work may be much more widely extended. I have engaged to assist in the interpretation of the results. Such experiments would not only benefit the individual, but would be of educational and pecuniary value to the neighborhood in which they are made, and also would be valuable adjuncts to the more complete experiments in the same line made here. Similar work is done in several other States.

The growth of the experimental work has been so great as to compel the employment of a trained assistant, in addition to the available labor force. I have secured the services of Mr. H. J. Patterson, a graduate student in my department; he has, under my drection, done much of the routine analytical work, and has given valuable assistance in the observations upon the growing crops, and in the collection of other data. He has also had charge of the meteorological observations since last July.

As he is giving the larger share of his time to the experimental work of the department, I would suggest that his pay be increased, if possible, to an amount equal to that received by the assistant in the chemical laboratory.

The improvements in the Central experimental farm stables have enabled me to carry on digestive experiments, for which facilities have previously been lacking. The new covered scales are very satisfactory, and have, by their saving of time and freedom from exposure during the winter months, enabled me to carry on work previously impossible.

The improvements in the fittings of the agricultural laboratory were necessarily delayed in completion; in consequence, analytical work was not fairly under way until the first of April, and the amount performed is less than had been expected. The added apparatus has very considerably increased the facilities for work, but is not by any means sufficient for that demanded by the present state of the experiments.

In September I took charge of the Eastern farm. I find it far from what it should be in the state of its buildings and in its general condition. The management, as at present arranged, requires all business of any moment to be transacted here, and all the accounts must be kept here. This is disadvantageous. It would be far more desirable if the local superintendent were competent to carry on the general business transactions and keep the accounts. The experimental work there is continued, but is unsatisfactory, because it is difficult to make exact, carefully checked experiments by proxy; and it is impossible for me to spend more time for close personal attention to those experiments than I now give. The only advantage these experiments can have over the system of farmers' experiments mentioned above, lies in the fact that their continuance through a longer period of years is assured, and that the directions of the professor in charge can be, to some degree, enforced. I desire to renew the suggestion that the interest of the money invested in the outlying experimental farms could be invested to better advantage in experiments directly under the control and supervision of the experimenter; and to add that, with the increased number of private experimenters, the original aim of the outlying farms, that of studying the variation produced by differences in climate and soil, will be to a large degree provided for.

A large share of my work consists in preparing the records of experiments and in collating the results for publication. A large part of this labor is purely clerical, and is accumulating so rapidly as to encroach upon time, which should be applied to work requiring more purely technical skill. Reference to the appended report will show that a large amount of purely arithmetical work is required; but it reveals only a small fraction of that work. If other provision could be made for the performance of this work, under my supervision, my time could be more profitably spent in investigations. Since the publication of the college report for 1883–1884, there have been issued by Prof. Jordan, agricultural bulletins Nos. 10 and 11, and by myself, Nos. 12, 14, and 16. The demand for these publications is rapidly increasing. The mailing list now contains about ten thousand names. In addition to this work, my correspondence in answer to questions relating to agriculture is constantly growing, and occupies a very considerable portion of time.

In concluding this report on the work of the past year, I desire to refer briefly to an exhibit of products, illustrating a portion of the results from the experimental plots. This was sent to the Union county agricultural fair, its preparation being unavoidably delayed, so that it was too late for other fairs. It elicited a very considerable interest, and much favorable comment. Indications seem to favor the extension of this line of educational work.

For the coming year, I estimate the necessary expense for the work in the department of agricultural chemistry proper, including the fitting of increased shelf and other storage room for samples, as not less than the sum appropriated last year, viz: three hundred dollars, of which two-thirds should be immediately available. This does not include expenditure for clerical work, or for the preparation of exhibits; nor does it include any high-priced or rarely used apparatus, but only the common articles of every-day necessity.

I would suggest that, in making appropriation for the experimental farms, allowance be made for the expenditure at the Central farm, necessary in fitting quite completely a meteorological observatory for agricultural purposes, and for the mechanical preparations of samples preliminary to the strictly chemical work. The Eastern farm will require some outlay for repairs, for which I suggest that provision be made as heretofore.

In addition to these estimates and the previous suggestions relative to representation in the Association of Official Agricultural Chemists, the increase of compensation for my assistant, and the exhibit of concrete results of experiments at different fairs, I would respectfully call attention to the following urgent needs:

1. Provision for the purely clerical work now carried by the professor in charge of the experimental work.

2. Provision for experiments on subjects relating to the dairy and dairy products.

3. The purchase of a gas manufacturing apparatus; the use of other combustibles, as laboratory sources of heat is inconvenient and tedious and adds to the dangers from fire.

4. The continuance of the provisions made last year for the completion of the files of chemical periodicals in the college library.

In closing, I desire, Mr. President, to express my appreciation of the studious and zealous encouragement you have extended to the work in my department.

Very respectfully,

WILLIAM FREAR,
Professor of Agricultural Chemistry.

AGRICULTURAL EXPERIMENT WORK FOR 1885 AND 1886.

*The feeding experiments of 1884–5, and the preliminary portions of those on the crops of 1885 were conducted by Prof. Jordan. The later work has been done by Prof. Frear, with the assistance of Mr. H. J. Patterson. While the means available have not been all that could be desired, this report will indicate the extent of the work performed, besides contributing something of value, it is hoped, to agricultural science and practice.

TABLE OF CONTENTS.

GENERAL FERTILIZER EXPERIMENTS.

In order to determine the true value of a fertilizer, it is necessary to know:

1. The immediate effect on the quantity and quality of the crop to which it is applied.
2. The residual effect on the fertility of the soil.

A full determination of fertilizing value requires the observation of effects through a number of years. The design of the following series of experiments, which has been in progress since 1881, is to aid in arriving at trustworthy conclusions concerning the value of the principal fertilizers at the command of the farmers of this State. The design of this series is, further, to throw light especially upon the following points:

(*a.*) The comparative effect of the single valuable ingredients of commercial fertilizers.

(*b.*) The effect of complete, as compared with incomplete, fertilizers.

(*c.*) The comparative effect of different forms of nitrogen.

(*d.*) The necessary artificial supply of nitrogen.

(*e.*) The comparative effect of commercial fertilizers and yard manure.

(*f.*) The effect of lime, ground limestone and plaster.

(*g.*) The permanency of effect of the different fertilizers.

(*h.*) The effect of the various fertilizers upon the comparative growth of the different crops.

(*i.*) The effect of the various fertilizers upon the relation of grain to straw.

The method of conducting these experiments has been fully described several times, and full information on these points may be obtained by reference to the college reports for 1882 and 1883, the latter of which was printed in the Agriculture of Pennsylvania for that year; and also to Bulletins Nos. 1, 2, 8, 9, 11 and 14.

For the sake of those who may not have access to the above-named papers, the following outline of the plan followed on the Central experimental farm is given.

These experiments occupy Tiers I, II, III and IV, each containing 36 polts of one-eighth acre, and lying east of the Superintendent's house. The plots are numbered from 1 to 36, beginning with the north-east end of the tiers. Prior to 1880–81, the plots had been used for miscellaneous experiments. The rotation since then has been as follows:

	1881.	1882.	1883.	1884.	1885.	1886.
Tier I,	Oats.	Wheat.	Grass.	Corn.	Oats.	Wheat.
II,	Corn.	Oats.	Wheat.	Grass.	Corn.	Oats.
III,	....	Corn.	Oats.	Wheat.	Grass.	Corn.
IV,	....	....	Corn.	Oats.	Wheat.	Grass.

TABLE I *shows the Kind and Amount of the Fertilizers applied to each crop of Wheat and Corn. The Oats and Grass crops received nothing.*

	Plot.	Kind of Fertilizer.	Quantity of fertilizer applied to plots.	Quantity of fertilizer per acre.	Quantities of Valuable Ingredients. Lbs, per Acre. Nitrogen.	Phosphoric acid.	Potash.
			Lbs.	*Lbs.*			
Valuable ingredients, singly.	1	Nothing,	. . . . .	. . . . .	. . .	. . .	. . .
	2	Dried blood,	30	240	24	. . .	. . .
	3	Dissolved bone-black,	37½	300	. . .	48	. . .
	4	Muriate of potash,	25	200	. . .	. . .	100
Valuable ingredients, two by two.	5	Dried blood, / Dissolved bone-black,	30 / 37½	540	24	48	. . .
	6	Dried blood, / Muriate of potash,	30 / 25	440	24	. . .	100
	7	Dissolved bone-black, / Muriate of potash,	37½ / 25	500	. . .	48	100
	8	Nothing,	. . . . .	. . . . .	. . .	. .	. . .
Complete fertilizers, with nitrogen in different proportions. Nitrogen furnished by dried blood.	9	No. 7, / Dried blood,	62½ / 30	740	24	48	100
	10	No. 7, / Dried blood,	62½ / 60	980	48	48	100
	11	No. 7, / Dried blood,	62½ / 90	1,220	72	48	100
	*12	Ground bone, / Muriate of potash, / Dried blood,	28 / 25 / 30	664	30	48	100
	13	Plaster,	40	320	. . .	. . .	. . .
	14	Nothing,	. . . . .	. . . . .	. . .	. . .	. . .
Commercial fertilizers and yard manure compared.	15	No. 7,	62½	500	. . .	48	100
	16	Yard manure,	1,500	12,000	?	?	?
	17	No. 7, / Dried blood,	62½ / 30	740	24	48	100
	18	Yard manure,	2,000	16,000	?	?	?
	19	No. 7, / Dried blood,	62½ / 60	980	48	48	100
	20	Yard manure,	2,500	20,000	?	?	?
	21	No. 7, / Dried blood,	62½ / 90	1,220	72	48	100
	22	Yard manure, / Lime,	1,500 / 500	16,000	?	?	?

* Prior to 1884-5, received the same as No. 9.

	Plot.	Kind of Fertilizer.	Quantity of fertilizer applied to plots.	Quantity of fertilizer per acre	Quantities of Valuable Ingredients. Lbs. per Acre.		
					Nitrogen.	Phosphoric acid.	Potash.
			Lbs.	Lbs.			
	†23	Lime,	500	4,000	...	...	...
	24	Nothing,	....	.....	...	...	...
	25	No. 7,	62½	500	...	48	100
Complete fertilizers, with nitrogen in different proportions. Nitrogen furnished by nitrate of soda.	26	No. 7, Nitrate of soda,	62½ 20	660	24	48	100
	27	No. 7, Nitrate of soda,	62½ 40	820	48	48	100
	28	No. 7, Nitrate of soda,	62½ 60	980	72	48	100
	29	No. 7,	62½	500	...	48	100
Complete fertilizer, with nitrogen in different proportions. Nitrogen furnished by sulphate of ammonia.	30	No. 7, Sulphate of ammonia,	62½ 15	620	24	48	100
	31	No. 7, Sulphate of ammonia,	62½ 30	740	48	48	100
	32	No. 7, Sulphate of ammonia,	62½ 45	860	72	48	100
	33	Plaster,	40	320	...	...	...
	34	Ground limestone,	500	4,000	...	...	...
	*35	No. 12,	83	664	30	48	100
	36	Nothing,	....	.....	...	...	...

* Prior to 1884-5, received the same as No. 7.   † Applied only to corn.

The same general scheme was used on the Eastern experimental farm, except that the number of plots was less, and that only three tiers of plots have thus far been laid out.

The soil of the Central farm, as has been noted in previous reports, is a heavy, calcareo-magnesian clay, containing a large quantity of flint. The surface soil is a fine loam, nine inches in depth; the subsoil is in some places very thin. The natural drainage is everywhere excellent.

The soil of the Eastern farm is a micaceous loam. The plots are situated on a gentle slope, and are well drained naturally. The surface soil has about the same depth as that of the Central farm.

The general difference in the climate will be fairly well represented by the statement of the mean monthly temperatures and rainfalls at State college and at Philadelphia, which is tabulated elsewhere in this report (p. ——.)

EXPERIMENTS OF 1885 AND 1886.

These experiments were carried on exactly as in preceding years. The yields of the different crops in rotation upon the various plots of the Central and Eastern experimental farms are reported in following tables (II–IV).

In addition to the work on the college experimental farms, several series of experiments in the same line have been undertaken under my direction by private individuals in different parts of the State.

The experiments are, of course, much more limited in scope, and are chiefly designed to throw light upon the specific fertilizer required by the soil upon which the crops are grown. Nevertheless, they may be made to contribute largely to the value of the fuller and more systematic experiments made here. They also serve as local guides to neighboring farmers, and may be instrumental in extending the application of a systematic method of experiment among farmers, which cannot fail to be greatly beneficial, both directly and indirectly. During the past year, Mr. John A. Gundy, of Lewisburg, Union county, made a series of experiments on corn, which are reported here.

It must be remembered that the reports on all these experiments can, as yet, assume only the form of "reports of progress."

TABLE II.—*Yield per acre of the Plots of the General Fertilizer Series, Central Experimental Farm, 1885.*

Plot number.	Kind of Fertilizer.	Quantity of single fertilizing ingredients per acre.	Total quantity of fertilizer per acre.	Corn, Tier II. Ears.	Corn, Tier II. Fodder.	Corn, Tier II. Total crop.	Oats, Tier I. Grain.	Oats, Tier I. Straw.	Oats, Tier I. Total crop.	Wheat, Tier IV. Grain.	Wheat, Tier IV. Straw.	Wheat, Tier IV. Total crop.	Grass, Tier III. Hay.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	. . . . .	. . .	3,120	2,040	5,160	696	824	1,520	152	328	480	800
2	Dried blood,	240	240	2,840	1,600	4,440	808	992	1,800	136	64	200	960
3	Dissolved bone black,	300	300	3,200	2,120	5,320	1,040	1,080	2,120	252	348	600	760
4	Muriate of potash,	200	200	2,696	1,720	4,416	936	864	1,800	80	80	160	800
5	Dried blood, Dissolved bone-black,	240 300	540	3,104	2,040	5,144	1,004	996	2,000	300	420	720	1,040
6	Dried blood, Muriate of potash,	240 200	440	2,944	1,520	4,464	736	664	1,400	108	172	280	1,160
7	Dissolved bone-black, Muriate of potash,	300 200	500	3,261	2,320	5,581	1,092	1,148	2,240	380	540	920	1,080
8	Nothing,	. . . . .	. . . . .	3,504	2,360	5,864	1,208	672	1,880	272	208	480	2,000
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	2,944	2,040	4,984	1,160	960	2,120	572	948	1,520	1,600
10	Dissolved bone black, Muriate of potash, Dried blood,	300 200 480	980	2,504	1,440	3,944	1,192	1,328	2,520	432	408	840	1,560
11	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2,844	2,040	4,884	1,176	944	2,120	720	880	1,600	1,400
12	Ground bone, Muriate of potash, Dried blood,	224 200 240	664	2,704	1,520	4,224	1,240	1,160	2,400	444	516	960	1,240
13	Plaster,	320	320	3,344	1,840	5,184	1,028	972	2,000	212	268	480	680
14	Nothing,	. . . . .	. . . . .	3,624	1,880	5,504	976	904	1,880	252	268	520	960
15	Dissolved bone-black, Muriate of potash,	300 200	500	3,344	2,640	5,984	1,384	1,496	2,880	552	658	1,210	1,200
16	Yard manure,	12,000	12,000	3,368	1,880	5,248	1,280	1,400	2,680	352	328	680	1,240
17	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	3,221	2,400	5,621	1,380	1,180	2,560	488	712	1,200	1,440
18	Yard manure,	16,000	16,000	3,464	1,970	5,434	1,248	1,112	2,360	380	380	760	2,040
19	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	3,864	2,680	6,544	1,352	1,408	2,760	704	816	1,520	1,760
20	Yard manure,	20,000	20,000	3,504	1,760	5,264	1,344	1,056	2,400	420	540	960	1,200

21	Dissolved bone-black,	300	1,220	3,456	2,361	5,816	1,512	1,148	2,960	760	1,000	1,760	1,320
	Muriate of potash,	200											
	Dried blood,	720											
22	Yard manure,	12,000	16,000	3,160	1,600	4,760	1,236	1,444	2,680	512	728	1,240	1,010
	Lime,	4,000											
23	Lime,	4,000	4,000	2,872	1,680	4,552	914	856	1,800	352	488	810	7.0
24	Nothing,	. . . .	. . . .	3,221	1,360	4,584	1,160	840	2,000	401	356	760	920
25	Dissolved bone-black,	300	550	3,432	2,240	5,672	1,616	1,504	3,120	848	872	1,720	1,520
	Muriate of potash,	200											
26	Dissolved bone-black,	300	660	3,272	1,840	5,112	1,552	1,328	2,880	912	1,368	2,280	1,560
	Muriate of potash,	200											
	Nitrate of soda,	160											
27	Dissolved bone-black,	300	820	3,336	2,080	5,416	1,488	1,352	2,840	1,008	2,152	3,160	1,240
	Muriate of potash,	200											
	Nitrate of soda,	320											
28	Dissolved bone-black,	300	980	2,888	1,440	4,328	1,504	1,616	3,120	903	652	2,560	1,560
	Muriate of potash,	200											
	Nitrate of soda,	480											
29	Dissolved bone-black,	300	500	3,040	1,720	4,760	1,512	1,168	2,680	944	1,296	2,240	1,040
	Muriate of potash,	200											
30	Dissolved bone-black,	300	620	3,016	1,600	4,616	1,544	1,416	2,960	1,232	1,648	2,880	1,880
	Muriate of potash,	200											
	Sulphate of ammonia,	120											
31	Dissolved bone-black,	300	740	2,952	1,840	4,792	1,656	1,624	3,280	1,348	2,492	3,840	1,920
	Muriate of potash,	200											
	Sulphate of ammonia,	440											
32	Dissolved bone-black,	300	860	2,880	1,440	4,320	1,560	1,600	3,160	1,572	2,468	4,040	1,840
	Muriate of potash,	200											
	Sulphate of ammonia,	360											
33	Plaster,	320	320	2,360	1,760	4,120	1,000	2,560	3,560	496	744	1,240	1,520
34	Ground limestone,	4,000	4,000	2,520	1,560	4,080	1,160	2,880	4,040	456	624	1,080	1,760
35	Ground bone,	224	664	2,912	1,960	4,872	1,592	1,568	3,160	724	1,196	1,920	1,920
	Muriate of potash,	200											
	Dried blood,	240											
36	Nothing,	. . . .	. . . .	2,112	1,400	3,512	1,360	1,520	2,880	322	188	520	2,240

TABLE III.— *Yield per acre of Plots of the General Fertilizer Series, Central Experimental Farm, 1886.*

Plot number.	KIND OF FERTILIZER.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	CORN. TIER III. Number of stalks.	CORN. Ears.	CORN. Fodder.	CORN. Total crop.	OATS. TIER II. Grain.	OATS. Straw.	OATS. Total crop.	OATS. Weight per bushel.	WHEAT. TIER I. Grain.	WHEAT. Straw.	WHEAT. Total crop.	WHEAT. Wheat per bush'l.	GRASS. TIER IV. Hay.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	10,780	3,120	1,820	4,940	1,910	2,604	4,514	36.50	144	351	495	49.6	5,160
2	Dried blood,	240	240	6,872	3,200	1,780	4,980	1,948	2,652	4,600	25.00	253	1,066	1,319	55.8	5,280
3	Dissolved bone-black,	300	300	10,032	3,280	1,960	5,240	2,084	2,612	4,696	30.00	524	2,328	2,852	67.0	4,160
4	Muriate of potash,	200	200	10,736	3,488	2,360	5,848	2,080	2,760	4,840	36.50	202	776	978	57.0	4,820
5	Dried blood, Dissolved bone-black,	240 300	540	11,064	4,000	2,416	6,416	2,256	2,864	4,120	30.50	574	2,072	2,646	62.0	5,160
6	Dried blood, Muriate of potash,	240 200	440	11,384	4,480	2,840	7,320	2,160	3,520	4,680	16.00	155	720	875	55.8	5,116
7	Dissolved bone-black, Muriate of potash,	300 200	500	11,018	3,680	2,740	6,420	2,258	3,162	5,420	37.00	834	1,969	2,803	65.7	5,160
8	Nothing,	....	....	11,288	4,680	3,044	7,724	1,854	3,066	4,920	36.50	603	985	1,588	65.7	5,040
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	10,680	3,880	2,776	6,656	2,424	3,476	5,900	36.50	908	2,512	3,420	65.7	4,700
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	10,464	4,120	2,800	6,920	2,396	3,484	5,880	36.50	1,070	2,547	3,617	68.3	5,000
11	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	10,920	4,600	2,920	7,520	2,304	3,416	5,720	37.00	1,246	2,430	3,676	62.0	4,320
12	Ground bone, Muriate of potash, Dried blood,	224 200 240	664	10,992	4,656	2,896	7,552	2,360	3,551	5,911	36.50	660	1,411	2,071	68.2	4,310
13	Plaster,	320	320	10,552	3,810	2,104	5,914	2,100	3,660	5,760	35.00	283	939	1,222	59.5	3,620
14	Nothing,	....	....	10,152	3,400	1,880	5,280	2,220	3,200	5,420	31.50	396	1,244	1,640	[illegible]	3,900
15	Dissolved bone-black, Muriate of potash,	300 200	500	10,818	3,740	2,556	6,296	2,290	3,360	5,650	35.00	863	1,399	2,262	65.7	3,600
16	Yard manure,	12,000	12,000	10,168	3,616	2,000	5,616	2,284	3,436	5,720	32.25	860	1,243	2,103	65.7	4,300
17	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	10,608	2,976	2,240	5,216	2,164	2,736	5,000	37.00	977	2,243	3,220	68.2	4,000
18	Yard manure,	16,000	16,000	10,512	4,096	2,280	6,376	2,188	3,012	5,200	36.50	1,219	2,051	3,270	65.7	4,596

19	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	10,496	3,680	2,410	6,120	2,196	3,084	5,280	36.50	1,150	2,475	3,625	68.2	4,600
20	Yard manure,	20,000	20,000	10,101	3,216	1,760	4,976	2,010	3,090	5,120	35.50	1,352	2,183	3,535	70.7	4,080
21	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	10,461	3,656	2,200	5,856	2,152	2,928	5,080	37.00	1,281	3,827	5,011	69.4	4,720
22	Yard manure, Lime,	12,000 4,000	16,000	9,928	3,000	1,680	4,680	2,232	3,818	6,080	31.50	1,339	1,953	3,292	70.7	4,560
23	Lime,	4,000	4,000	9,172	2,120	1,200	3,320	1,920	3,000	4,920	33.00	163	837	1,000	60.7	4,660
24	Nothing,	....	....	9,808	2,920	1,680	4,600	1,968	2,672	4,640	35.00	137	865	1,002	55.8	5,060
25	Dissolved bone-black, Muriate of potash,	300 200	500	10,526	3,480	2,680	6,160	2,548	2,032	4,580	36.50	611	1,663	2,301	61.5	4,696
26	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	10,832	3,360	2,656	6,016	2,056	2,844	4,900	35.00	906	2,099	3,005	68.2	4,100
27	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	10,560	3,160	2,120	5,280	2,128	2,528	4,656	34.50	803	1,693	2,496	61.5	4,760
28	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	10,752	3,280	2,000	5,280	2,008	2,712	4,720	35.50	997	2,264	3,461	61.5	4,820
29	Dissolved bone-black, Muriate of potash,	300 200	500	10,768	2,080	2,200	4,280	1,976	2,464	4,440	36.00	750	1,917	2,667	63.2	5,680
30	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	10,741	3,080	2,376	5,456	2,004	2,556	4,560	34.25	996	1,927	2,923	68.2	6,320
31	Dissolved bone black, Muriate of potash, Sulphate of ammonia,	300 200 210	710	10,621	3,420	2,456	5,876	2,016	2,684	4,700	35.00	1,121	2,060	3,191	62.0	5,880
32	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 20 360	860	10,896	3,780	2,600	6,400	1,976	2,464	4,440	35.00	1,211	2,424	3,665	68.2	5,680
33	Plaster,	320	320	10,141	3,810	2,136	5,976	2,080	2,480	4,560	35.50	195	850	1,015	57.0	6,080
34	Ground limestone,	4,000	4,000	10,216	2,720	1,520	4,240	1,810	2,840	4,680	32.00	169	699	868	60.7	5,160
35	Ground bone, Muriate of potash, Dried blood,	224 200 240	664	10,544	4,300	2,376	6,676	1,872	2,288	4,160	35.00	766	1,678	2,444	65.7	6,380
36	Nothing,	....	....	9,861	3,920	2,320	6,240	1,536	1,924	3,460	33.00	592	1,471	2,063	67.0	5,910

*See note on corn crop from Plot No. 35, in 1885.

TABLE IV.— *Yield per acre of the Plots of the General Fertilizer Series, Eastern Experimental Farm, 1885 and 1886.*

Plot number.	KIND OF FERTILIZER.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	1885.						1886.					
				OATS.			WHEAT.			WHEAT.			CORN.		
				Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Ears.	Fodder.	Total crop.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	. . . .	. . . .	700	1,270	1,660	360	920	1,280	640	1,520	2,160	1,360	1,920	3,280
2	Dried blood,	240	240	740	1,380	2,120	440	760	1,200	860	1,420	2,280	1,920	2,800	4,720
3	Dissolved bone-black,	300	300	1,020	1,540	2,560	620	740	1,360	1,040	1,700	2,740	3,120	3,100	6,220
4	Muriate of potash,	200	200	700	1,500	2,200	300	680	980	800	1,160	1,960	2,760	2,900	5,660
5	Dried blood, Dissolved bone-black,	240 300	540	980	1,580	2,560	720	880	1,600	1,240	1,720	2,960	3,720	3,840	7,560
6	Dried blood, Muriate of potash,	240 200	440	820	1,500	2,320	300	500	600	820	1,120	1,940	2,200	3,560	5,760
7	Dissolved bone-black, Muriate of potash,	300 200	500	1,140	1,660	2,800	660	340	1,000	1,180	1,360	2,540	3,120	3,720	6,840
8	Nothing,	. . . .	. . . .	680	780	1,460	300	260	560	820	920	1,740	2,000	2,320	1,320
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	1,200	1,560	2,760	740	1,260	2,000	1,400	2,410	3,810	3,200	3,120	6,320
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	1,180	1,410	2,600	920	1,540	2,460	1,620	2,520	4,140	3,000	2,920	5,920
11	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	1,140	1,860	3,000	1,120	1,640	2,760	1,860	3,080	4,940	4,040	3,120	7,160
12	Dissolved bone-black, Muriate of potash,	300 200	500	1,080	1,120	2,200	518	640	1,180	1,180	1,740	2,920	3,400	3,200	6,600
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1,100	1,260	2,369	820	880	1,700	1,280	2,100	3,380	3,640	3,340	6,980
14	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1,180	1,260	2,440	1,000	1,300	2,300	1,600	2,680	4,280	4,080	3,560	7,640
15	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	880	1,260	1,300	2,560	970	1,440	2,410	1,760	3,160	4,920	4,760	3,920	8,680
16	Nothing,	. . . .	. . . .	740	860	1,600	220	380	600	960	1,600	2,560	3,840	3,280	7,120

17	Dissolved bone-black, Muriate of potash,	300 200	500	1,080	1,200	2,280	660	780	1,440	1,280	2,080	3,360	2,880	2,800	5,680
18	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1,010	2,120	3,160	820	980	1,800	1,520	2,660	4,180	3,200	3,080	6,280
19	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1,140	1,760	2,900	980	1,420	2,400	1,560	2,800	4,360	3,560	3,180	6,740
20	Dissolved bone black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1,120	1,860	2,980	1,040	1,760	2,800	1,780	3,040	4,820	3,520	2,840	6,360
21	Yard manure,	12,000	12,000	1,120	1,280	2,400	500	540	1,040	1,200	1,880	3,080	2,600	2,280	4,880
22	Plaster,	320	320	870	1,050	1,920	180	120	300	680	840	1,520	1,600	2,000	3,600

To allow a readier comparison of the results, they have been arranged in tables showing the average yield of the plots receiving the same fertilizer. The results for each cereal are considered separately.

A. Corn.

(1.) EXPERIMENTS OF 1885—CENTRAL EXPERIMENTAL FARM.

The crop of corn this year occupied the plots of tier II; the diagram given in the statement of the plan of experiment shows that it is the fifth crop in the rotation on the plots, that it is the second corn crop, and that the plots have received three applications of their various fertilizers.

Table V gives the average yield of previous corn crops from plots in all the tiers, grouping together those that received the same fertilizer; a similar statement of the yield for 1885, and a statement of the gain in each case of the fertilized plots over the unfertilized.

TABLE V.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Corn, 1885.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Mean of tiers II, III, IV and I. 1881-1884. Ears.	Fodder.	Total crop.	Yield per Acre. Tier II.—1885. Ears.	Fodder.	Total crop.	Gain over Unfertilized Plots. Mean of tiers II, III, IV and I. 1881-1884. Ears.	Fodder.	Total crop.	Gain over Unfertilized Plots. Tier II—1885. Ears.	Fodder.	Total crop.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	. . . .	. . . .	5	3,278	2,603	5,881	3,117	1,808	4,925	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
2	Dried Blood,	240	240	1	3,486	2,734	6,220	2,810	1,600	4,410	208	131	339	—277	—208	—185
3	Dissolved bone-black,	300	300	1	3,231	2,512	5,976	3,200	2,120	5,320	—11	139	95	83	312	395
4	Muriate of potash,	200	200	1	3,514	2,970	6,481	2,696	1,720	4,416	236	367	603	—121	—88	—509
5	Dried blood, Dissolved bone-black,	210 300	510	1	3,611	2,850	6,461	3,101	2,010	5,141	333	247	580	—13	232	219
6	Dried blood, Muriate of potash,	210 200	440	1	3,252	3,060	6,312	2,914	1,520	4,461	—26	457	431	—173	—288	—161
7	Dissolved bone-black, Muriate of potash,	300 200	500	*5	3,793	3,026	6,819	3,270	2,225	5,495	515	423	938	153	417	570
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	**3	3,461	3,053	6,514	3,084	2,220	5,301	183	450	633	—33	412	379
9	Dissolved bone-black, Muriate of potash, Dried Blood,	300 200 480	980	2	3,492	3,140	6,632	3,181	2,060	5,241	214	537	751	67	252	319
10	Dissolved bone-black, Muriate of potash, Dried Blood,	300 200 720	1,220	2	3,519	3,165	6,714	3,150	2,200	5,350	271	562	833	33	392	425
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	3,892	3,214	7,106	3,272	1,810	5,112	614	611	1,225	155	32	187
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	3,640	3,180	6,820	3,336	2,080	5,416	362	577	939	219	272	491
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	3,699	3,210	6,939	2,888	1,440	4,328	421	637	1,058	—229	—368	—597
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	3,653	3,311	6,997	3,016	1,600	4,616	375	741	1,116	—101	—2 8	—309
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	3,768	3,308	7,076	2,952	1,810	4,792	490	705	1,195	—165	32	—133

* 4 after 1881-1885.

** 2 after 1884-1885.

TABLE V—Continued.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Corn, 1885.*

Number.	KIND OF FERTILIZER.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots	Yield per Acre. Mean of Tiers II, III, IV and I. 1881-1884. Ears.	Fodder.	Total crop.	Tier II.—1885. Ears	Fodder.	Total crop	Gain over Unfertilized Plots. Mean of Tiers II, III, IV and I. 1881-1884. Ears.	Fodder.	Total crop.	Tier II.—1885. Ears.	Fodder.	Total crop.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1	3,432	3,300	6,732	2,880	1,440	4,320	151	692	816	−237	−368	−305
17	Yard manure,	12,000	12,000	1	3,931	2,815	6,716	3,368	1,880	5,248	653	212	865	231	72	323
18	Yard manure,	16,000	16,000	1	4,179	2,640	6,819	3,461	1,969	5,121	901	37	938	347	152	499
19	Yard manure,	20,000	20,000	1	3,699	2,696	6,395	3,501	1,760	5,261	421	93	514	387	−18	339
20	Yard manure, Lime,	12,000 4,000	16,000	1	3,759	2,810	6,569	3,160	1,600	4,760	481	207	688	43	−208	−165
21	Lime,	4,000	4,000	1	3,313	2,300	5,613	2,872	1,680	4,552	65	−303	−238	−245	−128	−373
22	Ground limestone,	4,000	4,000	1	3,343	2,562	5,905	2,520	1,560	4,080	65	−11	21	−597	−218	−815
23	Plaster,	320	320	§2	3,226	2,595	5,821	3,341	1,840	5,181	−52	−8	−60	247	32	259
24	Ground bone, Muriate of potash, Dried blood,	221 200 240	661	***2	. . . .	. . . .	. . . .	2,808	1,740	4,548	. . . .	. . . .	. . . .	−309	−68	−377
	Average yield of plots receiving complete fertilizers containing dried blood,	. . . . .	. . . . .	†7	3,495	3,110	6,605	3,056	2,055	5,111	217	507	724	−61	217	186
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	. . . . .	. . . . .	3	3,741	3,214	6,955	3,165	1,787	4,952	466	608	1,074	48	−21	27
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	. . . . .	. . . . .	3	3,618	3,317	6,935	2,919	1,627	4,576	340	714	1,051	−168	−181	−349
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	. . . . .	. . . . .	‡5	3,585	3,144	6,729	3,012	1,893	4,905	307	511	818	−105	85	−20
	Average yield of plots receiving complete fertilizers containing 18 pounds of nitrogen,	. . . . .	. . . . .	4	3,598	3,192	6,790	3,161	2,010	5,174	320	589	909	47	202	249
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	. . . . .	. . . . .	4	3,557	3,217	6,774	3,017	1,820	4,837	279	614	893	−100	12	−88
	Average yield of plots receiving yard manure,	. . . . .	. . . . .	4	3,892	2,740	6,632	3,371	1,800	5,171	614	131	748	257	−8	249

*** First applied to wheat, 1881-1885.
† 6 after 1881-1885.
‡ 8 after 1881-1885.
§ By error, plot 33 received application of fertilizer for plot 35, at corn-planting, 1885.

Before proceeding to the discussion of the effect of the various fertilizers, it may be well to recall the fact that the season of 1885 was one unfavorable in this locality to all crops. A late spring followed by an early drought retarded vegetation at the period of vigorous growth.

(*a.*) Confining attention first to the effect of the various fertilizers on the absolute yield of corn, the observations of previous years are corroborated in the following particulars:

1. The yield of the fertilized plots shows no great gain in any case over that of the unfertilized plots. The greatest gain in ears is a little less than five bushels, and in fodder, four hundred pounds; the greatest gain in total crop is less than six hundred pounds.
2. The addition of nitrogen and potash singly produced no good effect, as before; the only fertilizer constituent effective when applied singly was phosphoric acid. The former even seemed injurious.
3. The addition of burnt lime and of ground limestone seems to work injuriously rather than beneficially; this was true of the latter especially. If, however, reference is made to table II, and a comparison instituted between the plots receiving these fertilizers and the contiguous unfertilized plots, it will be shown that the figures of table V do not, in this case, afford a proper idea of the facts. The burnt lime seems to have diminished the product of ears and correspondingly increased that of fodder, so that the total crop remains nearly the same. The ground limestone seems to have increased both ears and fodder, especially the latter. Plaster seems to have had a slightly beneficial effect.
4. The use of dried blood with phosphoric acid did not add to the value of the latter; on the other hand, phosphoric acid and potash gave the highest total crop, though the yield of ears produced was inferior to that with certain complete fertilizers.
5. As may be inferred from the last paragraph, the addition of nitrogen to phosphoric acid and potash to form a complete fertilizer, was without any useful effect on the total yield. In the yield of ears, the nitrate of soda plots receiving small and medium quantities of nitrogen, and the yard manure plots were the only ones receiving complete fertilizer that surpassed those receiving the mixture of mineral fertilizers.
6. Comparing the different complete artificial fertilizers containing different forms of nitrogen, it is seen that only those containing nitrate of soda produced any increase in ears, dried blood standing next, and sulphate of ammonia last; while in total crops, dried blood took the lead, nitrate of soda stood next, and sulphate of ammonia last.

7. Of the complete artificial fertilizers, those containing forty-eight pounds of nitrogen gave the highest yield in all particulars, that containing twenty-four pounds standing next.
8. Yard manure, while giving a gain in total crop equal to that of complete artificial fertilizers containing forty-eight pounds of nitrogen, caused an increase in the yield of ears, while the artificial fertilizer caused an increase in the fodder.
9. The substitution of ground bone for dissolved bone-black in a complete fertilizer containing dried blood, proved unfavorable, there being a great loss in the total crop, falling almost equally upon the yield of ears and of fodder.

(*b*.) In comparing the yields of 1885 with the averages of previous years, it must be recalled that differences may arise from a dissimilarity in the original character of the soil of tier II to that of the other tiers, from a gradual change in the fertility of the soil due to its exhaustion, or to an accumulative amount of available plant-food, and, finally, from a difference in the season of growth. Owing to the complexity of the causes, it would be a futile task to attempt any detailed study into the effect of the dry season. The following striking general variations may, however, be noted:

1. A marked decrease in the total crop, which is due mainly to a decrease in the amount of fodder, the loss in the yield of ears being comparatively slight.
2. A great decrease in the effect of all fertilizers. The single fertilizers, as a whole, suffered more heavily. Of the complete artificial fertilizers, the effect of the more soluble was more diminished: the effect of those containing the most and the least nitrogen decreased at about the same rate, and more than those of the fertilizer containing the medium amount.
3. The value of yard manure was relatively increased. This is probably attributable to the indirect effect of the yard manure in the retention of water in the soil; in dry years this increase of moisture would, in turn, cause a greater availability of the plant-food present. This is in keeping with the results of the experiments of Lawes and Gilbert, who observed that the drainage from plots receiving yard manure was less than from those to which commercial artificial fertilizers had been applied. It will be useless to attempt a study of the residual effects of the fertilizers upon any crop until there are data from a sufficient number of crops to eliminate the error arising from the effects of season and differences in the soil of the separate tiers.

2. EXPERIMENTS OF 1886—CENTRAL EXPERIMENTAL FARM.

The data are arranged in Table VI after the plan adopted for those of last year, and the number per acre of stalks that arrived at maturity is included.

Table VI.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Corn, 1886.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of Plots.	Yield per Acre.							Gain over Unfertilized Plots.						
					Average of previous crops—1881-1885.			Tier III—1886.				Average of previous crops—1881-1885.			Tier III—1886.			
					Ears.	Fodder.	Total crop.	Ears.	Fodder.	Total crop.	Number of stalks per acre.	Ears.	Fodder.	Total crop.	Ears.	Fodder.	Total crop.	Number of stalks per acre.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
1	Nothing,	. . . .	. . . .	5	3,246	2,111	5,690	3,608	2,153	5,761	10,238	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .
2	Dried blood,	240	240	1	3,356	2,507	5,863	3,200	1,780	4,980	9,872	110	63	173	—108	—373	—781	—366
3	Dissolved bone-black,	300	300	1	3,227	2,618	5,845	3,280	1,960	5,240	10,032	—19	174	155	—328	—193	—521	—206
4	Muriate of potash,	200	200	1	3,3 0	2,720	6,075	3,480	2,360	5,840	10,736	101	276	380	—128	207	79	498
5	Dried blood, Dissolved bone black,	240 300	540	1	3,540	2,688	6,198	4,000	2,416	5,416	11,061	261	244	508	392	263	655	826
6	Dried blood, Muriate of potash,	240 200	440	1	3,190	2,752	5,942	4,480	2,840	7,320	11,381	—56	308	252	872	687	1,559	1,146
7	Dissolved bone black, Muriate of potash,	300 200	500	*5	3,688	2,866	6,551	3,250	2,539	5,789	10,797	442	422	861	—358	386	28	559
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	*3	3,386	2,886	6,272	3,428	2,508	5,936	10,614	140	442	582	—180	355	175	406
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	3,430	2,921	6,351	3,900	2,620	6,520	10,480	184	480	661	292	467	759	242
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	3,469	2,976	6,445	4,128	2,560	6,688	10,692	223	532	755	520	407	927	454
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	3,688	2,939	6,627	3,360	2,656	6,016	10,832	442	495	937	—248	503	255	594
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	3,579	2,960	6,539	3,160	2,120	5,280	10,560	333	546	849	—448	—33	—481	322
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	3,536	1,880	6,416	3,280	2,000	5,280	10,752	290	436	726	—328	—153	—481	514
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	3,526	2,995	6,521	3,080	2,376	5,456	10,744	280	551	831	—528	223	295	506
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	3,605	3,014	6,619	3,420	2,456	5,876	10,624	359	570	929	—188	303	115	386

TABLE VI—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.							Gain over Unfertilized Plots.						
					Average of previous crops—1881-1885.			Tier III—1886.				Average of previous crops—1881-1885.			Tier III—1886.			
					Ears.	Fodder.	Total crop	Ears.	Fodder.	Total crop.	Number of stalks per acre.	Ears.	Fodder.	Total crop.	Ears.	Fodder.	Total crop	Number of stalks per acre.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300, 200, 360	860	1	3,322	2,928	6,250	3,780	2,680	6,460	10,896	76	481	560	172	527	699	658
17	Yard manure,	12,000	12,000	1	3,819	2,628	6,447	3,616	2,000	5,616	10,168	573	184	757	8	—153	—115	—70
18	Yard manure,	16,000	16,000	1	4,036	2,504	6,540	4,096	2,280	6,376	10,512	790	60	850	488	127	615	274
19	Yard manure,	20,000	20,000	1	3,660	2,509	6,169	3,216	1,760	4,976	10,104	414	65	479	—392	—393	—785	—134
20	Yard manure, Lime,	12,000, 4,000	16,000	1	3,639	2,568	6,207	3,000	1,680	4,680	9,928	393	124	517	—608	—173	—1,081	—310
21	Lime,	4,000	4,000	1	3,248	2,176	5,424	1,120	1,200	3,320	9,472	2	—268	—266	—1,148	—953	—2,441	—866
22	Ground limestone,	4,000	4,000	1	3,178	2,362	5,540	2,720	1,520	4,240	10,256	—68	—82	—150	—888	—633	—1,521	18
23	Plaster,	320	320	2	3,250	2,444	5,694	3,840	2,120	5,960	10,448	4	0	4	232	—33	199	110
24	Ground bone, Muriate of potash, Dried blood,	224, 200, 240	664	*2	2,808	1,740	4,548	4,478	2,636	7,114	10,768	—138	—704	—1,142	870	483	1,353	530
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	*7	3,407	2,899	6,306	3,983	2,581	6,564	10,646	161	455	616	375	428	803	408
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	3,628	2,926	6,554	2,267	2,259	5,526	10,715	386	482	868	—311	106	—235	477
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	3,484	2,979	6, 63	3,427	2,504	5,931	10,755	238	535	773	—184	354	170	517
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	*5	3,470	2,894	6,364	3,709	2,553	6,262	10,733	234	450	684	101	400	501	495
	Average yield of plots receiving complete fertilizers containing 18 pounds nitrogen,	....	....	4	3,511	2,956	6,467	3,595	2,454	6,049	10,586	265	512	777	—13	301	288	298
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	4	3,449	2,938	6,387	3,829	2,450	6,279	10,758	203	494	697	221	297	518	520
	Average yield of plots receiving yard manure,	....	....	4	3,788	2,552	6,340	3,482	1,930	5,412	10,165	542	108	650	—126	223	—249	—173

*Same remarks as to number of plots apply as were made in the table for 1885.

The season of 1886 was very different from that of 1885; the temperature was higher than usual in spring and lower in summer; during both periods the rainfall was greater than the average, and in summer more irregularly distributed. The conditions were exceedingly favorable for grass, fairly good for corn.

(*a.*) The effect of the fertilizers upon the number of stalks taken about the time of ripening, deserves some attention.

1. The number of hills was four thousand one hundred and twenty-eight per acre, with three stalks per hill; the full number then would be twelve thousand three hundred and eighty-four stalks. It will be observed that in the unfertilized plots over eighty per cent. reached maturity, and that the entire range of variation on the several plots was about two thousand stalks, or about seventeen per cent.
2. Dried blood and dissolved bone-blacks singly seemed to cause a loss; muriate of potash a gain, which was surpassed by its mixture with dried blood, the gain in this case being the highest found; the mineral fertilizers combined produced also a slight increase over that produced by the muriate alone; dried blood mixed with bone-black gave an increase intermediate between those with the last named mixtures.
3. Comparing the plots receiving burnt lime and ground limestone, with contiguous unfertilized plots, the former seems to cause a decrease, the latter an increase. Plaster causes a slight increase.
4. As may be inferred from the previous remarks, the complete fertilizers do not show any advantage, as far as the number of stalks is concerned, over the partial fertilizers containing two ingredients; sulphate of ammonia and nitrate of soda produced a higher increase than dried blood; likewise, a higher result was obtained with the smallest and the highest amounts of nitrogen than with the medium quantity. Yard manure seems to cause a slight decrease. A complete artificial fertilizer, containing ground bone as its source of phosphoric acid, produced a greater increase than one similar in all respects except that it contained an equivalent quantity of dissolved bone-black. This is in accord with the results of special experiments on the effects of different forms of phosphoric acid mentioned later.

It will, of course, be seen that with the narrow range of the above mentioned variations, and with the many uncontrollable conditions, which might produce a variation, it will not be advisable to do more than place these observations on record for check by future experiments. Moreover, while the number of stalks which arrive at maturity will have a marked effect upon the yield, the effect, as will be seen by a glance at the table, is by no means in exact proportion to the number of stalks; this is the case even on plots treated in all respects alike.

(*b*.) Comparing the yields of this year with the average of previous years, it is noticed that the yield is slightly lower, though on some of the plots it rises considerably above, and on others sinks as far below.

As differing from the results of previous seasons and especially from those of 1885, the following points may be noted :

1. The diminished yield with all the incomplete commercial fertilizers that did not contain nitrogen.
2. The marked increase of injury wrought by the application of lime and ground limestone, the chief loss falling on the yield of ears. Plaster, on the contrary, gave an increase, which was considerably less than it was in 1885.
3. Of the complete fertilizers containing different forms of nitrogen, none produced as large an increase as did the mixtures containing dried blood and a single mineral ingredient. As in 1885, dried blood, in complete fertilizers, produced an increase, a very considerable portion of which is in the yield of ears. This year, however, sulphate of ammonia surpasses yard manure in total yield, and in each case there is a gain in the amount of fodder, and a loss in the quantity of ears. Comparison with the average of previous years shows further, that the relations of these ingredients to the amount of increase are in 1886 exactly the reverse of those previously observed.
4. This year, of the fertilizers containing nitrogen, those containing the greatest and the least quantities produced the greatest total yield, the greatest quantity producing the highest yield of ears, the least the highest yield of fodder. This is the reverse of the effects produced last year.
5. Yard manure falls far behind the complete artificial fertilizers this year, yielding less of both ears and fodder than is obtained from the unfertilized plots.
6. The substitution of ground bone for dissolved bone-black in a complete fertilizer, resulted this year in a large increase, which occurred almost wholly in the yield of ears.

Taking these results as a whole, they seem to indicate :

I. An increased effect of the nitrogen as compared with phosphoric acid in a somewhat moist season as compared with a dry one, especially when the preceding seasons were dry.

II. That the superiority of yard manure in dry seasons for corn is, in these experiments, largely due to its retentive power for moisture, which ceases to be an advantage in a wet season. There is no doubt that the influence on the healthy germination and early vegetation of the seed may account in large measure for the difference in final yield between yard manure and complete artificial fertilizers when they are applied directly to spring crops: an excess of moisture rotting the seed and retarding vegetation.

III. The availability of the phosphoric acid in ground bone seems to be greater in moist seasons.

All the facts thus far considered, tend to prove that corn grown on sod is able to find enough food for a good crop, providing that the soil is sufficiently fertile and the previous season sufficiently favorable for the formation of a good sod; that in such case, the addition of fertilizers containing nitrogen produces no direct, material benefit. In measure, however, as the soil is not fertile, or the previous season unfavorable to the formation of sod, the effect of the nitrogenous fertilizers is increased. This is in accordance with the results of experiments made elsewhere.

(3.) Eastern Experimental Farm.

The crop of this year was grown on Tier III. The average yields of plots receiving the same fertilizer are stated in Table VII.

TABLE VII.—*Average Yield of Plots receiving the same Fertilizer, Eastern Experimental Farm, Corn, 1886.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Average of previous crops.* Ears.	Fodder.	Total crop.	Yield per Acre. Corn. Tier III, 1886. Ears.	Fodder.	Total crop.	Gain over Unfertilized Plots. Average of previous crops. Ears.	Fodder.	Total crop.	Gain over Unfertilized Plots. Corn. Tier III, 1886. Ears.	Fodder.	Total crop.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	3	3,352	2,496	5,848	2,400	2,501	4,907	....	....	....	....	....	....
2	Dried blood,	240	240	1	3,718	2,500	5,218	1,920	2,800	4,720	366	4	370	—480	293	197
3	Dissolved bone black,	300	300	1	4,378	2,740	7,118	3,120	3,100	6,220	1,026	244	1,270	720	593	1,313
4	Muriate of potash,	200	200	1	3,145	2,600	5,745	2,760	2,900	5,660	—207	104	—108	360	393	753
5	Dried blood, Dissolved bone-black,	240 300	540	1	4,902	3,010	7,912	3,720	3,910	7,560	1,550	514	2,064	1,320	1,434	2,753
6	Dried blood, Muriate of potash,	210 200	410	1	3,482	3,290	6,772	2,200	3,500	5,760	130	794	924	—200	1,053	853
7	Dissolved bone-black, Muriate of potash,	30 200	500	1	4,493	3,073	7,566	3,133	3,240	6,373	1,141	577	1,718	733	733	1,466
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	1	4,391	3,140	7,531	3,200	3,120	6,320	1,039	644	1,653	800	613	1,413
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	1	4,451	3,290	7,441	3,000	2,920	5,920	1,102	701	1,896	600	412	1,013
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 20 720	1,220	1	4,745	3,430	8,175	4,010	3,420	7,460	1,393	934	2,327	1,610	913	2,553
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	4,550	3,040	7,590	3,640	3,340	6,980	1,198	544	1,742	1,210	833	2,073
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	5,240	3,320	8,560	4,080	2,560	7,640	1,888	824	2,712	1,680	1,053	2,733
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	5,016	3,350	8,396	4,760	3,920	8,680	1,694	854	2,548	2,360	1,413	3,773
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	4,670	3,000	7,670	3,200	3,080	6,280	1,318	504	1,822	800	673	1,373

*1882 to 1884.

15	Dissolved bone-black, ... Murlate of potash, ... Sulphate of ammonia, ...	300 200 240	740	1	4,575	3,310	7,885	3,560	3,180	6,740	1,223	814	2,037	1,160	673	1,833
16	Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 360	860	1	4,782	3,160	7,942	3,520	2,810	6,360	1,430	664	2,094	1,120	333	1,453
17	Yard manure, ...	12,000	12,000	1	3,555	2,440	5,995	2,600	2,280	4,880	203	—56	147	200	—227	—27
18	Plaster, ...	320	320	1	3,190	2,160	5,350	1,600	2,000	3,600	—162	—336	—498	—800	—507	—1,307
	Average yield of plots receiving complete fertilizers containing dried blood, ...	. . . .	. . . .	3	4,530	3,286	7,816	3,413	3,153	7,566	1,178	790	1,968	1,013	646	1,659
	Average yield of plots receiving complete fertilizers containing nitrate of soda, ...	. . . .	. . . .	3	4,445	3,237	7,681	5,160	3,607	7,767	1,093	741	1,831	1,760	1,100	2,860
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia, ...	. . . .	. . . .	3	4,676	3,156	7,832	3,427	3,033	6,460	1,324	660	1,984	1,027	526	1,553
	Average yield of plots receiving complete fertilizers containing 24 lbs. of nitrogen, ...	. . . .	. . . .	3	4,537	3,060	7,597	3,317	3,180	6 527	1,185	561	1,749	917	673	1,620
	Average yield of plots receiving complete fertilizers containing 48 lbs. of nitrogen, ...	. . . .	. . . .	3	4,756	3,307	8,053	3,513	3,220	6,767	1,401	811	2,215	1,147	712	1,860
	Average yield of plots receiving complete fertilizers containing 72 lbs. of nitrogen, ...	. . . .	. . . .	3	4,357	3,313	7,670	4,107	3,393	7,500	1,005	817	1,822	1,707	886	2,583

The season in Eastern Pennsylvania was somewhat unfavorable to early vegetation, as compared with that at the Central farm. The following facts are worthy of note:

1. Complete nitrogenous fertilizers, and, to a less degree, other fertilizers, produced, as has been noticed in previous years, more gain here than at the Central farm. This is to be attributed largely to an inferiority in the fertility of the Eastern farm.

2. Plaster produced a decided decrease, instead of a slight increase, as at the Central farm, and the loss fell chiefly on the ears.

3. Potash had a greatly increased effect over that of other years.

4. The yield with dried blood and phosphoric acid combined, was surpassed by only one of the complete fertilizers. The great effect of dissolved bone-black alone is very striking.

5. Yard manure, as at the Central farm, caused a decrease in the total yield, which is due to a loss of fodder more than sufficient to offset the very considerable gain in ears. The average effect in previous years has here been much smaller than at the Central farm.

6. Of the groups of complete artificial fertilizers, those containing nitrate of soda produced the largest yield in all respects, while dried blood and sulphate of ammonia followed in order, not far apart, but very considerably behind the nitrate. The effects were even more noticeable on the ears than on the fodder. Dried blood owes its superiority in total yield over sulphate of ammonia to a larger amount of fodder. This is different from the record of previous years at the Eastern farm, and more nearly agrees with the average result at the Central farm, where, on the other hand, this year's results agree, in this respect, with the yield of previous years at the Eastern farm. In other words, there was in each case an exact reverse of the previous results.

7. The use of large quantities of nitrogen resulted in a large increase of ears as well as of total crop. In previous years, a medium amount produced the best result.

8. As compared with previous years, the yield of fodder was relatively greater, while the total crop was on the average considerably less.

The striking differences in the results at the two farms, as far as the minor points under investigation are concerned, serve to emphasize the necessity for repeated experiment under as wide a range of conditions as possible.

(4.) EXPERIMENT BY J. A. GUNDY, LEWISBURG, UNION COUNTY, PA.

Of the land on which the experiments were tried, Mr. Gundy writes as follows:

"The location is one mile south of Lewisburg. The soil is a sandy loam overlying 'Lewistown limestone,' and charged with lime from it; it would be called 'limestone land.' The 'Clinton red shale' crops out within twenty rods of the plots.

"The land had lain in grass (clover and timothy) for two or three years. It was plowed seven inches deep on April 23 and 24, the grass being about four inches high. All the fertilizers (except yard manure) were broadcast by hand and harrowed in. It was planted. May 13, with Leaming corn. It was first cultivated on June 7, and but once afterward. The fodder was cut off September 21, and husked and weighed October 12 and 13."

The results of these experiments are given in Table VIII.

TABLE VIII.—*Fertilizer Experiments on Corn, J. A. Gundy, Lewisburg, Pa.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Gain over Unfertilized Plots. Ears. Solid corn.	Gain over Unfertilized Plots. Ears. Soft corn.	Gain over Unfertilized Plots. Ears. Total ears.	Gain over Unfertilized Plots. Fodder.	Gain over Unfertilized Plots. Total crop.	Yield per Acre. Ears. Solid corn.	Yield per Acre. Ears. Soft corn.	Yield per Acre. Ears. Total ears.	Yield per Acre. Fodder.	Yield per Acre. Total crop.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	. . . . .	. . . .	2,420	270	2,690	3,130	5,820	. . . .	. . . .	. . . .	. . . .	. . . .
2	Muriate of potash,	200	200	2,730	480	3,210	4,310	7,520	388	140	528	1,405	1,933
3	Dissolved bone-black,	300	300	2,430	460	2,890	3,320	6,210	88	120	208	415	623
4	Dried blood,	240	240	2,910	390	3,300	3,220	6,520	568	50	618	315	933
5	Muriate of potash, Dissolved bone-black,	200 300	500	3,270	410	3,710	4,760	8,470	828	100	928	1,856	2,763
6	Muriate of potash, Dried blood,	200 240	440	3,470	465	3,935	4,660	8,595	1,028	125	1,153	1,755	2,908
7	Dissolved bone-black, Dried blood,	300 240	540	2,610	500	3,110	3,330	6,440	268	160	428	425	853
8	Muriate of potash, Dissolved bone-black, Dried blood,	300 300 240	740	3,550	380	3,930	5,120	9,050	1,208	40	1,218	2,215	3,463
9	Yard manure,	20,000	20,000	3,070	360	3,430	4,460	7,890	728	20	748	1,555	2,303
10	Burnt lime,	4,000	4,000	2,270	280	2,550	3,050	5,600	—72	—60	—132	145	13
11	Plaster,	1,000	1,000	2,370	360	2,730	2,830	5,560	28	20	48	—75	—27
12	Nothing,	. . . . .	. . . .	2,265	410	2,675	2,680	5,355	. . . .	. . . .	. . . .	. . . .	. . . .
	Average yield of unfertilized plots,	. . . . .	. . . .	2,342	340	2,682	2,905	5,587	. . . .	. . . .	. . . .	. . .	. . . .

Mr. Gundy says: "The season was too wet for corn in the early part of the spring and summer. A hail-storm about the last of July greatly injured the crop. * * All the plots receiving potash looked much better than the others. No. 4 looked bad all summer; No. 8 looked best all summer, and No. 9 looked well. No. 10 looked very bad and showed injury by lime."

The following points are prominent:

1. The agreement with this year's results at the Central farm as to the effect of phosphoric acid, and the relatively increased effect of muriate of potash.

2. The relatively increased effect of dried blood singly over that at both experimental farms. While the total yield with it is far below that of the potash, the yield of ears is somewhat greater.

3. As at the Central farm, this year, the yield of dried blood and muriate combined, compared well with that obtained with complete artificial fertilizer.

4. That, as elsewhere, burnt lime was decidedly injurious, and plaster produced very slight benefit—less than at the Central farm.

5. Complete artificial fertilizer far surpassed yard manure in the production both of ears and of fodder. The gain with yard manure was, however, quite large, and the results differed considerably from those obtained at the experimental farms.

6. The application of all fertilizers produced very marked gains.

7. The proportion of soft corn was greater with phosphoric acid than with dried blood or muriate of potash. With burnt lime it diminished, while plaster had little effect. A smaller proportion was produced with complete than with partial fertilizers. The artificial fertilizer produced less than the yard manure. At the Central farm this year there was no soft corn on any of the plots.

(5.) THE RELATIONS OF FERTILIZERS TO THE LOSS IN CURING AND THE PROPORTION OF COB TO KERNEL.

Although a fertilizer may prove beneficial, using the field-cured weight as a criterion, it may be questioned whether there might not be such a variation during the process of crib-curing as to materially alter the result as stated in terms of the weight of marketable, or cured corn, in the ear.

Another question, too, will naturally arise, viz: What is the effect of fertilizers on the proportion of cob to kernel in the ear produced on plots differently fertilized? Or, in other words, What is the effect of the fertilizer upon the yield of cured shelled corn?

To assist in the answer of these questions, the following observations were made: A small number of ears were selected, with the greatest care from the wagons at the time the crops of the various plots were being gathered in 1885. These ears may be regarded as representing fairly well the average of those produced by each plot. They were carefully weighed, strung, and suspended to the rafters of the barn, and were surrounded by an open paper sack to prevent the loss of any grain that might be detached. After a period of between three and four months they were moved to the laboratory, weighed, hand-shelled, and the weights of the cob and of the kernels taken. The results of these weighings are given in Table IX.

TABLE IX.—*Loss in Curing Ears, and Proportion of Cob to Kernels, Central Experimental Farm, 1885.*

Plot.	KIND OF FERTILIZER.	Single fertilizer ingredients per acre.	Fertilizer per acre.	LOSS OF EAR IN CURING.					PROPORTION OF COB TO KERNEL, CURED.					
				Number of ears used.	Fresh weight.	Cured weight.	Loss.	Loss per cent.	Total weight of cobs.	Total weight of kernels.	Average weight of cob.	Average weight of kernel.	Average weight of ear.	Proportion of cob to kernel.
		Lbs.	*Lbs.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	
1	Nothing,	.....	.....	11	1,803	1,551	219	13.81	291	1,263	26.5	114.8	141.3	1 : 4.3
2	Dried blood,	240	240	13	2,830	2,417	403	14.14	475	1,972	36.7	151.5	188.2	1 : 4.1
3	Dissolved bone-black,	300	300	14	2,691	2,303	388	14.42	487	1,816	34.8	129.7	164.5	1 : 3.7
4	Muriate of potash,	200	200	16	3,116	2,923	493	14.43	510	2,383	33.8	148.9	182.7	1 : 4.2
5	{ Dried blood, Dissolved bone-black,	240 300	540	12	2,193	1,660	533	24.30	314	1,316	26.2	112.1	138.3	1 : 4.3
6	{ Dried blood, Muriate of potash,	240 200	440	12	2,454	1,881	573	23.37	365	1,516	30.4	126.4	156.8	1 : 4.2
7	{ Dissolved bone-black, Muriate of potash,	300 200	500	14	2,945	2,251	691	23.57	417	1,831	29.8	131.0	160.8	1 : 4.4
8	Nothing,	.....	.....	13	2,961	2,352	612	20.65	437	1,915	33.6	147.3	180.9	1 : 4.4
9	{ Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	14	2,957	2,548	414	14.00	511	2,032	36.5	145.1	181.6	1 : 4.0
10	{ Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	11	2,243	1,732	511	22.78	315	1,417	26.8	130.7	157.5	1 : 4.5
11	{ Dissolved bone black, Muriate of potash, Dried blood,	300 200 720	1,220	14	2,327	1,933	394	16.93	412	1,521	29.4	108.7	138.1	1 : 3.8
12	{ Ground bone, Muriate of potash, Dried blood,	224 200 240	664	11	2,168	1,858	310	14.30	412	1,446	37.5	131.4	168.9	1 : 3.5
13	Plaster,	320	320	13	3,179	2,627	552	17.36	528	2,097	40.6	161.5	202.1	1 : 4.0
14	Nothing,	.....	.....	14	2,849	2,471	378	13.27	476	1,995	34.0	142.5	176.5	1 : 4.2
15	{ Dissolved bone black, Muriate of potash,	300 200	500	14	3,179	2,675	504	15.85	448	2,227	32.0	159.1	191.1	1 : 5.0
16	Yard manure,	12,000	12,000	13	3,381	2,789	592	17.51	476	2,313	36.6	177.9	214.5	1 : 5.0
17	{ Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	15	2,837	2,376	461	16.25	420	1,956	28.0	130.5	158.5	1 : 4.7

TABLE IX.—*Continued.*

Plot.	Kind of Fertilizer.	Single fertilizer ingredients per acre	Fertilizer per acre.	Loss of Ear in Curing. Number of ears used.	Fresh weight.	Cured weight.	Loss.	Loss per cent.	Proportion of Cob to Kernel, Cured. Total weight of cobs.	Total weight of kernels.	Average weight of cob.	Average weight of kernel.	Average weight of ear.	Proportion of cob to kernel.
		Lbs.	*Lbs.*		*Grams.*	*Grams.*	*Grams.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	
18	Yard manure,	16,000	16,000	12	2,816	2,392	424	15.06	412	1,980	31.3	165.0	199.8	1 : 4.8
19	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	12	2,580	2,115	465	18.02	373	1,742	31.1	145.2	176.3	1 : 4.7
20	Yard manure,	20,000	20,000	11	2,907	2,459	448	15.41	468	1,991	33.4	142.2	175.6	1 : 4.2
21	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 7.0	1,22)	14	3,068	2,468	600	19.56	477	1,991	34.1	142.2	176.3	1 : 4.2
22	Yard manure, Lime,	12,000 4,000	16,000	12	2,490	1,983	507	20.11	376	1,607	31.3	131.0	165.3	1 : 4.2
23	Lime,	4,0.0	4,000	14	2,674	2,381	393	14.70	443	1,838	31.6	161.3	162.9	1 : 4.1
24	Nothing,	. . . .	. . . .	18	2,612	2,280	353	13.37	433	1,856	33.3	142.8	176.1	1 : 4.3
25	Dissolved bone black, Muriate of potash,	300 200	500	12	2,735	2,353	382	13.97	400	1,944	31.5	149.5	181.0	1 : 4.7
26	Dissolved bone black, Muriate of potash, Nitrate of soda,	300 200 160	660	13	2,890	2,177	713	24.67	407	1,770	31.3	135.6	166.9	1 : 4.3
27	Dissolved bone-black, Muriate of potash, Nitrate of soda;	300 200 320	860	14	2,773	2,250	483	17.67	428	1,822	35.7	125.0	160.7	1 : 4.3
28	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	13	2,821	2,381	437	15.49	421	1,960	32.6	150.8	183.4	1 : 4.6
29	Dissolved bone-black, Muriate of potash,	300 200	500	13	3,014	2,481	533	17.68	481	2,000	37.0	163.8	190.8	1 : 4.2
30	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	13	2,916	2,391	352	12.82	471	1,923	36.2	817.9	181.1	1 : 4.1
31	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 210	740	11	2,926	2,369	567	19.31	426	1,913	30.4	138.8	169.2	1 : 4.6

32	Dissolved bone-black,	300	860	13	2,737	2,210	527	19.25	432	1,778	33.2	136.8	170.0	1 : 4.1
	Muriate of potash,	200												
	Sulphate of ammonia,	360												
33*	Plaster,	320	320	14	2,495	2,154	341	13.71	419	1,735	29.9	135.4	165.3	1 : 4.1
34	Ground lime-stone,	4,000	4,000	13	2,815	2,343	472	16.76	433	1,910	33 3	146.9	180.2	1 : 4.4
35	Ground bone,	2[illegible]4	664	14	2,589	2,140	449	17.31	430	1,710	30.7	122.2	152.9	1 : 4.0
	Muriate of potash,	200												
	Dried blood,	240												
36	Nothing,	. . . . .	. . . . .	16	2,939	2,133	806	27.42	410	1,723	25.6	107.7	133.3	1 : 4.2

* By error received same application as No. 35.

For the sake of convenience in the discussion, the final results have been arranged in Table X so as to show the averages from the corn of plots receiving the same fertilizer.

TABLE X.—*Average Loss in Curing Ears, and Average Proportion of Cob to Kernel on Plots receiving Different Fertilizers, Corn, 1885.*

Number.	KIND OF FERTILIZER.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Loss in curing.	AVERAGE WEIGHT. Cob.	AVERAGE WEIGHT. Kernels.	AVERAGE WEIGHT. Ear.	Proportion of cob to kernel.
		Lbs.	*Lbs.*		*Per cent.*	*Grams.*	*Grams.*	*Grams.*	
1	Nothing,	. . . .	. . . .	5	17.70	30.6	131.0	161.6	1 : 4.3
2	Dried blood,	210	210	1	11.11	36.7	151.5	188.2	1 : 4.1
3	Dissolved bone-black,	300	300	1	11.42	31.8	129.7	161.5	1 : 3.7
4	Muriate of potash,	200	200	1	14.43	33.8	118.9	182.7	1 : 4.2
5	Dried blood, Dissolved bone-black,	210 300	510	1	24.30	26.2	112.1	138.3	1 : 4.3
6	Dried blood, Muriate of potash,	210 200	410	1	23.37	30.4	126.4	156.8	1 : 4.2
7	Dissolved bone-black, Muriate of potash,	300 200	500	*5	17.77	32.6	148.3	180.9	1 : 4.6
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 210	740	*3	15.12	32.2	137.8	170.0	1 : 4.3
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	20.40	29.0	137.9	166.9	1 : 4.6
10	Dissolved bone black, Muriate of potash, Dried blood,	300 200 720	1,220	2	18.24	31.7	125.5	157.2	1 : 4.0
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	21.67	31.3	135.6	166.9	1 : 4.3
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	17.67	35.7	125.0	160.7	1 : 4.3
13	Dissolved bone black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	15.49	32.6	150.8	183.4	1 : 4.6

14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	12.82	36.2	117.9	181.1	1 : 4.1
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	19.31	30.4	138.8	169.2	1 : 4.6
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1	19.25	33.2	136.8	170.0	1 : 4.1
17	Yard manure,	12,000	12,000	1	17.51	36.6	177.9	214.5	1 : 5.0
18	Yard manure,	16,000	16,000	1	15.06	31.3	165.0	199.3	1 : 4.8
19	Yard manure,	20,000	20,000	1	15.41	33.4	142.2	175.9	1 : 4.2
20	Yard manure, Lime,	12,000 4,000	16,000	1	20.11	31.3	131.0	165.3	1 : 4.2
21	Lime,	4,000	4,000	1	14.70	31.6	13[illegible].3	162.9	1 : 4.1
22	Ground limestone,	4,000	4,000	1	16.76	33.3	146.9	180.2	1 : 4.4
23	Plaster,	320	320	*2	17.36	40.6	161.5	202.1	1 : 4.0
24	Ground bone, Muriate of potash, Dried blood,	221 200 240	661	*2	15.82	34.1	126.8	160.9	1 : 3.7
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	*7	17.92	31.0	133.7	164.7	1 : 4.3
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	19.28	33.2	137.1	170.3	1 : 4.1
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	17.13	33.3	141.2	174.4	1 : 4.2
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	*5	16.56	33.4	135.4	168.8	1 : 4.1
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	4	19.44	31.0	134.9	165.9	1 : 4.4
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	4	17.81	32.3	131.6	166.9	1 : 4.2
	Average yield of plots receiving yard manure,	....	....	4	17.02	33.9	154.8	188.7	1 : 4.6

*See remarks on table giving average yield for 1885, In discussing these results, the topics will be treated in the following order:

(a.) The Relation of Fertilizers to the Loss in Curing.

On this point, the following conclusions may be drawn:

1. That, although there is reason to believe that the extent of the yield may have a marked relation to the proportion of water contained by a crop, and therefore have a noticeable effect on the loss in curing, such an effect has not been conspicuous in this year's results, even on different plots receiving the same fertilizers. (Compare Tables II and IX.)

2. It will be seen from Table IX that there is frequently a greater variation between the results from different plots receiving the same fertilizer than there is between the averages of those receiving differing fertilizers. For this reason, none but the most general conclusions can safely be drawn from observations on a single crop.

3. That while the corn from plots receiving single fertilizer ingredients in every case lost less than the unfertilized plots, this was also true of many receiving the complete fertilizers, and in every instance where yard manure was applied alone.

4. Corn from plots receiving yard manure lost less than that produced by any group of complete fertilizers containing a single nitrogenous compound.

5. The greatest loss where the artificial fertilizers were used, occurred with the group containing nitrate of soda and that containing forty-eight pounds of nitrogen.

6. There seemed to be little difference in effect between dissolved bone-black and ground bone.

(b.) The Proportion of Cob to Kernel.

By examination of the tables, the following facts will be discovered:

1. The extreme range of variation was from 1:3.5 to 1:5.

2. That the range in the case of plots receiving the same fertilizer was very considerable, leading to the same remarks as were made under the preceding topic. Here, however, the variation is relatively less.

3. Comparison of the proportion of kernel to cob in the ears from plots receiving the same fertilizer gives negative testimony as to any relations which may exist between this proportion and that of ear to fodder, or the absolute yield of any portion of the crop. It must be remarked that the data are too few to expect any prominence of such relations where influencing conditions are so complex.

4. With the exception of ground limestone, all ingredients applied singly seemed to diminish the proportion of kernel, taking the unfertilized plots as the standard.

5. That the proportion of kernel was as high with potash and phosphoric acid combined, as the average with yard manure.

6. That dissolved bone-black produced a higher proportion of kernel than did ground bone.

7. That the complete artificial fertilizers containing soluble nitrogen compounds diminished the proportion of kernel; that dried blood produced no change, and nitrate of soda the most.

8. That the highest proportion of kernel where complete artificial fertilizers containing different quantities of nitrogen were used was obtained with that group containing forty-eight pounds.

9. That yard manure produced relatively more kernel than any complete artificial fertilizer.

(c.) *The Weight of the Ears.*

It may be interesting to note the following facts on this subject:

1. That the weight was, with few exceptions, increased by the application of fertilizers. This points to the fact that the use of fertilizers may be advantageous as well in diminishing the labor of harvesting as in increasing the yield or in improving the fertility of the soil.

2. The soluble nitrogen fertilizers increased the weight more than the dried blood did.

3. The cured weight was slightly greater with twenty-four pounds of nitrogen than with greater quantities.

4. The average weight with yard manure was greater than with any group of complete fertilizers.

(6.) THE RELATION OF FERTILIZERS TO THE WEIGHT OF SEED CORN, AND ITS GERMINATIVE POWER.

In order to discover what relations might exist between the different fertilizers used in these experiments and the above-mentioned properties, a series of experiments was undertaken, at my suggestion, by Mr. H. J. Patterson, of the class of 1886, and made the subject of his agricultural thesis. Observations were made upon the following special points:

I. The weight of one hundred kernels representing the average product of each plot.

II. The proportion by number, and the weight of large, medium, and small grains in an average sample of five hundred kernels from each plot.

III. The germinative power of the average seed from each plot.

IV. The germinative power of the largest seed selected from the sample of five hundred kernels.

The results obtained are presented in Tables XI–XIV. The germination trials were made in the apparatus described later under the head of germination experiments. The temperature varied only a few degrees from seventy degrees F. Observations were also made upon a sample of the seed used in planting the crop. None of the ungerminated seed was sound at the end of the germination test.

TABLE XI.—*Size and Weight of Seed.*

Plot.	Average Seed.		Small Seed in 500.			Medium Seed in 500.			Large Seed in 500.		
	Number.	Weight.*	Number.	Per cent.	Weight.	Number.	Per cent.	Weight.	Number.	Per cent.	Weight.
		Grams.			*Grams.*			*Grams.*			*Grams.*
†0, ...	100	29.05	32	6.4	5.5	75	15.0	18.0	393	78.6	122.0
1, ...	100	22.52	85	17.0	11.0	100	20.0	21.5	315	63.0	85.0
2, ...	100	27.64	53	10.6	7.5	120	24.0	27.5	327	65.4	101.5
3, ...	100	27.15	88	17.6	12.5	125	25.0	33.0	287	57.4	97.5
4, ...	100	29.23	71	14.2	13.5	93	18.6	23.0	336	67.2	118.5
5, ...	100	27.22	93	18.6	13.0	103	20.6	28.0	304	60.8	95.0
6, ...	100	25.92	113	22.6	22.0	110	22.0	28.0	274	54.8	86.5
7, ...	100	29.42	71	14.2	11.0	112	22.4	29.5	317	63.4	105.5
8, ...	100	29.22	31	6.2	4.0	121	22.2	29.5	348	69.6	118.0
9, ...	100	26.93	48	9.6	8.5	107	21.4	27.0	345	69.0	114.0
10, ...	100	29.22	47	9.4	8.0	91	18.2	23.5	362	72.4	118.0
11, ...	100	28.35	135	27.0	21.0	106	21.2	26.0	259	51.8	88.0
12, ...	100	28.05	100	20.0	17.5	147	29.4	37.0	253	50.6	82.5
13, ...	100	28.72	89	17.8	15.0	132	26.4	33.5	269	53.8	95.0
14, ...	100	26.70	70	14.0	13.0	130	26.0	33.0	300	60.0	88.5
15, ...	100	30.38	75	15.0	16.0	109	21.8	31.0	316	63.2	108.0
16, ...	100	29.61	50	10.0	10.5	98	19.6	25.5	352	70.4	115.0
17, ...	100	27.12	108	21.6	21.0	115	23.0	30.0	278	55.6	89.0
18, ...	100	28.11	91	18.2	16.0	132	26.4	32.0	278	55.6	90.0
19, ...	100	28.44	75	15.0	13.0	138	27.6	38.5	287	57.4	82.0
20, ...	100	27.28	75	15.0	14.0	146	29.2	37.0	279	57.8	86.0
21, ...	100	26.71	131	26.2	24.0	131	26.2	34.0	238	47.6	79.0
22, ...	100	25.93	82	16.4	14.5	128	25.6	32.0	290	58.0	81.0
23, ...	100	22.39	181	36.2	20.5	170	34.0	37.0	149	29.8	61.5
24, ...	100	24.42	119	23.8	20.5	136	27.2	[illegible]	245	49.0	69.5
25, ...	100	28.66	135	27.0	27.5	136	27.2	35.0	229	45.8	74.0
26, ...	100	24.66	124	24.8	28.0	150	30.0	36.0	226	45.2	68.5
27, ...	100	26.99	75	15.0	13.0	159	31.8	36.0	274	54.8	81.0
28, ...	100	27.22	91	18.2	18.0	129	25.8	32.5	281	56.2	92.0
29, ...	100	26.18	85	17.0	15.5	157	31.4	40.0	255	51.0	80.0
30, ...	100	26.93	102	20.4	18.0	145	29.0	33.5	253	50.6	79.5
31, ...	100	26.15	123	24.6	20.0	180	36.0	42.0	197	39.4	58.5
32, ...	100	21.81	141	28.2	21.5	128	25.6	32.0	231	46.2	70.0
33, ...	100	23.39	143	28.6	22.5	127	25.4	28.0	230	46.0	65.5
34, ...	100	22.90	141	28.2	21.5	160	32.0	35.0	199	39.8	58.0
35, ...	100	21.60	135	27.0	21.0	144	28.8	30.5	221	44.2	64.0
36, ...	100	22.49	122	24.4	17.5	149	29.8	32.0	229	45.8	68.0

* Weight expressed in grams. † Original seed.

TABLE XII.—*Germination of Corn Grown with Different Fertilizers—Average Seed.*

PLOT.	Date of beginning experiment.	Number seeds used.	Hours soaked.	DAYS. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Per cent. germinated.	Time required for one-half to germinate.
*0, ...	May 6, 1886,	100	16½	0	73	20	5	0	0	1	0	0	0	99	2 days.
1, ...	"	100	16½	0	73	21	2	0	0	0	0	0	0	96	"
2, ...	"	100	16½	0	67	23	2	4	1	0	0	0	0	96	"
3, ...	"	100	16½	0	52	27	13	4	0	0	0	0	0	96	"
4, ...	"	100	16½	0	53	28	11	4	2	0	0	0	6	98	"
5, ...	"	100	16½	0	56	29	5	3	0	0	0	0	0	93	"
6, ...	"	100	16½	0	51	22	12	3	0	0	0	0	0	88	"
7, ...	"	100	16½	0	47	29	11	6	1	1	0	0	0	88	3 days.
8, ...	"	100	16½	0	61	21	5	2	2	1	0	0	0	92	2 days.
9, ...	"	100	16½	0	71	15	5	1	0	0	1	0	0	93	"
10, ...	"	100	16½	0	75	14	2	1	0	0	0	0	0	92	"
11, ...	"	100	16½	0	67	20	6	1	0	0	0	0	0	94	"
12, ...	"	100	16½	0	64	24	5	1	1	0	0	0	0	95	"
13, ...	"	100	16½	0	35	32	16	8	1	0	0	0	0	87	3 days.
14, ...	"	100	16½	0	67	18	11	1	0	0	0	0	0	97	2 days.
15, ...	"	100	16½	0	72	18	2	1	1	0	0	0	0	94	"
16, ...	"	100	16½	0	64	21	4	1	1	0	0	0	0	91	"
17, ...	"	100	16½	0	67	22	4	0	1	0	0	0	0	94	"
18, ...	"	100	16½	0	69	18	3	0	2	0	0	0	0	92	"
19, ...	"	100	16½	0	71	15	10	2	0	0	0	0	0	98	"
20, ...	May 11, 1886,	100	16½	38	44	16	0	0	0	1	0	0	0	99	"
21, ...	"	100	16½	27	35	19	6	0	0	0	0	0	0	97	"
22, ...	"	100	16½	35	40	23	0	0	0	0	0	0	0	98	"
23, ...	"	100	16½	34	50	12	2	0	0	0	0	0	0	94	"
24, ...	"	100	17½	23	37	19	4	0	3	0	0	0	1	88	"
25, ...	"	100	16½	22	43	22	0	0	0	0	0	0	0	87	"
26, ...	"	100	16½	36	38	16	7	0	1	0	0	0	0	98	"
27, ...	"	100	16½	29	35	24	8	0	1	0	0	0	0	97	"
28, ...	"	100	16½	31	34	12	8	0	7	0	0	1	0	93	"
29, ...	"	100	16½	29	41	18	1	0	0	1	0	1	0	91	"
30, ...	"	100	16½	50	33	12	2	0	0	0	0	0	0	97	"
31, ...	"	100	16½	40	44	14	1	0	0	0	0	0	0	99	"
32, ...	"	100	16½	52	32	6	3	0	0	0	0	0	0	93	"
33, ...	"	100	16½	32	34	21	3	0	1	0	0	0	0	91	"
34, ...	May 18, 1886,	100	16½	11	58	18	6	0	1	0	0	0	0	94	"
35, ...	"	100	16½	15	57	18	3	0	0	0	0	0	0	93	"
36, ...	"	100	16½	12	44	33	8	0	2	0	0	0	0	99	"

* Original seed.

TABLE XIII.—*Germination of Corn Grown with Different Fertilizers—Large Seeds selected.*

PLOT.	Date.	Seed used.	Hours soaked.	DAYS. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10	Per cent. germinated.	Time required for one-half to germinate.
*0, ...	May 18, 1886,	100	16½	34	51	12	3	0	. .	. .	. .	. .	. .	100	2 days.
1, ...	“	100	16½	35	57	8	0	0	1	0	0	0	0	96	“
2, ...	“	100	16½	18	40	23	10	0	1	0	0	1	0	93	“
3, ...	“	100	16½	4	29	24	30	0	8	0	1	0	0	98	3 days.
4, ...	“	100	16½	11	40	23	19	0	2	0	0	0	0	95	2 days.
5, ...	“	100	16½	19	53	20	5	0	0	0	0	0	0	97	“
6, ...	“	100	16½	12	47	21	15	0	5	. .	. .	. .	. .	100	“
7, ...	“	100	16½	13	57	19	9	0	1	0	0	0	0	99	“
8, ...	“	100	16½	12	42	21	12	0	12	0	0	0	0	99	“
9, ...	“	100	16½	21	45	16	6	0	0	0	0	0	0	98	“
10, ...	“	100	16½	12	51	28	7	0	0	0	0	0	0	98	“
11, ...	“	100	16½	21	53	20	1	0	0	0	0	0	0	98	“
12, ...	“	100	16½	22	53	11	3	0	1	0	0	0	0	90	“
13, ...	“	100	16½	22	49	20	1	0	0	0	0	0	0	92	“
14, ...	May 25, 1886,	100	16½	15	49	26	7	3	0	0	0	0	0	97	“
15, ...	“	100	16½	23	39	17	13	5	0	0	0	0	0	97	“
16, ...	“	100	16½	9	30	18	24	7	3	0	0	0	0	91	3 days.
17, ...	“	100	16½	14	25	29	24	8	. .	. .	. .	. .	. .	100	“
18, ...	“	100	16½	17	23	28	18	8	1	0	0	0	0	95	“
19, ...	“	100	16½	18	43	20	14	3	1	1	. .	. .	. .	100	2 days.
20, ...	“	100	16½	45	37	15	1	0	0	0	0	0	0	98	“
21, ...	“	100	16½	20	35	23	8	2	1	1	1	0	0	91	“
22, ...	“	100	16½	27	35	23	13	2	. .	. .	. .	. .	. .	100	“
23, ...	“	100	16½	40	32	23	2	0	1	0	0	0	0	98	“
24, ...	“	100	16½	38	37	8	3	0	0	1	1	0	0	88	“
25, ...	“	100	16½	42	38	12	0	0	1	0	0	0	0	93	“
26, ...	“	100	16½	21	33	36	10	. .	. .	. .	. .	. .	. .	100	“
27, ...	“	100	16½	29	44	16	8	2	0	0	0	0	0	99	“
28, ...	“	100	16½	14	28	22	12	11	7	0	2	1	0	97	3 days.
29, ...	“	100	16½	16	21	31	15	7	1	0	0	0	0	91	“
30, ...	May 28, 1886,	100	16½	9	55	26	5	0	0	0	0	0	0	95	2 days.
31, ...	“	100	16½	19	60	20	1	. . .	. .	. .	. .	0	. .	100	“
32, ...	“	100	16½	8	64	20	4	1	0	0	0	0	0	97	“
33, ...	“	100	16½	3	43	23	14	8	0	0	0	0	0	91	3 days.
34, ...	“	100	16½	7	47	27	10	5	0	0	0	0	1	97	2 days.
35, ...	“	100	16½	4	58	26	8	2	0	0	0	0	0	98	“
36, ...	“	100	16½	0	37	32	7	11	2	1	. .	0	. .	100	3 days.

* Original seed.

TABLE XIV.—*Average Weight, Size, and Germination of Seeds from Corn Plots, 1885.*

Number.	Fertilizer.	Weight of 100 kernels.	Small Seed in 500.		Medium-sized Seed in 500.		Large Seed in 500.		Average seed germinated.	Large seed germinated.
			Per cent.	Weight.	Per cent.	Weight.	Per cent.	Weight.		
		Grams.		*Grams.*		*Grams.*		*Grams.*	*Per cent.*	*Per cent.*
0	Original seed,	29.05	6.4	5.5	15.0	18.0	78.6	122.0	99.0	100.0
1	Nothing,	25.07	17.0	13.2	25.0	29.4	57.5	83.4	94.4	96.0
2	Dried blood,	27.64	10.6	7.5	24.0	27.5	65.4	101.5	96.0	93.0
3	Dissolved bone-black,	27.15	17.6	12.5	25.0	33.0	57.4	97.5	96.0	98.0
4	Muriate of potash,	29.23	14.2	13.5	18.6	23.0	67.2	113.5	98.0	95.0
5	Dried blood, Dissolved bone-black,	27.22	18.6	13.0	20.6	28.0	60.8	95.0	93.0	97.0
6	Dried blood, Muriate of potash,	25.92	22.6	22.0	22.0	28.0	51.8	86.5	88.0	100.0
7	Dissolved bone-black, Muriate of potash,	28.66	18.3	17.4	25.7	34.1	55.8	91.7	90.0	95.0
8	Dissolved bone-black, Muriate of potash, Dried blood, 240 lbs.,	27.02	15.6	14.7	22.2	28.5	62.3	101.5	93.5	99.0
9	Dissolved bone-black, Muriate of potash, Dried blood, 480 lbs.,	28.83	12.2	10.5	22.9	31.0	64.9	102.5	95.0	99.0
10	Dissolved bone-black, Muriate of potash, Dried blood, 720 lbs.,	27.53	26.6	25.5	23.7	30.0	49.8	83.5	95.5	94.5
11	Dissolved bone-black Muriate of potash, Nitrate of soda, 160 lbs.,	24.66	24.8	23.0	30.0	36.0	45.2	68.5	98.0	100.0
12	Dissolved bone-black, Muriate of potash, Nitrate of soda, 320 lbs.,	23.99	15.0	13.0	31.8	36.0	54.8	81.0	97.0	99.0
13	Dissolved bone-black, Muriate of potash, Nitrate of soda, 480 lbs.,	27.22	18.2	18.0	25.8	32.5	56.2	92.0	93.0	97.0
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 120 lbs.,	26.93	20.4	18.0	29.0	33.5	50.6	79.5	97.0	95.0

TABLE XIV.—*Continued.*

Number.	FERTILIZER.	Weight of 100 kernels.	SMALL SEED IN 500.		MEDIUM-SIZED SEED IN 500.		LARGE SEED IN 500.		Average seed germinated.	Large seed germinated.
			Per cent.	Weight.	Per cent.	Weight.	Per cent.	Weight.		
		Grams.		*Grams.*		*Grams.*		*Grams.*	*Per cent.*	*Per cent.*
15	Dissolved bone black, Muriate of potash, Sulphate of ammonia, 240 lbs.,	26.15	21.6	20.0	36.0	42.0	30.4	58.5	99.0	100.0
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 360 lbs.,	21.81	28.2	22.5	25.6	32.0	46.2	70.0	93.0	97.0
17	Yard manure, 12,000 lbs.,	29.61	10.0	10.5	19.6	25.5	70.4	115.0	91.0	91.0
18	Yard manure, 16,000 lbs.,	28.11	18.2	16.0	26.4	32.0	55.6	90.0	92.0	95.0
19	Yard manure, 20,000 lbs.,	27.28	15.0	14.0	29.2	37.0	57.8	86.0	99.0	93.0
20	Yard manure, Lime,	25.93	16.4	14 5	25.6	32.0	58.0	81.0	98 0	100 0
21	Lime,	22.39	36.2	20.5	34.0	37.0	29.8	64.5	94 0	98.0
22	Ground limestone,	22.90	28.2	21.5	32.0	35.0	39.8	58.0	94.0	97.0
23	Plaster,	26.05	17.8	15.0	26.4	33.5	53.8	95.0	89.0	91.5
24	Ground bone, Muriate of potash, Dried blood,	24.82	23.5	19.2	20.1	33.7	47.4	73.2	94.0	94.0
	Average of plots receiving complete fertilizers containing—									
	Dried blood,	27.05	19.5	16.7	21.5	30.8	56.1	90.2	94.5	96.6
	Nitrate of soda,	25.29	19.9	18.0	29.2	31.8	52.1	47.2	96.0	95.3
	Sulphate of ammonia,	21.96	21.4	20 2	30.2	35.8	45.4	69.3	96.3	97.6
	Nitrogen, 24 lbs.,	25.88	20.6	18.2	26.9	32.8	52.5	82.2	95.0	96.8
	Nitrogen, 48 lbs.,	26 95	16.0	13.5	28.4	35.0	54.0	86.4	96.5	99.2
	Nitrogen, 72 lbs.,	26.02	21.9	21.4	21.7	31.1	45.5	82.2	94.2	95 7
	Yard manure,	27.98	11.9	13.7	25.2	31.6	60.4	93.0	95.0	96.0

a. On examining these tables the following facts appear respecting the weight of the average seed:

1. As is found in the comparison in all other respects of plots receiving the same fertilizer, the variation is great, and only the averages from a considerable number can be accepted as trustworthy.
2. In only a few cases the weight of average seeds from fertilized plots was less than that from the unfertilized.
3. The heaviest seeds were obtained from the plots receiving only potash and those receiving the smallest amount of yard manure.
4. The plot receiving the largest amount of sulphate of ammonia yielded the lightest seed, whereas that receiving the largest amount of nitrate of soda produced a heavier sample than was obtained with smaller amounts.
5. The seeds produced on the lime and ground limestone plots were smaller than those from unfertilized plots.
6. That among plots to which were applied complete fertilizers containing different forms of nitrogen, the lightest seed was produced from plots receiving those containing nitrate of soda and sulphate of ammonia.
7. Of the complete artificial fertilizers containing various quantities of nitrogen. that containing the medium quantity seemed to produce the heaviest seed.

b. The following facts with reference to the size of the seeds are noticeable:

1. The plots receiving the incomplete fertilizers produced a larger proportion of large seed than those receiving the complete fertilizers did; this is with the exception of lime and ground limestone, where the proportion was excessively low.
2. Of the complete artificial fertilizers containing different forms of nitrogen, the group containing dried blood seemed to produce the largest, nitrate of soda next, and sulphate of ammonia least.
3. The group of complete artificial fertilizers containing forty-eight pounds of nitrogen gave a higher proportion of large seed than the groups containing other amounts.
4. Yard manure surpassed all the groups of artificial fertilizers in this respect.
5. Ground bone was quite inferior to dissolved bone-black.

c. Regarding the germination results, the following comments may be made:

1. There was considerable variation among plots receiving fertilizers of the same general character.

2. Lime and ground limestone seemed to produce little effect; plaster a slightly unfavorable one. Other single ingredients were above the average.
3. Of the seeds produced by use of complete artificial fertilizers containing nitrogen in different forms, those from plots receiving the soluble nitrogen compounds had the highest germinative power.
4. The germinative capacity of the average seed was greatest with a medium quantity of nitrogen. This was not the case when the nitrogen was comparatively insoluble as in dried blood and yard manure.
5. On the average, the germinative capacity of seeds produced with yard manure did not reach that of those produced with the complete artificial fertilizers containing soluble nitrogenous compounds.
6. The rapidity of germination was practically equal.
7. As a rule, the large seed was superior to the average seed in germinative power.
8. Some of the differences from the original seed must be attributed to the dryness of the latter, which often has a marked effect on the germinative properties of seeds.

Finally, as has been previously remarked, it will need the observations of several years on these and other detailed points before any attempt can be made to discover the physiological differences arising from differences in fertilization. There is in progress a complete chemical analysis of the corn samples for 1885 which may give assistance in this matter, but the results are not yet sufficiently complete for report.

B. Oats.

EXPERIMENTS OF 1885—(1.) CENTRAL EXPERIMENTAL FARM.

This crop was grown upon tier I. As the oats receive no direct application of fertilizer, but are influenced only by the residual effect after the removal of the corn crop, it is necessary, in order to gain a true idea of the real relation and total effect of a single application of fertilizers, to keep before the mind the yield of the previous corn crop, and also the total yield of the two crops. These data for the different fertilizers are given in Table XV, including also the averages of the same for the previous oats and their preceding corn crops.

TABLE XV.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Corn and Oats, 1884–5.*

Number.	KIND OF FERTILIZER.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	YIELD PER ACRE. Average of previous crops. Corn, 1881–1883. Ears.	Fodder.	Total crop.	Oats, 1882–1884. Grain.	Straw.	Total crop.	Combined crops, 1881–1884.	Crop of 1884 and 1885. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops, 1884–1885.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	5	3,080	2,788	5,868	1,313	1,919	3,292	9,160	4,480	2,018	6,528	1,080	952	2,032	8,[illegible]6[illegible]
2	Dried blood,	240	240	1	3,034	2,965	5,999	1,418	1,977	3,395	9,391	3,486	2,734	6,220	808	992	1,800	8,0[illegible]0
3	Dissolved bone-black,	300	300	1	2,698	2,960	5,658	1,361	1,869	3,233	8,891	3,231	2,742	5,976	1,040	1,080	2,120	8,096
4	Muriate of potash,	200	200	1	3,058	3,253	6,311	1,408	1,920	3,328	9,639	3,514	2,970	6,481	936	861	1,800	8,284
5	Dried blood, Dissolved bone-black,	240 300	540	1	3,148	3,010	6,188	1,469	2,000	3,469	9,657	3,611	2,850	6,461	1,001	996	2,000	8,461
6	Dried blood, Muriate of potash,	240 200	440	1	3,056	3,453	6,509	1,385	2,091	3,476	9,985	3,252	3,060	6,312	736	661	1,400	7,712
7	Dissolved bone-black, Muriate of potash,	300 200	500	*5	3,231	3,181	6,415	1,497	2,076	3,573	9,988	5,320	2,672	7,992	1,439	1,377	2,816	10,808
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	*3	3,028	3,236	6,261	1,465	2,057	3,522	9,786	4,760	2,507	7,267	1,260	1,100	2,360	9,627
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	3,002	3,360	8,362	1,487	2,012	3,499	9,861	4,960	2,980	7,910	1,272	1,368	2,640	10,580
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	2,959	3,2[illegible]3	6,232	1,526	2,216	3,742	9,974	5,300	2,810	8,140	1,311	1,383	2,732	10,872
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	3,202	3,325	6,527	1,527	2,008	3,535	10,062	5,560	2,880	8,440	1,552	1,328	2,880	11,320
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	3,120	3,387	6,507	1,603	2,187	3,790	10,297	5,200	2,560	7,760	1,188	1,352	2,840	10,600
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	3,198	3,400	6,598	1,516	2,280	3,796	10,391	5,200	2,760	7,960	1,504	1,616	3,120	11,080
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	3,137	3,525	6,612	1,611	2,520	4,132	10,791	5,200	2,800	8,000	1,511	1,416	2,960	10,960
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	3,221	3,504	6,728	1,602	2,408	4,010	10,738	5,400	2,720	8,120	1,656	1,624	3,280	11,400

TABLE XV—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Average of previous crops. Corn, 1881-1883. Ears.	Fodder.	Total crop.	Oats, 1882-1884. Grain.	Straw.	Total crop.	Combined crops, 1881-1884.	Crop of 1884 and 1885. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops, 1884-1885.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1	2,816	3,533	6,319	1,685	2,419	4,131	10,138	5,280	2,600	7,880	1,560	1,600	3,160	11,010
17	Yard manure,	12,000	12,000	1	3,255	2,840	6,095	1,376	2,200	3,576	9,671	5,960	2,760	8,720	1,280	1,400	2,680	11,400
18	Yard manure,	16,000	16,000	1	3,932	2,747	6,679	1,415	2,196	3,611	10,290	4,920	2,320	7,240	1,248	1,126	2,374	9,614
19	Yard manure,	20,000	20,000	1	3,105	6,795	5,900	1,483	2,043	3,526	9,426	5,480	2,400	7,880	1,344	1,056	2,400	10,280
20	Yard manure, Lime,	12,000 4,000	16,000	1	3,332	2,920	6,252	1,474	2,325	3,799	10,051	5,040	2,480	7,520	1,236	1,444	2,680	10,200
21	Lime,	4,000	4,000	1	3,097	2,153	6,216	1,428	2,088	3,516	9,732	4,080	1,840	5,920	944	856	1,800	7,720
22	Ground limestone,	4,000	4,000	1	2,631	2,643	5,274	1,438	2,176	3,614	8,888	5,480	2,320	7,800	1,160	2,880	4,040	11,840
23	Plaster,	320	320	2	2,861	2,826	5,687	1,347	1,885	3,232	8,919	4,320	1,900	6,220	1,014	1,766	2,780	9,400
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	7	3,001	3,282	6,283	1,494	2,092	3,586	9,869	4,971	2,737	7,708	1,287	1,259	2,516	10,251
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	3,173	3,371	6,511	1,549	2,158	3,707	10,251	5,320	2,733	8,053	1,515	1,432	2,947	11,000
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	3,059	3,521	6,580	1,633	2,459	4,092	10,672	5,293	2,707	8,000	1,587	1,547	3,134	11,134
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	5	3,084	3,311	6,395	1,507	2,143	3,650	10,045	5,208	2,610	7,818	1,375	1,209	2,584	10,402
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	4	3,087	3,403	6,490	1,595	2,155	3,750	10,240	5,130	2,810	7,940	1,396	1,354	2,750	10,690
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	4	2,980	3,370	6,350	1,561	2,353	3,914	10,264	5,270	2,760	8,030	1,438	1,498	2,936	10,966
	Average yield of plots receiving yard manure,	....	....	4	3,106	2,575	5,981	1,437	2,191	3,628	9,609	5,350	2,190	7,840	1,277	1,253	2,530	10,370

TABLE XV.—*Continued.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Gain over Unfertilized Plots. Average of previous crops. Corn, 1881-1883. Ears.	Fodder.	Total crop.	Oats, 1882-1884. Grain.	Straw.	Total crop.	Combined crops, 1881-1884.	Crop of 1884 and 1885. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops, 1884-1886.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
2	Dried blood,	240	—46	177	131	75	28	103	231	—994	686	—308	—272	40	—232	—540
3	Dissolved bone-black,	300	—322	172	—2[illegible]0	21	—80	—59	—269	—1,246	691	—552	—40	128	—88	—464
4	Muriate of potash,	200	—22	465	443	65	—29	36	479	—966	922	—44	—144	—112	—256	—276
5	Dried blood, Dissolved bone-black,	240 300	68	252	320	126	51	177	497	—869	802	—67	—76	41	—32	—99
6	Dried blood, Muriate of potash,	240 200	—21	665	644	42	142	184	825	—1,228	1,012	—216	—344	—288	—632	—848
7	Dissolved bone-black, Muriate of potash,	300 200	151	393	517	151	127	281	828	840	624	1,464	359	425	784	2,243
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	—52	448	396	122	108	230	626	280	459	739	180	148	328	1,067
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	—78	572	494	144	63	207	701	480	932	1,312	192	416	608	2,020
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	—121	485	364	184	267	450	814	820	792	1,612	264	436	700	2,312
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	122	537	659	186	59	243	902	1,080	832	1,912	472	376	248	2,760
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	40	599	639	260	238	498	1,137	720	512	1,232	408	400	808	2,040
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	118	612	730	173	331	504	1,234	720	712	1,432	420	664	1,084	2,520
14	Dissolved bone black, Muriate of potash, Sulphate of ammonia,	300 200 120	57	737	794	268	571	840	1,634	720	752	1,472	464	464	928	2,400
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	144	716	860	259	459	718	1,578	920	672	1,592	576	672	1,248	2,810

TABLE XV.—*Continued.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Gain over Unfertilized Plots.													
			Average of Previous Crops.							Crop of 1884 and 1885.						
			Oats, 1881-1883.			Oats, 1882-1884.			Combined crops, 1881-1884.	Corn, 1884.			Oats, 1885.			Combined crops, 1884-1886.
			Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.		Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.	
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	—264	745	481	342	500	842	1,323	800	552	1,352	480	648	1,128	2,480
17	Yard manure,	12,000	175	52	227	33	251	284	511	1,480	712	2,192	200	418	618	2,840
18	Yard manure,	16,000	852	—41	811	72	217	319	1,130	440	272	712	168	171	342	1,051
19	Yard manure,	20,000	25	7	32	140	94	231	266	1,000	352	1,352	261	101	368	1,720
20	Yard manure, Lime,	12,000 4,000	252	132	384	131	376	507	891	560	432	992	156	492	648	1,640
21	Lime,	4,000	17	—335	—218	85	136	221	572	—400	—208	—608	—136	—96	—232	—840
22	Ground limestone,	4,000	—449	—145	—594	95	227	322	—272	1,000	272	1,272	80	1,928	2,008	3,280
23	Plaster,	320	—219	38	—181	4	136	140	—241	—160	118	308	—66	814	748	440
	Average yield of plots receiving complete fertilizers containing dried blood,	....	—79	494	415	151	143	294	709	490	689	1,180	207	307	514	1,694
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	93	583	676	206	209	415	1,091	840	685	1,525	435	480	915	2,240
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	—21	733	712	290	510	800	1,512	813	659	1,472	537	495	1,032	2,574
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	4	523	527	164	194	358	885	728	592	1,320	295	257	552	1,872
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	7	615	622	252	206	458	1,080	650	762	1,412	316	402	718	2,130
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	—100	582	482	218	404	622	1,004	790	712	1,502	358	546	904	2,406
	Average yield of plots receiving yard manure,	....	326	—213	113	94	212	336	449	830	442	1,272	197	301	498	1,810

It will be remembered that, as was stated before, this season was not favorable for grass, and that the corn crop was not as good as usual.

a. Examining the table with reference to the oats crop alone, the following facts are evident:

1. That the yield of the unfertilized plots which had received no fertilizer for at least six years, and had been in grass only once during that time, was above the average yield in Pennsylvania,—about 29.9 bushels. That is to say, the soil was above the average arable soil in fertility, and the effect of fertilizers in general would therefore be less.
2. That the entire range between yields was 920 pounds, or 28.8 bushels, of grain, 2,216 pounds of straw, and 2,640 pounds of total crop: so that the application of various fertilizers to soil already above the average in fertility produced a variation in yield nearly equal to the total average crop of grain, and an even greater variation in the weight of straw.
3. That the single fertilizer ingredients, not including the lime group, seemed to produce an invariable gain in grain, greatest with phosphoric acid, least with dried blood; the gain in straw was even greater, though dried blood and potash changed their order of yield. These gains are only apparent when the plots receiving these fertilizers are compared with the contiguous unfertilized plot.
4. That burnt lime seemed to cause a considerable loss in grain, and no change in straw; there was likewise a loss in grain with ground limestone, but a very large increase in straw (compared with contiguous unfertilized plots). Plaster had an effect like that of ground limestone, but the loss of grain and the increase of straw are both less than with ground limestone.
5. The combination of dried blood and potash seemed to cause a diminution in the yield of both grain and straw, while the combination of mineral fertilizers produced a very considerable increase in both yields.
6. The use of complete manures in every case produced an increase of grain and an increase of total crop, but only the plots receiving artificial fertilizers containing soluble nitrogen compounds produced more grain or straw than those receiving combination of potash and phosphoric acid without nitrogen.
7. For the complete artificial fertilizers, the order, according to their yield both of grain and straw, was sulphate of ammonia, nitrate of soda, and dried blood.
8. The yield of grain and straw increased with the increased amount

of nitrogen in artificial fertilizers, though not in proportion to it.

9. Yard manure produced less than either of the complete artificial fertilizers.

b. Comparing the yield with that of the previous year's corn, and observing the total product from a single application of fertilizer, the following facts are observed:

1. That the same fertilizer affected the grain yield in each case in a similar manner, and often to nearly the same degree. This was not the case with the straw.
2. There was a loss in combined crops after the application of all incomplete fertilizers except the ground limestone, plaster, and potash and phosphoric acid combined.
3. Of the complete fertilizers, the highest average yield of combined crops was obtained from the complete fertilizers containing sulphate of ammonia; next came, in order, nitrate of soda, dried blood, and yard manure.
4. The yield of combined crops increased with the amount of nitrogen in artificial fertilizers.

c. The oats crop of 1885 and the combined crops for 1884–1885 differ from previous crops in the following particulars:

1. The oats crop was smaller than in previous years, but the effect of the complete fertilizers was much greater and was shown by the grain as well as the straw; the relations of fertilizer effect were strikingly similar for the complete fertilizers.
2. In spite of the fact that the corn crop of 1884 was above the average of preceding crops, the yield of the combined crops, taking the yield of the unfertilized plots as the safest criterion of the effect of season, was less than heretofore.
3. The yield of combined crops with incomplete fertilizers, except ground limestone, plaster, and the potash and phosphoric acid combination, was also less than in previous years.
4. Where complete fertilizers were applied, the yield of combined crops was relatively greater than in previous years.
5. The order of complete fertilizers, according to the yield of combined crops, was the same as heretofore, except that in this case yard manure preceded dried blood, and that there was a constant increase in effect with the increase of nitrogen in artificial fertilizers.

2. EASTERN EXPERIMENTAL FARM.

The crop of 1885 was grown on tier I. The data gathered are presented in Table XVI.

TABLE XVI.—*Average Yield of Plots receiving the same Fertilizer, Eastern Experimental Farm, Corn and Oats, 1884 and 1885.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Average yield of previous oats crops.* Grain.	Straw.	Total crop.	Tier II. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	....	....	3	767	1,136	1,903	2,929	2,113	5,012	707	967	1,674	6,716
2	Dried blood,	240	240	1	768	1,075	1,843	3,776	2,320	6,096	740	1,380	2,120	8,216
3	Dissolved bone-black,	300	300	1	840	1,170	2,010	4,760	2,600	7,360	1,020	1,540	2,560	9,920
4	Muriate of potash,	200	200	1	865	1,227	2,092	3,104	2,400	5,501	700	1,500	2,200	7,704
5	Dried blood, Dissolved bone-black,	240 300	540	1	906	1,200	2,106	5,440	2,980	8,420	980	1,580	2,560	10,980
6	Dried blood, Muriate of potash,	240 200	440	1	893	1,140	2,033	3,440	3,100	6,540	820	1,500	2,320	8,860
7	Dissolved bone-black, Muriate of potash,	300 200	500	1	993	1,308	2,301	4,757	2,533	7,290	1,100	1,327	2,427	9,717
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	1	965	1,195	2,160	4,920	2,600	7,520	1,200	1,560	2,760	10,280
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	1	981	1,100	2,081	5,008	3,100	8,108	1,180	1,440	2,600	10,708
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	1	1,022	1,230	2,252	5,200	3,180	8,380	1,140	1,860	3,000	11,380
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	857	1,255	2,112	4,976	2,400	7,376	1,100	1,260	3,360	9,736
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	1,070	1,675	2,745	5,080	2,960	8,010	1,180	1,260	2,440	10,480
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,015	1,420	2,165	4,880	3,000	7,880	1,060	1,500	2,560	10,440

*Owing to gaps in the records the corn crops immediately preceding cannot be ascertained.

XVI.—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Average yield of previous oat crops. Grain.	Straw.	Total crop.	Tier II. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
14	Dissolved bone-black,	300	620	1	959	1,420	2,379	4,976	2,720	7,696	1,010	2,120	3,160	10,856
	Muriate of potash,	200												
	Sulphate of ammonia,	120												
15	Dissolved bone-black,	300	740	1	1,101	1,420	2,121	5,160	3,140	8,300	1,140	1,760	2,900	11,200
	Muriate of potash,	200												
	Sulphate of ammonia,	240												
16	Dissolved bone-black,	300	860	1	981	1,110	3,121	5,200	3,000	8,200	1,120	1,860	2,980	11,180
	Muriate of potash,	200												
	Sulphate of ammonia,	360												
17	Yard manure,	12,000	12,000	1	853	1,070	1,923	3,720	2,500	5,920	1,120	1,280	2,400	8,320
18	Plaster,	320	320	1	809	900	1,709	2,810	1,800	4,610	870	1,050	1,920	7,560
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	3	889	1,175	2,061	5,013	2,960	8,003	1,173	1,620	2,793	10,796
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	991	1,150	2,141	4,979	2,787	7,766	1,180	1,273	2,453	10,219
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	980	1,327	2,307	5,112	2,953	8,065	1,100	1,193	3,013	11,078
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	3	927	1,290	2,217	4,957	2,573	7,530	1,113	1,617	2,760	10,290
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	3	1,017	1,398	2,415	5,083	3,067	8,150	1,167	1,153	2,320	10,470
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	3	1,016	1,263	2,279	5,093	3,030	8,153	1,173	1,607	2,780	10,933

TABLE XVI—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Gain over Unfertilized Plots. Average yield of previous oats crops. Grain.	Straw.	Total crop.	Tier II. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2	Dried blood,	210	1	−61	60	847	207	1,054	33	413	446	1,500
3	Dissolved bone-black,	300	73	31	107	1,831	487	2,318	313	573	886	3,201
4	Muriate of potash,	200	98	91	189	175	287	462	—7	533	526	988
5	Dried blood, Dissolved bone-black,	210 300	139	64	203	2,511	867	3,378	273	613	886	4,264
6	Dried blood, Muriate of potash,	210 200	126	4	130	511	987	1,498	113	533	646	2,144
7	Dissolved bone-black, Muriate of potash,	300 200	226	172	398	1,828	420	2,218	393	360	753	3,001
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	198	59	257	1,991	487	2,478	493	593	1,086	3,564
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	214	−36	178	2,079	987	3,066	473	473	946	4,012
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	255	91	319	2,271	1,067	3,338	433	893	1,326	4,661
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	90	119	209	2,047	287	2,334	393	293	696	3,030
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	303	539	842	2,151	817	2,998	473	293	766	3,764
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	278	284	562	1,951	887	2,838	553	333	886	3,724
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	192	284	476	2,047	607	2,654	333	1,153	1,486	4,140

TABLE XVI—Continued.

Number.	Name of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Gain over Unfertilized Plots. Average yield of previous oats crops. Grain.	Straw.	Total crop.	Tier II. Corn, 1884. Ears.	Fodder.	Total crop.	Oats, 1885. Grain.	Straw.	Total crop.	Combined crops.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
15	Dissolved bone black, Muriate of potash, Sulphate of ammonia,	300 / 200 / 240	234	284	518	2,231	1,027	3,258	433	793	1,226	4,484
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 / 200 / 360	214	4	218	2,271	887	3,158	413	893	1,306	4,464
17	Yard manure,	12,000	86	—66	20	791	87	878	413	313	726	1,604
18	Plaster,	320	42	—236	—194	—39	—313	—402	163	83	246	—156
	Average yield of plots receiving complete fertilizers containing dried blood,	....	122	39	161	2,114	847	2,961	467	653	1,120	4,081
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	224	314	538	2,050	674	2,724	473	306	779	3,503
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	213	191	404	2,182	840	3,022	393	946	1,339	4,361
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	160	154	314	2,028	460	2,488	406	680	1,086	3,574
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	250	262	512	2,154	954	3,108	460	186	646	3,754
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	249	127	376	2,164	947	3,111	467	640	1,107	4,218

a. On comparing the results on the oats with those obtained at the Central farm for the same year, the following facts are prominent:

1. The yield was much less on the Eastern farm, and, as in the case of the corn crops, the effect of all the fertilizers with the exception of plaster, was greater.
2. The relative effects of the single ingredients were very similar, phosphoric acid leading. Potash was relatively more unfavorable to the development of grain, and on account of the greater development of straw attending its use, was slightly in advance of dried blood in total effect.
3. The effect of the combination of potash and phosphoric acid is not relatively advantageous as far as total yield is concerned, but the proportion of grain in the increase is very greatly enlarged.
4. More marked differences are apparent in the relative effects of the various complete fertilizers. In the order of their effects on straw and on total yield, the complete artificial fertilizers stand as follows: Those containing sulphate of ammonia, dried blood, nitrate of soda; but, when they are arranged in accordance with their production of grain, the order is exactly reversed.
5. The grain increased with the amount of nitrogen in the artificial fertilizers, but the straw was most abundant where the least nitrogen was applied.
6. Yard manure produced slightly more grain than sulphate of ammonia fertilizers, and more straw than nitrate of soda, but the total yield was less than with any other complete fertilizer.

b. Compared with the previous oats crops at the Eastern farm, it is noticeable

1. That, accepting the results from the unfertilized plots as the criterion, the crop is less than in previous years.
2. That, as in other cases, the fertilizers have had relatively more effect under conditions unfavorable to the crop. This effect was noticeable with all the fertilizers, and resulted in a large increase of both grain and straw.
3. That the complete artificial fertilizers containing nitrogen in a soluble form, have had relatively less effect on the yield of grain, compared with those containing the more insoluble forms.
4. That yard manure, as far as its effect on the yield is concerned, maintained its position at the foot of the list of complete fertilizers.

c. Turning now to a comparison of the yield of the combined corn and oats crops for 1884–1885, on the two farms, we find that on the Eastern farm.

1. The good effects of phosphoric acid are much more noticeable. This is true in good degree of all other single ingredients except plaster.
2. That all the complete fertilizers surpass yard manure far more than at the Central farm.
3. That in both cases the order of complete artificial fertilizers, according to effect on the combined yield, agrees with that arranged according to the effect on the entire oats crop, and, therefore, the differences in position for the two farms are the same as those recorded in discussing the oats crop alone.
4. The effect of an increased amount of nitrogen on the combined crops was similar at both farms.

3. EXPERIMENTS OF 1886—CENTRAL EXPERIMENTAL FARM.

The data are arranged in Table XVII.

TABLE XVII.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Corn and Oats, 1885–1886.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Average of Previous Crops. Corn, 1881-1884. Ears.	Corn, 1881-1884. Fodder.	Corn, 1881-1884. Total crop.	Oats, 1882-1885. Grain.	Oats, 1882-1885. Straw.	Oats, 1882-1885. Total crop.	Combined crops, 1881-1885.	Tier II. Corn, 1885. Ears.	Corn, 1885. Fodder.	Corn, 1885. Total crop.	Oats, 1886. Grain.	Oats, 1886. Straw.	Oats, 1886. Total crop.	Oats, 1886. Weight per bushel.	Combined crops, 1885-1886.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	5	3,278	2,608	5,881	1,277	1,699	2,976	8,857	3,117	1,808	4,925	1,904	2,693	4,597	35.10	9,522
2	Dried blood,	240	240	1	3,486	2,734	6,220	1,266	1,731	2,997	9,217	2,840	1,600	4,440	1,948	2,652	4,600	35.00	9,040
3	Dissolved bone-black,	300	300	1	3,234	2,742	5,976	1,283	1,272	2,575	8,551	3,200	2,120	5,320	2,084	2,612	4,696	36.00	10,016
4	Muriate of potash,	200	200	1	3,514	2,970	6,484	1,290	1,656	2,946	9,430	2,696	1,720	4,416	2,080	2,760	4,840	36.50	9,256
5	Dried blood, Dissolved bone-black,	240 300	540	1	3,611	2,850	6,461	1,353	1,749	3,102	9,563	3,104	2,040	5,144	2,256	2,864	4,120	36.50	9,264
6	Dried blood, Muriate of potash,	240 200	440	1	3,252	3,060	6,312	1,223	1,734	2,957	9,269	2,944	1,520	4,464	2,160	3,520	4,680	35.00	9,144
7	Dissolved bone-black, Muriate of potash,	300 200	500	*5	3,793	3,026	6,819	1,482	1,901	3,383	10,202	3,270	2,225	5,495	2,265	2,759	5,024	36.10	10,519
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	*3	3,461	3,053	6,514	1,414	1,817	3,231	9,745	3,084	2,220	5,304	2,294	3,106	5,400	36.75	10,704
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	3,492	3,140	6,632	1,433	1,851	3,284	9,916	3,184	2,060	5,244	2,796	3,284	6,080	36.50	11,324
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	3,549	3,165	6,714	1,480	2,009	3,489	10,263	3,150	2,200	5,350	2,228	3,172	5,400	37.00	10,750
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	3,892	3,214	7,106	1,533	1,838	3,371	10,477	3,272	1,840	5,112	2,056	2,844	4,900	35.00	10,012
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	3,640	3,180	6,820	1,574	1,978	3,552	10,372	3,336	2,080	5,416	2,128	2,528	4,656	34.50	7,944
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	3,699	3,240	6,939	1,513	2,114	3,627	10,566	2,888	1,440	4,328	2,008	2,712	4,720	35.50	9,048

TABLE XVII—Continued.

Number.	Kinds of Fertilizer.	Quality of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. — Average of previous crops. — Corn, 1881-1884. — Ears.	Corn, 1881-1884. — Fodder.	Corn, 1881-1884. — Total crop.	Oats, 1882-1885. — Grain.	Oats, 1882-1885. — Straw.	Oats, 1882-1885. — Total crop.	Combined crops, 1881-1885.	Tier II. — Corn, 1885 — Ears.	Corn, 1885 — Fodder.	Corn, 1885 — Total crop.	Oats, 1886. — Grain.	Oats, 1886. — Straw.	Oats, 1886. — Total crop.	Oats, 1886. — Weight per bushel.	Combined crops, 1885-1886.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
14	{ Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 120	620	1	3,653	3,344	6,997	1,595	2,244	3,839	10,836	3,016	1,600	4,616	2,016	2,684	4,700	35.00	9,316
15	{ Dissolved bone black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 240	740	1	3,768	3,308	7,076	1,615	2,212	3,827	10,903	2,952	1,840	4,792	1,976	2,464	4,440	35.00	9,233
16	{ Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 360	860	1	3,432	3,300	6,732	1,651	2,237	3,891	10,623	2,880	1,440	4,320	2,080	2,480	4,560	35.50	8,880
17	Yard manure, ...	12,000	12,000	1	3,931	2,815	6,746	1,352	2,000	3,352	10,098	3,368	1,880	5,248	2,284	3,436	5,720	35.25	10,960
18	Yard manure, ...	16,000	16,000	1	4,179	2,640	6,819	1,373	1,925	3,298	10,117	3,464	1,960	5,424	2,188	3,012	5,200	37.00	10,624
19	Yard manure, ...	20,000	20,000	1	3,699	2,696	6,395	1,448	1,796	3,244	9,639	3,504	1,760	5,264	2,040	3,080	5,120	35.50	10,384
20	{ Yard manure, ... Lime, ...	12,000 4,000	16,000	1	3,759	2,810	6,569	1,414	2,105	3,519	10,088	3,160	1,600	4,760	2,232	3,848	6,080	34.50	10,840
21	Lime, ...	4,000	4,000	1	2,843	2,300	5,643	1,307	1,780	3,087	8,730	2,872	1,680	4,552	1,968	2,672	4,640	35.00	9,192
22	Ground limestone, ...	4,000	4,000	1	2,843	2,562	5,905	1,368	2,352	3,720	9,625	2,520	1,560	4,080	1,810	2,840	4,680	32.00	8,760
23	Plaster, ...	320	320	*2	3,226	2,595	5,821	1,264	1,854	3,118	8,939	3,344	1,840	5,184	2,400	3,660	6,060	35.00	11,244
24	{ Ground bone, ... Muriate of potash, ... Dried blood, ...	224 200 240	664	*2	....	....	...	....	....	....	....	2,808	1,740	4,548	2,116	2,936	5,052	35.75	9,600
	Average yield of plots receiving complete fertilizers containing dried blood, ...	....	....	*7	3,495	3,110	6,605	1,442	1,884	3,326	9,931	3,056	2,055	5,111	2,358	3,124	5,482	36.50	10,593
	Average yield of plots receiving complete fertilizers containing nitrate of soda, ...	....	....	3	3,744	3,211	6,955	1,540	1,977	3,517	10,472	3,165	1,787	4,952	2,064	2,695	4,159	35.00	9,111
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia, ...	....	....	3	3,618	3,317	6,935	1,621	2,231	3,852	10,787	2,949	1,627	4,576	2,024	2,543	4,567	35.17	9,143

Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen, ...	. . . .	. . . .	*5	3,585	3,144	6,729	1,474	1,910	3,381	10,113	3,012	1,893	4,905	2,149	2,899	5,048	35.80	9,953
Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen, ...	. . . .	. . . .	4	3,598	3,192	6,790	1,545	1,951	3,499	10,289	3,164	2,010	5,174	2,424	2,890	5,314	35.62	10,488
Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen, ...	. . . .	. . . .	4	3,557	3,217	6,774	1,530	2,139	3,669	10,443	3,017	1,820	4,837	2,136	2,884	5,020	36.25	9,857
Average yield of plots receiving yard manure, ...	. . . .	. . . .	4	3,892	2,740	6,632	1,397	1,956	3,353	9,985	3,374	1,800	5,174	2,186	3,344	5,520	35.56	10,694

* Same remarks apply as were made in the table giving the average yields of corn for 1885.

TABLE XVII—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Gain over Unfertilized Plots. Average of previous crops. Corn, 1881-1884. Ears.	Corn, 1881-1884. Fodder.	Corn, 1881-1884. Total crop.	Oats, 1882-1885. Grain.	Oats, 1882-1885. Straw.	Oats, 1882-1885. Total crop.	Combined crops, 1881-1885.	Tier II. Corn, 1885. Ears.	Corn, 1885. Fodder.	Corn, 1885. Total crop.	Oats, 1886. Grain.	Oats, 1886. Straw.	Oats, 1886. Total crop.	Combined crops, 1885-1886.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
2	Dried blood,	240	208	111	319	−11	32	21	860	277	−208	−485	44	−41	3	−482
3	Dissolved bone-black,	300	−44	139	95	6	−427	−421	−306	83	312	395	180	−81	99	494
4	Muriate of potash,	200	236	367	603	13	−43	−30	578	−421	−88	−509	176	67	213	−266
5	Dried blood, 240; Dissolved bone-black, 300	240; 300	333	217	580	76	50	126	706	−13	232	219	352	171	523	−258
6	Dried blood, 240; Muriate of potash, 200	240; 200	−26	457	431	−54	35	−19	412	−173	−288	−161	256	827	1,083	−578
7	Dissolved bone-black, 300; Muriate of potash, 200	300; 200	515	423	938	205	202	407	1,315	153	417	570	361	66	427	997
8	Dissolved bone-black, 300; Muriate of potash, 200; Dried blood, 240	300; 200; 240	183	450	633	137	118	255	888	−33	412	379	390	416	806	1,182
9	Dissolved bone-black, 300; Muriate of potash, 200; Dried blood, 480	300; 200; 480	214	537	751	156	152	308	1,039	67	252	319	892	591	1,483	1,802
10	Dissolved bone-black, 300; Muriate of potash, 200; Dried blood, 720	300; 200; 720	271	562	833	203	310	513	1,346	93	892	425	324	479	803	1,228
11	Dissolved bone-black, 300; Muriate of potash, 200; Nitrate of soda, 160	300; 200; 160	614	611	1,225	256	139	395	1,620	155	32	187	152	151	303	490
12	Dissolved bone-black, 300; Muriate of potash, 200; Nitrate of soda, 320	300; 200; 320	362	577	939	297	279	576	1,515	219	272	491	224	−165	59	−1,578
13	Dissolved bone-black, 300; Muriate of potash, 200; Nitrate of soda, 480	300; 200; 480	421	637	1,058	236	415	651	1,709	−229	−368	−597	104	19	123	−471
14	Dissolved bone-black, 300; Muriate of potash, 200; Sulphate of ammonia, 120	300; 200; 120	375	741	1,116	318	515	863	1,979	−101	−208	−309	112	−9	103	−206

15	Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 240	490	705	1,195	338	513	851	2,016	−165	32	−133	72	−229	−157	−290
16	Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 360	151	697	851	377	538	915	1,766	−237	−368	−605	176	−213	−37	−612
17	Yard manure, ...	12,000	653	212	865	75	301	376	1,241	251	72	323	380	713	1,123	1,438
18	Yard manure, ...	16,000	901	37	938	96	226	322	2,260	347	152	499	284	319	603	1,102
9	Yard manure, ...	20,000	421	93	514	171	97	268	782	387	−48	339	136	387	523	862
20	Yard manure, ... Lime, ...	12,000 4,000	481	207	688	137	106	543	1,231	43	−208	−165	328	1,155	1,483	1,318
21	Lime, ...	4,000	65	−206	−241	30	81	111	−127	−245	−128	−373	61	21	53	−330
22	Ground limestone, ...	4,000	65	−44	21	91	653	741	768	−597	−218	−845	−61	117	83	−762
23	Plaster, ...	320	48	−11	37	−13	155	142	82	227	32	259	496	967	1,463	1,722
24	Ground bone, ... Muriate of potash, ... Dried blood, ...	224 200 240	. . . .	. . . .	. . . .	. . . . .	. . . . .	. . . . .	. . . . .	−309	−68	−377	212	243	455	78
	Average yield of plots receiving complete fertilizers containing dried blood, ...	. . . .	217	507	721	165	185	350	1,074	−61	217	186	431	131	885	1,071
	Average yield of plots receiving complete fertilizers containing nitrate of soda, ...	. . . .	466	608	1,074	263	278	511	1,615	48	−21	27	160	2	162	−411
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia, ...	. . . .	340	714	1,054	344	532	876	1,930	−168	−181	−319	120	−150	−30	−379
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen, ...	. . . .	308	541	849	197	211	408	2,256	−105	85	−20	215	206	451	431
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen, ...	. . . .	320	589	909	268	255	523	1,631	47	202	249	520	197	717	966
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen, ...	. . . .	279	611	893	253	440	693	1,000	−100	12	−88	232	191	423	385
	Average yield of plots receiving yard manure, ...	. . . .	614	137	751	120	257	377	1,837	257	−8	249	282	651	933	1,172

The season was very favorable for the development of oats. The straw was especially long.

a. Comparing the yields of oats with those of the previous season, to determine as nearly as possible the effect of an especially good growing season as compared with a quite unfavorable one, it is observed

1. That, in general, the fertilizers had much less effect than usual, and very much less than in 1885.
2. That the single fertilizer ingredients, excluding the lime group, had, nevertheless, a better effect.
3. The plot receiving burnt lime gave more straw and more total crops than the contiguous unfertilized plot; ground limestone, compared in the same way, caused a very considerable increase of both grain and straw; plaster this time seemed to cause an increase of both grain and straw.
4. The order, in point of yield, of the complete artificial fertilizers containing different forms of nitrogen is, in all particulars, the reverse of that in 1885, and of that in all previous years, taking the average.
5. The yield, instead of increasing as usual, with the increase of nitrogen in artificial fertilizers, was greatest in grain and in entire crop, although less in straw, where a medium amount of nitrogen had been applied.
6. That yard manure gave a higher yield of entire crop than usual, but the proportion of straw in the increase was exceptionally large, so that in yield of grain it was surpassed by dried blood.
7. Ground bone in complete fertilizer produced less than dissolved bone-black.

b. Comparing the combined crops with those of 1884–1885 and of previous years, it is observed

1. That there was a much greater increase from the use of dissolved bone-black alone.
2. That burnt lime and ground limestone both produced an increase; plaster a decrease.
3. Comparing the groups of complete artificial fertilizers distinguished by containing different forms of nitrogen, plots receiving dried blood are observed to show a decided increase; those receiving soluble nitrogenous compounds an actual decrease in yield.
4. The highest yield produced by artificial fertilizers containing different qualities of nitrogen, was obtained with the group containing 48 pounds.
5. Yard manure was more effective than any group of artificial fertilizers.

c. Concerning the effect of the various fertilizers on the weight per bushel of the grain, the following points may be noted:

1. Excluding the lime group, the combination of potash and phosphoric acid was the only one of the incomplete fertilizers which produced an increase when compared with contiguous unfertilized plots; dried blood, dissolved bone-black, and the combination of dried blood and muriate of potash seemed to cause a decrease.

2. Lime and ground limestone decreased, while plaster increased the weight.
3. Dried blood produced a much greater weight than the soluble forms of nitrogen.
4. Yard manure produced oats much lighter per bushel than were obtained with dried blood, but heavier than with the soluble forms of nitrogen.
5. The substitution, in complete fertilizer, of ground bone for dissolved bone-black resulted in a decrease in the weight per bushel.

(4.) THE EFFECT OF FERTILIZERS ON THE WEIGHT OF SEED AND THE GERMINATIVE POWER OF OATS.

The weight of one hundred grains and the germinative power of average samples of the seed of the crops taken from the different plots in 1886, were determined. The results obtained are presented in the following tables, XVIII and XIX. In the germinative trials, one hundred seeds were used, and they were soaked sixteen hours before the beginning of the trial; no sound seed remained at the end of the trial. The date of beginning the trial was the same for all.

TABLE XVIII.—*Weight and Germination of Seeds from Oats Plots, 1886.*

Index number.	Plot number.	Weight of 100 grains.	Days of Germinative Trial.										Per cent. germinated.
			1.	2.	3.	4	5	6.	7.	8.	9.	10.	
		Grams.											
517	1	2.1200	0	68	3	—	—	3	0	1	0	0	75
518	2	2.1600	0	65	1	—	—	3	0	1	0	1	71
519	3	2.4600	0	62	4	—	—	4	0	0	0	0	70
520	4	2.3000	0	58	3	—	—	6	0	0	1	0	68
521	5	2.2500	0	65	4	—	—	1	0	0	1	1	72
522	6	2.2100	0	73	1	—	—	0	0	0	0	0	74
523	7	2.4500	0	71	0	—	—	3	0	0	1	0	76
524	8	2.3000	0	63	2	—	—	4	0	0	0	1	70
525	9	2.4300	0	62	2	—	—	1	0	0	0	0	65
526	10	2.5200	0	77	2	—	—	2	0	0	0	0	81
527	11	2.4400	0	57	6	—	—	6	0	0	0	1	70
528	12	2.6200	0	72	2	—	—	1	0	0	0	0	75
529	13	2.1200	0	46	2	—	—	5	0	0	2	0	55
530	14	2.2500	0	53	3	—	—	1	0	1	0	0	58
531	15	2.3400	0	66	3	—	—	2	0	0	0	0	71
532	16	2.2300	0	60	7	—	—	3	0	0	0	0	70
533	17	2.3200	0	59	4	—	—	2	0	0	0	0	65
534	18	2.3500	0	28	4	—	—	1	1	0	1	1	36
535	19	2.3600	0	42	3	—	—	7	0	0	0	2	54
536	20	2.2700	0	30	6	—	—	3	0	1	0	0	40
537	21	2.4300	0	75	2	—	—	3	0	0	0	0	80
538	22	2.2900	0	73	2	—	—	3	0	0	0	0	78
539	23	2.1200	0	75	5	—	—	4	1	0	0	0	85
540	24	2.3600	0	62	2	—	—	2	0	0	0	1	67
541	25	2.4000	0	57	2	—	—	4	0	0	0	0	63
542	26	2.1900	0	73	2	—	—	4	0	0	1	0	80
543	27	2.2300	0	64	5	—	—	4	0	0	0	0	73
544	28	2.2500	0	77	0	—	—	4	0	0	0	0	81
545	29	2.2000	0	79	0	—	—	1	0	1	0	0	81
546	30	2.1400	0	73	1	—	—	5	0	0	0	1	80
547	31	2.3200	0	73	3	—	—	1	0	0	0	0	77
548	32	2.3900	0	72	5	—	—	6	0	0	0	1	84
549	33	2.0600	0	62	2	—	—	0	0	1	0	0	65
550	34	2.0800	0	56	5	—	—	6	0	0	0	1	68
551	35	2.2100	0	88	0	—	—	2	0	1	0	0	91
552	36	2.1600	0	56	4	—	—	7	0	0	0	2	69

TABLE XIX.—*Average Weight and Germinative Power of Oat Seed from Plots. 1886.*

Fertilizer number.	KIND OF FERTILIZER.	Weight of 100 grains.	Germinated.
		Grams.	*Per cent.*
1	Nothing	2.34	69
2	Dried blood	2.16	71
3	Dissolved bone-black	2.46	70
4	Muriate of potash	2.30	65
5	Dried blood, Dissolved bone-black	2.25	72
6	Dried blood, Muriate of potash	2.21	74
7	Dissolved bone-black, Muriate of potash	2.35	73
8	Dissolved bone-black, Muriate of potash, Dried blood, 240 pounds	2.37	65
9	Dissolved bone-black, Muriate of potash, Dried blood, 480 pounds	2.44	67
10	Dissolved bone-black, Muriate of potash, Dried blood, 720 pounds	2.48	75
11	Dissolved bone-black, Muriate of potash, Nitrate of soda, 160 pounds	2.19	80
12	Dissolved bone-black, Muriate of potash, Nitrate of soda, 320 pounds	2.23	78
13	Dissolved bone-black, Muriate of potash, Nitrate of soda, 480 pounds	2.25	81
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 120 pounds	2.14	80
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 240 pounds	2.32	77
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 360 pounds	2.39	84
17	Yard manure, 12,000 pounds	2.23	70
18	Yard manure, 16,000 pounds	2.35	36
19	Yard manure, 20,000 pounds	2.27	40
20	Yard manure, 12,000 pounds, Lime	2.29	78
21	Lime	2.12	65
22	Ground limestone	2.08	66
23	Plaster	2.12	55
24	Ground bone, Muriate of potash, Dried blood, 240 pounds	2.41	83
	Average of plots receiving complete fertilizers containing—		
	Dried blood	2.42	73
	Nitrate of soda	2.22	78
	Sulphate of ammonia	2.28	80
	Nitrogen, 24 pounds	2.32	74
	Nitrogen, 48 pounds	2.36	71
	Nitrogen, 72 pounds	2.38	79
	Yard manure	2.28	56

a. Examining these tables with reference to the effect of fertilizers on the weight of the seed, the following facts may be noticed:

1. That the single ingredients seemed to cause a gain, except in the case of the lime group; the gain with phosphoric acid is especially remarkable (Use Table XVIII for this comparison.)
2. The other incomplete fertilizers that contain nitrogen give a lighter seed, while the seed from the plots receiving the purely

mineral combination of potash and phosphoric acid is very little heavier than that from the unfertilized plots. Examining Table XVIII. it is found that the weight of seed from plots receiving the last-named fertilizer was, with a single marked exception, considerably greater than that of contiguous unfertilized plots.

3. Examining with reference to the complete artificial fertilizers containing different forms of nitrogen, we find that the groups containing soluble forms caused a decrease in weight, while dried blood gave a very decided increase.
4. As in the case of the corn, the weight of the seed increased with the amount of nitrogen.
5. Yard manure had the same effect in this particular as complete fertilizer containing sulphate of ammonia.

b. With reference to the germinating power, the following points are evident:

1. The incomplete fertilizers, including the lime group, seemed generally to cause a slight decrease in germinative power. The combination of potash and phosphoric acid apparently caused little change (Compare Table XVIII).
2. As with corn, burnt lime caused an increase, while plaster and ground limestone effected a slight decrease, compared with contiguous unfertilized plots.
3. The soluble nitrogenous fertilizers increased the germinative power somewhat more than the insoluble did.
4. Among complete artificial fertilizers, those containing the most nitrogen produced seed of the highest germinative power, while the seed of the least power was produced with 48 pounds of nitrogen.
5. Seeds from those plots receiving yard manure, especially those receiving it in the larger quantities, showed a decidedly decrease germinative power.

C. Wheat.

1. EXPERIMENTS OF 1885—CENTRAL EXPERIMENTAL FARM.

This crop was grown upon tier IV. It was the third crop grown upon that tier in this series of experiments, and, therefore, there had previously been only one application of the various fertilizers to the plots. The results are presented in Table XX.

TABLE XX.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Wheat, 1885.*

Number.	Kind of Fertilizer.	Quantity of fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Tiers I, II, and III, 1882-4.* Grain.	Yield per Acre. Tiers I, II, and III, 1882-4.* Straw.	Yield per Acre. Tiers I, II, and III, 1882-4.* Total crop.	Yield per Acre. Tier IV, 1885. Grain.	Yield per Acre. Tier IV, 1885. Straw.	Yield per Acre. Tier IV, 1885. Total crop.	Gain over Unfertilized Plots. Tiers I, II, and III, 1882-4. Grain.	Gain over Unfertilized Plots. Tiers I, II, and III, 1882-4. Straw.	Gain over Unfertilized Plots. Tiers I, II, and III, 1882-4. Total crop.	Gain over Unfertilized Plots. Tier IV, 1885. Grain.	Gain over Unfertilized Plots. Tier IV, 1885. Straw.	Gain over Unfertilized Plots. Tier IV, 1885. Total crop.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	5	1,233	1,792	3,025	182	270	452	....	....	....	....	....	....
2	Dried blood,	240	240	1	840	2,027	2,867	136	64	200	—393	235	—158	— 46	—206	—252
3	Dissolved bone-black,	300	300	1	1,419	1,989	3,408	252	348	600	186	197	383	70	78	148
4	Muriate of potash,	200	200	1	1,243	1,816	3,059	80	80	160	10	21	31	—102	—190	—292
5	Dried blood, Dissolved bone-black,	240 300	540	1	1,555	2,099	3,651	300	420	720	322	307	629	118	150	268
6	Dried blood, Muriate of potash,	240 200	440	1	1,281	1,947	3,228	108	172	280	48	155	203	— 71	— 98	—172
7	Dissolved bone-black, Muriate of potash,	300 200	500	†5	1,572	2,223	3,795	289	849	1,138	339	431	770	107	579	686
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	†3	1,638	2,614	4,252	530	830	1,360	405	822	1,227	348	560	908
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	1,761	2,909	4,610	568	612	1,180	468	1,117	1,585	386	342	728
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	1,788	2,962	4,750	740	940	1,680	555	1,170	1,725	558	670	1,228
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	1,862	2,901	4,763	912	1,368	2,280	629	1,109	1,738	730	1,098	1,828
12	Dissolved bone-black, Muriate of potash, Nitrate of potash,	300 200 320	820	1	1,907	3,315	5,222	1,008	2,152	3,160	674	1,523	2,197	826	1,882	2,708
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,966	3,304	5,270	908	1,652	2,560	733	1,512	2,245	726	1,382	2,108
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	1,738	2,723	4,461	1,232	1,648	2,880	505	931	1,436	1,050	1,378	2,428

* Corrected for winter killed areas in crop of 1883.

† Compare notes on Table V.

15	Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 240	740	1	2,010	3,163	5,173	1,348	2,492	3,840	777	1,371	2,148	1,166	2,222	3,388
16	Dissolved bone-black, ... Muriate of potash, ... Sulphate of ammonia, ...	300 200 360	860	1	1,911	3,008	4,932	2,468	2,468	4,936	711	1,215	1,926	2,286	2,198	4,484
17	Yard manure, ...	12,000	12,000	1	1,765	2,877	4,612	352	328	680	532	1,085	1,617	170	58	228
18	Yard manure, ...	16,000	16,000	1	1,814	3,147	4,961	380	380	760	581	1,355	1,936	198	110	308
19	Yard manure, ...	20,000	20,000	1	1,673	2,862	4,535	420	540	960	410	1,070	1,510	238	270	508
20	Yard manure, ... Lime, ...	12,000 4,000	16,000	1	1,781	2,780	4,561	512	728	1,240	518	988	1,536	330	458	788
21	Lime, ...	4,000	4,000	1	1,387	2,064	3,451	352	488	840	151	272	126	170	218	388
22	Ground limestone, ...	4,000	4,000	1	1,255	1,816	3,071	456	624	1,080	22	24	16	274	354	628
23	Plaster, ...	320	320	2	1,265	1,960	3,225	354	506	860	32	168	200	172	236	408
24	Ground bone, ... Muriate of potash, ... Dried blood, ...	224 200 240	664	†2	. . . .	. . . .	. . . .	581	856	1,440	. . . .	. . . .	. . . .	402	586	988
	Average yield of plots receiving complete fertilizers containing dried blood, ...	. . . .	. . . .	†7	1,699	2,798	4,497	512	809	1,321	466	1,002	1,468	330	539	869
	Average yield of plots receiving complete fertilizers containing nitrate of soda, ...	. . . .	. . . .	3	1,912	3,173	5,085	943	1,724	2,667	679	1,381	2,060	761	1,454	2,215
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia, ...	. . . .	. . . .	3	1,897	2,981	4,878	1,683	2,203	3,886	661	1,189	1,853	1,501	1,933	3,434
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen, ...	. . . .	. . . .	†5	1,703	2,693	4,396	729	1,065	1,794	470	901	1,371	517	795	1,312
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen, ...	. . . .	. . . .	4	1,830	3,074	4,901	873	1,467	2,340	517	1,282	1,829	591	1,197	1,788
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen, ...	. . . .	. . . .	4	1,871	3,059	4,930	1,214	1,500	2,714	638	1,297	1,935	1,032	1,230	2,262
	Average yield of plots receiving yard manure, ...	. . . .	. . . .	4	1,758	2,916	4,874	416	494	910	525	1,124	1,649	231	224	458

a. Confining attention to the crop of 1885 alone, we observe:

1. That the crop on the unfertilized plots was exceedingly small.
2. That the yields from plots receiving complete fertilizers more nearly approach those of previous years.
3. That the effect of these fertilizers on wheat is greater than it is on the other crops of the rotation; this is in accordance with the observations of previous years.
4. That, of the single fertilizer ingredients, excluding the lime group, none but those containing phosphoric acid gave a gain over the yield of the unfertilized plots. That its combination with dried blood gave better results than the dissolved bone-black alone. That the combination of potash and phosphoric acid gave a higher than any other incomplete fertilizer.
5. That the tendency of all the lime group fertilizers seemed to be to increase the straw; plaster and ground limestone increased the yield of grain also, but with burnt lime it suffered a slight decrease.
6. The substitution in a complete fertilizer of ground bone for dissolved bone-black apparently results in an increase of grain, both absolutely and relatively to the straw.
7. The order, in point of yield, of the complete artificial fertilizer groups containing different forms of nitrogen, beginning with the highest, was sulphate of ammonia, nitrate of soda, and dried blood. This was true for both grain and straw.
8. The yield of grain and straw increased with the amount of nitrogen applied. The increase was especially noticeable with 72 pounds of nitrogen.
9. Yard manure gave a lower yield than any group of complete artificial fertilizers; the proportion of grain to straw was high.

b. As compared with the average of former years, it is noticeable

1. That incomplete fertilizers, except ground limestone and plaster, had absolutely less, and complete fertilizers absolutely more effect.
2. That nitrate of soda changed positions with sulphate of ammonia, particularly in the yield of straw.
3. That the influence of large quantities of nitrogen was especially beneficial as regards the yield of grain.
4. That yard manure had far less than its ordinary effect.

(2.) EASTERN EXPERIMENTAL FARM.

This crop was grown upon tier I. The yield of plots receiving the same fertilizer is shown in Table XXI.

Table XXI.—*Average Yield of Plots receiving the same Fertilizer, Eastern Experimental Farm, Wheat, 1885.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.						Gain over Unfertilized Plots.					
					Average of previous crops.			Wheat. 1885, Tier I.			Average of previous crops.			Wheat, 1885, Tier I.		
					Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	. . . .	. . . .	3	938	1,233	2,171	293	520	813	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
2	Dried blood,	240	240	1	1,020	1,340	2,360	440	760	1,200	82	107	189	147	240	387
3	Dissolved bone-black,	300	300	1	1,278	1,520	2,798	620	740	1,360	340	287	627	327	220	547
4	Muriate of potash,	200	200	1	858	1,140	1,998	300	680	980	—80	—93	—173	7	160	167
5	Dried blood, Dissolved bone-black,	240 300	540	1	1,386	1,600	2,986	720	880	1,600	448	367	815	427	360	787
6	Dried blood, Muriate of potash,	200 240	440	1	900	1,100	2,000	300	300	600	—38	—133	—171	7	—220	—213
7	Dissolved bone-black, Muriate of potash,	300 200	500	1	1,274	1,827	3,104	620	587	1,207	336	594	930	327	67	391
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	1	1,500	2,460	3,960	740	1,260	2,000	562	1,227	1,789	447	740	1,187
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	1	1,680	2,520	4,200	920	1,540	2,460	742	1,287	2,029	627	1,020	1,647
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	1	1,890	3,110	5,000	1,120	1,640	2,760	952	1,877	2,829	827	1,120	1,947
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	1,380	2,140	3,520	820	880	1,700	442	907	1,349	527	860	887
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	1,620	2,740	4,360	1,000	1,300	2,300	682	1,507	2,189	707	780	1,487
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,788	3,001	4,789	980	1,460	2,440	850	1,768	2,618	687	940	1,627
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	1,578	2,540	4,118	820	980	1,800	640	1,307	1,947	527	460	987
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	1,560	2,760	4,320	980	1,420	2,400	622	1,527	2,149	687	900	1,587

TABLE XXI—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.						Gain over Unfertilized Plots.					
					Average of previous crops.			Wheat, 1885, Tier 1.			Average of previous crops.			Wheat, 1885, Tier 1.		
					Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
16	Dissolved bone-black,	300	860	1	1,800	3,000	4,800	1,040	1,760	2,800	862	1,767	2,629	717	1,240	1,987
	Muriate of potash,	200														
	Sulphate of ammonia,	360														
17	Yard manure,	12,000	12,000	1	1,206	1,990	3,196	500	540	1,040	268	757	1,025	207	20	227
18	Plaster,	320	320	1	696	900	1,596	180	120	300	—242	—333	—575	—113	—400	—513
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	3	1,690	2,697	4,387	927	1,480	2,407	752	1,464	2,216	631	960	1,591
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	1,596	2,627	4,223	933	1,213	2,146	658	1,394	2,052	640	693	1,333
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	1,646	2,767	4,418	917	1,387	2,331	708	1,534	2,242	654	867	1,521
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	3	1,486	2,380	3,866	793	1,040	1,833	548	1,147	1,695	500	520	1,020
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	3	1,620	2,673	4,293	967	1,420	2,387	682	1,440	2,122	674	900	1,574
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	3	1,826	3,037	4,863	1,047	1,620	2,667	888	1,804	2,692	754	1,100	1,854

a. Comparing this crop with that at the Central farm, it is observed:

1. That here, too, there was a very light crop, but taking into consideration the lower fertility of the soil, the diminution by reason of the unfavorable season was considerably less.
2. Partly, it may be, in consequence of this fact, there was greater gain from the use of incomplete fertilizers, except plaster and the combination of phosphoric acid and potash, and relatively less from that of the complete. As noticed in several other instances, the effect of phosphoric acid is especially great at the Eastern farm. The effect of all these fertilizers, except plaster, was to cause a gain in grain and a loss in straw. Plaster caused a decided loss, instead of gain as at the Central farm.
3. As far as the effects of the complete fertilizers, both the artificial and yard manure, are concerned, the only difference in tendency was shown in the yield of straw, dried blood producing most, sulphate of ammonia next, and nitrate least. The effect of large quantities of nitrogen was not quite as great.

b. Compared with previous crops, it is noticed

1. That the gain from the use of all fertilizers in the drier season of 1885 was as great or even greater than in the average season, because the increase consisted more largely of grain, sometimes to so great an extent as to make the total gain almost equal to that of average years.
2. That the gain effected by dried blood and potash increased, and that the yield with plaster decreased.
3. There was a change in the effect of the complete artificial fertilizers containing different forms of nitrogen, the order in point of yield being usually the same for both straw and grain, and the same as that for the straw of 1885; whereas this order for 1885 is somewhat different as is noted above.
4. The falling off in the effect of yard manure was chiefly confined to the straw.

(3.) EXPERIMENTS OF 1886—CENTRAL EXPERIMENTAL FARM.

This crop was grown upon tier I. The results are stated in Table XXII.

TABLE XXII.—*Average Yield of Plots receiving the same Fertilizer, Central Experimental Farm, Wheat, 1886.*

Number.	Kind of Fertilizer.	Quantity of fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.*	Yield per Acre. Tiers I-IV, 1882-5.† Grain.	Straw.	Total crop	Tier I, 1886.‡ Grain.	Straw.	Total crop.	Weight per bushel.	Gain over Unfertilized Plots. Tiers I-IV, 1882-5. Grain.	Straw.	Total crop.	Tier I, 1886. Grain.	Straw.	Total crop.	Weight per bushel.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	5	970	1,411	2,381	374	1,023	1,397	60.0	....	....	....	....	....	....	....
2	Dried blood,	240	240	1	664	1,536	2,200	253	1,096	1,349	65.7	—306	125	—181	—121	73	— 48	5.7
3	Dissolved bone-black,	300	300	1	1,127	1,579	2,706	524	2,328	2,852	67.0	157	168	325	150	1,305	1,455	7.0
4	Muriate of potash,	200	200	1	952	1,132	2,084	202	776	978	57.0	— 18	- 279	—297	—172	—247	—419	—3.0
5	Dried blood, Dissolved bone-black,	240 300	540	1	1,241	1,679	2,920	571	2,072	2,643	62.0	271	268	539	197	1,049	1,246	2.0
6	Dried blood, Muriate of potash,	240 200	440	1	988	1,503	2,491	155	720	875	55.8	18	92	110	—219	—303	—522	—4.2
7	Dissolved bone-black, Muriate of potash,	300 200	500	5	1,251	1,879	3,130	732	1,625	2,357	65.7	281	467	748	358	602	960	5.7
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	3	1,361	1,418	2,779	942	2,378	3,320	66.9	391	7	398	568	1,355	1,928	6.9
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	1,418	2,335	3,753	1,110	2,511	3,621	68.2	448	924	1,372	736	1,488	2,224	8.2
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	1,676	2,456	4,132	1,265	3,128	4,393	65.7	706	1,045	1,751	891	2,105	2,996	5.7
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	1,624	2,518	4,142	1,906	2,099	3,005	68.2	654	1,107	1,761	532	1,076	1,608	8.2
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	1,682	3,024	4,706	803	1,693	2,496	64.5	712	1,613	2,325	429	670	1,099	4.5
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,701	1,891	3,592	997	2,264	3,461	64.5	731	480	1,211	623	1,241	1,864	4.5
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	1,611	2,454	4,065	996	1,927	2,923	68.2	641	1,043	1,684	622	904	1,526	8.2
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	1,844	2,995	4,849	1,131	2,060	3,191	62.0	874	1,581	2,458	757	1,037	1,794	2.0

* Same remarks apply as were made on table for 1885.
† Corrected for winter-killing of 1883.
‡ Corrected for winter-killing and fly-killing.

16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1	2,075	2,873	4,918	1,241	2,424	3,665	68.2	1,105	1,462	2,567	867	1,401	2,277	8.2
17	Yard manure,	12,000	12,000	1	1,412	2,240	3,652	860	1,243	2,103	65.7	442	829	1,371	486	220	706	5.7
18	Yard manure,	16,000	16,000	1	1,455	2,455	3,910	1,219	2,051	3,270	65.7	485	1,044	1,529	845	1,028	1,873	5.7
19	Yard manure,	20,000	20,000	1	1,360	2,281	3,641	1,352	2,183	3,535	70.7	390	870	1,260	978	1,160	2,138	10.7
20	Yard manure, Lime,	12,000 4,000	16,000	1	1,464	2,267	3,731	1,339	1,953	3,292	70.7	491	856	1,350	965	930	1,895	10.7
21	Lime,	4,000	4,000	1	1,128	1,670	2,798	163	837	1,000	60.7	158	559	717	—211	—186	—397	.7
22	Ground limestone,	4,000	4,000	1	1,055	1,518	2,573	169	699	868	60.7	85	407	492	—205	—324	—529	.7
23	Plaster,	320	320	2	1,037	1,596	2,633	239	894	1,133	58.2	67	485	552	—135	—129	—264	—1.8
24	Ground bone, Muriate of potash, Sulphate of ammonia,	224 200 240	664	2	581	856	1,440	713	1,546	2,259	66.9	—386	—555	—941	339	523	862	6.9
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	7	1,402	2,301	3,703	1,008	2,391	3,399	66.9	432	890	1,322	631	1,368	2,002	6.9
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	1,670	2,811	4,481	902	2,019	2,921	65.7	700	1,400	2,100	528	996	1,524	5.7
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	1,843	2,786	4,629	1,123	2,137	3,260	66.1	873	1,375	2,248	749	1,114	1,863	6.1
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	5	1,459	2,286	3,745	877	1,979	2,856	67.4	489	875	1,364	503	956	1,459	7.4
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	4	1,591	2,670	4,261	1,038	2,194	3,232	65.7	621	1,259	1,880	664	1,171	1,835	5.7
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	4	1,707	2,669	4,376	1,192	2,736	3,928	66 0	737	1,258	1,995	818	1,713	2,531	6.0
	Average yield of plots receiving yard manure,	....	....	4	1,422	2,060	3,482	1,192	1,857	3,049	68.2	452	649	1,101	818	834	1,652	8.2

The growing season of 1886 was fairly favorable for wheat, but during the winter all wheat in this locality suffered extremely from "winter-killing." In the spring the fly developed and did great injury to the remaining plants. The results stated in Tables III and XXII have been corrected according to the results of a careful survey of the plots taken after the action of the fly had practically ceased. It will be noticed that, even after these corrections have been made, the crop is less than the average.

a. Comparing the gains from the use of fertilizers this season and last, as well as those of previous years, the following facts are observed:

1. That phosphoric acid, singly and in combination with nitrogen, caused a much greater yield of straw than it usually has; there being little change in the gain of grain.
2. That burnt lime had, as before, little effect when compared with the contiguous unfertilized plot; that with plaster and ground limestone there was a loss in both grain and straw.
3. Dissolved bone-black in complete fertilizer gave a greater yield of grain and straw than was obtained with ground bone.
4. The effect of dried blood in complete fertilizer was greater than usual as compared with the soluble forms of nitrogen.
5. The relative effect of yard manure was greater, and under its influence the proportion of grain to straw was greatly increased.

b. Observing the relations of fertilizers to the weight of grain per bushel, the following points may be noted:

1. Comparing contiguous plots, all incomplete fertilizers, except plaster and ground limestone, are seen to cause an increase in weight. The effects of phosphoric acid and nitrogen among these are greatest.
2. The order of the complete fertilizers containing different forms of nitrogen, in point of weight per bushel of grain produced, is yard manure, dried blood, sulphate of ammonia, and nitrate of soda.
3. The smallest amount of nitrogen produced the greatest weight per bushel, the medium quantity the least weight.
4. The weight with dissolved bone-black and ground bone in complete fertilizer is the same.

(4.) EASTERN EXPERIMENTAL FARM.

This crop was grown on tier II. The results are stated in Table XXIII.

TABLE XXIII.—*Average Yield of Plots receiving the same Fertilizer, Eastern Experimental Farm, Wheat, 1886.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre. Average of previous crops.* Grain.	Straw.	Total crop.	Wheat, 1886, Tier II. Grain.	Straw.	Total crop.	Gain over Unfertilized Plots. Average of previous crops. Grain.	Straw.	Total crop.	Wheat, 1886, Tier II. Grain.	Straw.	Total crop.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	. . . .	. . . .	3	615	870	1 491	807	1,380	2,187	. . .	. .	. .	. .	. . .	. . .
2	Dried blood,	240	240	1	730	1 050	1,780	860	1 420	2.280	115	174	289	53	40	93
3	Dissolved bone black,	300	300	1	949	1 130	2 079	1,040	1,700	2,740	334	254	588	233	320	553
4	Muriate of potash,	200	200	1	579	910	1 489	800	1,160	1.960	—36	34	—2	—7	—220	—227
5	Dried blood, Dissolved bone-black,	240 300	540	1	1,053	1,240	2,293	1,240	1,720	2,960	438	364	802	433	340	773
6	Dried blood, Muriate of potash,	240 200	440	1	600	700	1,300	820	1 120	1,940	—15	—176	—191	13	—260	—247
7	Dissolved bone-black, Muriate of potash,	300 200	500	1	947	1,207	2,154	1,213	1,727	2,940	332	331	663	406	347	753
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	1	1 120	1 860	2,980	1,400	2,440	3,840	505	984	1,489	593	1,060	1,653
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	1	1,300	2,030	3,330	1,620	2,520	4,140	685	1,154	1,839	813	1,140	1,953
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	1	1,505	2 375	3,880	1,830	3,080	4,940	890	1,499	2,389	1,053	1,700	2,753
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	1,100	1 510	2,610	1,280	2,100	3,380	485	634	1,119	473	720	1,193
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	1,310	2 020	3,330	1,600	2,680	4,280	695	1,144	1,839	793	1,300	2,093
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,384	2,230	3,614	1,760	3,160	4,920	769	1,354	2,123	953	1,780	2,733
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	1,199	1,760	2,959	1,520	2,660	4,180	584	884	1,468	713	1,280	1,993

* Crops of 1884 and 1885.

TABLE XXIII—Continued.

Number.	Kind of Fertilizer.	Quantity of fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.						Gain over Unfertilized Plots.					
					Average of previous crops.*			Wheat, 1886, Tier II.			Average of previous crops.			Wheat, 1886, Tier II.		
					Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.	Grain.	Straw.	Total crop.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	1,270	2,090	3,360	1,560	2,800	4,360	655	1,214	1,869	753	1,420	2,173
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1	1,420	2,380	3,800	1,780	3 040	4,820	805	1,504	2,309	973	1,660	2 633
17	Yard manure,	12,000	12,000	1	853	1,265	2,098	1,200	1,880	3,080	238	389	627	393	500	893
18	Plaster,	320	320	1	438	510	948	680	840	1,520	−177	−366	−543	−127	−540	−667
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	3	1,308	2,088	3,396	1,627	2,680	4,307	693	1,212	1 905	820	1,300	2,120
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	1,264	1,920	3 184	1,547	2,647	4,194	649	1,044	1,693	740	1,267	2,007
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	1,296	2,077	3,373	1,620	2,833	4,453	681	1,201	1,882	813	1,453	2,266
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	3	1,139	1,710	2,849	1,400	2,733	4,133	524	834	1,358	593	1,353	1,946
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	3	1,293	2 046	3,339	1,593	2,667	4,260	678	1,170	1,848	786	1,287	2 073
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	3	1,436	2,328	3,764	1,800	3,093	4,893	821	1,452	2,273	993	1,713	2,706

The variations produced by the various fertilizers are so exactly similar to those which have usually been produced on the Eastern farm, and which are brought out in the discussion of the crop of 1885, that no further discussion seems necessary.

(5.) EFFECT OF DIFFERENT FERTILIZERS ON THE WEIGHT AND GERMINATIVE POWER OF WHEAT SEEDS.

Observations similar to those upon oats, detailed above, were made upon wheat. The same method was adopted, except that it was impossible to examine all the seeds at the same time. No sound seed remained at the end of the trial. The data obtained are given in Table XXIV.

TABLE XXIV.—*Size and Germinative Power of Wheat Seeds from Plots, 1886.*

Index number.	Plot number.	Weight of 100 seeds.	Days of germinative trial.										Per cent.—germinated.
			1.	2.	3.	4.	5.	6.	7.	4.	9.	10.	
		Grams.											
478	1	2.7800	100	....	....	....	....	....	....	....	....	....	100
479	2	2.8100	93	2	0	0	0	0	—	—	0	0	95
480	3	3.0100	98	0	0	0	0	0	—	—	0	0	98
481	4	2.8300	95	1	0	1	0	0	—	—	1	0	98
482	5	2.8600	95	2	0	0	0	0	—	—	0	0	97
483	6	2.6200	93	1	0	1	1	0	—	—	0	0	96
484	7	2.9200	—	98	0	0	0	0	—	—	0	0	98
485	8	3.1300	—	98	0	0	0	0	—	—	1	0	99
486	9	3.8500	—	96	2	0	0	1	—	—	0	0	99
487	10	4.0900	—	91	4	1	1	0	—	—	3	—	100
488	11	3.7200	—	95	3	1	0	0	—	—	0	1	100
489	12	3.4600	—	95	2	2	0	0	—	—	0	0	99
490	13	3.3600	—	96	0	2	0	0	—	—	1	1	100
491	14	2 5800	—	97	0	0	0	1	—	—	0	0	98
492	15	3.6400	—	96	2	0	0	0	—	—	2	—	100
493	16	3.5300	—	98	0	1	0	1	—	—	—	—	100
494	17	4.0200	—	98	1	0	0	0	—	—	0	1	100
495	18	3.8800	—	93	0	2	0	0	—	—	3	0	98
496	19	3.9200	—	90	4	3	1	0	—	—	1	0	99
497	20	4.1000	—	95	1	1	0	0	—	—	2	0	99
498	21	4.2000	—	90	5	0	1	1	—	—	1	0	98
499	22	3.5900	—	91	7	0	1	0	—	—	0	0	99
500	23	2.8200	—	96	1	0	0	0	—	—	0	0	97
501	24	2.8400	—	96	1	1	1	0	—	—	1	—	100
502	25	3.4500	—	91	1	1	3	0	—	—	0	1	97
503	26	3.6600	—	86	3	8	1	0	—	—	0	1	99
504	27	3.4600	—	95	0	1	1	0	—	—	1	0	98
505	28	3.7200	—	93	3	1	1	0	—	—	1	1	100
506	29	3.5000	87	3	—	—	4	0	0	0	0	0	94
507	30	3.7000	90	4	—	—	5	0	0	0	0	0	99
508	31	3.6700	82	7	—	—	5	1	0	0	0	0	95
509	32	3.7200	90	6	—	—	1	0	0	0	0	0	97
510	33	2.8800	85	8	—	—	2	0	1	0	1	0	97
511	34	2.7300	88	4	—	—	2	3	0	0	0	0	94
512	35	3.4400	70	18	—	—	9	0	0	0	0	0	97
513	36	3.3300	85	3	—	—	3	4	1	0	0	0	96

TABLE XXV.—*Average Weight and Germinative Power of Wheat Seeds from Plots receiving the same Fertilizer, 1886.*

Fertilizer number.	KIND OF FERTILIZER.	Weight of 100 seeds.	Germinated.
		Grams.	*Per cent.*
1	Nothing,	2.93	99
2	Dried blood,	2.81	95
3	Dissolved bone-black,	3.01	96
4	Muriate of potash,	2.83	98
5	Dried blood, Dissolved bone-black,	2.86	97
6	Dried blood, Muriate of potash,	2.62	96
7	Dissolved bone-black. Muriate of potash,	3.38	97
8	Dissolved bone-black, Muriate of potash, Dried blood, 240 pounds,	3.93	99
9	Dissolved bone-black. Muriate of potash, Dried blood, 480 pounds,	4.00	99
10	Dissolved bone-black, Muriate of potash. Dried blood, 720 pounds,	3.96	99
11	Dissolved bone-black, Muriate of potash, Nitrate of soda, 160 pounds,	3.66	99
12	Dissolved bone-black, Muriate of potash, Nitrate of soda, 320 pounds,	3.46	98
13	Dissolved bone-black. Muriate of potash, Nitrate of soda, 480 pounds,	3.72	100
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 120 pounds,	3.70	99
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 240 pounds,	3.67	95
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 360 pounds,	3.72	97
17	Yard manure, 12,000 pounds,	3.53	100
18	Yard manure, 16,000 pounds,	3.83	98
19	Yard manure, 20,000 pounds,	4.10	99
20	Yard manure, 12,000 pounds, Lime,	3.59	99
21	Lime,	2.92	97
22	Ground limestone,	2.73	97
23	Plaster,	3.12	98
24	Ground bone, Muriate of potash, Dried blood, 240 pounds,	3.45	98
	Average of plots receiving complete fertilizers containing—		
	Dried blood,	3.84	99
	Nitrate of soda,	3.61	99
	Sulphate of ammonia,	3.70	97
	Nitrogen, 24 pounds,	3.69	99
	Nitrogen, 48 pounds,	3.78	98
	Nitrogen, 72 pounds,	3.84	99
	Yard manure,	3.76	99

a. The effects upon the weight of the seed were as follows:

1. It is shown by comparing the figures of Tables XXIV and XXV that the incomplete fertilizers, with the exception of the lime group and the combination of blood and potash, seemed to increase the weight of the seed. This increase was greatest with phosphoric acid.

2. The increase seems less with ground bone in complete fertilizer than with dissolved bone-black.
3. The order, in point of weight of seed produced, of the different complete fertilizers containing various forms of nitrogen is, dried blood, yard manure, sulphate of ammonia, and nitrate of soda.
4. The weight increases with the amount of nitrogen as in the case of oats.

b. With regard to the effects on germinative power it is seen that all the variations are small, and within the limits of error with so few observations. It may, however, be remarked that the average germinative power of seeds produced with complete fertilizers, is greater than of those produced with the incomplete; also, that in all probability the sulphate of ammonia has not had so favorable an influence as the other forms of nitrogen in complete fertilizers.

(6.) NOTES ON THE EFFECTS OF THE FLY ON THE DIFFERENTLY FERTILIZED PLOTS.

In making the survey of the plots for the estimation of the correction for "winter killing" and "fly killing," several quite striking variations in the latter were noticed, which seemed to be at least partly due to a variation in fertilizer; or, in other words, the kind of fertilizer seemed to affect markedly the amount of damage done by the fly. Whether the "winter-killing" varied in like manner, could not be noted, because of the differences in exposure due to slight irregularities in the surface of the tier.

The results of the survey stated in fractions of total area are given in Tables XXVI and XXVII.

TABLE XXVI.—*Effect of Fly on Wheat Plots, 1886.*

Plot number.	Area fly-killed.	Plot number.	Area fly-killed.	Plot number.	Area fly-killed.	Plot number.	Area fly-killed.	Plot number.	Area fly-killed.	Plot number.	Area fly-killed.
1, ...	.067	7, ...	.250	13, ...	.250	19, ...	.010	25, ...	.067	31, ...	.050
2, ...	.125	8, ...	.125	14, ...	.250	20, ...	.083	26, ...	.100	32, ...	.050
3, ...	.125	9, ...	.050	15, ...	.013	21, ...	.010	27, ...	.100	33, ...	.077
4, ...	.100	10, ...	.020	16, ...	.050	22, ...	.067	28, ...	.100	34, ...	.250
5, ...	.067	11, ...	.040	17, ...	.010	23, ...	.200	29, ...	.083	35, ...	.040
6, ...	.000	12, ...	.020	18, ...	.083	24, ...	.250	30, ...	.050	36, ...	.077

TABLE XXVII.—*Average effect of Fly on Plots receiving the same Fertilizer, 1886.*

Fertilizer number.	KIND OF FERTILIZER.	Area fly killed.
1	Nothing,	.154
2	Dried blood,	.125
3	Dissolved bone-black,	.125
4	Muriate of potash,	.100
5	Dried blood, Dissolved bone-black,	.067
6	Dried blood, Muriate of potash,	.000
7	Dissolved bone-black, Muriate of potash,	.103
8	Dissolved bone-black, Muriate of potash, Dried blood, 240 pounds,	.030
9	Dissolved bone-black, Muriate of potash, Dried blood, 480 pounds,	.015
10	Dissolved bone-black, Muriate of potash, Dried blood, 720 pounds,	.025
11	Dissolved bone-black, Muriate of potash, Nitrate of soda, 160 pounds,	.100
12	Dissolved bone-black, Muriate of potash, Nitrate of soda, 320 pounds,	.100
13	Dissolved bone-black, Muriate of potash, Nitrate of soda, 480 pounds,	.100
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 120 pounds,	.050

Fertilizer number.	KIND OF FERTILIZER.	Area fly killed.
15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 240 pounds,	.050
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia, 360 pounds,	.050
17	Yard manure, 12,000 pounds,	.050
18	Yard manure, 16,000 pounds,	.083
19	Yard manure, 20,000 pounds,	.083
20	Yard manure, 12,000 pounds, Lime, 4,000 pounds,	.067
21	Lime,	.200
22	Ground limestone,	.250
23	Plaster,	.163
24	Ground bone, Muriate of potash, Dried blood,	.060
	Average of plots receiving complete fertilizers containing—	
	Dried blood,	.025
	Nitrate of soda,	.100
	Sulphate of ammonia,	.050
	Nitrogen, 24 pounds,	.045
	Nitrogen, 48 pounds,	.045
	Nitrogen, 72 pounds,	.044
	Yard manure,	.071

The well-known variation in the attack of the fly on various parts of the same fields forbids the attachment of importance to the results of observations on single plots. The following general observations are, however, of interest:

1. Comparing contiguous plots, the destruction seems to be greater on plots receiving incomplete fertilizers than on the unfertilized. Those receiving a single mineral ingredient with dried blood seem to have suffered somewhat less. The total immunity of Plot No. 6, receiving dried blood and potash, is noticeable.

2. The plots receiving complete fertilizers in every instance suffered less than the unfertilized plots, except No. 36.

3. Dissolved bone-black seemed to have a better effect than ground bone.

4. There is quite a marked difference between the effects of the groups of fertilizers containing different forms of nitrogen; plots receiving dried blood suffered least, sulphate of ammonia next, yard manure next, and nitrate of soda most.

5. A variation in the amount of nitrogen, within the limits of the experiments, seems to have had no effect.

This year's observations on the effect of fly, as shown in the fall, confirms the above statement as to the comparatively favorable results from the use of dried blood. A comparison of the results in 1885 on plots 16, 18, 20, 22, and 17, 19, 21, where yard manure and dried blood alternate, show very distinctly the differences with these two fertilizers. It seems difficult to offer at present any explanation for this difference that shall be satisfactory in view of all the facts.

D. Experiments on Grass.

(1.) Experiments of 1885—Central Experimental Farm.

The grass crop of 1885 was grown on the plots of tier III, and completed the first experimental period of rotation. The grass was a mixture of clover and timothy, the timothy being drilled in with the wheat, and the clover sown in the last part of the following March, two quarts of each seed being used. The grass was cut June 22, and stored June 24.

The growing season of 1885 was late and dry, and very unfavorable for grass. The season of 1884 was also drier than usual.

In discussing the yields of hay from different plots, account must be taken of the fact that grass is the second crop removed after a single application of fertilizers, so that any variations it may show, tend to indicate mainly the effects of the several fertilizers on the *permanence* of fertility. To gain a fair idea of the full effect of the various fertilizers, it is necessary to consider also the preceding wheat crop, and the combined weight of the two crops. In comparing the results from tier III with the mean of those from tiers I and II in preceding years, it must be remembered that although a large part of any variation must be attributed to differences in the respective growing seasons, some part is probably due to differences in the soil of the different tiers.

The following table, XXVIII, gives the average results from tier III, and the means of those from tiers I and II.

TABLE XXVIII.—*Average Yield of Plots receiving the same Fertilizers, Grass of 1885.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yields per Acre. — Means from Tiers I and II. — Wheat, 1882-83. — Grain.	Wheat, 1882-83. — Straw.	Wheat, 1882-83. — Total crop.	Grass, 1883-4—Hay	Combined crops.	Tier III. — Wheat, 1884. — Grain.	Wheat, 1884. — Straw.	Wheat, 1884. — Total crop.	Grass, 1885—Hay.	Combined crops.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	. .	. .	5	1,116	1,777	2,893	3,548	6,441	1,390	1,697	3,087	1,384	4,471
2	Dried blood,	240	240	1	1,176	2,184	3,360	3,340	6,700	1,200	1,600	2,800	960	3,760
3	Dissolved bone-black,	300	300	1	1,452	2,228	3,680	3,560	7,240	1,248	1,352	2,600	760	3,360
4	Muriate of potash,	200	200	1	1,142	1,878	3,020	3,300	6,320	1,392	1,608	3,000	800	3,800
5	Dried blood, Dissolved bone-black,	240 300	540	1	1,564	2,196	3,760	3,840	7,600	1,506	1,856	3,362	1,040	4,402
6	Dried blood, Muriate of potash,	240 200	440	1	1,092	1,928	3,020	3,000	6,020	1,626	1,936	3,562	1,160	4,722
7	Dissolved bone-black, Muriate of potash,	300 200	500	5	1,445	2,307	3,752	4,016	7,768	1,724	*1,822	3,426	1,436	4,861
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	3	1,445	2,608	4,053	4,180	8,233	1,766	1,968	3,731	1,427	5,161
9	Dissolved bone black, Muriate of potash, Dried blood,	300 200 480	980	2	1,544	3,010	4,551	4,250	8,804	1,854	2,404	4,258	1,660	5,918
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	1,598	2,902	4,500	4,460	8,960	1,979	2,452	4,431	1,360	5,791
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	1,786	3,136	4,922	4,300	9,222	1,998	2,400	4,398	1,560	5,958
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	1,724	3,116	4,840	4,160	9,000	2,256	2,664	4,920	1,240	6,160
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,748	3,292	5,040	3,860	8,900	2,370	?	?	1,560	?
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	1,508	3,072	4,580	4,240	8,820	2,070	1,768	3,838	1,880	5,718

* Mean of four plots.

15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	1,804	3,136	4,940	4 360	9,300	2,406	3,192	5,598	1,920	7,518
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	2	1 802	3,180	4,982	4.164	9,146	2,346	3,416	5,762	1,840	7,602
17	Yard manure,	12,000	12,000	1	1,656	2,912	4,568	3,840	8,408	1,830	2,568	4,398	1,240	5,638
18	Yard manure,	16,000	16,000	1	1,416	2,704	4,120	3,912	8,032	1,896	2,104	4,000	1,440	5,440
19	Yard manure,	20,000	20,000	1	1,536	2,944	4,480	3,760	8,240	1,962	2,800	4,762	2,040	6,802
20	Yard manure, Lime,	12,000 4,000	16,000	1	1,580	2,920	4 500	3,900	8,400	1,734	2,104	3,838	1,040	4,878
21	Lime,	4 000	4,000	1	1,304	1,928	3,232	4,000	7,232	1,368	1,592	2,960	720	3,680
22	Ground limestone,	4,000	4 000	1	1,070	1,932	3,002	3.940	6,942	1,530	1,672	3,202	1,760	4,962
23	Plaster,	320	320	2	1,045	1,846	2,891	3,380	6,271	1,428	1,722	3,150	2,200	5,350
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	7	1,587	2,807	4,324	4,280	8,604	1 852	2,231	4,083	1,474	5,557
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	...	3	1,753	3,181	4,934	4,107	9,041	2,208	†2,532	4,659	1,453	6,112
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	1,705	3,129	4,834	4,255	9,089	2,274	2,792	5,066	1,880	6,946
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	5	1,525	2,807	4,332	4,216	8,548	1,873	2,014	3,887	1,544	5,431
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	...	4	1,654	3,068	4 722	4,255	8,977	2,092	2 666	4,758	1,625	6,383
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	4	1,686	3,069	4,755	4,236	8,991	2,168	†2,773	4,875	1,530	6,405
	Average yield of plots receiving complete fertilizers containing yard manure,	....	....	4	1,547	2,870	4,417	3,875	8,292	1,855	2,394	4,249	1,440	5,689

† Mean of two plots. ‡ Mean of three plots.

TABLE XXVIII—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Gain over Unfertilized Plots. Means from Tiers I and II. Wheat, 1882-83. Grain.	Straw.	Total crop.	Grass, 1883-4—Hay	Combined crops.	Tier III. Wheat, 1884. Grain.	Straw.	Total crop.	Grass, 1885—Hay.	Combined crops.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	.	.			.	.			.	
2	Dried blood,	240	60	407	467	—208	259	—190	— 97	—287	—424	—711
3	Dissolved bone-black,	300	336	451	787	12	799	—142	—345	—487	—624	—1 111
4	Muriate of potash,	200	26	101	127	—248	—121	2	— 89	— 87	—584	—671
5	Dried blood, Dissolved bone-black,	240 300	448	419	867	292	1,159	116	159	275	—344	— 69
6	Dried blood, Muriate of potash,	240 200	— 21	151	127	—548	—421	236	239	475	—224	251
7	Dissolved bone-black, Muriate of potash,	300 200	329	530	859	468	1 327	354	125	359	52	391
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	329	831	1,160	632	1,792	376	271	647	43	690
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	428	1,233	1,661	702	2 363	461	707	1 171	276	1,447
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	482	1,125	1,607	912	2,519	889	755	1 344	— 24	1,320
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	670	1,359	2,029	752	2,781	608	703	1,311	176	1 487
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	608	1 339	1,947	612	2,559	866	967	1,833	—144	1,689
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	632	1,515	2,147	312	2,459	980	?	?	176	?
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	392	1,295	1,687	692	2,379	680	71	751	496	1,247

15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	688	1,359	2 047	812	2,859	1,016	1,495	2,511	536	3,047
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	686	1,403	2 089	616	2,705	956	1,719	2,675	456	3 131
17	Yard manure,	12,000	540	1,135	1 675	292	1,967	440	871	1,311	—141	1,157
18	Yard manure,	10,000	300	927	1,227	364	1,591	506	407	913	56	969
19	Yard manure,	20,000	420	1,167	1,587	212	1,799	572	1,103	1,675	656	2 331
20	Yard manure, Lime,	12,000 4,000	464	1 143	1 607	352	1 959	344	407	751	—344	407
21	Lime,	4,000	188	151	339	452	791	— 22	—105	—127	—664	—791
22	Ground limestone,	4,000	— 16	155	109	392	501	140	— 25	115	376	491
23	Plaster,	320	— 71	69	— 2	—168	—170	38	25	63	816	879
	Average yield of plots receiving complete fertilizers containing dried blood,		471	1,030	1,431	732	2,163	462	534	996	90	1,086
	Average yield of plots receiving complete fertilizers containing nitrate of soda,		637	1 404	2,041	559	2,600	818	835	1,572	69	1,641
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,		589	1,352	1 941	707	2 648	884	1,095	1,979	496	2,475
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,		409	1,030	1,439	668	2,107	483	317	800	160	960
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,		538	1,291	1,829	707	2,536	702	969	1,071	241	1,912
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,		570	1,292	1 862	688	2,550	778	1,170	1,788	146	1,934
	Average yield of plots receiving complete fertilizers containing yard manure,		431	1,093	1,521	327	1,851	465	697	1,162	56	1,218

An examination of these results shows the following facts:

1. Partial fertilizers, in general, produce little effect.

2. Complete commercial fertilizers surpass yard manure as far as the effects upon the two crops following a single application are concerned.

3. Dried blood is inferior, as a source of nitrogen, to nitrate of soda and sulphate of ammonia, the last two producing nearly the same effect in ordinary seasons; yard manure increases the yield of wheat more than dried blood, but the yield of combined crops is ordinarily less.

4. A marked increase is shown in the yield from the addition of forty-eight pounds of nitrogen, over that obtained from plots receiving twenty-four pounds; but there seems to be no considerable further increase in yield from the use of a greater quantity, so that forty-eight pounds seems to be the highest addition which can profitably be made under existing conditions, including current prices; the average addition of yard manure (fifteen thousand pounds per acre) produces about the same increase of wheat as that produced by the addition of commercial fertilizer containing twenty-four pounds of nitrogen, but the increase of combined crops is ordinarily less.

5. Ordinarily, the high yields of grass are obtained from plots which have given large yields of wheat.

6. No marked relation seems to exist between the proportion of straw in the wheat crop and that of grass in the combined crops.

7. As variations from the effect produced upon the same crops in previous years, there be noted—

(*a*) The very low yields with partial fertilizers.

(*b*) The relatively increased value of sulphate of ammonia and yard manure.

(*c*) The increased yield of grass with the increase in the amount of yard manure applied.

(*d*) The much greater effect of plaster on the grass crop.

(*e*) The decrease in the yield of the plots receiving lime, and the relatively greater value of ground limestone.

An examination of the yields of corn and oats grown upon tier III seems to indicate that most of the above variations are, to a very considerable degree, due to the peculiarities of the soil of this tier; so that the present data are insufficient to indicate the precise effects of the season upon the action of the different fertilizers, as distinguished from the effects of the soil.

(2.) EXPERIMENTS OF 1886.

The grass crop of 1886 was grown on the plots of tier IV. The treatment was the same as in the experiments of 1885. The grass was cut

July, 1 and stored July 2 and 3; the harvesting having been belated by a rainy season.

The growing season of 1886 was excellent, though the plots were greatly exposed to the action of frost during the preceding winter. Table XXIX shows the results for this season.

TABLE XXIX.—*Average Yield of Plots receiving the same Fertilizers, Central Experimental Farm, Grass, 1886.*

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yields per Acre. Means from Tiers I, II and III. Wheat, 1882-84 ‖ Grain	Straw.	Total wheat crop.	Grass, 1883-5—Hay	Combined crops.	Tier IV. Wheat, 1885. Grain.	Straw.	Total wheat crop.	Grass, 1886—Hay.	Combined crops.
		Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	....	....	5	1,207	1,750	2,957	2,827	5,784	182	270	452	5,120	5,572
2	Dried blood,	240	240	1	1,191	1,989	3,180	2,517	5,727	136	61	200	5,280	5,480
3	Dissolved bone-black,	300	300	1	1,384	1,936	3,320	2,627	5,947	252	348	600	4,160	4,760
4	Muriate of potash,	200	200	1	1,225	1,788	3,013	2,467	5,480	80	80	160	4,820	4,980
5	Dried blood, Dissolved bone black,	240 300	540	1	1,545	2,083	3,628	2,907	6,535	300	420	720	5,160	5,880
6	Dried blood, Muriate of potash,	240 200	440	1	1,270	1,929	3,199	2,387	5,586	108	172	280	5,116	5,396
7	Dissolved bone-black, Muriate of potash,	300 200	500	**5	1,538	2,145	3,683	3,156	6,839	289	849	1,138	4,284	5,422
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	§3	1,552	2,395	3,947	3,262	7,109	530	830	1,360	4,380	5,740
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	1,644	2,808	4,452	3,387	7,839	568	612	1,180	4,830	6,010
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	1,725	2,752	4,477	3,427	7,904	740	940	1,680	4,520	6,200
11	Dissolved bone black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	1,857	2,891	4,748	3,387	8,135	912	1,368	2,280	4,100	6,380
12	Dissolved bone black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	1,901	2,965	4,866	3,187	8,053	1,008	2,152	3,160	4,760	7,920
13	Dissolved bone black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	1,955	18,292	5,147	3,093	8,240	908	1,652	2,560	4,820	7,380
14	Dissolved bone black, Muriate of potash, Sulphate of ammonia,	300 200 120	620	1	1,695	2,637	4,332	3,787	8,119	1,232	1,648	2,880	6,320	9,200

15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	740	1	2,005	3,155	5,160	3,517	8,707	1,318	2,492	3,840	5,880	9,720
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	860	1	1,983	3,259	5,242	3,388	8,630	2,468	2,468	4,936	5,680	10,616
17	Yard manure,	12,000	12,000	1	1,714	2,197	3,911	2,907	6,818	353	328	680	4,360	5,040
18	Yard manure,	16,000	16,000	1	1,576	2,659	4,235	3,088	7,325	380	380	760	4,496	5,256
19	Yard manure,	20,000	20,000	1	1,678	2,896	4,574	3,187	7,761	420	540	960	4,080	5,040
20	Yard manure, Lime,	12,000 4,000	16,000	1	1,631	2,618	4,279	2,917	7,226	512	728	1,240	4,560	5,800
21	Lime,	4,000	4,000	1	1,325	1,816	3,141	2,907	6,018	352	488	840	4,660	5,500
22	Ground limestone,	4,000	4,000	1	1,223	1,845	3,068	3,213	6,281	456	624	1,080	5,160	6,240
23	Plaster,	320	320	2	1,173	1,805	2,978	2,987	5,965	354	506	860	4,850	5,710
24*	Ground bone, Muriate of potash, Dried blood,	224 200 240	664	2	....	....	....	....	....	584	856	1,440	5,360	6,800
	Average yield of plots receiving complete fertilizers containing dried blood,	....	....	***7	1,675	2,615	4,290	3,315	7,635	512	809	1,321	4,772	6,093
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	....	....	3	1,905	2,965	4,870	3,222	8,092	913	1,724	2,667	4,560	7,227
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	....	....	3	1,895	3,017	4,912	3,859	8,771	1,683	2,203	3,886	5,960	9,846
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	....	....	†5	1,641	2,543	4,184	3,325	7,509	729	1,065	1,794	4,983	6,777
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	....	....	4	1,800	2,934	4,734	3,378	8,112	873	1,467	2,340	5,075	7,415
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	....	....	4	1,847	2,970	4,817	3,681	8,498	1,214	1,500	2,714	4,885	7,599
	Average yield of plots receiving yard manure,	....	....	4	1,650	2,711	4,361	3,063	7,424	416	494	910	4,374	5,284

* First applied in 1884. ** Four plots after 1883-4. *** Eight plots after 1883-4.

† Six plots after 1883-4, the nitrogen of the bone on plots 12 and 35 being comparatively little. ‡ Straw of 1882 and 1883. § Two plots after 1883-4.

‖ The wheat of 1883 was badly winter killed; the figures included in these means represent the actual yield obtained.

TABLE XXIX—Continued.

Number.	Kind of Fertilizer.	Quantity of fertilizer ingredients per acre.	Gain over Unfertilized Plots.									
			Means from Tiers I, II and III.					Tier IV.				
			Wheat, 1882-84					Wheat, 1885.				
			Grain.	Straw.	Total wheat crop.	Grass, 1883-5—Hay	Combined crops.	Grain.	Straw.	Total wheat crop.	Grass, 1886—Hay.	Combined crops.
		Lbs	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Nothing,	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
2	Dried blood,	240	— 16	239	223	—280	—57	—46	—206	—252	160	—92
3	Dissolved bone-black,	300	177	186	363	—200	163	70	78	148	—960	—812
4	Muriate of potash,	200	18	38	56	—360	—304	—102	—190	—292	—300	—592
5	Dried blood, Dissolved bone-black,	240 300	338	333	671	80	751	118	150	268	40	308
6	Dried blood, Muriate of potash,	240 200	63	179	242	—440	—198	—74	—98	—172	—4	—176
7	Dissolved bone-black, Muriate of potash,	300 200	331	395	726	329	1,055	107	579	686	—836	—156
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	345	645	990	435	1,425	348	560	908	—740	168
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	437	1,058	1,495	560	2,055	386	342	728	—290	438
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	518	1,002	1,520	600	2,120	558	670	1,228	—600	628
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	650	1,141	1,791	560	2,351	730	1,098	1,828	—1,020	808
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	694	1,215	1,909	360	2,269	826	1,882	2,708	—360	2,348
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	748	1,542	2,290	266	2,556	726	1,382	2,108	—300	1,808
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 120	488	887	1,375	960	2,335	1,050	1,378	2,428	1,200	3,628

15	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 240	798	1,405	2,203	720	2,923	1,166	2,222	3,388	760	4,148
16	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	300 200 360	776	1,509	2,285	561	2,816	2,286	2,193	4,484	560	4,914
17	Yard manure,	12,000	507	447	954	80	1,034	170	58	228	—760	—532
18	Yard manure,	16,000	369	909	1,278	261	1,539	198	110	308	—621	—316
19	Yard manure,	20,000	471	1,146	1,617	360	1,977	238	270	503	—1,040	—532
20	Yard manure, Lime,	12,000 4,000	421	898	1,322	20	1,342	330	458	788	—560	228
21	Lime,	4,000	118	66	181	80	261	170	218	388	—160	—72
22	Ground limestone,	4,000	16	95	111	386	497	274	354	628	40	668
23	Plaster,	320	—31	55	21	60	81	172	236	408	—270	138
24*	Ground bone, Muriate of potash, Dried blood,	224 200 240	.....	.....	.....	.....	.....	402	586	988	240	1,228
	Average yield of plots receiving complete fertilizers containing dried blood,	.....	468	865	1,333	518	1,851	330	539	869	—318	521
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	.....	698	1,215	1,913	395	2,308	761	1,451	2,215	—560	1,655
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	.....	688	1,267	1,955	1,032	2,987	1,501	1,933	3,434	840	4,274
	Average yield of plots receiving complete fertilizers containing 24 pounds of nitrogen,	.....	434	793	1,227	498	1,725	547	795	1,342	—137	1,205
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	.....	593	1,184	1,777	551	2,328	591	1,197	1,788	—45	1,743
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	.....	640	1,220	1,860	854	2,714	1,032	1,260	2,262	—235	2,027
	Average yield of plots receiving yard manure,	.....	443	961	1,404	236	1,640	234	224	458	—746	—288

a. Examining the grass crop of 1886, in comparison with those of former years, especially with that of 1885, the following points are brought out:

1. The crop was far above the average.
2. Of the incomplete fertilizers, only dried blood and plaster caused any gain. (Compare Table III.)
3. The substitution of ground bone for dissolved bone-black in complete fertilizer seemed to cause a gain.
4. Of the complete fertilizers, those containing sulphate of ammonia were the only ones producing an increase, which was greatest with the least quantity of the sulphate. Dried blood produced the least loss, nitrate of soda next, and yard manure most.
5. Among the most complete fertilizers the least loss occurred on plots receiving 48 pounds of nitrogen: the greatest on those receiving 72 pounds.

b. Studying the combined wheat and grass crops of 1885 and 1886, in comparison with those of 1884 and 1885, the following differences are observed:

1. A gain with dried blood and dissolved bone-black combined, and a loss with the other incomplete fertilizers containing two ingredients.
2. A gain from the substitution of ground bone for dissolved bone-black in complete fertilizer.
3. That while the same order, in point of yield, of the complete commercial fertilizers is maintained, the relative importance of sulphate of ammonia is greatly increased.
4. An actual loss with yard manure, and a more favorable effect of the admixture of lime with yard manure.

(3.) EFFECTS OF VARIOUS FERTILIZERS ON THE PROPORTION OF CLOVER IN MIXED HAY.*

It is a recognized fact that the natural clovers of a meadow are destroyed by the continuous use of highly nitrogenous manure, but are developed by the application of potash and lime manure.

It was deemed that it might be useful to examine the effects of the different fertilizers in use in the general experiments, on the development of clover under the conditions of soil, climate, and cultivation existing here. Observations were accordingly made on the plots of tier IV during the present year. It will be remembered that the plots of this tier had received two applications of their respective fertilizers, beginning with the corn crop of 1883, the present grass crop completing the first rotation.

In comparing the development of clover on the different plots, a certain plot upon which the areas of clover and timothy were appar-

*In part, a paper read before the Society for the Promotion of Agricultural Science, Buffalo, August 17, 1886.

ently equal was chosen as a standard, and a survey made with reference to this. A day or two before the time of mowing a small area of the standard growth was cut and weighed; the clover and timothy were rapidly separated, weighed, and dried. The weights obtained are as follows:

	Green. *Grams.*	*Air-dry.* *Grams.*
Weight of whole sample,	574.1	163.0
Weight of clover,	276.4	92.1
Weight of timothy,	297.7	70.9

From these weights of air-dry substance it is possible to estimate the proportion by weight of clover in the hay from any plot, if, also, the proportion by area of the clover to timothy is known. It is, of course, apparent that the method is crude, assuming, as it does, that the relation of the clover to the hay of any plot is the same as that found to exist in the dried sample which may have been more fully dried. Still, the hay was mown July 1, and weighed July 2 and 3, and as these were hot, breezy days, it is probable that the figures given may be accepted as fair approximations to the truth.

The following table gives the data obtained, together with the weight of the previous wheat crop and that of the combined crops, to which it may be interesting to refer:

TABLE XXX.—*Showing the average effect of different Fertilizers on the proportion of Clover in Mixed Hay.*

Fertilizer number.	KIND OF FERTILIZER.	Single ingredients per acre.	Total quantity of fertilizer per area.	Number of plots.	Proportion of clover to timothy by area.	Weight of hay per acre.	Weight of clover hay.	Weight of timothy hay.	Proportion of clover to timothy, air-dry, by weight.	Weight of preceding wheat crop.	Weight of combined crops.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nothing,	. . . . .	. . . . .	5	1 : 1.38	5,120	1,655	3,465	1 : 2.09	452	5,572
2	Dried blood,	240	240	1	1 : 2	5,280	1,988	3,292	1 : 1.66	200	5,480
3	Dissolved bone-black,	300	300	1	1 : 19	4,160	235	3,925	1 : 16.7	600	4,760
4	Muriate of potash,	200	200	1	1 : 1.57	4,820	2,120	2,700	1 : 1.27	160	4,980
5	Dried blood, Dissolved bone-black,	240 300	540	1	1 : 99	5,160	58	5,102	1 : 88	720	5,880
6	Dried blood, Muriate of potash,	240 200	440	1	1 : 1.5	5,016	2,268	2,748	1 : 1.21	280	5,396
7	Dissolved bone-black, Muriate of potash,	300 200	500	4	1 : 12.34	4,784	483	4,301	1 : 8.9	1,138	5,422
8	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 240	740	2	1 : 7	4,380	673	3,707	1 : 5.51	1,360	5,740
9	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 480	980	2	1 : 39	4,830	130	4,700	1 : 36.2	1,180	6,010
10	Dissolved bone-black, Muriate of potash, Dried blood,	300 200 720	1,220	2	0 : 1	4,520	0	4,520	0 : 1	1,680	6,200
11	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 160	660	1	0 : 1	4,100	0	4,100	0 : 1	2,280	6,380
12	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 320	820	1	0 : 1	4,760	0	4,760	0 : 1	3,160	7,920
13	Dissolved bone-black, Muriate of potash, Nitrate of soda,	300 200 480	980	1	0 : 1	4,820	0	4,820	0 : 1	2,560	7,380
14	Dissolved bone-black, Muriate of potash, Sulphate of ammonia,	[illegible] 200 120	620	1	1 : 4	6,320	714	5,038	1 : [illegible].06	2,880	9,200

15	Dissolved bone-black, / Muriate of potash, / Sulphate of ammonia,	300 / 200 / 240	740	1	1 : 9	5,880	665	5,606	1 : 8.43	3,810	9,720
16	Dissolved bone-black, / Muriate of potash, / Sulphate of ammonia,	300 / 200 / 360	860	1	1 : 199	5,680	32	5,215	1 : 163	4,936	10,616
17	Yard manure,	12,000	12,000	1	1 : 1.5	4,360	1,972	2,388	1 : 1.21	680	5,040
18	Yard manure,	16,000	16,000	1	1 : 1.57	4,496	1,978	2,518	1 : 1.27	760	5,256
19	Yard manure,	20,000	20,000	1	1 : 19	4,080	231	3,819	1 : 16.6	960	5,040
20	Yard manure, / Lime,	12,000 / 4,000	16,000	1	1 : 3	4,560	1,289	3,271	1 : 2.54	1,210	5,800
21	Lime,	4,000	4,000	1	1 : 11.5	4,660	421	4,239	1 : 10.1	810	5,500
22	Ground limestone,	4,000	4,000	1	1 : 15.7	5,160	319	4,811	1 : 13.8	1,080	6,240
23	Plaster,	320	320	2	1 : 1.25	4,850	2,360	2,490	1 : 1.06	860	5,710
21	Ground bone, / Muriate of potash, / Dried blood,	224 / 200 / 240	664	2	1 : 2.89	5,360	1,397	3,963	1 : 2.84	1,440	6,800
	Average yield of plots receiving complete fertilizers containing dried blood,	. . . . .	. . . . .	8	1 : 8.33	4,773	550	4,223	1 : 7.68	1,321	6,093
	Average yield of plots receiving complete fertilizers containing nitrate of soda,	. . . . .	. . . . .	3	0 : 1	4,560	0	4,560	0	2,667	7,227
	Average yield of plots receiving complete fertilizers containing sulphate of ammonia,	. . . . .	. . . . .	3	1 : 9	5,960	470	5,490	1 : 11.7	3,886	9,846
	Average yield of plots receiving complete fertilizers containing 21 pounds of nitrogen,	. . . . .	. . . . .	6	1 : 6.29	4,983	809	4,174	1 : 6.49	1,791	6,777
	Average yield of plots receiving complete fertilizers containing 48 pounds of nitrogen,	. . . . .	. . . . .	4	1 : 25.7	5,075	231	4,841	1 : 21	2,340	7,415
	Average yield of plots receiving complete fertilizers containing 72 pounds of nitrogen,	. . . . .	. . . . .	4	1 : 799	4,885	8	4,877	1 : 610	2,714	7,599
	Average yield of plots receiving yard manure,	. . . . .	. . . . .	4	1 : 2.67	4,374	1,368	3,006	1 : 2.2	910	5,281

Since these are the results of a single season, it will not be advisable to enter into any detailed discussion: a brief notice will be made of only the most salient features:

1. Muriate of potash and gypsum, among the single fertilizers, produce clover in higher amounts, both absolute and proportional, than either of the other single fertilizers. Lime, ground limestone, and, especially, dissolved bone-black seem to have been injurious rather than beneficial. The ground bone in No. 24 does not seem to have been so deleterious as the more soluble bone-black; dried blood, singly, seems to have had no markedly injurious effect. The injurious influence of the dissolved bone-black is noticeable also in the case of plots receiving ingredients two by two.

2. Of the plots receiving complete fertilizers, those receiving six and eight tons per acre of yard manure are the only ones that surpass the unfertilized plots in clover yield. The yields with other fertilizers are far inferior.

3. Of the various nitrogenous fertilizers, nitrate of soda seems the most injurious, sulphate of ammonia next, and dried blood least. This result is quite different from that commonly expected.

4. Comparing the yields with reference to the amounts of nitrogen applied, it is seen that the clover decreases rapidly and almost invariably with the increase of nitrogen: the only exception is in the case of the moderate use of yard manure.

5. Notwithstanding the above conclusions from the results with complete fertilizer, comparison with the yield obtained with purely mineral fertilizer containing dissolved bone-black (No. 7) showed that the addition of small quantities of dried blood or sulphate of ammonia to such a fertilizer may be beneficial to clover.

6. An examination of the *general averages* to determine the relations of the various fertilizers to timothy, does not show an exact reverse of their relations to clover. The lowest absolute yield occurs with yard manure, next follow in order the unfertilized plots and those receiving dried blood, nitrate of soda, and sulphate of ammonia. An increase in the amount of nitrogen is beneficial.

In studying the data given, the fact must be remembered that for *cereal* crops phosphates and nitrogen have always repaid highly on this soil, while potash has proven totally without value.

As before indicated, the above conclusions may be very materially modified by the results of further observation.

It would be of interest to know whether the ratios are considerably changed by applying the soluble nitrogenous fertilizers in the spring as a top dressing.

E. Effect of the Different Fertilizers on the Proportion of Grain to Straw.

There seems to be considerable variation in the proportion of grain to straw produced by the same fertilizer under different climatic conditions. It becomes a matter of interest to determine the relation of the two products in these experiments, considering the effects of the complete fertilizers especially. Table XXXI gives the mean of these results for the different crops of the Central Experimental Farm since the beginning of these experiments in 1881, with corn. For comparison, the averages of the unfertilized plots and those receiving the potash and phosphoric acid combination are given.

TABLE XXXI.—*Average Yield of Grain and Straw on Plots receiving similar Fertilizers.*

	Kind of Fertilizer.	Average Yield.						Proportion of Grain to Straw.*		
		Corn. 1881-1886.		Oats. 1882-1886.		Wheat. 1882-1885.				
		Ears.	Fodder.	Grain.	Straw.	Grain.	Straw.	Corn.	Oats.	Wheat.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*			
A	Nothing, ...	3,306	2.397	1,402	1,898	851	1.333	1 : .725	1 : 1.354	1 : 1.566
B	Dissolved bone-black, . / Muriate of potash, . . .	3,615	2,811	1,639	2,073	1,147	1.928	1 : .778	1 : 1.265	1 : 1.681
	Complete fertilizers containing—									
C	Dried blood, ...	3,503	2,846	1,625	2,132	1.323	2,319	1 : .812	1 : 1.312	1 : 1.753
D	Nitrate of soda, . . .	3.568	2,815	1.645	2,121	1.516	2.653	1 : .789	1 : 1.289	1 : 1.750
E	Sulphate of ammonia,	3.474	2.900	1.702	2,293	1.699	2,656	1 : .835	1 : 1.347	1 : 1.563
F	Nitrogen, 24 pounds, .	3,510	2,837	1,609	2,108	1,563	2,400	1 : .808	1 : 1.310	1 : 1.536
G	Nitrogen, 48 pounds, .	3,525	2,872	1,721	2.141	1.480	2,575	1 : .815	1 : 1.244	1 : 1.740
H	Nitrogen, 72 pounds, .	3,512	2,857	1,651	2,288	1,604	2,682	1 : .813	1 : 1.386	1 : 1.672
I	Yard manure, ...	3,737	2,465	1,555	2,234	1,376	2,019	1 : .660	1 : 1.437	1 : 1.467

* Grain, 1.

Comparing the proportions of grain to straw produced by the different fertilizers, with those obtained on the unfertilized plots, the following facts are evident:

1. That, with the purely mineral fertilizer, the proportion of fodder in corn, and of straw in wheat was increased, but that of straw in oats was diminished.

2. That, except in the case of nitrate of soda on oats, and sulphate of ammonia on wheat, the groups of complete artificial fertilizers distinguished by different forms of nitrogen, caused an increase in the proportion of straw. Their order of precedence, that producing the greatest proportion of straw being placed first, was, for corn and oats, sulphate of ammonia, dried blood, nitrate of soda; for wheat, dried blood, nitrate of soda, sulphate of ammonia. There is scarcely any difference between dried blood and nitrate of soda as far as the effect in this regard is concerned.

3. That the groups of commercial artificial fertilizers, arranged according to the amount of nitrogen they contain, caused, in the case of oats and wheat, an increase in the proportion of straw with the increase in nitrogen, except in the case of that containing 48 pounds with oats, and that containing 24 pounds with wheat: in the case of

corn, on the other hand, the proportion of ears increased with the increase in nitrogen. Their order of precedence, in point of proportion of grain to straw, beginning with the highest, is, for corn, 72 pounds, 48 pounds, 24 pounds; for oats, 48 pounds, 24 pounds, 72 pounds; for wheat 24 pounds, 72 pounds, 48 pounds.

4. The effect of yard manure was, in the case of corn and wheat, to reduce the proportion of straw to an amount lower than that produced with any other fertilizer or without fertilizer; with oats, on the contrary, the proportion obtained with yard manure was higher than in any other case under consideration.

II. EXPERIMENTS WITH DIFFERENT KINDS OF PHOSPHORIC ACID.

(1.) GRASS, 1885.

These experiments were made at the Central Experimental Farm on plots A to L, of $\frac{1}{20}$ acre area, whose uniformity was tested by the unfertilized oats crop of 1883.* The experiments proper began with wheat in 1884.†

The grass received no fertilizer. The details of sowing and cultivation were identical with those of the general fertilizer series. The following table (I) shows the kind and amount of fertilizers applied, the average yield of wheat and grass from the plots receiving the same fertilizer, after correction in accordance with the results of the uniformity test, and the weight of the wheat and grass crops combined.

TABLE I.—*Yield of Plots Fertilized with Different Kinds of Phosphoric Acid.*

PLOTS.	KIND OF FERTILIZER.	Quantity of fertilizer ingredients per acre.	Quantity of fertilizer per acre.	WHEAT, 1884. Grain.	Straw.	Total wheat crop.	Grass, 1885—Hay.	Combined crops.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
A and G	Dissolved bone-black (phosphoric acid largely soluble), Muriate of potash, Sulphate of ammonia,	200 200 240	640	1,848	3,400	5,248	1,550	6,79[illegible]
B and H	Dissolved bone-black (phosphoric acid all reverted), Muriate of potash, Sulphate of ammonia,	200 200 240	640	2,076	3,486	5,562	1,611	7,203
C and I	Fine ground bone, Muriate of potash, Sulphate of ammonia,	150 200 240	590	2,052	3,430	5,482	1,5[illegible]0	6,982
D and J	Ground South Carolina rock, Muriate of potash, Sulphate of ammonia,	150 200 240	590	2,070	3,299	5,369	1,555	6,924
E and K	Muriate of potash, Sulphate of ammonia,	200 240	440	1,704	2,839	4,543	1,005	5,548
F and L	Nothing,	. . .	. . .	1,452	2,132	3,584	1,073	4,657

The same remarks must be made concerning this year's grass as were applied to last year's wheat: That, under the conditions of the experiment, all the forms of phosphoric acid used caused an appreci-

* See Bulletin No. 9. † See College Report for 1883 and 1884.

able gain, which was nearly equal in all cases. This indicates an equality of effect on the permanence of fertility during the second year after the application of the fertilizer. Controlling conditions, other than the amount of available phosphoric acid present, seem to have been active in both years. The experiments serve to show that in a good soil, and under some other conditions not yet well known, ground rock may be as valuable a fertilizer as any other source of phosphoric acid. Further experiments must be made before any more definite statement can be warranted.

(2.) CORN, 1886.

(a.) *Yield.*

This season the same plots were fertilized according to the above-mentioned scheme, and sown with corn. The planting and cultivation were as usual.

The following table (II) shows the average yield of the plots treated in the same manner.

TABLE II.—*Yields of Plots Fertilized with Different Kinds of Phosphoric Acid, Corn, 1886.*

PLOTS.	KIND OF FERTILIZER.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	CORN. Number of stalks.	Ears.	Fodder.	Total crop.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*
A and G	Dissolved bone-black (phosphoric acid largely soluble),	200	640	6,090	3,450	2,000	5,450
	Muriate of potash,	200					
	Sulphate of ammonia,	240					
B and H	Dissolved bone-black (phosphoric acid all reverted),	200	640	6,520	3,400	2,000	5,400
	Muriate of potash,	200					
	Sulphate of ammonia,	240					
C and I	Fine ground bone,	150	590	6,550	3,700	2,220	5,920
	Muriate of potash,	200					
	Sulphate of ammonia,	240					
D and J	Ground South Carolina rock,	150	590	6,210	3,475	2,150	5,625
	Muriate of potash,	200					
	Sulphate of ammonia,	240					
E and K	Muriate of potash,	200	440	5,490	3,075	1,700	4,775
	Sulphate of ammonia,	240					
F and L	Nothing,	....	....	5,870	2,400	1,150	3,550

Examination of these results reveals the following facts:

1. That the use of phosphoric acid increased in every case both the number of stalks and also the yield of both ears and fodder.

2. That the greatest number of stalks reached maturity where fine ground bone and reverted phosphate were used, while ground rock gave higher results, in this particular, than the soluble phosphate.

3. That the highest yields of both ears and fodder were obtained with fine ground bone.

4. That ground rock stood next in order, though its yield in fodder was relatively high.

5. That the soluble phosphate gave a yield almost identical with that of the reverted.

These experiments give additional emphasis to the statement that it is not always necessary to use the high priced "available acid" to obtain the best results. But actual experiment is, at present, the only means of determining when such is the case.

(b.) THEIR EFFECTS ON THE RATE OF DEVELOPMENT OF CORN.

It was thought that the effects of the different kinds of phosphoric acid under the conditions of the experiment might be more clearly shown if observations should be made upon the rate of development of the crop grown. Mr. H. J. Patterson accordingly made such observations: unfortunately, it was impossible to extend them to the earlier stages of growth; nevertheless, they are quite indicative of the effects of the fertilizers for the season. The data obtained are presented in the following tables:

Table III shows the mean daily temperature and the rainfall during the period of observation.

Table IV shows the height of the stalks selected for observation at various intervals. The stalks at the beginning of the experiment represented the average height of the stalks of the same plot, and were situated some distance apart, and so as to represent the average as nearly as possible.

Table V shows the gains of the stalks in inches, and the average gain per day of the stalks on each plot.

Table VI presents a summary of the results for the plots treated alike.

TABLE III.—*Showing Temperature and Rainfall during the Period of Observation.*

DATE.		Mean daily temperature.	Rainfall—Inches.	DATE.		Mean daily temperature.	Rainfall—Inches.	DATE.		Mean daily temperature.	Rainfall—Inches.	DATE.		Mean daily temperature.	Rainfall—Inches.
		Deg. Fahr.				*Deg. Fahr.*				*Deg. Fahr.*				*Deg. Fahr.*	
July	17	73.0	0	July	29	75.2	0	Aug.	10	74.7	0	Aug.	22	69.0	0
	18	69.4	Trace.		30	73.0	0		11	76.2	0		23	71.7	0
	19	69.0	0		31	73.6	0.65		12	72.5	0.10		24	71.5	0
	20	69.7	0	Aug.	1	73.7	0		13	72.0	0.04		25	70.5	0
	21	68.9	0.73		2	69.6	0		14	72.7	0		26	72.7	0
	22	73.5	Trace.		3	60.5	0		15	67.0	0.27		27	77.0	0
	23	68.0	0		4	63.0	0		16	70.5	0		28	75.2	0
	24	72.6	0		5	63.9	0		17	70.7	0		29	78.5	.01
	25	75.2	0		6	64.9	0.05		18	60.0	0		30	71.9	1.32
	26	69.7	0.52		7	62.9	0		19	60.5	0		31	64.0	0
	27	69.2	1.00		8	66.9	0		20	68.0	0	Sept.	1	59.0	0
	28	[illegible]	0		9	73.5	0		21	65.9	0		2	60.0	0

Table IV.—*Showing Height of Corn (in inches) at the times of Observation.*

1886.	A.		B.		C.		D.		F.		G.		H.		I.		J.		L.	
	Stalk No. 1.	Stalk No. 2.	Stalk No. 1.	Stalk No 2.	Stalk No. 1.	Stalk No. 2.	Stalk No. 1.	Stalk No. 2.	Stalk No. 1.	Stalk No. 2.	Stalk No. 1.	Stalk No. 2.	Stalk No. 1.	Stalk No. 2.	Sta k No. 1.	Stalk No. 2.	Stalk No. 1.	Stalk No 2.	Stalk No. 1.	Stalk No. 2.
July 17, ...	48	39	53	50	51	43	50	48	51	32	57	53	61	36	56	44	52	36	36	. . . .
20, ...	52.5	52	60	57	67	55	62	48	60.5	37	68	57	75	56	62	49	62	42	45	35
21, ...	62	57	67	62	72	60	65	52	65	40	72	62.5	80	60	67	59	67	47	49	39
22, ...	63	61	70	66	76	64	70	56.5	69	44	76	67	84	63	72	63	71	54	52	41
23, ...	65	61.5	71	71	79	68	73.5	60	74	48	80	72	88	65	77	65	74	55	55	13
24, ...	68	64.5	73	74	83	71	76	64	76	50	82	73	90	66	79	67	76	58	56	49
26, ...	75	76	79	77	85	76	79	66	76	55	87	81	94	71	84	71	81	72	57	51
27, ...	81	78	81	82	87	81	81	70	81	58	92	86	96	75	89	71	86	78	60	57
28, ...	83	83	86	86	90	81	86	75	87	62	98	91	100	78	96	79	88	81	64	61
29, ...	85	86	91	90	94	90	92	80	93	67	102	95	100	83	101	85	90	87	69	63
30, ...	91	87	98	97	97	95	95	85	*89	73	106	101	102	88	105	92	92	95	76	61
31, ...	96	92	101	98	99	101	101	90	93	75	109	103	102	91	108	97	95	97	80	70
Aug. 2, ...	102	†91	101	102	105	103	108	98	99	80	111	105	102	91	110	103	102	98	85	80
3, ...	103	91	106	102	106½	101	108	98	99	81	111	105	102	95	110	103	102	98	85	82
4, ...	103	93	108	102	107	101	108	99	99	81	111	105	102	95	110	103	102	98	85	82
7, ...	103	93	112	102	111	106	108	99	99	90	111	105	102	95	110	105	107	98	85	90
12, ...	113	94	119	102	114	106	113	118	99	99	111	112	102	96	110	105	111	98	91	96
18, ...	113	94	119	102	114	106	113	120	99	99	111	112	102	106	110	105	111	98	93	96
Sept. 2, ...	113	94	119	102	114	106	113	120	99	99	111	112	102	107	110	105	111	98	93	96

* Nine (9) inches broken off from top by wind.

† Seven (7) inches broken off from top.

TABLE V.—*Showing the Gain of the Corn in inches per day.*

1886.	A.			B			C.			D.			F.		
	Stalk No. 1.	Stalk No. 2.	Average gain of stalks for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain of stalks for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain of stalks for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain of stalks for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain of stalks for 1 day.
July 17,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20,	4.5	13	2.92	7	7	2.33	16	12	4.66	12	5	2.83	9.5	5	2.38
21,	9.5	5	7.25	7	5	6.00	5	5	5.00	3	4	3.50	4.5	3	3.75
22,	1	4	2.50	3	4	3.50	4	4	4.00	5	4.5	4.75	4	4	4.00
23,	2	0.5	1.25	1	5	3.00	3	4	3.50	3.5	3.5	3.50	5	4	4.50
24,	3	3	3.00	2	3	2.50	4	3	3.50	2.5	4	3.25	2	2	2.00
26,	7	12	4.75	6	3	2.25	2	5	1.75	3	2	1.25	0	5	1.25
27,	6	2	4.00	5	5	5.00	2	5	3.50	2	4	3.00	8	3	5.50
28,	2	5	3.50	2	4	3.00	3	3	3.00	5	5	5.00	3	4	3.50
29,	2	3	2.50	5	4	4.50	4	6	5.00	6	5	5.50	6	5	5.50
30,	6	1	3.50	7	7	7.00	3	5	4.00	3	5	4.00	5	6	5.50
31,	5	5	5.00	3	1	2.00	2	6	4.00	6	5	5.50	4	2	3.00
August 2,	6	6	3.00	3	4	1.75	6	2	2.00	7	8	3.75	6	5	2.75
3,	1	0	0.50	2	0	1.00	1.5	1	1.25	0	0	0	0	1	0.50
4,	0	2	1.00	2	0	1.00	0.5	0	0.25	0	1	0.50	0	3	1.50
7,	0	0	0	4	0	0.67	4	2	1.00	0	0	0	0	6	1.00
12,	10	1	1.10	7	0	0.70	3	0	0.30	2	9	1.10	0	9	0.90
18,	0	0	0	0	0	0	0	0	0	3	2	0.41	0	0	0
September 2,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sums,	65	55	60	66	52	59	63	63	63	63	77	70	48	67	57.5
Means,	1.35	1.15	1.25	1.38	1.08	1.23	1.31	1.31	1.31	1.31	1.60	1.46	1.00	1.39	1.19

TABLE V—Continued.

1886.	G.			H.			I.			J.			L.		
	Stalk No. 1.	Stalk No. 2.	Average gain for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain for 1 day.	Stalk No. 1.	Stalk No. 2.	Average gain for 1 day.
July 17,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20,	11	4	2.80	11	20	5.66	6	5	1.83	10	6	2.66	9	.....	3.00
21,	4	5.5	4.75	5	4	4.50	5	10	7.50	5	5	5.00	4	4	4.00
22,	4	4.5	4.25	4	3	3.50	5	4	4.50	4	7	5.50	3	2	2.50
23,	2	5	3.50	4	2	3.00	5	2	3.50	3	1	2.00	3	2	2.50
24,	5	1	3.00	2	1	1.50	2	2	2.00	2	3	2.50	1	6	3.50
26,	5	8	3.25	4	5	2.25	5	4	2.25	5	4	2.25	1	5	1.50
27,	6	5	5.50	2	4	3.00	5	3	4.00	5	6	5.50	3	3	3.00
28,	4	5	4.50	4	3	3.50	7	5	6.00	2	6	4.00	4	4	4.00
29,	4	4	4.00	1	5	3.00	4	6	5.00	2	3	2.50	5	2	3.50
30,	3	6	4.50	1	5	3.00	4	7	5.50	2	8	5.00	7	1	4.00
31,	2	2	4.00	0	3	1.50	3	5	4.00	3	2	2.50	4	6	5.00
August 2,	0	2	0.50	0	3	0.75	2	6	2.00	7	1	2.00	5	10	3.75
3,	0	0	0	0	1	0.50	0	0	0	0	0	0	0	2	1.00
4,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,	0	0	0	0	0	0	0	2	0.85	5	0	0.83	0	8	1.33
12,	0	7	0.70	0	1	0.10	0	0	0	4	0	0.40	6	6	1.20
18,	0	0	0	0	10	0.83	0	0	0	0	0	0	2	0	1.67
September 2,	0	0	0	0	1	0.07	0	0	0	0	0	0	0	0	0
Sums,	54	59	56.5	41	71	56	54	61	57.5	59	62	60.5	57	61	59
Means,	1.12	1.23	1.17	.85	1.48	1.16	1.12	1.29	1.21	1.23	1.30	1.26	1.19	1.35	1.27

TABLE VI.—*Average Growth of Stalks on Plots Receiving the same Fertilizer.*

	Plots A and G.	Plots B and H.	Plots C and I.	Plots D and J.	Plots F and L.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Average height on July 17,	49.2	50.0	48.5	45.2	39.6
Average height on September 2,	107.5	107.5	108.7	110.5	96.7
Average gain in height,	58.3	57.5	60.2	65.3	57.1
Average gain in height per day,	1.21	1.20	1.26	1.36	1.20

It will be noted in studying these tables that no observations were made on the stalks of plots L and K, which received fertilizer containing no phosphoric acid.

Examining the data with reference to the results of the addition of a phosphoric acid fertilizer upon corn in its earlier stages of growth, its very beneficial effect is noticed. A comparison with the table showing the yield of fodder and number of stalks matured, shows that a large share of this benefit is due to the phosphoric acid itself.

The plots receiving the more soluble forms of phosphoric acid were slightly in advance of those receiving the comparatively insoluble forms; of the former, the stalks on the plots receiving the reverted acid was slightly the taller; of the latter, that receiving the ground bone was slightly in advance.

During the period of observation the relations of the stalks on the different plots changed greatly. At the end of the period, the stalks on the plots receiving the insoluble phosphates were the tallest, those receiving "ground rock" standing first; those on the plots receiving the soluble and the reverted phosphates were equal.

During this period the plots receiving the more soluble phosphates gained at about the same rate as the unfertilized plots, while the gains of those receiving the ground rock and ground bone were, respectively, 13 and 5 per cent. greater.

A comparison of the number of stalks and yield of fodder with the height of the stalks on the plots receiving soluble and reverted acid, will show that the stalks in the latter case were lighter than in the former; this may have been due to some difference in leaf development, though this appears to have had very little effect on the yield of grain, or to a difference in the whole plant.

A similar comparison of the plots receiving ground rock and ground bone, shows a very close agreement in the field-cured weight of the stalks and ears, viz.: .906 pounds and .901 pounds per stalk, respectively.

That the more soluble phosphates should produce the greatest effect in the earliest stages of growth, and that their effects are so similar, is not unexpected; that these effects should relatively diminish later and thta the effect of the less soluble forms should somewhat increase is also to be anticipated; but it is somewhat surprising that at the end of two months, the former should cease to have any effect upon the crops while within the second period of two months, the insoluble phosphates, supposed to contain approximately an equal amount of total phosphoric acid, should have gained sufficiently to surpass the former.

These results corroborate the conclusions stated in discussing the effect of the different phosphates upon the yield. It is increasingly evident that the relation of the various phosphates to vegetable nutrition is not as simple as has been supposed. Practically, under conditions similar to those of these experiments, a fertilizer containing a small quantity of "available," *i. e.*, "soluble" or "reverted" acid, and a relatively large quantity of "insoluble" acid would seem as well, or even better fitted, than a fertilizer containing a relatively larger proportion of the "available acid," to meet the requirements of the crop at its different stages of growth. It must be borne in mind, however, that numerous experiments, under different conditions, have given very diverse testimony on this point.

III. Experiments with Various Potash Salts on Potatoes.

In response to a request, an experiment has been made on the Central Experimental Farm during the past season, upon the effect of the addition of various potash salts, in liberal quantity, to farm-yard manure, as a fertilizer for potatoes.

The land used had been in grass the previous season; the soil is like that of the rest of the farm, calcareo-magnesian clay, upon which potash fertilizers have hitherto been used for corn and cereals without any apparently direct or beneficial effect.

The soil was thoroughly pulverized, and four furrows marked out out, side by side. In the bottom of each was placed one hundred and fifty pounds of farm-yard manure; to the second was added four pounds of muriate of potash mixed with soil; to the third, in a similar manner, five pounds of sulphate of potash; to the fourth, sixteen pounds of kainite or double sulphate of potash and magnesia. The quantities of potash salts used contained the same quantity of potassium oxide. Each row represented about one eightieth of an acre.

After thoroughly mixing the fertilizers with the soil, a layer of several inches of soil was covered over them, and upon this the seed was placed. For the several rows an equal number of single-eye cuttings of "Beaty of Hebron" potatoes was used. The time of planting was May 19.

An observation taken June 25, showed that the row treated with yard manure alone was best, being most highly developed and having the fewest gaps; next in order stood the row to which yard manure and muriate had been added; then that receiving yard manure and sulphate; the row which received yard manure and kainit had a great many large gaps, and the few plants which were to be seen, seemed stunted and sickly.

The following table shows the yield per acre of the different rows, the proportion of large, medium and small tubers, and the amounts of dry substance and ash, which the tubers of different sizes from the different rows contained.

Effects of Various Potash Fertilizers on Potatoes.

Index number.	DESCRIPTION.	Yield per acre.	Dry substance.	Ash.
		Lbs.	*Per cent.*	*Per cent.*
561	Treated with yard manure only, large,	2,040	19.06	0.24
562	Do. do. medium,	1,020	21.45	0.22
563	Do. do. small,	1,200	20.74	0.25
	Total yield,	4,260	20.11	0.24
564	Treated with yard manure and muriate of potash, large,	1,920	21.47	0.21
565	Do. do. do. medium,	620	22.75	0.17
566	Do. do. do. small,	340	20.53	0.20
	Total yield,	2,880	21.63	0.20
567	Treated with yard manure and sulphate of potash, large,	1,860	21.62	0.25
568	Do. do. do. medium,	560	21.33	0.20
569	Do. do. do. small,	620	20.79	0.25
	Total yield,	3,040	21.40	0.24
570	Treated with yard manure and kainite, large,	420	20.98	0.20
571	Do. do. do. medium,	200	20.53	0.26
572	Do. do. do. small,	240	23.50	0.21
	Total yield,	860	21.57	0.22

A comparison of the yields of tubers shows that, under the conditions of the experiment, the addition of potash salts to yard manure instead of increasing, actually diminished the yield. The row treated with sulphate gave a higher total yield than that receiving muriate. The very low yield with kainite is in great part due to the rotting of the seed potatoes.

On the other hand, leaving the kainite row out of consideration, the results show that the decrease occurred mainly in the quantity of small and medium tubers, and the muriate stands between the yard manure and the sulphate in this respect; the muriate producing the least proportion of small potatoes.

Turning to an examination of the composition of the various products, the following facts will be noticed:

1. The percentage of dry substance (mainly starch) is greater in those potatoes treated with potash salts than where yard manure alone was used.

2. That, of the rows receiving potash salts, the one receiving the muriate produced tubers containing the highest percentage of dry matter, while those produced by the use of sulphate contained the least. The real difference is quite slight. These results do not sup-

port the common supposition that the sulphate produces a mealier potato than that obtained when the muriate is used.

3. The percentage of ash in potatoes obtained with yard manure and with the addition of sulphate is the same, and is considerably higher than where the muriate is used.

4. As regards *size*, it will be seen that the medium-sized potatoes, on the average, contain the most dry matter, and the least ash: there is quite a striking equality in the percentages of ash present in the large and small potatoes.

Summing up all the facts, the higher-priced sulphate does not seem to have any advantage over the muriate, though, in discussing these experiments, it must be recalled that the commercial sulphate used probably contained a very considerable quantity of muriate as an impurity.

Further, the very common practice of using potash manures alone or with nitrogen is not shown to be advantageous on soils of this character. In fact, general testimony is in favor of the use of potash only when it is combined with phosphoric acid and nitrogen.

Finally, the very common practice of applying concentrated potash manures in the furrow, or near the time of planting, is shown to result disastrously.

Experiments by Dr. Goesmann, on loamy soil, using at the same time liberal quanties of phosphoric acid and nitrogen, and using muriate and kainite as the sources of potash, gave, in 1884,* a lower yield of tubers for the kainite, but a higher percentage of starch; in 1885,† the kainite produced a slightly greater weight of tubers and a little less starch than the muriate. The results are thus inconclusive, though in this case the potatoes failed to mature.

Dr. Cook‡ says: "In the field experiments with sulphate of potash and muriate of potash, the results do not show any special benefit for one over the other to the growing crops, though the former has heretofore cost at least fifty per cent more than the latter."

Mayer§ computes, from twenty experiments, that 1 pound of muriate of potash (fifty per cent. potash) produced nearly 3½ pounds of increase; and a pound of sulphate of potash about as much or rather more than the muriate.

Prof. Storer‖ says concerning the use of the muriate: "With respect to potatoes, the accounts in our agricultural papers are somewhat conflicting, and the general inference seems to be that, while there is undoubtedly a considerable risk of harm, the quality of the tubers is not so universally liable to suffer from this cause as has sometimes been supposed. In so far as regards mere increase of crop, it is in evidence that the potato has shown itself to be

* Mass. Agric. Exp. Station Rep., 1884, p. 87.
† *Ib.*, 1885, p. 72.
‡ N. J. Agric. Exp. Station Rep., 1885, p. 13.
§ Cf. Bulletin of the Bussey Inst., Vol. II, p. 365.
‖ *Ib.*, p. 370.

less sensitive to harm from moderate doses of chloride of potassium, and better able to profit by this fertilizer, than several other plants."

Dr. Märcker,* of Halle, after a careful review of all recorded experiments to which he had access, makes the following observations on the effect of potash salts on potatoes: "In almost all cases potash salts have increased the yield, when used in connection with nitrogenous and phosphatic manures. In very few cases was the per cent. of starch in the potash increased; in many cases (12 out of 21) it was considerable diminished. The depression of starch was greatest when potash salts were applied nearest planting time. The muriates decreased the starch yield more than thesulphates, especially when applied late. Low grade salts or the muriate, if used, should therefore be applied as early as possible, at the latest in December. Any excess, which might do no harm on other crops, should be avoided; and if the potash must be applied near planting time, only sulphate should be used.

Necessary conditions for success in the use of potash salts are that there shall be no accumulation of free acid or of soluble iron salts in the soil nor of standing water in the subsoil. Standing water must be got rid of by drainage, iron salts and free acid by an application of lime."

According to the Stassfurt Syndicate of Potash Manufacturers, muriate should be applied to heavy soils in autumn or winter; to light soils in early spring. It should, after being mixed with dry earth, be sown broadcast on the unplowed land or on the rough furrows. Placing it near the seed in hills or drills is unadvisable.

IV.—EXPERIMENTS WITH DIFFERENT QUANTITIES OF COMMERCIAL FERTILIZER.

GRASS, 1885.

These experiments were made at the Central Experiment Farm on plots A. 1, to L. 1, of $\frac{1}{20}$ acre area, whose uniformity was tested by oats in 1883. The fertilizers were applied to wheat† in 1884, the plots being treated alike in every other particular. The fertilizer was made according to the following formula:

Dissolved bone-black,	72	pounds.
Muriate of potash,	8	"
Sulphate of ammonia,	20	"

The points to be noted are the effect on the permanence of fertility as shown by this year's grass crop, and the effect on the yield of the combined crops.

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*Cf. Conn. Agric. Exp. Station Rep., 1885, p. 113.

† See Bulletin No. 11 and the College report for 1883 and 1884.

Table showing Yield with Different Quantities of Commercial Fertilizer.

PLOTS RECEIVING THE SAME AMOUNT OF FERTILIZER.	Quantity of fertilizer per acre.	*WHEAT, 1884.			*Grass, 1885—Hay.	Combined crops.
		Grain.	Straw.	Total wheat crop.		
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
A. 1 and G. 1,	120	1,302	2,300	3,602	650	4,252
B. 1 and H. 1,	240	1,392	2,170	2,562	580	4,142
C. 1 and I. 1,	360	1,686	2,930	4,616	730	5,346
D. 1 and J. 1,	480	1,674	2,800	4,474	890	5,364
E. 1 and K. 1,	600	1,728	2,710	4,438	730	5,168
F. 1 and L. 1,	Nothing.	1,410	2,170	3,580	730	4,310

* Corrected in accordance with the uniformity test.

The soil was so fertile that the addition of commercial fertilizer produced little increase. The results seem to favor the use of 360 to 480 pounds per acre. At current prices, the plots receiving the former amount were the only ones to yield an immediate profit.

V.—EXPERIMENTS ON DEEP AND SHALLOW AND THICK AND THIN SOWING OF WHEAT.

(1.) EXPERIMENTS OF 1884–1885.

These experiments are a continuation of the experiments on this subject previously reported.* They were conducted on plots laid out for the purpose, the land having previously been cropped with potatoes. As fertilizer, there were used 250 pounds per acre of a mixture containing 200 pounds of nitrate of soda and 1800 pounds of dissolved South Carolina rock per ton.

The wheat was sown October 2, 1884; cut July 15, and housed July 18, 1885. In sowing, a regulator attachment to the drill was used.

The following table* shows the plan of the experiments and the results for 1885:

TABLE I—*Yields of Wheat Sown at Different Depths and with Different Quantities of Seed, 1885.*

No. of plots.	METHOD OF SOWING.	Quantity of seed.	YIELD PER ACRE.		
			Grain.	Straw.	Total crop.
		Bus.	*Lbs.*	*Lbs.*	*Lbs.*
1	Shallow (1–1½ in.),	1	649	1,737	1,386
2	Deep (2–3 in.),	1	555	1,270	1,825
3	Shallow,	1½	1,080	1,402	2,482
4	Deep,	1½	905	1,504	2,409
5	Shallow,	2	1,358	1,839	3,197
6	Deep,	2	1,007	1,913	2,920

* See Bulletin No. 11 and the College Report for 1883 and 1884.

An examination of these results shows the following facts:

1. That the shallow-sown wheat invariably gave the larger yield of grain: in this respect differing to some degree from the results of 1884.

2. That the deep-sown wheat gave the most straw, which was true, with only a single exception, in 1884.

3. That, under the conditions of this season's experiments, an increase in the amount of the seed, within the limits adopted, produced an increase in the yield of grain almost exactly corresponding to the amount of seed used. An increase in the amount of straw was also noticeable, but it was not proportionally as great. In 1884, there was little difference in the yield of either grain or straw with various amounts of seed.

The variation of the results indicates that a careful comparison of meteorological conditions is necessary before any safe conclusion can be reached.

(2.) EXPERIMENTS OF 1885–'86.

Plots M—R, of one-twentieth acre, were sown in 1885, according to the above mentioned scheme. The exposure of winter resulted, in a great degree, in the death of the plants, and since the plots were unevenly exposed, the yields obtained are not to be relied upon for any further study of this question. During the course of development, especially in the earlier stages, observations were taken which may throw some light on the subject.

Observations made September 22, and October 10, revealed little difference either in height above ground, or in thickness of growth, on the different plots. On October 22 a number of plants were removed from different parts of each plot. The shallow-planted plants had short, thick stems, with thickly matted roots: the deep-planted had slender underground stems, which at the base gave off straggling roots, and near the surface swelled with a bulbous portion, from which, also, a few roots were given off. It is very evident that frost would affect the two plants very differently.

Observations were also made on the total length of the plants from tip of leaf to tip of root, and on the number of leaf-stems given off from a single plant.

The results taken from a number of plants for each plot are as follows:

TABLE II.—*Effect of the Depth of Planting on the Length of Stems, &c.*

Number of plot.	METHOD OF SOWING.	Quantity of seed.	Total length of plant.	Number of leaf-stems.
		Bush.	*Inches.*	
M	Deep,	1	12	7
N	Shallow,	1	9	6
O	Deep,	1½	10	4
P	Shallow,	1½	9	6
Q	Deep,	2	10	4
R	Shallow,	2	9½	7

The effect upon the tillering of the plant is to be regarded as exceedingly important, and, in this instance, the inferiority of the deep-sown plants at this stage of development is very sharply marked.

(3.) THE EFFECTS UPON THE FOLLOWING GRASS CROP.

The plots used were M to R of the same tier as those used for the experiments with different kinds of phosphoric acid, and their uniformity was tested in the same way in 1883. The wheat † was sown as in the previously mentioned experiment. The following table (III) gives the yields of wheat and grass and the weights of the combined crops from the different plots.

TABLE III.—*Yields of Wheat Sown at Different Depths and with Different Quantities of Seed, and the following Grass Crop.*

Number of plots.	METHOD OF SOWING.	Quantity of seed.	* WHEAT, 1884. Grain.	Straw.	Total wheat.	Grass, 1885—Hay.†	Combined crops.
		Bushels.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
M	Deep,	1	1,740	2,760	4,500	1,200	5,700
N	Shallow,	1	1,680	2,620	4,300	1,300	5,600
O	Deep:	1½	1,866	2,960	4,826	990	5,816
P	Shallow,	1½	1,674	2,820	4,494	1,070	5,564
Q	Deep,	2	1,596	2,500	4,096	700	4,796
R	Shallow,	2	1,980	3,280	5,260	1,320	6,580

* Corrected according to the test of 1883.

1. That the shallow planting was best for the grass.

2. That the highest average yield of grass was obtained where the smallest amount of wheat seed was used.

Owing to the exceptional character of the season of 1885, the yield of the combined crops cannot be considered as fairly representative of those grown under ordinary conditions.

† See Bulletin No. 11, and the College Report for 1883 and 1884.

VI. EFFECT OF KILN-DRYING ON THE VITALITY OF SEED CORN.

Among the many interesting experiments carried on at the New York Agricultural Experimental Station which look toward the improvement of seed corn, are several upon the effect of drying upon the vitality of the seed.

The following abstracts from the reports of the director, Dr. Sturtevant, will indicate the results obtained:

*"An interesting experiment upon the effect of drying seed corn is appended, the seed in all trials being taken from the same bin."

TABLE I.—*Germinative Results.*

Number.	DURATION AND TEMPERATURE OF EXPERIMENT.	Days required to give results.	Total days of trial.
1	Taken from the bin March 9, 1887,	6	6
2	Exposed to temperature of 200° F. for 42 hours,	6	12
3	Dried at 120° F. for 3 days,	5	9
*4	No. 3, further dried at 200° F. for 24 hours,	15	15
5	Dried at 95° F. for 4 days,	4	99
6	No. 5, further dried at 200° F. for 24 hours,	4	100
7	Dried at 90° F. for 3 days,	6	99
8	No. 7, further dried at 200° F. for 24 hours,	6	99

* No. 4 mildewed very badly in three pockets. The 25 kernels in the fourth pocket germinated 100 per cent.

"These figures correspond to a mass of unrecorded experiences which tend to show that thoroughly dried corn germinates more quickly than does ordinary seed corn, or that corn dried at a high temperature, say 90°–100° F., is superior for seed purposes."

Again,† "last year, as published, we determined the fact that in our trials the kiln-drying of seed corn increased greatly its value and certainty for seed purposes. Other experiments at that time indicated a larger germinating quality in corn that was kiln-dried than in the best selected corn of the same variety from the crib."

"This spring, experiments in the same line have not indicated the same difference in germinative properties, the seed having been dried only immediately preceding the trial, but what is more important, they have indicated the greater vigor of the plant which is grown from the kiln-dried seed. While in germination, in one trial, the vitality as expressed in per cents, was precisely the same as between two lots of five hundred seeds each, the one corn from the crib and the other thoroughly dried over the radiator, viz: 94 per cent., yet when this same corn was planted in the earth, the difference became very marked; the corn from the crib giving but 20 per cent. vegetation, and the same corn kiln-dried giving 80 per cent. vegetation. The difference was even more marked in the growth, the corn from the crib only attaining a height of three inches, while that from the kiln-dried seed had reached the height of five inches in the same time."

* Fourth Annual Report New York Agricultural Experimental Station, p. 73.

† New York Agricultural Experimental Station, Bulletin VIII, New Series, (April 15, 1886,) p. 1.

In order to test more fully the truth of these important conclusions, a similar experiment has been made during the past year on the Central Experimental Farm.

Two separate lots of common yellow dent corn were selected, and a portion of each was dried for five or six days at 105° F., and afterward for ten hours at 140° F.

A germination test of the seeds thus prepared was made, with the following results:*

Table II.

Number.	Germinative number.	Description.	Per cent. germinated.	Days required for ½ to germinate.	Total days of trial.
1	96	Lot 1, (row 1),	100	3	5
2	98	Lot 1, kiln-dried, (row 4),	100	2	4
3	97	Lot 2, (row 3),	97	2	10
4	99	Lot 2, kiln-dried, (row 2),	100	3	6

These samples were planted side by side. Observation taken June 11, 1886, gave the following results:

No. 1. Fair color, but very uneven in development.

No. 2. Excellent, leaves large and broad, full set, good color and even development.

No. 3. Color very good, but development very uneven and many hills missing.

No. 4. Development very good, color moderately good, leaves curly and narrow, but far better than No. 3.

Another observation taken September 7th, showed little difference in height between the common and the kiln-dried seed.

On October 7th the corn was cut. The weight of corn and fodder harvested from each row of fifty hills, grown from the different seeds, are as follows:

Table III.

Number.	Description.	Ears.	Fodder.	Total crop.
		Lbs.	*Lbs.*	*Lbs.*
1	Lot 1,	30	35	65
2	Lot 1, kiln-dried,	42½	37½	80
3	Lot 2,	50	52½	102½
4	Lot 2, kiln-dried,	52½	50	102½

As a further test of any difference in the vitality of the original seed, a germination trial of the fresh seed from these different products was made:

*Cf. Table of Germinations, p.

TABLE IV.

Number.	Germination table number.	DESCRIPTION.	Per cent. germinated.	Days required for ½ to germinate.	Total days of trial.	Weight of 100 seeds.
						Grams.
1	586	Corn grown from lot 1,	97	2	10	26.0200
2	589	Do. do. 1, kiln-dried,	96	2	10	26.3900
3	588	Do. do. 2,	90	2	10	28.7300
4	587	Do. do. 2, kiln-dried,	98	2	10	28.6700

In examining these results, it will be observed that there is considerable difference in the behavior of the two original lots of seed chosen. This is explained by the fact that one was selected from a few ears left in an open crib, the other chosen from the carefully selected seed-corn which had been stored during the winter in a room whose temperature was maintained at about 60° F.

The germination test of the original seeds shows that the kiln-dried samples complete their germination in advance of the undried seeds, although the percentage of germination is little different.

The observations taken during the earlier stages of growth, at a time when corn is threatened to the greatest extent with injury from insects and from cold, show the same advancement and increased vigor of the plants from kiln-dried seeds. This difference is not apparent in the later stages of growth.

An examination of the weights of ears and fodder produced, reveals a marked tendency toward an increase of the proportion of ears to fodder. With lot 1, the increase in product is 40 per cent. of ears and 7 per cent. of fodder; with lot 2, the increase is 5 per cent. of ears and nearly the same decrease in fodder.

Taken as a whole, therefore, the results indicate that kiln-drying has a markedly advantageous effect. Further, it will be remembered that in the experiment the rapid drying was not effected till just before planting time, and that the advantage will probably be even more marked where the drying at a high temperature, (about 100° F.,) is accomplished in the fall.

VII. EXPERIMENTS ON THE GROWTH OF SORGHUM AND SUGAR BEETS FOR SUGAR.

The manufacturing difficulties which have impeded the progress of the sorghum sugar manufacture, even in the climates best adapted to its growth, seem to be yielding, one by one, before the advance of scientific investigation and the application of the results of practical experience. It has also been shown by actual practice that in some localities of the United States, sugar can be profitably made from sugar beets. It becomes, then, a matter of considerable importance to determine the climatic limits of the successful culture of both sorghum and beets for sugar.

This problem must not be confused, as it so often is, with the question of growing sorghum and beets as feeding stuffs, nor even with the production of sorghum for the manufacture of syrup. The problem is the production of plants containing a sufficient proportion of crystallizable sugar to pay for extraction and refining.

As a contribution to the knowledge on this subject, experiments in the growth of sorghum and sugar beets have been conducted during the past season on the Central Experimental Farm.

In order that the bearings of the results obtained may be most clearly perceived, it may be well in the first place to note very briefly the climatic conditions shown by actual experience to be most favorable to these crops, and also to summarize the results of other experiments previously made within our own State.

In summing up the results of experiments in different parts of the United States, Dr. Wiley, Chief Chemist, United States Department of Agriculture, states *that usually a season of about 100 to 110 days is necessary before the cane is ready for the beginning of manufacturing operations in latitude 42°. Also, that "by almost unanimous consent, those who are interested in sorghum as a sugar-producing plant have assigned the isotherm of 70°F. for the summer as the northern limit of successful sorghum culture, while the growers of the sugar beet look for their success north of that line." * * * * "While the isotherm of 70° for the summer months is of greatest interest to sorghum growers, the manufacturer will devote more attention to the lines of 65° for September, and 55° for October. The season of manufacture must include these two months, and perhaps also November. * * * * "A mean line, showing the mean position of the isotherms of 65° for September, 55° for October, and 40° for November, in my opinion, would mark out very nearly the northern limit of successful manufacture of sugar from sorghum." * * * * "Generally, a sufficient rainfall can be expected for the needs of plants as hardy as sorghum."

Concerning soil, it may be said in general, that any good corn land is adapted to sorghum growing. A sandy loam, not too light, with a permeable sub-soil is best.

The climatic conditions governing the growth of the sugar beet are much more complex. The time from sowing to harvest may be divided into three, more or less well defined periods:

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* Bulletin No. 3, Chemical Division, United States Department of Agriculture.

I. The period of germination;

II. The period of cellular growth;

III. The period of sugar formation.

Period I. To gain a sufficiently long season for maturing and forming sugar, the European growers sow from the latter part of April to the middle of May, the season extending to the middle of October. In no case must there be exposure to sudden cold or frost. The atmospheric temperatures should be 45.7°–51.3° F., in April and May, and at the time of sowing the temperature of the soil should be about 50° F.

The rainfall also has an important influence at this time; if it is too light, the dryness of the soil may prevent germination; if too great, the soil may not be prepared, or the seed may rot after sowing.

Period II. During the second period there should be as vigorous growth as possible; there should be a fair development of the root, but especially, a great growth of leaf. As a rule, the larger leaves occur with roots richest in sugar, they being the sugar factory, while the root serves as the store-house for the product. For this growth ample heat, moisture, and sunshine are requisite. Briem * says: "From May till the middle of June should be warm and tolerably moist, with a day temperature of 60°–65° F. June and July should be relatively cool and rainy, with a day temperature of 65°–67° F. A dry July makes the roots run to seed." On the other hand, excessively rainy weather increases the weight of the root, but by reason of the diminished sunlight, the growth of the leaf is retarded, and the elaborative power of the plant during the following period is in that manner impaired.

Period III. The sugar-storing season is marked by quite different meteorological characters. Briem says: "August and September should be warm and relatively dry, with an average temperature of 64,5°–67.5° F. October cool and fresh, with an average temperature of 47.7° F. Dry September increases the sugar, while a wet September produces the opposite effect." An increase of temperature in the latter part of September or early part of October, if accompanied by an increase in moisture, may lead to a second period of growth of the leaves and upper part of the root, which, even though it does not decrease the absolute amount of sugar, will, by the introduction of other constituents, greatly diminish it relatively, and thus make the crop less valuable to the manufacturer.

Finally, after harvesting, cold, dry weather is best for the preservation of the beet.

A brief survey of a meteorological chart of Europe will show that

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* J. des Fabric. de Sucre, October 23, 1875.

by far the greater part of the territory devoted to beet culture lies north of a line passing through localities having a mean summer temperature of 70° F. During the summer months this territory never has less than two inches rainfall per month. Nevertheless, the importance of the total rainfall is subsidiary to that of its distribution through the different months.

To sum up the various statements upon the characters of the soil best adapted to beet culture, it may be said that the soil and sub-soil should be sufficiently porous to admit of a free circulation of air and water, and the spreading of rootlets. A purely sandy soil is liable to drought, unless there is a very wet sub-soil, and will scarcely contain sufficient nutriment. On the other hand, pure clay or limestone soils are too compact and wet. The presence of some humus is desirable. Whatever opinions may be held concerning the influence of the general chemical nature of the soil, it will always be true that there must be sufficient food in the shape of lime, potash, nitrogen, and phosphoric acid. An excess of these foods, may, however, cause the plant to continue its active cellular growth through the whole period, thus preventing full sugar production. An excess of nitrogen is universally admitted to be hurtful. In general, it is considered that soils should contain 15 to 30 per cent. of clay, 60 to 70 per cent. of siliceous sand, and .01 to .20 of nitrogen.

Notwithstanding that Pennsylvania is not as well supplied as it should be with data for meteorological study, something may be done in that direction with the meagre material at hand. Dr. McMurtrie* has, by the aid of Schott's Temperature and Rain Tables, traced a line passing through localities that have a mean summer temperature of 70° F., and a mean monthly rainfall of 2 inches. Its course indicates that Bradford, Tioga, Potter, McKean, Warren, Erie, and Crawford, of the northern tier of counties, and Allegheny, Westmoreland, and Somerset in the south-western corner, are climatically best adapted to beet culture. Dr. Wiley† traced, by aid of the United States Signal Office, the isothermal lines which bound the regions best fitted for sorghum They indicate that only the south-eastern and possibly the south-western or western parts of the State have a sufficiently high mean temperature during the proper season for the successful culture of sorghum for sugar.

In order to gain a fuller knowledge of this matter, a comparison was made between the mean temperatures and monthly precipitation for the different parts of the season at Erie, Pittsburgh, State College, and Philadelphia, and those of Cambrai, in the Department del Nord, one of the most favored centres of beet culture in France. The figures for Erie, Pittsburgh, and Philadelphia represent the seasons from July, 1879, to July, 1884, and were obtained from the records of

* Culture of the Sugar Beet. † *Loc. cit.*

the United States Signal Service; the data for State College were taken from the observations of Professors Smith and Osmond, and represent the seasons from June, 1880 to the end of 1884. They are shown in the following table:

TABLE I.—*Comparative Table of Temperature and Raintalls.*

Months.	Cambrai.*		Erie.		Pittsburgh.		Phila.		State College.		
	Temperature.	Rainfall.	Temperature.	Rainfall.	Temperature.	Rainfall.	Tempe ature.	Rainfa'l.	Temper..ture.	Rainfall.	Number of rainy days.
	F.°	*Inches.*	*F.°*	*Inches.*	*F.°*	*Inches.*	*F.°*	*In·hes.*	*F.°*	*Inches.*	
January,	38.75	.9[illegible]	27.4	3.24	31.7	3.84	29.9	3.87	23.1	3.29	12
February,	40.33	.70	30.8	4.12	36.5	3.74	37.2	4.43	30.1	3.75	12
March,	44.83	1.18	33.1	2.81	38.9	3.22	40.2	3.53	34.4	3.01	12
April,	52.70	1.81	43.3	2.67	50.3	2.08	49.9	1.85	36.8	1.98	8
May,	60.35	1.37	57.5	4.10	63.4	3.65	62 7	2.72	61.7	4.28	12
June,	68.00	1.77	66.4	3.94	70.7	4.21	72.0	3.27	70.5	4.70	12
July,	68.23	2.40	71.5	2.85	73.6	4.26	75.9	3.09	73.2	2.41	10
August,	67.55	1.71	69.5	3.76	71.8	3.59	73 7	4.64	70.4	2.83	8
September,	62.60	1.71	64.6	3.71	66.1	2.29	68.1	3.90	65.8	2.21	7
October,	50.90	1.88	55.3	3.53	57.5	2.27	58.6	2.06	54.0	2.34	8
November,	40.33	1.68	40.9	5.03	42.5	2.26	45.1	1.49	37.4	1.70	8
December,	38.75	.83	32.6	3.88	35.0	3.34	36.3	3.22	29.2	2.43	9
Mean for April May,	56.52	1.59	50.4	3.38	56.8	3.86	56.3	2.28	49.7	3.08	10
" " June-August,	67.93	1.96	69.1	3.52	72.0	4.02	73.9	3.67	71.4	3 31	10
" " September-October,	56.75	1.79	59.9	3.62	61.8	2.28	63.3	2.98	59.9	2.27	7

* McMurtrie, "Culture of the Sugar Beet," p. 50.

It is seen that the temperatures in portions of Pennsylvania are considerably lower during spring than at Cambrai, while other parts are very similar to it; at this season the rainfall is higher than at Cambrai, but not higher than in many good European beet localities.

In the summer months the temperature is somewhat higher than at Cambria, but not higher than that of other good beet localities, and there is no protracted drought; the rainfall, too, approaches the upper limit, but is quite evenly distributed, and with the fair degree of sunshine, which the records of the United States Signal Service Office show to prevail in the State during the Summer, should favor rather than be injurious to rapid, cellular growth.

Again, the mean temperatures for September and October are a little high, but not beyond the limits for successful culture, while the rainfall is subject to the same remark.

As far as soil is concerned, there is no doubt that Pennsylvania, with its varied topography and geological formations, can furnish many areas well adapted to beet or sorghum, and sufficiently large to supply a good-sized factory.

In other words, there seem to be no conditions of climate or soil which will render impossible the culture of beets in the northern part of the State. and that of sorghum in the southern. The principal danger lies in the fact that the line of separation between the two areas may change its position from year to year, so as to prevent any certainty of success in a given locality. Careful trial alone can decide.

Although frequent attempts at the culture of sorghum have been made in the State, I do find not find any analytical records to show the success of the attempts. That the culture has been a success for the production of syrups, is, as has previously been stated, no criterion of success in the manufacture of crystallizable sugar.

There are records of two sets of experiments on the production of the sugar beet in the State. The first experiments were made, for two years, at the Eastern Experimental Farm, and the results are recorded in the Agriculture of Pennsylvania. The yield was, with a single exception, far below the limit of successful manufacture. In a number of cases, the immediate application of stable manure interfered with the development of a high percentage of sugar; the beets seem to have been planted too wide apart; and, finally, if any part of the State is climatically unfitted for beet culture, it is that portion.

The other experiments were made at York, Pa., and are noted in the report of the United States Department of Agriculture for 1883. These beets were similar to those grown at the Eastern Farm, as far as their sugar content is concerned. Beets grown at Oswego, N. Y., in the same year, were rich in sugar, containing 13.15 per cent. York is also indicated as climatically unfitted for beet culture.

Thus it is seen that there is lacking as yet, positive evidence for the determination of this question. The following experiments were designed to throw light upon the problem, as far as its relation to the central portions of the State are concerned.

Experiments of 1886.

(1.) Sorghum.

Two varieties of seed were sown, May 17, on plots C_1 and D_1, of one-twentieth acre area. The seeds were the Early Amber and the Early Orange varieties, obtained from Kansas through the courtesy of Prof. Magnus Swenson, of Ottawa, Kansas.

The soil was thoroughly pulverized by means of a spring-tooth harrow. Fertilizer was applied at the rate of 500 pounds per acre, the following mixture being used:

Dissolved South Carolina rock, ...	300 pounds.
Muriate of potash, ...	100 "
Nitrate of soda, ...	100 "
	500 pounds.

The seed was sown in drills, three and one half feet apart. The smoothing harrow was used in cultivation, and when the plants were of 8-10 inches in height, they were thinned to twelve stalks per yard in the drills. and kept clear as long as cultivation was possible. The plants failed to develop evenly, the Early Orange being far inferior in this respect.

The following is a summary of the weather record during all the growing months of the past year:

TABLE II.—*Weather Record for Growing Season of 1886.*

PERIOD.	Mean temperature.	Mean rainfall.	Mean number of rainy days.
	F.°	*Inches.*	
April-May,	59.62	4.00	11
June-August,	68.12	3.68	7
September-October,	58.25	2.22	9

The season was somewhat peculiar; notwithstanding the rather late spring, the period of growth was prolonged by the very favorable weather of September. May was warmer than usual, the summer months not so warm, and the fall months a little cooler than usual. The rainfall during spring and summer was heavier than usual, but in the autumn was about the average. The rainfall in the summer was less regularly distributed than usual. The first sharp frost occurred October 3. The leaves of the sorghum were slightly wilted by it. At this time the seeds of the Early Amber cane were just getting doughy, while the Early Orange had barely arrived at full bloom. The Amber cane was much better than the Orange, and much thicker. The cane was only moderately sweet, and in both instances the presence of large quantities of starch could be noticed by taste.

The yield of cane and the analytical results are as follows:

TABLE III.—*Sorghum Results.*

	Total yield per acre.	Glucose.*	Sucrose.*
	Pounds.	*Per cent.*	*Per cent.*
Early Amber,	10,880	3.70	8.20
Early Orange,	9,600	3.19	3.65

*In stripped cane.

The determination of the sugars was made in a sample of cane chips, using Fehling's solution.

As was expected, the very immature cane contained small quantities of cane sugar, and very considerable quantities of glucose. Thus, for sugar making, it is altogether worthless. As experiments in previous years have failed to produce mature cane here, the results seem decisive against success, so far as this locality is concerned.

(2.) SUGAR-BEETS.

On the adjoining plots, (A_1) and (B_1)—one-twentieth acre—sugar beets were sown May 19. Three varieties were used, the seed being obtained from the United States Department of Agriculture. Plot (A_1) was sown with the "Sublime" beet, of which none came up. Four rows of plot (B_1) were planted with the "White Imperial," and the remaining four with "Imported."

In order to give a good deep soil, the surface soil was plowed to the depth of nine inches; a sub-soil plow followed in the furrow, plowing six inches deeper. There was plowed under by the sub-soil plow the following fertilizer, at the rate of 660 pounds per acre. It is a modification of Ville's* sub-soil fertilizer, containing less potash, the soil being already quite well supplied with that ingredient:

Dissolved South Carolina rock,	175 pounds.
Chloride of potash,	175 "
Chloride of ammonia,	90 "
Nitrate of soda,	90 "
Plaster,	130 "
	660 pounds.

There was also harrowed into the surface soil the following modification of Ville's surface fertilizer, at the rate of 1,010 pounds per acre:

Dissolved South Carolina rock,	355 pounds.
Chloride of potash,	175 "
Sulphate of ammonia,	20 "
Chloride of ammonia,	100 "
Nitrate of soda,	265 "
Plaster,	95 "
	1,010 pounds.

The soil was thoroughly pulverized and rolled lightly. The softened seeds were sown in drills twenty inches apart, and covered to the depth of one half inch. As soon as the leaves appeared enough to mark the rows, the weeds were hoed out. Two weeks later the rows were thinned out to one plant for each eight inches in the row, corresponding to seven or eight for each square yard. The cultivation was repeated till the size of the leaves prevented. None of the seeds on plot A_1 vegetated.

The early vegetation was fair, but during the second period, in spite of the moist weather, there was a poor development of leaf and root. While the last period seemed quite favorable for sugar storing, the small amount of leaf was unfavorable to its production.

*Artificial manures. Crooke's translation, p. 363.

The following table shows the yield and the analytical results:

TABLE IV.—*Beet Results.*

	Topped yield per acre.	Average weight of beets.	Ash.	Sugar.
	Pounds.	*Pounds.*	*Per cent.*	*Per cent.*
White Imperial.	14,200	0.91	1.56	4.67
Imported.	14,400	0.75	1.59	7.52

These results show an exceedingly low yield, due mainly to the small size of the beets. There is an abnormally high percentage of ash in both samples. The amount of sugar is very low in the first sample, while that in the second sample more nearly approaches the minimum limit of successful culture—eight per cent. The yield should be about fifteen tons per acre instead of seven, to ensure the possibility of success.

To conclude, the results of this year's experiments are unfavorable to the culture of the beet in this and similar localities.

VIII. EXPERIMENTS ON THE CULTIVATION OF NEW GRASSES.

At the request of the United States Commissioner of Agriculture, small plots were sown with the seeds of the following grasses, chiefly of southern and western origin:

1. *Paspalum dilatatum.* (root.)
2. " " (seed. No. 322.)
3. " *platycaule.* (root.)
4. " " (seed. No. 323.)
5. *Panicum proliferum.* (No. 324.)
6. " *Texanum.* (No. 325.)
7. " *Germanicum.* (No. 317.)
8. *Setaria Italica.* (No. 315.)
9. *Penicillaria spicata.* (No. 316.)
10. *Phalaris intermedia.* (No. 326.)
11. *Stipa viridula.* (No. 350.)
12. *Oryzopsis (Eriocoma) cuspidata.* [Colorado.] (No. 342.)
13. " " " [Rocky Mts.] (No. 343.)
14. *Phleum pratense.* (No. 354.)
15. " sp.? (No. 348.)
16. *Sporobolus cryptandrus.* (No. 349.)
17. *Agrostis exarata.* [Rocky Mts.] (No. 327.)
18. " " [Oregon.] (No. 328.)
19. *Deyeuxia* sp.? (No. 337.)
20. *Danthonia Californica.* (No. 338.)
21. *Bouteloua oligostachya.* (No. 334.)
22. *Koeleria cristata.* (No. 346.)
23. " and *Eatonia*, mixed. (No. 347.)

24. *Festuca gracillima*, (No. 344.)
25. " *scabrella*, (No. 345.)
26. *Bromus Suksdorfii*, (No. 335.)
27. " sp.? (No. 336.)
28. *Agropyrum divergens*, (No. 330.)
29. " *glaucum*, (No. 331.)
30. " *tenerum*, (No. 332.)
31. " and *Elymus*, mixed, (No. 333.)
32. *Elymus condensatus*, (No. 339.)
33. " *triticoides*, (No. 340.)
34. " sp.? (No. 341.)

In spite of a great deal of pains taken in preparing the soil, the grasses refused to grow, few blades appearing, and all dying soon after their appearance. A reference to the germination results will show that the failure must be attributed in many cases to a lack of vitality in the seed.

IX. Test of New Varieties of Wheat.

The following varieties of wheat were sent by the United States Department of Agriculture for trial. They were drilled in, side by side.

Observations on Development October 31, 1885.

White Crimean. (Imported, winter.) In excellent condition.

Genoese. (Imported, winter.) Compares well with White Crimean.

Indian. (Imported, winter.) Very small percentage vegetated.

Egyptian. (Imported, winter.) Good vegetation; height twice as great as any other; moderately good color.

McGehee. (Native, winter.) Vegetated well; color very deep green.

Extra Early Oakley. (Native, winter.) Similar to McGehee.

Diehl—Mediterranean. (Native, winter.) Deep green; broad leaf; well vegetated, and taller than either of the other native varieties.

Martin's Amber. (Native, winter.) Not so well stooled as the preceding variety, and color inferior.

Subsequent Observations.

The trying winter of 1885–1886, and the exposed condition of the ground upon which the trials were made, made the test of hardiness a very severe one. All the varieties suffered considerably from winter-killing. Afterward inroads were made by the fly, but no appreciable difference in degree of effect upon the different varieties was noticed.

Under these conditions, the imported varieties failed completely, none reaching maturity, and Martin's Amber was almost exterminated.

From one quart of seed, the following yields were obtained:

Diehl—Mediterranean,	68 lbs.
McGehee,	22 lbs.
Extra Early Oakley,	22 lbs.
Martin's Amber,	13 oz.

Reference to Nos. 112–115 of the germination table will show the relative weights of the seeds produced.

All attained about the same height, and had straw of nearly the same stiffness. The color of the Martin's Amber straw was white; that of the others purplish at the top. The Diehl–Mediterranean was the only bearded variety.

X. TESTS OF NEW VARIETIES OF OTHER CEREALS.

The following varieties from the United States Department of Agriculture were also tested:

Harris Oats. (Alabama.) Rust-proof, loose-husked seed. Drilled in about May 20, 1886. By June 11, had reached a height of 18 inches. The leaf is dark, narrow and very curly. When ripe, the total height above ground was 43 inches; the head was loose, and 13 inches long. This variety matures much earlier than our native varieties, but because of its dark color, inferior lustre, and large proportion of husk, is not to be preferred.

White Victoria Oats. A variety of potato oats, plume of good white color, and bright lustre; quite heavy. June 11, 1886, had somewhat poorer color than the Harris variety, and a height of 16 inches. When ripe, the height was 54 inches, and the head 20 inches long. The time of ripening was about the same as that of the native varieties. The yield was good, and the variety seems worthy of more extended trial.

Melon Barley. Sown at the same time with the preceding varieties of oats. June 11, had reached a height of fourteen inches; plants seemed quite evenly developed, with thrifty tops. Later they suffered from smut about as much as the other varieties grown in the locality. When ripe, the height was 36 inches; head, 5 inches long. The yield was fair.

Little Willis Corn. A white dent; was planted a little late. June 11, had a good set, dark color, and medium development. About the time of tasseling, the leaves at the top form a compact brush, which is quite peculiar. The variety did not approach maturity, although the season was exceptionally long for this climate.

XI. TESTS OF FOREIGN FORAGE PLANTS.

During the past year a trial of the various foreign forage crops has been made with reference to their suitability for our climate. The results are not fully in shape for report, but the following notes may be made:

Jaeger Bean. (A Russian forage plant.) Seed from United States Department of Agriculture. The dark, almost spherical seeds were sown about May 20, in warm mellow soil, and covered to the depth of two inches. June 11th, a height of 7 inches had been attained. The final height was 3 feet. The stem was upright, coarse, and succulent, with thick, juicy pods. The weight at the period of full bloom, July 24, was 12,251 pounds fresh, and 1,809 pounds dry, per acre; in seed, August 2, 7,941 pounds fresh, and 2,609 pounds dry. Cattle would not eat the green plant.

Vicia villosa (?) Vetch. (Russian forage plant, the ordinary European vetch being *Vicia sativa.*) The vetch in Europe is very useful as a forage and soiling crop. It is proposed for cultivation here in places where clover fails, and as a sheep fodder. The European species has not proven well adapted to America. The seeds obtained from the United States Department of Agriculture were drilled in mellow clay soil, about May 20. The height at June 11 was 3 inches. The development was more rapid after this time. The long, slender, vine-like stems attained a length of 6 to 8 feet, and were covered with long, slender leaf stems, forming a dense network of vegetation, which bloomed till after the time of frost. The weight did not increase after the period of bloom, being 14,520 pounds fresh, and 4,877 pounds dry, per acre, on August 2, and 12,251 fresh, and 4,814 pounds dry, on October 4. It was very acceptable to milch cattle.

Spergula maxima. (Russian spurrey, from United States Department of Agriculture.) Spurrey.

S. arvensis is extensively used in Europe as a soiling and general forage crop, and as a green manure. It is an especially valuable sheep fodder on sandy soils, where other plants do not thrive. It was planted with the previously mentioned forage plants, and by June 11 had attained a height of 3 inches, and matured by July 24, when its height was 16 inches, and its weight 12,932 pounds fresh, and 3,403 pounds dry, per acre. It will be remembered that the soil on which it was grown is a heavy clay loam. It was eaten by cattle with relish.

Ornithopus sativus. (?) Seradilla. (Russian forage plant, distributed by United States Department of Agriculture.) Grown for forage on sandy soils in Europe. Planted with the other Russian forage crops. Its height June 11, was only ½ inch. It finally reached a height of 14 inches. It yielded 14,066 pounds fresh, and 3,063 pounds dry per acre, at the period of bloom, August 2, and 8,848 pounds fresh, and 3,170 dry, at the time when the seed was ripe, October 4, though it was still blooming. It was very palatable.

Setaria Italica—Golden Millet. This was drilled into the very mellow soil of plot F_1 on May 17. The drills were 8 inches apart, and 4 pounds of seed per acre were used. This plant is very valuable as a green forage plant, and also for its seed, which is very abundant. For some reason, a very uneven vegetation and subsequent uneven development occurred, and in consequence a very low aggregate yield was obtained. That portion which reached the fuller and more even development was 44 inches in height, with heads 4 to 7 inches long and one to one and one half inches in diameter. The same portion yielded at the rate of 21,419 pounds fresh and 6,124 pounds dry per acre, on July 24, when it was not yet in bloom; 38,458 pounds fresh and 7,487 pounds dry on August 2, in bloom, and 26,544 pounds fresh and 10,720 pounds dry October 4, when the seed was fully ripe.

Pennicillaria spicata—Pearl Millet. None of this seed vegetated. It was planted on plot G_1, under exactly the same conditions as the Golden Millet.

Panicum Germanicum (?)—German Millet or Hungarian Grass. This plant is quite widely used in the eastern portions of the United States on dairy farms. The seed was drilled in on plot H, in exactly the same manner as the Golden Millet. Here again the vegetation was very imperfect, though it was better than with either of the other millets. The millet attained a height of 38 inches, and its heads were 4 inches in long., and one fourth to one half inch in diameter. It was in bloom by July 24, and yielded at the rate of 20,419 pounds fresh and 8,167 pounds dry per acre, and had increased to 30,628 pounds fresh and 9,188 pounds dry by August 2.

Medicago sativa, Alfalfa or Lucerne. This clover is one of the principal crops in European rotations. It will yield two or three crops per annum on fair soil, and may be kept on land for from six to twelve years continuously. It is a very nutritious, green-forage and hay crop. It has been successfully cultivated in the Southern States and in Colorado. Good, mellow, clay loam is considered its favorite soil. In this trial the seed was sown on plot I_1, the soil of which had been thoroughly pulverized with a spring harrow. The drills were 16 to 18 inches apart, and 10 pounds of seed per acre were used. The date of sowing was May 17. It was cultivated by hand once. It is not supposed to attain its full development till the second or third year. Nevertheless, two cuttings of 21 inches height were removed from the plot. The weight on July 24 was 4,764 pounds fresh, and 1,361 pounds dry per acre; August 2, in bloom, 16,940 pounds fresh and 5,294 pounds dry. A later portion in seed weighed 7,487 pounds fresh and 2,949 pounds dry. Further observations will be made on it.

Trifolium hybridum, Alsike or Swedish Clover. This small clover is said to be well adapted to moist, strong soils, and to grow continuously on the same soil for many years, seeding itself down. It was planted on plot J_1, which was very mellow, in drills 10 to 12 inches apart. It came up quite unevenly, but the plants were quite thrifty.

Melilotus alba, Bokhara, or Sweet-scented Clover. This tall, straggly plant is said to be well adapted to sandy soils, and on account of its pleasant flavor and odor forms quite an agreeable addition to hay from other plants. It was planted on plot K_1, in drills 16 to 20 inches apart, and cultivated once to keep down the weeds. It did not vegetate evenly; its final height was 29 inches. On July 24 it weighed 6,352 pounds fresh, or 1,361 pounds dry per acre; on August 2, 18,755 pounds fresh and 4,991 pounds dry per acre, and on October 4, 10,209 pounds fresh, and 3,403 pounds dry.

Onobrychis sativa, Sainfoin. This leguminous plant is a favorite in France, where it is considered indispensable. Its favorite soil is calcareous, but it grows successfully in very dry, sandy soils. It is somewhat delicate for the first two or three years of its life. The seeds were planted on plot L_1, which was previously treated as the other plants first mentioned, had been. The drills were 2 to 2½ feet apart, and were cultivated once. The seed did not come up evenly, and in spite of cultivation, weeds interfered considerably with the full development.

XII. Cost of Crops.

In the College report for 1883, there was given a statement of the expenditures and income for various crops of the College and Central Experimental Farms. A similar statement for some of the crops of 1886 is given below:

The following rates are allowed for the labor of men and teams, per day:

1 man,	$1 00
1 mule,	1 00
2 mules, man, and plow,	3 00

College Farm.

Potatoes.—2 Acres.

Expense—Plowing, planting, and digging,	$50 50	
Seed,	7 00	
Fertilizer,	30 00	
		$87 50
Income—300 bushels potatoes, @ 30 cents,		90 00
Excess of income, total,		$2 50
" " per acre,		1 25

Corn.—22 Acres.

EXPENSE—	Plowing, planting, and cultivating,	$141 00	
	Fertilizer and seed,	36 85	
	Harvesting,	65 16	
			$243 01
INCOME—	1,338 bushels corn, (in ear,) @ 20 cents,	$267 60	
	18.2 tons of fodder, @ $5 00,	91 00	
			358 60
	Excess of income, total,		$115 59
	" " per acre,		5 25

Grass.—73 Acres.

EXPENSE—	Picking stones, rolling, etc.,	$19 05	
	Seed,	45 00	
	Harvesting, first crop,	153 00	
	" *second crop,	42 60	
			$259 65
INCOME—	182 tons hay, first crop, @ $10 00,	$1,820 00	
	30 " " second crop, @ $8 00,	240 00	
			2,060 00
	Excess of income, total,		$1,800 35
	" " per acre,		24 66

CENTRAL EXPERIMENTAL FARM.

Potatoes.—1 Acre.

EXPENSE—	Plowing, planting, and digging,	$29 50	
	Seed,	3 50	
	Fertilizer, (yard manure,)	15 25	
			$47 25
INCOME—	200 bushels potatoes, @ 30 cents,		60 00
	Excess of income,		$13 75

Corn.—9 Acres.

EXPENSE—	Plowing, planting, and cultivating,	$63 10	
	Fertilizer, (Diss. S. C. Rock,) and seed,	18 35	
	Harvesting,	36 82	
			$118 27
INCOME—	701 bushels corn, (in ear,) at 20 cents,	$140 20	
	8.5 tons of fodder, @ $5 00,	42 50	
			182 70
	Excess of income, total,		$64 43
	" " per acre,		7 16

Grass.—27 Acres.

EXPENSE—	Picking stone, rolling, etc.,	$9 00	
	Seed,	15 00	
	Harvesting,	63 25	
			$87 25
INCOME—	65 tons of hay, @ $10 00,		650 00
	Excess of income, total,		$562 75
	" " per acre,		22 51

* 24 acres were cut for second crop.

The threshing of the oats and wheat not being completed, no statement can be given for those crops. It will be observed that the term "gain" is not applied to the annual excess of income over expenditures, since there must also be taken into consideration the residual effect of cultivation and fertilization upon the fertility of the soil. Thus, reference to the yields from the experimental plots shows that a portion of the expense for fertilizer applied to corn and wheat, should be charged to oats and grass. There are so many variables entering as factors into the final result that a full statement of profit and loss is practically impossible, except after the exact observations for a series of years.

XIII. PLOW TEST.

In the Spring of 1886, the Newcastle Plow Company, of Newcastle, Pa., sent here for trial one of their Keystone Chill Plows (No. 2). A test of its draught was made, using the Oliver Chill Plow, No. 2, for comparison. The test was made on a mixed timothy and clover sod, on a loamy, calcareous, clay soil. The Oliver Chill has a sloping land-side, the Keystone Chill a vertical one; so each was tested as it followed its own furrow, but on exactly the same soil. The cross-section of the furrow in each case was 16 in. by 8 in., as an average of a number of measurements. Conditions were in all other respects the same. The following results were obtained from nearly forty readings, in each case taken with a Fairbank's dynamometer:

1. Oliver Chill, ... 511 lbs.
2. Keystone Chill, ... 491 "

The turning of the furrow and pulverizing of the soil was equally well accomplished by each. Owing to the greater length of handle and a difference in shape, the "Keystone" was a little the lighter to handle.

XIV. GERMINATION EXPERIMENTS.

One of the most important elements in successful agriculture, and especially in vegetable gardening, is the vitality of the seeds sown. While no statistics can be given showing the annual loss resulting from the use of seeds lacking vital power, it is well known to all farmers that it is not inconsiderable. It is also known that a large percentage of this loss can be avoided by proper care and knowledge of the quality of the seeds used.

In Germany there are a number of agricultural experiment stations which exercise a seed control fully as stringent as our best fertilizer control. In this country the pressing need for such control is each year more widely recognized, and our experiment stations are doing much in the way of preliminary work.

During the past year the agricultural laboratory has been supplied with germinating apparatus, and such seeds as came to hand were tested.

The apparatus used is that described by Dr. Jenkins.* The seed-bed is formed by grooved, porous tiles, made from filter-ware. These rest in a shallow galvanized tray, at one end of which there is a tube, usually closed by a cork, provided as an outlet for the water, which stands in the tray to the depth of $\frac{1}{4}$ to $\frac{1}{3}$ inch, and keeps the seed-beds constantly and evenly moist. The bed is protected by an arched galvanized cover, the edges of which rest inside on the bottom of the pan, and which is provided with two tubulated openings on the top, through which fresh air enters, and through which a thermometer may be introduced to determine the temperature. The temperature is maintained at about 70° F. Thus moisture, darkness, the proper temperature, and fresh air, the essential conditions of normal germination are maintained. It will, of course, be readily seen that this test only shows what percentage of the seed will *sprout*, and cannot afford the means of determining what will be the effect upon the seeds of those conditions which act upon them after sprouting and before their appearance at the surface.

The method of experiment was as follows: 100 seeds, or 200 in case of the smaller kinds, were counted out, and allowed to soak for some hours; they were then transferred to one of the grooves of the seed-bed, which was properly moistened. Those that germinated from day to day were counted and removed. A seed was not considered as having germinated until the rootlet had attained a length of about 1 millimeter, or $\frac{1}{25}$ in. This process was continued for 10 to 14 days, varying with different kinds of seed; at the conclusion of this time, those seeds which remained ungerminated and *sound* were counted. In the case of *perennials* $\frac{1}{2}$ of the sound seed are added to the number of germinated seeds in determining the percentage of germination, numerous experiments having shown that this proportion of their seeds will germinate at a later period.

The following table gives the result of the germination experiments made during the past year, together with the weight of 100 seeds.

*Report of the Conn. Agric. Experiment Station, 1877, pp. 46—50.

Results of Germination Tests.

Number.	Index number.	Description.	Weight of 100 seeds.	Number of seeds used.	Hours soaked.	Days of Germination. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	Sound seed left.	Per cent. germinated.	Days required for one-half to germinate.
		Grasses and other Forage Plants.	*Grams.*																			
1	322	Hairy-flowered paspalum, *Paspalum dilatatum*, from C. N. Eley, Smith's Point, Texas,	0.1165	100	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100?	33	—
2	323	Broad-stemmed paspalum, *Paspalum platycaule*, from C. N. Eley, Smith's Point, Texas,	0.0145	100	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100?	33	—
3	324	Sprouting crab-grass, *Panicum proliferum*, from C. N. Eley, Smith's Point, Texas,	0.0421	200	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200?	0	—
4	325	Texas millet, *Panicum Texanum*, from C. N. Eley, Smith's Point, Texas,	0.3200	100	6	0	1	0	7	2	0	2	1	1	0	0	1	1	0	84?	16	—
5	326	Canary grass, *Phalaris intermedia*, from C. N. Eley, Smith's Point, Texas,	0.0618	200	6	0	0	0	0	0	2	4	2	3	0	4	0	0	1	?	8	—
6	327	Mountain red-top, *Agrostis exarata* (Rocky Mountains,) U. S. Department of Agriculture,	0.0051	200	6	0	0	27	0	42	3	0	0	0	0	0	0	0	0	?	36	—
7	328	Mountain red-top, *Agrostis exarata*, (Oregon,) U. S. Department of Agriculture,	0.0085	200	6	0	2	0	0	1	0	0	0	1	0	0	0	0	0	196?	4	—
8	329	*Agropyrum divergens*, (sample 1,) U. S. Dep't of Agriculture,	0.1972	200	6	0	0	0	21	5	1	1	0	1	0	0	0	0	0	171?	43	—
9	330	" " (sample 2,) " "	0.2122	200	6	0	0	17	8	0	2	1	0	0	0	0	0	0	0	172?	43	—
10	331	Blue stem, *Agropyrum glaucum*, " "	0.3038	200	6	0	0	0	1	2	0	0	0	0	0	0	0	0	0	197?	35	—
11	332	*Agropyrum tenerum*, " "	0.3115	200	6	0	0	0	104	39	10	0	3	0	3	1	2	1	2	35?	89	4
12	333	*Agropyrum* and *Elymus* mixed, " "	0.3114	100	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	99?	34	—
13	334	Gramma grass, *Bouteloua oligostachya*, " "	0.0382	200	6	0	0	2	12	12	9	4	3	0	3	1	1	0	1	152?	99	—
14	335	Brome grass, *Bromus Suksdorfii*, " "	0.3607	100	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	99?	1	—
15	336	" " *Bromus* species ? " "	0.3621	100	6	0	0	0	28	46	13	3	1	0	2	1	0	0	0	6?	91	5
16	337	*Deyeuxia* species ? " "	0.0105	200	6	0	0	6	13	0	0	0	0	0	1	0	0	0	0	180?	40	—
17	338	California oat-grass, *Danthonia Californica*, U. S. Department of Agriculture,	0.3185	100	6	0	0	0	0	0	1	1	1	0	0	0	0	0	0	97?	35	—
18	339	Giant rye-grass, *Elymus condensatus*, U. S. Dep't of Agriculture,	0.2974	100	6	0	0	0	0	0	0	2	3	1	3	0	2	0	5	84?	44	—
19	340	*Elymus triticoides*, U. S. Department of Agriculture,	0 0600	100	6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	99?	31	—
20	341	*Elymus* species ? U. S. Department of Agriculture,	0.3130	100	6	0	0	0	0	1	0	2	0	0	1	0	1	0	2	98?	38	—
21	342	Bunch grass, *Eriocoma cuspidata*, (sample 1,) U. S. Department of Agriculture,	0.1780	100	6	0	0	0	0	1	0	0	0	0	0	0	0	0	0	99?	31	—
22	343	Bunch grass, *Eriocoma cuspidata*, (sample 2,) U. S. Department of Agriculture,	0.4581	100	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100?	33	—
23	344	Fescue grass, *Festuca gracillima* ? U. S. Department of Agriculture,	0.1645	200	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	199?	67	—
24	345	Bunch grass, *Festuca scabrella*, " "	0.0820	100	6	0	0	0	0	3	0	13	0	2	2	0	0	0	3	78?	48	—

Results of Germination Tests—Continued.

Number.	Index number.	Description.	Weight of 100 seed.	Number of seed used.	Hours soaked.	Days of Germination. 1.	2.	3.	4.	5.	6	7.	8.	9	10.	11.	12.	13.	14.	Sound seed left.	Per cent. germinated.	Days required for one-half to germinate.
		Grasses and other Forage Plants.	*Grams.*																			
25	346	Crested Koeleria, *Koeleria cristata*, U.S. Department of Agriculture,	0.0130	100	6	0	0	0	4	2	0	0	1	0	0	0	0	0	0	93?	38	—
26	347	*Koeleria* and *Eatonia* mixed, " "	0.0115	200	6	0	0	0	5	65	65	23	0	5	0	3	0	0	0	31?	89	6
27	318	*Phleum* species ? " "	0.0690	200	6	0	0	0	178	11	1	0	1	1	0	0	0	0	0	5?	99	4
28	349	*Sporobolus cryptandrus*, " "	0.0071	200	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200?	33	—
29	350	Bunch grass, *Stipa viridula*, " "	0.2111	100	6	0	0	0	1	5	2	0	0	0	0	0	0	0	0	92?	39	—
30	315	Golden millet, *Setaria Italica*, P. Henderson & Co.,	0.1835	200	6	68	51	26	6	0	5	0	0	0	1	0	0	0	0	36	79	2
31	316	Pearl millet, *Penicillaria spicata*, P. Henderson & Co.,	0.3830	200	6	117	22	9	5	0	0	0	1	0	0	0	0	0	0	13	72	1
32	317	Hungarian grass, *Setaria Italica*, P. Henderson & Co.,	0.2055	200	6	52	31	7	2	0	10	1	6	2	0	0	0	0	0	70	56	6
33	318	Alsike, *Trifolium hybridum*, P. Henderson & Co.,	.0635	200	6	95	32	19	7	0	6	5	0	0	0	0	0	0	0	9	81	2
34	411	Alsike, *Trifolium hybridum*, U.S. Department of Agriculture,	0.0740	100	17	0	73	3	3	0	0	0	0	1	0	0	0	0	0	0	80	2
35	320	Lucerne or alfalfa, *Medicago sativa*, P. Henderson & Co.,	0.1845	200	6	164	10	3	1	0	1	0	0	0	0	0	0	0	0	17	93	1
36	410	Lucerne or alfalfa, *Medicago sativa*, U.S. Department of Agriculture,	0.1870	100	17	0	63	3	0	0	2	0	0	0	0	0	0	0	0	0	68	2
37	319	Bokhara clover, *Melilotus alba*, P. Henderson & Co.,	0.1670	200	6	25	25	8	1	0	9	0	0	0	0	0	0	1	0	80	50	—
38	351	Bokhara clover, *Melilotus alba*, U. S. Department of Agriculture,	0.2092	200	6	23	21	0	0	0	0	2	1	0	0	3	0	0	1	102?	43	—
39	321	Sainfoin, *Onobrychis sativa*, P. Henderson & Co.,	1.8075	200	6	0	4	10	20	0	31	7	8	1	2	2	0	0	0	70	56	—
40	352	Red clover, *Trifolium pratense*, Western seed,	0.1309	200	6	120	46	4	2	2	0	1	0	0	0	0	1	1	0	13	91	1
41	412	Jaeger bean, (Russian), U.S. Department of Agriculture,	48.7280	50	17	0	1	4	6	0	15	0	0	13	0	2	0	0	0	1	82	6
42	413	Vetch, *Vicia villosa ?* (Russian), U. S. Department of Agriculture,	3.4110	100	17	0	39	5	5	5	2	0	0	8	0	0	0	0	0	32	64	5
43	414	Spurry, *Spergula maxima*, (Russian.) U. S. Dep't of Agriculture,	0.3240	100	17	0	1	2	3	6	4	0	0	13	2	0	0	0	0	22	31	—
44	415	Serradilla, *Ornithopus* species ? U. S. Department of Agriculture,	0.0875	100	17	0	98	0	0	1	0	0	0	0	0	0	0	0	0	0	99	2?
		Sorghum and Sugar Beets.																				
45	359	"Sublime" sugar beet, U.S. Department of Agriculture,	2.6855	100	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100?	0	—
46	360	"White Imperial" sugar beet, U.S. Department of Agriculture,	2.7800	100	16	0	0	3	2	13	0	2	0	0	2	0	0	0	0	78?	7	—
47	361	"Imported" sugar beet, U. S. Department of Agriculture,	3.6415	100	16	0	0	0	13	7	0	2	0	0	1	0	0	0	1	76?	8	—
48	362	"Early Orange" sorghum, U.S. Department of Agriculture,	1.8560	100	16	0	0	48	3	0	0	2	0	0	0	0	0	0	2	0	55	4
49	416	"Early Amber" sorghum, Prof. M. Swenson, Fort Scott, Kansas,	1.8930	100	17	0	66	5	1	6	0	0	0	0	0	0	0	0	0	0	78	2
50	417	"Early Orange" sorghum, Prof. M. Swenson, Fort Scott, Kansas,	2.1010	100	17	0	58	7	6	2	0	0	0	1	0	0	0	0	0	0	74	2
		Vegetables.																				
51	373	Beet, "Dark Blood Turnip," U.S. Department of Agriculture,	1.9065	100	16	0	0	42	7	7	2	3	0	0	3	2	0	0	2	32	68	5
52	374	Beet, "Improved Long Dark Blood," D. M. Ferry & Co.,	2.0005	100	16	0	0	22	10	1	1	2	0	0	1	2	0	0	0	61	39	—
53	375	Beet, "Extra Early Egyptian Blood Turnip," D. M. Ferry & Co.,	1.3615	100	16	0	0	15	31	13	3	2	2	0	1	0	1	0	2	30	70	5
54	376	Cabbage, "Early Winningstadt," P. Henderson & Co.,	0.2960	100	16	0	0	79	5	2	0	1	0	0	0	0	0	0	0	0	87	3?

55	377	Cabbage, "Early Flat Dutch," P. Henderson & Co.,	0.3670	100	16	0	0	93	2	0	0	0	0	0	0	0	0	0	0	0	95	3½
56	378	Cabbage, "Marblehead Mammoth Drumhead," P. Henderson & Co.,	0.3145	100	16	0	0	93	2	0	1	0	0	0	0	0	0	0	0	0	96	3½
57	386	Cauliflower, "Extra Early Dwarf Erfurt," P. Henderson & Co.,	0.3680	100	17	0	13	16	4	0	3	0	0	4	0	0	0	0	0	0	40	
58	363	Celery, "Henderson's New Rose," P. Henderson & Co.,	0.0338	200	16	0	0	0	0	0	0	0	0	0	11	4	0	0	0	100	9	—
59	364	Celery, "London Red," P. Henderson & Co.,	0.0543	200	16	0	0	0	0	0	0	0	0	0	5	2	2	0	4	97	7	—
60	365	Celery, "Boston Market," P. Henderson & Co.,	0.0493	200	16	0	0	0	0	0	0	0	0	0	2	2	0	0	0	105	2	½
61	384	Egg plant, "New York Improved," P. Henderson & Co.,	0.3460	100	17	0	0	5	2	0	4	0	0	11	0	2	0	0	0	75	21	½
62	385	Egg plant, "New York Improved," U. S. Dep't of Agriculture,	0.3740	100	17	0	0	0	3	0	10	0	0	10	0	0	0	0	0	77	23	½
63	366	Lettuce, "Green Fringed," P. Henderson & Co.,	0.1150	200	16	0	0	198	0	0	0	0	0	0	0	0	0	0	0	0	99	3½
64	367	Lettuce, "Yellow-seeded Butter," P. Henderson & Co.,	0.1143	200	16	0	0	197	2	0	0	0	0	0	0	0	0	0	0	0	99	3½
65	372	Lettuce, "Early Curled Simpson," P. Henderson & Co.,	0.1150	200	16	0	0	198	0	0	0	0	0	0	0	0	0	0	0	0	99	3½
66	368	Lettuce, "Early Boston Curled," U. S. Department of Agriculture,	0.1065	200	16	0	0	179	2	0	0	0	0	0	0	0	0	0	0	15	90	3½
67	388	Potato, "Pringle's Hybridized," U. S. Department of Agriculture,	0.0340	100	17	0	0	0	30	0	31	0	0	16	0	1	0	0	0	22½	85	6
68	369	Radish, "Early White Turnip," P. Henderson & Co.,	0.6860	200	16	0	0	125	12	2	2	2	0	0	1	0	0	0	0	11	72	3½
69	370	Radish, "Wood's Early Frame," P. Henderson & Co.,	1.3155	100	16	0	0	85	6	0	0	1	0	0	0	0	0	0	0	0	92	3½
70	371	Radish, "White Tipped Scarlet," P. Henderson & Co.,	0.8655	100	16	0	0	93	4	0	0	1	0	0	0	0	0	0	0	0	98	3½
71	379	Tomato, "Livingston's Favorite," P. Henderson & Co.,	0.2860	100	16	0	0	33	40	10	7	0	0	0	0	0	0	0	1	0	91	4
72	380	Tomato, "Livingston's Favorite," U. S Department of Agriculture,	0.2690	100	17	0	42	32	4	0	2	0	0	3	0	0	0	0	0	17	83	3
73	381	Tomato, "Perfection," U. S. Department of Agriculture,	0.2730	100	17	0	27	38	13	0	7	0	0	3	0	1	0	0	0	11	89	2
74	382	Tomato, "Cardinal," U. S. Department of Agriculture,	0.2930	100	17	0	69	20	5	0	3	0	0	0	0	1	0	0	0	2	98	2
75	383	Tomato, "Cardinal," P. Henderson & Co.,	0.2850	100	17	0	49	29	6	0	2	0	0	1	0	1	0	0	0	12	88	3
76	387	Watermelon, "Peerless," U. S. Department of Agriculture,	7.5200	50	17	0	0	8	14	0	6	0	0	2	0	0	0	0	0	0	60	6
		Tobacco.																				
77	389	Tobacco, "White Barley," U. S. Department of Agriculture,	0.0045	200	17	0	0	0	0	0	0	0	0	22	0	5	0	0	0	173	14	—
78	390	" "Gooch Broad Leaf," " "	0.0075	100	17	0	0	0	0	0	80	0	0	13	0	0	0	0	0	7	93	6½
79	391	" "Big Orinoco," " "	0.0080	100	17	0	0	0	0	0	17	0	0	11	0	4	0	0	0	68	32	·
80	392	" "Pure Havana Imported," " "	0.0070	100	17	0	0	0	0	0	0	0	0	5	0	5	0	0	0	90	10	—
81	393	" "Golden Leaf," " "	0.0055	100	17	0	0	0	0	0	57	0	0	12	0	2	0	0	0	29	71	6
82	394	" "One Sucker Virginia," " "	0.0075	100	17	0	0	0	0	0	51	0	0	20	0	3	0	0	0	26	71	6
83	395	" "Cuboni," " "	0.0075	100	17	0	0	0	0	0	60	0	0	8	0	2	0	0	0	30	70	6
84	396	" "Fiji Orinoco," " "	0.0075	100	17	0	0	0	0	0	72	0	0	8	0	3	0	0	0	17	83	6
85	397	" "White-stem Orinoco," " "	0.0060	100	17	0	0	0	0	0	78	0	0	15	0	5	0	0	0	2	98	6
86	398	" "Connecticut Seed Leaf," " "	0.0070	100	17	0	0	0	0	0	37	0	0	3	0	0	0	0	0	60	40	
87	399	" "General Grant," " "	0.0075	100	17	0	0	0	0	0	65	0	0	5	0	0	0	0	0	30	70	6
88	400	" "Vuelta Abajo," " "	0.0075	100	17	0	0	0	0	0	0	0	0	2	1	5	0	0	0	92	8	
		Miscellaneous Cereals.																				
89	355	Oats, "White Victoria," U. S. Department of Agriculture,	2.9130	100	16	0	0	81	0	0	0	1	0	0	0	0	0	0	0	0	85	3½
90	356	Oats, "Harris'," (Alabama,) " "	1.9975	100	16	0	0	80	2	0	0	2	0	0	0	0	0	0	0	0	84	3½
91	357	Barley, "Melon," " "	4.4220	100	16	0	0	93	1	1	0	0	0	0	0	0	0	0	0	0	95	3½
92	515	Barley, "Melon," grown from above seed, on C. E. farm,	4.2300	100	17	0	88	8	2	0	0	0	0	0	0	0	0	0	0	0	98	2
93	516	Oats, "White Victoria," grown from above seed, on C. E. farm,	3.3600	100	17	0	62	4	3	1	0	0	0	0	0	0	0	0	0	0	70	2
94	514	Oats, "Harris," grown from above seed, on C. E. farm,	2.3800	100	17	0	69	8	1	3	0	0	0	0	0	0	0	0	0	0	81	2
95	422	Corn, "Little Willis," U. S. Department of Agriculture,	......	100	16½	21	61	15	0	0	0	1	0	0	0	0	0	0	0	0	98	2
96	418	Seed corn, lot 1, C. E. farm,	......	100	16½	6	42	29	13	10	0	0	0	0	0	0	0	0	0	0	100	3
97	419	Seed-corn, lot 2, C. E. farm,	......	100	16½	7	44	28	10	5	2	1	0	0	0	0	0	0	0	0	97	2
98	420	Seed-corn, No. 96, kiln-dried,	......	100	16½	2	63	28	7	0	0	0	0	0	0	0	0	0	0	0	100	2
99	421	Seed corn, No. 97, kiln-dried,	......	100	16½	2	38	36	12	11	1	0	0	0	0	0	0	0	0	0	100	3
100	586	Corn, grown from seed used in No. 96,	26.0100	100	17	0	75	15	3	2	0	0	0	1	1	0	0	0	0	0	97	2
101	587	Corn, grown from kiln-dried seed used in No. 97,	28.6700	100	17	0	73	15	8	1	0	0	0	2	0	0	0	0	0	0	98	2
102	588	Corn, grown from seed used in 97,	28.7300	100	17	0	73	7	8	2	0	0	0	0	0	0	0	0	0	0	90	2
103	589	Corn, grown from kiln-dried seed used in No. 96,	26.3900	100	17	0	85	10	1	0	0	0	0	0	0	0	0	0	0	0	96	2

Results of Germination Tests—Continued.

Number.	Index number.	Description.	Weight of 100 seeds.	Number of seed useds.	Hours soaked.	Days of Germination. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12	13.	14.	Sound seed left.	Per cent. germinated.	Days required for one-half to germinate.
		Miscellaneous Cereals.	*Grams.*																			
104	4	Wheat, Indian, (imported winter wheat,) from U. S. Department of Agriculture, 1885,	3.0700	100	17	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	4	
105	5	Wheat, Genoese, (imported winter wheat,) from U. S. Department of Agriculture, 1885,	3.8200	100	17	0	97	0	0	0	0	0	0	0	0	0	0	0	0	0	97	2
106	6	Wheat, Egyptian, (imported winter wheat,) from U. S. Department of Agriculture, 1885,	5.2700	100	17	0	85	6	0	0	0	0	0	0	0	0	0	0	0	0	91	2
107	7	Wheat, White Crimean, (imported winter wheat,) from U. S. Department of Agriculture, 1885,	5.5510	100	17	0	49	9	5	0	0	0	0	0	1	0	0	0	0	0	61	3
108	8	Wheat, McGehee, (native, winter,) U. S. Dep't of Agriculture, 1885,	2.9900	100	17	0	95	1	0	0	0	0	0	0	0	0	0	0	0	0	96	2
109	9	Wheat, Martin's Amber, (native, winter,) U. S. Department of Agriculture, 1885,	3.5100	100	17	0	96	0	0	0	0	0	0	0	0	0	0	0	0	0	96	2
110	10	Wheat, Extra Early Oakley, (native, winter,) U. S. Department of Agriculture, 1885,	3.8500	100	17	0	87	2	0	2	0	0	0	0	0	0	0	0	0	0	91	2
111	11	Wheat, Diehl-Mediterranean, (native, winter,) U. S. Department of Agriculture, 1885,	4.4300	100	17	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	99	2
113	468	Wheat, McGehee, grown from seed of No. 8, on C. E. farm, 1886,	4.2400	100	17	0	96	3	0	1	0	0	0	0	0	0	0	0	0	0	100	2
113	469	Wheat, Extra Early Oakley, grown from seed of No. 10, on C. E. farm, 1886,	4.5100	100	17	0	81	4	5	0	3	0	0	2	3	0	0	0	0	0	98	2
114	470	Wheat, Diehl-Mediterranean, grown from seed of No. 11, on C. E. farm, 1886,	5.0000	100	17	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	100	2
115	471	Wheat, Martin's Amber, grown from seed of No. 9, on C. E. farm, 1886,	3.6700	100	17	0	97	1	0	0	1	0	0	0	0	0	0	0	0	0	99	2
116	601	Wheat, Fulcaster, native winter, from U. S. Department of Agriculture, 1886,	4.1700	100	17	0	98	1	0	0	0	0	0	0	0	0	0	0	0	0	99	2
117	605	Wheat, German Emperor, winter, from U. S. Department of Agriculture, 1886,	3.1800	100	17	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	95	2
118	606	Wheat, Raub's Black Prolific, winter, from U. S. Department of Agriculture, 1886,	3.4500	100	17	0	90	1	1	1	0	0	0	0	0	0	0	0	0	0	93	2
119	607	Wheat, Dietz's Longberry, grown on College farm, 1886,	5.3700	100	17	0	89	4	0	1	0	0	0	0	0	0	0	0	0	0	94	2
120	644	Wheat, Fultz, grown on College farm, 1886,	3.1800	100	17	0	97	1	0	0	0	0	0	0	0	0	0	0	0	0	98	2

An examination of these figures shows that the seeds of the wild grasses had a very low germinative power under the conditions of the experiment. This will, in part, account for the fact that an attempt at field growth proved an utter failure. The seeds of the cultivated forage plants, on the contrary, except in the case of No. 43, show a good degree of activity.

The seeds of the sugar-beet show an exceedingly inferior vitality. The Kansas sorghum shows a higher vitality than that sent by the United States Department of Agriculture.

Of the vegetable seeds, seven varieties failed to germinate to any extent. Other experiments mentioned later seem to indicate that the conditions were unfavorable to the normal germination of celery seed.

Of the twelve varieties of tobacco seed examined, five proved very inferior.

Of the wheat varieties, the Indian seems almost worthless; the germination tests were necessarily delayed till some months after the time of planting, but this delay should not materially alter the value of this seed.

With the view of extending this branch of work, the following circular was appended to bulletin No. 16, issued November 1, 1886:

SEED TESTS.

With a view of diminishing the loss suffered by Pennsylvania farmers from the use of poor seed, it has been decided to offer the opportunity for a free examination of their germinating power, under the following conditions:

I. That they be accompanied by a statement of—

1. Name or label of seed.
2. Name and address of producer or importer.
3. Name and address of dealer from whom they are purchased.
4. Date of taking the sample.
5. Selling price, per pound or bushel.
6. Known or reputed age of seed.
7. Number of packages from which the sample is taken.
8. Signature and post-office address of the person taking the sample.

Send with each sample any printed circular or statement that accompanies the seed or is used in its sale.

II. Seeds may be sent by mail or otherwise, but must in all cases be *pre-paid*, and plainly addressed to the Professor of Agricultural Chemistry, State College, Centre county, Pa.

III. Great care should be taken in sampling seeds, by carefully mixing the contents of the bag, barrel, or other package in which they are contained and drawing samples from different parts, finally mixing these and taking the necessary amount for the sample to be sent.

Of the smaller seeds—red top, white clover, etc.—send two (2) ounces: of beets, turnips, etc., four (4) ounces; of grains, peas, beans, etc., eight (8) ounces.

For the present, it will be possible to examine the seed only with reference to its germinating power, as any further examination will involve more labor than can be performed under existing conditions.

As some time is required for the completion of these tests, a reply must not be expected in less than two or three weeks.

XV. VEGETATION EXPERIMENTS.

It has been stated above that the number of seeds which vegetate may be less than that of those which germinate. For experiment one hundred seeds of each of a number of the varieties that had been subjected to the germination test, were planted in a hot-bed, and the number which appeared above the surface was noted. The seeds were planted at equal depths in the same bed side by side. The date of planting was March 16, 1886, that of counting April 5. The results of this observation, together with the heights observed on April 30, are given in the following table:

Table Showing Results of Vegetation Experiment.

Number.	Index number.	Germination number.	SEED.	Per cent. vegetated.	Per cent. germinated.	Height April 30.
1	374	52	Beet, Improved Long Dark Blood, ...		39	8 inches.
2	375	53	Beet, Extra Early Egyptian Blood Turnip.		70	9 inches.
3	376	54	Cabbage, Early Winningstadt, ...	73	87	8 inches.
4	377	55	Cabbage, Early Flat Dutch, ...	72	95	6½ inches.
5	378	56	Cabbage, Marblehead Mammoth Drumhead, . . .	72	96	7 inches.
6	386	57	Cauliflower, Extra Early Dwarf Erfurt, ...	30	40	4½ inches.
7	363	58	Celery, Henderson's New Rose, ...	31	9	1½ inches.
8	364	59	Celery, Henderson's London Red, ...		7	1¼ inches.
9	384	61	Egg-Plant, New York Improved, ...	12	24	1 inch.
10	366	63	Lettuce, Green Fringed, ...	52	99	5 inches.
11	367	64	Lettuce, Yellow-seeded Butter, ...	70	99	4 inches.
12	372	65	Lettuce, Early Curled Simpson, ...	83	99	5 inches.
13	368	66	Lettuce, Early Boston Curled.	9	80	4 inches.
14	369	68	Radish, Early White Turnip, ...	72	72	5½ inches.
15	370	69	Radish, Wood's Early Frame, ...	84	92	9 inches.
16	371	70	Radish, White-tipped Scarlet, ...	71	98	7 inches.
17	379	71	Tomato, Livingston's Favorite, (Henderson,)	32	91	5 inches.
18	380	72	Tomato, Livingston's Favorite, (United States Department of Agriculture,)	71	83	6 inches.
19	381	73	Tomato, Livingston's Perfection, (United States Department of Agriculture,) . . .	72	89	?
20	. .	. . . .	Tomato, Livingston's Beauty, . . .	. .	. . .	6 inches.
21	382	74	Tomato, Cardinal, (United States Department of Agriculture,)	85	95	7½ inches.
22	383	75	Tomato, Cardinal, (Henderson,)	74	88	6 inches.
23	. . . .	. . . .	Tomato, Mikado, ...		49	5 inches.

These results indicate that even under like conditions of vegetation, there is no fixed relation between the vegetative power and the germinative power, other than the very obvious one expressed by the rule that the former cannot be greater than the latter. This statement applies not only to members of different species of plants, but also to closely related varieties of the same species. Thus in the cases of Nos. 10—12, the percentages of germination of the different varieties of lettuce are exactly the same, but there is a vast difference in the percentage of vegetation; a reference to the germination table shows that these varieties germinated with practically equal rapidity: further, No. 13, which has a lower germination percentage, and which germinated less rapidly, has a higher percentage of vegetation than either of the others.

Reference to the results with different varieties of tomatoes shows further the fact that the percentage of germination can give no exact knowledge as to the percentage of vegetation, *i. e.*, that a high percentage does not necessarily imply a correspondingly high percentage of vegetation; still less that slight differences in germinative power must be accompanied by similar differences in vegetation.

These facts may seem to disprove the practical utility of any trial of seeds which stop with germination. But it must be noted that there cannot be a high percentage of vegetation without a high germinative power, and the discovery of any lack in the latter must, by preventing the use of the poor seed, result in a great positive benefit. It is further to be remarked that the cases in which seeds showing high germinative power, prove, under proper conditions, to lack in vegetative power, are comparatively rare; therefore a high germinative power indicates a *probably* good percentage of vegetation.

XVI. HOT-BED TEMPERATURES.

During the above mentioned vegetation experiments certain observations were made upon the seed-bed and and bottom temperatures of the hot-beds. In making the hot-beds, horse-manure, which was heaped and turned frequently, was placed in excavations 2 feet in depth, and built up to a height of about 3 feet above the surface. The frames were 5 ft. by 6 ft., and the beds projected about 1½ ft. on each side. The body of manure in No. 2 was somewhat less than that in No. 1. The seed-bed was composed of fine, dark loam, and was 8 in. in depth.

The bottom temperature observations were taken by means of a pair of soil-thermometers buried in the manure to the depth of 6 inches; in order to take the reading it was necessary to shut back the soil of the seed-bed by means of a box-tube.

The thermometer used for taking the seed-bed temperature was buried just deep enough to protect its bulb from the direct rays of the sun, and thus represented quite accurately the temperature at the depth at which the seeds were planted. The following table gives the observations, together with the mean atmospheric temperature for each day, as recorded by Prof. Osmond; the latter, not being taken near the seed-bed, will serve for only the most general comparison.

Hot-Bed Temperatures.

Date.	Mean atmospheric temperature.	Hot Bed No. 1.						Hot-Bed No. 2.					
		Seed-Bed Temperature.			Bottom Temperature.			Seed-Bed Temperature.			Bottom Temperature.		
		8, A. M.	12, M.	5, P. M.	8, A. M.	12, M.	5, P. M.	8, A. M.	12, M.	5, P. M.	8, A. M.	12, M.	5, P. M.
		F.°	F.°	F.°	F.°	F.°	F.°	F.°	F.°	F.°	F.°	F.°	F.°
March 17,	39.0	75.0	80.0	81.0	157.0	159.0	158.0	.....	.....	76.0	157.0	159.0	157.0
18,	43.5	75.0	79.0	75.5	157.0	157.0	157.0	72.0	75.5	72.5	155.5	155.5	155.0
19,	45.0	72.0	71.5	68.0	155.5	156.0	157.0	71.0	77.0	65.5	151.0	151.0	151.0
20,	47.5	72.5	81.0	69.0	156.5	156.5	157.0	71.5	72.0	64.0	153.5	153.5	153.0
21,	43.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22,	32.5	66.0	63.5	60.0	156.0	155.5	154.0	65.0	61.0	56.0	151.0	151.0	151.0
23,	27.2	59.0	69.0	60.0	153.0	153.5	154.5	59.0	65.0	57.0	151.5	152.5	153.5
24,	31.2	65.0	82.5	73.5	151.5	155.5	154.5	61.0	76.0	68.0	151.5	153.5	155.0
25,	39.0(?)	69.5	84.0	72.0	151.5	151.5	152.0	68.0	78.0	66.5	151.0	150.5	149.0
26,	40.7	63.5	*98.0	77.5	149.5	149.5	149.0	55.5	71.0	71.5	147.0	147.0	147.0
27,	35.7	71.0	73.0	67.0	148.0	148.5	148.0	66.0	68.0	63.0	146.0	145.5	144.5
28,	39.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29,	37.7	65.0	61.5	63.5	149.5	150.5	151.5	61.0	59.5	60.0	142.0	142.5	142.5
30,	44.2	67.0	67.0	65.5	159.5	149.5	149.5	59.5	57.0	58.0	141.5	141.0	140.0
31,	55.3	68.0	69.0	68.0	148.0	152.0	155.0	63.0	64.0	61.0	137.5	139.5	141.0
April 1,	.....	64.0	66.0	67.0	158.0	160.5	159.0	49.0	59.0	60.0	141.5	153.0	141.0
2,	.....	68.0	76.0	72.0	152.0	151.5	150.0	67.0	80.0	62.0	142.0	142.5	142.0
3,	.....	65.0	68.0	62.0	147.0	147.0	147.0	56.0	70.0	62.0	139.0	138.0	138.0
4,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5,	.....	57.0	58.0	56.0	142.5	142.0	142.0	51.0	56.0	52.0	131.0	131.0	132.0
6,	.....	52.0	62.0	62.0	139.5	138.0	138.0	50.0	57.0	56.0	123.0	121.0	122.0
7,	.....	53.0	60.0	59.0	147.0	138.0	137.0	47.0	50.0	48.0	122.0	122.0	122.0
8,	.....	56.0	70.0	60.0	136.0	131.5	131.0	46.0	52.0	51.0	122.0	122.0	122.5
9,	47.0(?)	61.0	92.0	70.0	133.0	134.0	131.0	56.0	78.0	60.0	122.0	122.5	122.0
10,	55.0	65.0	96.0	79.0	133.5	128.0	133.0	56.0	78.0	70.0	120.0	120.0	120.0
11,	45.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12,	51.7	62.0	72.0	60.0	131.0	135.0	138.0	52.0	62.0	57.0	120.0	120.0	121.0
13,	56.2	66.0	82.0	73.0	136.0	136.0	135.0	58.0	74.0	69.0	121.1	121.1	120.5
14,	60.5	68.0	100.0	77.0	132.0	132.0	132.0	60.0	81.0	76.0	120.0	120.0	120.0
15,	63.0	73.5	96.0	81.0	131.5	131.5	131.5	70.0	81.0	76.0	118.0	118.0	118.0
16,	55.2	72.0	88.0	68.8	134.0	136.0	137.0	70.0	78.0	68.0	118.0	118.0	118.0
17,	52.5	66.0	75.0	70.0	138.0	138.0	138.0	62.0	66.0	68.0	120.0	120.0	120.0
18,	58.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* The thermometer had been pulled up and exposed to direct sunlight.

19,	63.0	73.0	100.0	83.0	132.0	132.0	132.0	70.0	93.0	80.0	120.0	120.0	120.0
20,	61.0	76.0	100.0	78.0	130.0	130.0	130.0	68.0	88.0	72.0	118.0	118.0	118.0
21,	61.5	72.0	96.0	76.0	130.0	130.0	130.0	61.0	86.0	78.0	118.0	118.0	118.0
22,	63.2	72.0	98.0	82.0	129.0	129.0	129.0	66.0	86.0	79.0	118.0	118.0	118.0
23,	65.0	75.0	101.0	81.0	128.0	129.0	128.0	68.0	96.0	80.0	117.0	118.0	118.0
24,	59.7	74.0	82.0	.....	128.0	128.0	.....	67.0	78.0	.....	118.0	118.0	.....
25,	62.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26,	65.5	68.0	81.0	76.0	128.0	129.0	129.5	61.0	78.0	72.0	118.0	119.0	118.0
27,	59.2	68.0	80.0	74.0	128.0	128.0	128.0	61.0	71.0	70.0	118.0	119.0	118.5
28,	56.5	72.0	90.5	71.0	128.0	128.0	127.5	68.0	78.0	70.0	119.5	120.0	120.0
29,	55.5	72.0	96.0	.....	126.0	126.5	.....	62.0	82.0	.....	118.0	119.5	.....

It will, of course, be understood that the seed-bed temperatures are the result of the thermal condition of the atmosphere and sun's rays, the heat of the fermenting manure, and the variation of the position of the frames during the day. To eliminate, as far as possible, the effects of this third factor, comparisons should be confined to the morning observation.

The results show that bed No. 1, having a larger body of manure than No. 2, though starting with the same bottom temperature, decreased in temperature much less rapidly; that while there is, as a rule, very little daily variation in the bottom temperature, there are occasional marked exceptions, as in bed No. 1, April 7 and 10, and in bed No. 2, April 1. There seems to be no explanation of these variations from the data at hand. It will further be observed that the daily variation became less as the period of fermentation was prolonged.

The decrease from day to day is irregular, and is interrupted by short periods of increase, which do not appear to bear any direct relation to external temperature, but must be referred to unknown variations in the conditions of fermentation. The mean daily decrease is very slight near the end of a period of twenty or thirty days.

The seed-bed temperatures, although not depending for their daily variations upon any variation in bottom heat, do depend for their mean temperature upon the mean temperature of the manure, as will be seen by comparing the seed-bed and bottom heats of beds Nos. 1 and 2.

XVII. THE COMPOSITION OF SOILING RYE.

In consequence of the decrease in the area of cheap pasturage in the Eastern States, and the increased cost of maintaining interior fences, the soiling system of feeding milch cattle has of late attracted more general attention than formerly. In view of this fact, it is important to know the yields and food values of the fodders obtained under this system, as compared with that obtained by pasturage. The following notes on the composition of soiling rye are preliminary to a more general study of the whole subject.

Table I gives the data showing the character, yield, and amount of dry substance in samples taken at the Central Experimental Farm; also, for comparison, the data given by Jenkins* as the mean of the analyses of five other American samples, and those obtained by Weiske at Proskau,† from the examination of pasture grass, (clover and timothy mixed,) plucked by hand thirteen times during four months of the growing season, and of the hay from a portion of the same field, mown twice in the same interval.

Table II gives the percentage composition of the dry substance of the same samples.

* Report of the Conn. Agric. Exp. Station, 1884, p. 114.
† Wolff, Ernahrung Landw. Nutzthiere, p. 108; Armsby, Manual of Cattle Feeding, p. 296.

Table III gives the yield per acre of the different proximate constituents—starch, cellulose, albuminoids, etc.

TABLE I.—*Yield per Acre.*

SAMPLE.	Height.	Soil.	Weight of fresh substance—lbs.	Weight of dry substance—lbs.	Per cent. of dry substance.
Soiling rye, No 1,	18 inches.	Moderately manured.	14,817	2,448	16.52
Soiling rye, No. 2,	28 inches.	Heavily manured.	35,560	4,754	13.37
Soiling rye, No. 3,	52 inches.	Same as No. 2.	53,340	13,351	25.03
Mean of Nos. 2 and 3,	......	....	44,450	9,052	19.20
Jenkins' mean,	......	....	....	....	25.30
Pasture-grass,	......	....	....	3,699	....
Twice-mown hay,	......	....	....	5.914	....

TABLE II. *Percentage Composition of Dry Substance.*

SAMPLES.	Crude fat.	Crude fibre.	Nitrogen-free extract.	Crude protein.	Ash.	Total nitrogen.	Albuminoid nitrogen.	Non-albuminoid nitrogen.*	Per cent. total N non-alb. N.
Soiling rye, No. 1,	5.14	22.54	51.85	10.87	9.59	1.74	1.42	0.32	18.18
Soiling rye, No. 2,	5.07	26.21	39.26	17.06	12.41	2.73	1.76	0.97	35.77
Soiling rye, No. 3,	4.26	28.37	47.57	10.43	8.18	1.86	1.12	0.74	39.49
Mean of Nos. 2 and 3,	4.66	27.29	43.41	13 75	10.29	2.29	1.44	0.85	37.63
Jenkins' mean,	2.57	56.52	23.32	10.28	7.51	....	....	....	....
Pasture-grass,	5.09	16.74	42.09	27.07	9.01	....	....	....	....
Twice-mown hay,	3.69	27.14	49.69	13.42	6.06	....	....	....	....

* Assumed to contain 16 per cent. of nitrogen.

TABLE III. *Yield of Proximate Constituents per Acre.*

SAMPLES.	Dry substance.	Crude fat.	Crude fibre.	Nitrogen-free extract.	Crude portein.	Crude ash.	True albuminoids.*
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Soiling rye, No. 1,	2,448	126	571	1,270	267	234	218
Soiling rye, No. 2,	4,754	242	1,234	1,877	811	590	521
Soiling rye. No. 3,	13,351	571	3,787	6,348	1,552	1,093	939
Mean of No. 2 and 3,	9,062	406	2,511	4,113	1,181	841	730
Pasture-grass,	3,699	188	619	1,558	1,001	333	.....
Twice-mown hay,	5,914	218	1,606	2,939	794	358	.....

* Determined by Stutzer's method.

The early crop of rye, obtained by early sowing and heavy manuring, is best adapted for feeding when between the heights of two and four feet. A comparison of samples two and three, taken at the beginning and at the end of the feeding period, shows that there has been, during the interval, a rapid gain in dry substance, due mainly to the increase of the non-nitrogenous constituents. Of these, the nitrogen-free extract (starch, gums, &c.) gains much more rapidly than the crude fiber (cellulose). The crude protein drops far behind and the crude fat (which includes chlorophyll or leaf-green and waxes, as well as true fats) and ash are relatively diminished. There is a slight increase in the percentage of the total nitrogen present in a non-proteid form.

A comparison of No. 1, taken from a soil receiving a moderate amount of manure, with No. 2, taken from a much more highly manured plot, the plants being of nearly the same age, shows that No. 1 contains less moisture, a much higher percentage of nitrogen-free extract, and a much lower percentage of crude albuminoids. There is less crude fiber than in No. 2. There is also a much smaller proportion of the nitrogen present in a non-proteid form, so that the dry substance contains only two per cent. less of true proteids than the dry substance of No. 2. This is in full accord with Kellner's* observations on the effect of high manuring on fodder plants. It must be remembered that the non-proteid nitrogenous bodies are not regarded as having a nutritive value equal to that of the true proteids.

It will be perceived that the means of other analyses given by Jenkins, when compared with the means of Nos. 2 and 3, show less fat, ash, and protein, and very much less nitrogen-free extract, while the percentage of crude fiber is greatly increased. This would indicate that these samples were taken at a greater age.

Again, comparing the means of Nos. 2 and 3 with pasture-grass, we note the following facts :

Soiling rye yields twenty tons per acre of green crop, pasture-grass seven and one-half tons; soiling rye yields four and one-half tons per acre of dry substance, pasture grass two and three-fourths tons. The percentages of crude fat, nitrogen-free extract, and ash are nearly the same in both fodders, but soiling rye contains nearly twice as much crude fiber and only half as much protein as is present in pasture-grass. From Kellner's † observations on early-cut meadow hay, it seems probable that the proportion of nitrogen present in a non-proteid form is about the same in both substances.

From the preceding facts, we may conclude—

First. That, so far as chemical analysis can determine, soiling rye is much inferior to pasture-grass as an exclusive feed.

Second. That, fed with some nitrogenous rye-fodder, as malt-sprouts, oil-cake, etc., it may in many instances be more profitable on account of its much greater yield.

Third. That quite old soiling rye, such as sample No. 3, closely resembles the mean of first and second-crop hay in composition, but is, of course, juicier, and has a yield which is greater by one half.

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*Landw. Jahrb., 8, Supp. I, p. 243. †Ib.

Fourth. That high manuring produces a crop of better nutritive quality and in very much greater quantity. We have observed no distinction shown by the cattle against the ranker growth.

XVII. THE COMPOSITION AND FOOD VALUE OF DESICCATED APPLE-POMACE.

Every year millions of bushels of apples are converted into cider, and thousands of tons of pomace produced. How to utilize this by-product to the best advantage, has been for years a mooted question among cider-makers, and from the lack of any decisive answer, a large proportion of the product is annually wasted.

The general rule that a product should, if possible, be made to contribute, first, to the food supply, and last to the manure heap, coupled with the fact that apple pomace has a very slight manurial value, would indicate that any method by which it could be profitably used for food should receive careful consideration.

Two obstacles have prevented the general use of pomace for feeding purposes: First, the widely extended belief that apples are not fit to fill a large place in a ration for horses or cattle, and, therefore, that the pomace certainly is not; and, second, the ready fermentability of the pomace, by reason of which it is difficult to extend the period of its use.

There are two facts that should do much toward overcoming the prejudice against apples as a food supply: First, repeated experience has shown that farm animals can be fed on rations containing a large proportion of apples, not only without injury to health, but with positive advantage. The same has, in a more limited range of experience, been shown to hold true for the pomace. Second, the chemical composition of apples indicates that they are not inferior to turnips as a source of sugar, starch and pectin, and that the pomace has a larger percentage of dry substance, which contains nearly as much nitrogenous matter and carbhydrates as the dry matter of sugar beets. Moreover, it has been found possible to avoid any injury arising from excess of free acid by sprinkling the pomace with chalk before feeding.

To obviate the difficulties caused by the fermentability of pomace, several methods have been proposed. Prof. F. H. Storer* says: "It would be interesting to determine by actual trial whether a process of preservation which is largely employed in Europe for keeping a variety of soft and juicy materials might not be available for the preservation of pomace." Prof. Storer refers to the "sour fodder" of the Germans—a kind of ensilage.

A modification of this method has lately been tried. Dr. Goessmann† gives the following account of the experiment: "The pomace which served for the preparation of the apple ensilage, was taken from

* On the Fodder Value of Apples, Bulletin of the Bussey Institution, Vol. I, p. 362.
†Mass. Agric. Exp. Station, Bulletin No. 21, p. 7.

a cider-mill towards the close of October, 1885, and consisted of the clear. fresh refuse, of a mixture of different kinds of apples. Two casks of a capacity of from fifty to sixty gallons each, were used for the experiment. They were painted inside with black tar varnish to render them air and water tight. The pomace was stamped down solid, and subsequently covered with tar paper, which was held down by a layer of sand, several inches in thickness, and some larger stones. The casks thus filled, were kept in a corner of the barn floor until May 17th, '86, when they were opened to examine their contents. The material was found throughout apparently as fresh as when put up: neither mouldy, or rotten, or even discolored on its surface. It had a pleasant fruit-like acid odor and taste, and contained but traces of ammonia compounds. One hundred parts of the fresh apple ensilage required. 0.744 parts of sodium hydroxide for the neutralization of its free organic acide, which prove thus to be less than in corn ensilage. The ensilage of apple pomace is highly relished by cows and swine, and is, if not superior, at least equal, pound for pound. in feeding value to the apple pomace, which served for its production. The nitrogenous constituents had increased, at the expense of the saccharine constituents; the latter had been destroyed at a higher rate by fermentation than the former."

It has also been found possible to preserve pomace for a considerable time by freezing. In this state it forms an agreeable food for horses. Prof. S. W. Johnson has analyzed a sample of pomace prepared in this manner, and says:* "In respect to the quantities of the various food elements it contains, analysis shows that this pomace is superior to corn-fodder, and to turnips, mangels, and all of our root crops, except the potato, and that it is but little inferior to the last named tuber."

Some time ago, Mr. Christopher Shearer, of Tuckerton, Pa., sent a sample of "desiccated apple-pomace" for analysis. He states that it can be prepared at slight expense, and that every ton of pomace yields several hundred bushels of the desiccated product.

The sample in question came in large, brown flakes, somewhat leathery in texture, but possessing an agreeable apple flavor and odor.

The following table gives the result of its analysis, together with the mean of several American analyses of fresh pomace, given by Dr. Jenkins,† the analysis of apple ensilage by Dr. Goessmann, and that of frozen pomace by Prof. Johnson, for the sake of comparison:

*Conn. Agric. Experiment Station Report, 1881, p. 86.
†*Ib.* 1884, p. 117.

SAMPLE.	Moisture.	Crude fat.	Crude fiber.	N.-free extract. (a)	Protein. (b)	Ash.	Free acid.
Desiccated apple-pomace,	8.47	4.87	18.81	60.82	5.19	1.84	1.17 (c)
Fresh apple-pomace.	74.10	1.90	5.20	16.70	1.40	0.70	
Frozen apple-pomace,	72.62	1.97	5.92	17.01	1.65	0.81	
Apple ensilage,	85.33	1.08	3.25	8.51	1.21	0.62	1.12 (d)

(a) Including starch, sugar, pectose, &c.

(b) Including all the nitrogenous constituents = nitrogen × 6.25.

(c) Calculated as malic acid.

(d) Calculated as acetic acid.

The desiccated pomace is seen to contain a very considerable amount of nitrogenous matter, and a proportion of carbhydrates, (N-free extract,) nearly equal to that of wheat. The percentage of crude fiber is moderately high, but not greater than in palm-nut cake. The crude fat consists largely of wax and coloring matters.

According to chemical evidence, therefore, the desiccated pomace would seem to be a valuable source of carbonaceous food, to be fed with a generous admixture of nitrogenous foods, such as malt-sprouts, oil-cake, etc. The presence of so large a percentage of free acid may necessitate the softening of the pomace and subsequent treatment with small quantities of chalk before feeding. On the other hand, it may add to the appetizing qualities of a ration composed to a considerable extent of general feeding stuffs, such as hay or corn-fodder.

It is possible that objections to this preparation may be found by actual experiment in feeding, but it certainly is worth a careful trial.

XIX. ANALYSES OF VARIETIES OF WHEAT.

As a part of the test of the different varieties of wheat sent here by the U. S. Department of Agriculture for trial, it was thought desirable to make a study of the effect of climate and soil on the composition of the grain. The following analyses of the seed wheat were made. It has been impossible to make the analyses of this year's crop in time for this report, and they will be reported later.

Wheat Analyses.

Index No.	SAMPLE.	Weight of 100 grains.	Moisture.	Fat.	Fiber.	Nitrogen-free extract.	Protein.	Ash.	Moist gluten.	Dry gluten.
		Grains	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct
4	"Indian," imported winter.	3.0700	9.50	2.02	1.71	74.49	10.26	2.02	27.21	9.35
5	"Genoese," imported winter,	3.8200	8.35	1.69	1.72	77.43	9.13	1.68	26.41	9.92
6	"Egyptian," imported winter.	5 2701	8.68	2.22	1.35	76 05	10.00	1.70	28.50	10 29
7	"White Crimean," imported winter,	5 5400	8.64	2.60	1.34	73.94	11 66	1.[illegible]2	27.71	10.81
8	"McGehee," native winter,	2.2900	8.82	1.81	1.15	75.37	11.48	1.37	36 05	14.37
9	"Martin's Amber," native winter,	3.5400	8.72	2 16	1 48	75.39	10.70	1.55	31.28	11.25
10	"Extra Early Oakley," imported winter,	3.8500	10.83	1.56	1.38	72 65	12.18	1.40	34 50	14.16
11	"Diehl - Mediterranean," imported winter, ...	4.4300	9.35	1.77	1.18	77 73	8.75	1.22	27.57	12 61

XX. TEST OF WAGNER'S METHOD FOR THE VALUATION OF PHOSPHATES.

For some time past Dr. Paul Wagner has given his attention to the important. but difficult problem of obtaining a basis for determining the commercial value of phosphatic manures other than that dependent upon the amount of total and water-soluble phosphoric acid which they contain. The need for such a basis has been increasingly pressing since the extensive introduction upon the market of phosphatic manures consisting exclusively of precipitated phosphates insoluble in water.

After commenting upon the present state of confusion of terms and lack of agreement as to method among chemists, he says: "For some years I have been endeavoring to establish the ground-work necessary to throw some light upon this confused state of matters, and I proceeded upon the following lines: If the agriculturist be offered pure superphosphate of lime, it ought to be no difficult matter for him to obtain an opinion upon its value. If the manure merchant's price for phosphoric acid soluble in water averages about 1.3 cents per pound, the farmer knows that he will be right in paying $2.60 for 100 pounds of a superphosphate containing 20 per cent. of phosphoric acid soluble in water. It is different, however, in the case of the high-class and phosphorite superphosphates or precipitated phosphate. The buyer has then no idea in what relation the value of the precipitated phosphoric acid stands to soluble phosphoric acid of pure superposphate of lime. If such manures are to be freely salable, one should be able to inform the agriculturist positively what percentage of phosphoric

Chem. Zeitung. 10, 13; translated by H. H. B. Shepherd, Chem. News, 53, 133-136; Am. Chem. Journal, 8, 63-70.

acid equal in manurial value to phosphoric acid soluble in water is contained therein. If this could be done, the buyer would be in a position to tell exactly how much he could afford to pay for the manure, and how it should compare as regards cost with pure superphosphate of lime. For the requirements of the manure trade, therefore, an analytical method is wanted which will give the phosphoric acid of phosphorite of superphosphate, of high-class superphosphate, and of precipitated phosphate in their equivalents of phosphoric acid soluble in water, a method which will show how much per cent. of phosphoric acid of the manurial value of phosphoric acid soluble in water is present, or, in other words, the manurial value of the material expressed in terms of phosphoric acid soluble in water; or, if we call such phosphoric acid simply "soluble" phosphoric acid, and agree that by this term we are to understand phosphoric acid of the same manurial value as phosphoric acid soluble in water, then the question presents itself as follows:

1. By means of manurial experiments to fix the relative manurial values of certain phosphatic manures expressed in terms of "soluble" phosphoric acid—*i. e.*, in terms of phosphoric acid of the same manurial value as phosphoric acid soluble in water.

2. To find an analytical method which shall furnish results agreeing exactly with the percentage of soluble phosphoric acid obtained by the manurial experiments."

After determining the effect of phosphoric acid in different forms upon different crops in different soil, Dr. Wagner experimented upon numerous organic acids as solvents, and arrived at the conclusion that citric acid was best adapted to the purpose, and further, that the best results were reached by use of a suitable mixture of neutral ammonium citrate and free citric acid.

The results he obtained with the different substances tested are the following:

"Soluble" Phosphoric Acid.

	Calculated from the results of the manurial experiments. Per cent.	*Obtained by analysis. Per cent.*
1. Bicalcium phosphate, ...	30.60	29.30
2. Bicalcium phosphate, ...	18.00	19.10
3. Washed-out high-class superphosphate, . .	17.90	16.90
4. Washed-out phosphorite phosphate, ...	3.00	3.30
5. Finely ground phosphorite, ...	0.10	0.60

So satisfactory are these results, that, after proving by numerous experiments that the method is capable of giving concordant results, it was unanimously decided at a meeting of the manure manufacturers of South Germany and representatives of the experiment stations of Bonn, Darmstadt, Spier, and Wiesbaden, held at Mayence, Nov. 30, 1885, to adopt this method for the analysis of all superphosphates from January, 1886.

At my suggestion, a comparison of this method with that at present approved by the Association of Official Agricultural Chemists, which involves the successive to use of water, and of *neutral* citrate of ammonium as solvents, was made by Mr. H. B. McDonnell, of the class of 1886, who performed the analytical work in the chemical laboratory under Prof. Herrick, and presented the results in his chemical thesis.

*"The results of the analysis of various phosphatic substances are presented in the appended table.

"In determining Wagner's 'soluble' acid, (nearly corresponding to our 'available,') duplicates of samples 1*a* and 6*a* were taken from different flasks, which stood about twenty-four hours over night, and were frequently shaken during the afternoon and morning. Samples 1*b* to 6*b* were treated similarly, but only stood about six hours. The duplicates of 7*a* to 9*a* were taken from the same flasks and stood fourteen hours; 7*b* to 9*b* stood sixteen hours.

DESIGNATION.	ASSOCIATION METHOD.					WAGNER'S METHOD.	
						SOLUBLE.	
	Total phosphoric acid.	Soluble.	Insoluble.	Reverted.	Available.	*a.*	*b.*
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
(1.) Fine ground South Carolina rock,	27.11	.00	25.85	1.26	1.26	1.56	1.37
(2.) Fine ground apatite,	39.44	.00	38.59	0.85	0.85	0.66	0.63
(3.) Fine ground bone,	24.06	0.16	19.33	4.57	4.73	5.19	5.28
(4.) Dissolved South Carolina rock,	17.19	10.04	3.50	3.65	13.69	11.56	11.49
(5.) Dissolved bone-black,	16.02	12.32	0.66	3.04	15.36	15.24	14.80
(6.) Bicalcium phosphate,	43.76	3.77	11.85	28.14	31.91	23.67	23.44
(7.) Dissolved bone-ash,	21.87	14.29	3.61	3.72	18.01	14.39	14.74
(8.) Raw Navassa,	28.83	.00	27.80	1.03	1.03	2.42	2.51
(9.) Orchilla guano,	18.11	.00	14.43	3.69	3.69	3.25	3.27

"Accepting the means of the results of 1*a* to 6*a* and 7*b* to 9*b* as those best representing Wagner's method, a comparison with the 'available' acid obtained by the Association method shows that the former gives somewhat higher results with fine ground South Carolina rock and fine ground bone, and gives more than double the amount with raw Navassa rock. On the other hand, it gives somewhat lower results with fine-ground apatite, dissolved bone-black, and Orchilla guano, and several per cent. less with dissolved South Carolina rock, dissolved bone-ash and bicalcium phosphate.

"A comparison of the results in columns *a* and *b* to determine the

*Abstract from a paper read at the Third Annual Convention of the Association of Official Agricultural Chemists, Washington, Aug. 26, 1886.

limits of time in which the solution is completed, taking first samples 1–6, shows that sixteen hours suffices to practically complete the solution of the soluble acid in fine-ground apatite, fine-ground bone, and dissolved South Carolina rock; and that there is a gain of 0.1 to 0.4 per cent. from standing four hours longer in the other cases. In samples 7-9, the results with Orchilla guano show no material gain from an increase of two hours over the original fourteen hours allowed for solution, but in the other cases the gain is considerable."

Dr. H. C. White, after a similar comparison upon acid phosphate, both 'South Carolina' and 'Navassa,' says:†

"It is very evident that Wagner's method gives much lower percentages of what we are accustomed to call 'available' P_2O_5, than the method now in use by us. The introduction of this method into our work would clearly be attended with many embarrassments; and yet, if Dr. Wagner's crop experiments and his conclusions are to be relied on, it is a question if his analytical method is not a proper one to employ in the official work of experiment stations and State officers."

XXI. Comparative Fertilizer Analyses.

As was stated elsewhere, analyses were made of different commercial fertilizers forwarded by the various committees of the Association of Official Agricultural Chemists; these fertilizers included those requiring determinations of phosphoric acid in its various forms, potash and nitrogen, and represented as far as possible the range of combinations found on the market. The object of the comparison was to determine the accuracy of the methods recommended by the association, and, also, to place a check upon the work of the various analysts.

The results obtained will not be given here, because, to be of any value, they require a comparison with the results obtained elsewhere; those interested will find them fully reported in Bulletin 12, Division of Chemistry, United States Department of Agriculture.

XXII. Feeding Experiment.

The Use of Cottonseed Meal in Fattening Rations.

During the past two years the study of the fattening effect of a mixture of cottonseed meal and cornmeal, as compared with cornmeal alone, the experiments upon which were begun by Prof. Jordan, in 1881, has been continued. The results of the previous experiments may be found in the Agriculture of Pennsylvania for 1883, and in Bulletins Nos. 6 and 10, issued by the College.

†Proc. 3d Conv. Assoc. Official Agric. Chemists, p. 18.

The following abstract from Bulletin No. 6 states the

GENERAL PURPOSE AND PLAN OF THE EXPERIMENTS.

By reason of the many influences modifying the nutrient effects of food, investigations upon this subject are very complicated, and comparatively recent. In solving the problems of feeding, the German investigators have been most active, and, after many elaborate experiments, have established certain standards and laid down certain rules which have, to some degree, proven successful in practice.

American methods and standards of feeding are very far from uniform, both as to kinds, combinations, and quantities of food. Cornmeal is, however, the principal ingredient of the rations fed to fattening steers. This is sometimes fed nearly pure, sometimes in combination with oatmeal, wheat, bran, cottonseed or linseed meal.

German standards condemn a ration of cornmeal and cornstalks, because the digestible albuminoids and carbo-hydrates * are present in such ratio to each other that they are not wholly utilized. According to the above standards there should be added some highly nitrogenous material, as oil-cake or cottonseed meal.

While theories indicate that such an addition would be the most economical in material used, practical experiment is necessary to determine positively the relative value of the various rations made up from the feeding stuffs referred to: and there must be considered, as factors in profit, not only the relative values of the rations for fattening purposes, but also, their relative cost.

The experiments conducted during the past years have been, in part, an attempt to test the economy of a ration compounded according to a German feeding standard, as compared with a ration differing essentially from such a standard. The questions asked have not been answered as fully as was desired, but the results are reported as in the line of progress.

The experiments here reported were conducted at the Central Experimental Farm, and have been devoted largely to testing the economy of a ration composed of cornmeal and cornstalks, as compared with one composed of cornmeal, cottonseed meal and cornstalks. Cottonseed is used by English farmers to a great extent. Their supply comes from America, and it is a question worthy of attention, whether American farmers cannot use more of this material at home with profit.

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*All cattle foods contain four classes of substances, viz: Protein (albuminoids,) carbo-hydrates, fats and ash. The protein includes the nitrogenous compounds, like lean meat, gluten, etc.; the carbo-hydrates include sugar and starch, and bodies resembling these compounds. The fats or oils are very much like animal fats, and the ash is the mineral or non-combustible substances. Some foods are highly nitrogenous, like cottonseed and oil-cake. Others contain a small relative percentage of nitrogen, and a large relative percentage of carbo-hydrates, like turnips, potatoes, straw, cornstalks, etc.

For each trial four steers were selected, two being fed after one method and the other two after the method with which it was desired to make comparison. The steers were selected so that in each lot of four one pair should be as nearly like the other in size, weight, form, general appearance and habit, as possible.

The rations to be tested were weighed to the animals each day, any material they did not eat also being weighed.

The weight of the steers was in no case recorded until the animals had been eating their rations for one week. The weighings were made weekly at the same hour of the day, and always before drinking. In all things, except in what they ate, the steers were treated as nearly alike as possible.

(1.) Experiments of 1884–5.

In the experiments made during the winter of 1884–5, under the direction of Prof. Jordan, the same plan was adopted as in previous years.

For these experiments there were selected four two-year-old steers (first lot) and four three-year-olds (second lot.) The steers of the first lot were numbered 1, 2, 3 and 4, respectively; of the second lot, 5, 6, 7 and 8.

A period of feeding, during which all the steers received the same kind of food, (chopped cornfodder and cornmeal,) and those of the same lot in exactly the same quantity, preceded the experiment proper. This served to place all under like conditions at the time of the beginning of the experiment, and to show the relative fattening capacity of the different pairs. This period extended from December 13 to Januuary 24.

On January 24 the experimental rations were fed: the first pair of each lot received a mixture of cornfodder, cornmeal and cottonseed meal; the other, cornfodder and cornmeal only. The daily ration for each steer, from January 24 to February 28, was as follows:

First lot, (2 yrs. old.)	Steers 1 and 2, .	6 pounds cornfodder, 5 pounds cornmeal, $2\frac{1}{2}$ pounds cottonseed meal.
	Steers 3 and 4, .	6 pounds cornfodder, 10 pounds cornmeal.
Second lot, (3 yrs. old.)	Steers 5 and 6, .	8 pounds cornfodder, 7 pounds cornmeal, $3\frac{1}{2}$ pounds cottonseed meal.
	Steers 7 and 8, .	8 pounds cornfodder, 14 pounds cornmeal.

From February 28 to April 4, timothy hay was substituted for cornfodder, the ration being in other respects left without change.

Steers of the first lot (1–4) received 9 pounds of hay daily;

Steers of the second lot (5–8) received 11 pounds of hay daily.

The following table (I) gives the live-weight records of the experiment:

TABLE I.—*Live weights of Animals. Feeding Experiments of 1884–1885.*

DATE.	Steers 1 and 2.	Steers 3 and 4.	Steers 5 and 6.	Steers 7 and 8.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
December 13,	1,380	1.430	1,980	2,030
27,	1,415	1,410	2,100	2,165
January 3,	1,460	1.450	2,120	2,165
10,	1,445	1,485	2,120	2,180
17,	1,480	1,485	2,170	2,225
24,	1,490	1,510	2,210	2,255
31,	1,510	1,550	2,215	2,305
February 7,	1,510	1,575	2,225	3,335
14,	1,520	1,625	2,310	2,415
21,	1,580	1,645	2,340	2,420
28,	1,600	1,640	2.320	2,415
March 7,	1,615	1.670	2,350	2,470
14,	1,650	1,720	2,390	2,490
21,	1,690	1,705	2,445	2,575
28,	1.695	1,700	2,440	2,550
April 4,	1,705	1,745	2,490	2,560

The weight of the several pairs of steers, before and after feeding the preliminary rations, are given below:

TABLE II.

	1 and 2.	3 and 4.	5 and 6.	7 and 8.
Weight, December 27,	2,415	1,410	2,100	2,165
Weight, January 24,	1,490	1,510	2,210	2,255
Gain,	75	100	110	90

In the following tables are given the weights of the several pairs of steers, at the beginning and at the end of the periods during which different rations were fed, the amount of food actually consumed during each period by each pair, a statement of the total cost, the cost per pound of gain, and the amount of food consumed for each pound of gain:

Table III.—*First Period, (five weeks.)*

	1 and 2.	3 and 4.	5 and 6.	7 and 8.
Weight, January 31,	1,510	1,550	2,215	2,305
Weight, February 28,	1,600	1,640	3,320	2,415
Gain,	90	90	105	110
Cornfodder eaten,	217	68	218	170
Cornmeal eaten,	280	560	392	784
Cottonseed meal eaten,	140	....	196	....
Weight of food eaten,	637	628	806	954
Cost of materials,*	$5.15	$5.21	$7.01	$7.23
Cost per pound of gain,	0.057	0.058	0.067	0.066
Pounds of food used for each pound of gain,	7.78	6.98	7.68	8.67

* The valuation of the feeding stuffs used is as follows: cornfodder, $5 per ton; hay, (loose,) $10 per ton; cornmeal, 45 cents per 50 pounds; cottonseed meal, $30 per ton.

Table IV.—*Second Period, (five weeks.)*

	1 and 2.	3 and 4.	5 and 6.	7 and 8.
Weight, March 7,	1,615	1,670	2,350	2,470
Weight, April 4,	1,705	1,745	1,490	2,560
Gain,	90	75	140	90
Hay eaten,	504	478	616	616
Cornmeal eaten,	280	560	392	784
Cottonseed meal eaten,	140	....	196	....
Weight of food eaten,	924	1,038	1,204	1,400
Cost of materials,	$7.19	$7.43	$9.55	$10.14
Cost per pound of gain,	0.080	0.099	0.068	0.113
Pounds of food consumed for each pound of gain,	10.27	13.73	8.60	15.56

Table V.—*Summary of Both Periods.*

	1 and 2.	3 and 4.	5 and 6.	7 and 8.
Weight, January 31,	1,510	1,550	2,215	2,305
Weight, April 4,	1,705	1,745	2,490	2,560
Total gain,	195	195	275	255
Total cornfodder eaten,	217	68	218	170
Total hay eaten,	630	604	770	770
Total cornmeal eaten,	430	1,260	882	1,764
Total cottonseed meal eaten,	315	....	441	....
Total weight of food eaten,	1,792	1,932	2,311	2,704
Total cost of materials,	$14.09	$14.53	$18.95	$20.15
Cost per pound of gain,	0.072	0.075	0.069	0.079
Pounds of food consumed for each pound of gain,	9.19	9.91	8.40	10.60

Results of the Experiments of 1884–5.

From the data gathered during this season's experiments, the following observations may be noted:

1. That this year's results, unlike those of earlier seasons, do not show that the younger animals have any advantage over the older in point of cost for the same gain. Let it be observed, however, that for both lots the cost per pound of gain is nearly the same as in the case of the two-year-olds of last year.

2. That, with this season's prices, the cost is practically the same for each ration.

3. The cottonseed rations will, as has been shown in earlier experiments, yield greater gain, pound for pound, than the other rations. When the relative fattening capacity is considered, it will be seen that Period I offers no marked exception to this rule. It will be at once remarked that the difference between the two rations is much increased during Period II, notwithstanding the fact that, as the hay contains a greater proportion of digestible nitrogenous matter than the cornfodder, the nutritive ratios of the two rations approach more closely than during Period I.

In the cases of the pairs of the second lot for Period II, it is to be observed that from February 28 to March 7, (the week immediately following the change of rations,) while 5 and 6 gained 30 pounds, 7 and 8 gained 55 pounds, a difference which, in experiments for so short a period, and open to so many sources of error, should doubtless be taken into consideration; and this would tend to diminish the great differences in weight shown in the later weighing.

4. It will be noted that during the latter period there is a marked increase in the quantity of food required to produce one pound of gain, and of course a corresponding increase in cost.

As noted before in this connection, the cottonseed ration produces the more valuable manure.

As the experiments of other seasons have shown, indications are slightly in favor of the cottonseed ration; but this season's experiment, more than all earlier ones, shows that, under some conditions, a wide departure from the German standard may be made with but slight effects.

Nevertheless, the many sources of error in drawing deductions from mere live-weight results, must cause conclusions to be taken with much reserve, and tentatively to those based upon more searching methods of investigation.

(2.) FEEDING EXPERIMENTS OF 1885–1886.

During the winter of 1885–1886, the study of the same problem was continued; but in these latter experiments, certain precautions were taken to eliminate, as far as possible, some of the numerous sources of error to which mere live-weight experiments are open, especially when the weights are taken at infrequent intervals. Eight steers, Short-horn grades, were used for these experiments—four three years old at the end of the experiment, and four two years old. The former are grouped in set I, and the latter in set II. As the details of treatment were different for the two sets, they will be described separately.

(*a*.) EXPERIMENTS WITH THREE-YEAR-OLD STEERS.

The experiments with this set included daily observations upon the quantities of food and water taken, and the daily variations in weight made during the whole period, beside digestion experiments, occupying five days of each period.

The animals were confined in double stalls, with high partitions. The floor was made of stout oak plank, and sloped gently down to the rear. The floor of the passage-way was several inches lower than the rear of the stalls, and was also boarded. A slight projecting piece, nailed at the lower end of the sloping floor, served to keep any liquid from draining upon the passage-way; but a small portion of this piece could be removed whenever it was desired to run off any of the liquid excretions from the stall, and a small sheet-iron pan was provided for each stall, to receive such drainage. Further, the floor was smoothed, and to render it water-proof it was saturated with coal tar, all excess of tar being removed by scraping.

During the digestion period, the floor was bare, but at other times it was covered with dry sawdust, put on to a depth of three fourths of an inch. Although sawdust is not so good a bedding as straw, the use of the latter was prevented because the very appreciable quantity that would be eaten would enter into the rations as an unmeasurable variable.

The food was weighed separately for each steer each day, and the day's rations divided into three portions. The portions remaining in the manger uneaten at the beginning of the next period of twenty-four hours were weighed and recorded.

The steers were trained to go quietly at noon each day to the scales to be weighed, watered from buckets, and weighed again. The scales are a few yards distant from the stable door, and very little disturbance was caused by this operation. Record was also kept of the variations in the temperature of the stable.

To estimate the digestibility of the rations, it was necessary to know not only the weight of food eaten and water drank, but also its composition, and the weight and composition of the dung.

The cornfodder and hay were cut for feeding, the amount required during each digestion experiment being cut at one time. A channel was cut through the heap upon the barn floor, the material removed was thoroughly mixed, and a sample drawn.

A single lot of cottonseed meal was used. It was thoroughly mixed and sampled.

The cornmeal was sampled as it was brought from mill, and the sub-samples united to represent the periods indicated above.

In making up the principal samples, exact allowance was made for the loss of moisture suffered by the sub-samples from standing in the laboratory.

The separation, with the appliances at hand, of the dung from the urine, was a matter of considerable difficulty. A preliminary attempt was made to separate them by simple drainage of the urine from the bare floor, and the removal of the dung promptly after its fall. For this purpose watch was kept by two men, from 5, A. M., to 9, P. M. Separate pans and pails for the storage of the dung and urine, and separate spades and rubber-mops for cleaning the floor, were provided for each steer. With the utmost precaution, this plan proved unsatisfactory. Special rubber-bags were then devised to serve as receptacles for the urine, and were made to order by the Davol Rubber Co., of Providence, R. I. These were fastened about the body of the steers, and were frequently examined, any urine which might have accumulated being removed. This method, while not perfect, answered the purpose quite well. In case enough urine accumulated in the bags to cause an overflow, which happened infrequently, the sloping floor conducted away most of that lost into the pans previously mentioned.

The dung of each steer was thoroughly mixed after weighing, and a sample was drawn, which was weighed, quickly dried, and the loss of moisture noted. At the end of the digestion experiments of each period, the samples of dung taken daily from each steer were united in due proportion to form a single sample, representing all the dung excreted by that steer during the experiment.

As in previous years, the season of experiment was divided into three periods. The rations fed during these periods were those mentioned in the report of the experiments of 1884–1885.

The first, or preliminary period, began at noon, December 28, and closed at the same hour on February 1. Digestion experiments were begun in the third week of the period, but the appliances then at hand proved insufficient, and these experiments were postponed till the last week of the period, including January 26–30.

The second period began February 1, and continued till March 1. At first, the cornmeal alone was fed to steers Nos. 2 and 4, and the mixed meal to Nos. 1 and 3; but the cottonseed meal scoured No. 3 so severely that it became necessary on the 7th to exchange the rations of Nos. 3 and 4. Even after this, the effect of the cottonseed meal on No. 3 was noticeable till the close of the period. The digestion experiments extended from February 15–19.

The third period began March 1 and extended to March 29, 12 M. Steers Nos. 1 and 4 continued to receive the cottonseed ration. The digestion experiments extended from March 15–19.

In weighing back the uneaten food it is evident that some correction should be made for the saliva contained in it; it is further apparent that the correction required will vary, the proportion of saliva being greater in the smaller quanttiies of residual food. It was impossible to make exact correction for the whole period of experiment, so observations were made during the digestion week of Period II, and from March 22–27 in Period III. Unfortunately the samples of meal were lost through accident. The following table (VI) shows the results obtained for the cornfodder and hay.

TABLE VI.—*Proportion of Air-dry Substance in Food Weighed Back.*

	Weight when taken from the manger.	Weight, Air-dry.	Proportion of air-dry to fresh substance.
Cornfodder.	*Lbs.*	*Lbs.*	
Steer No. 1,	3.75	2.75	1:1.45
" No. 2,	28.25	22.00	1:1.28
" No. 3,	15.00	11.75	1:1.37
" No. 4,	....	....	....
Hay.			
Steer No. 1,	....	....	....
" No. 2,	26.50	14.50	1:1.86
" No. 3,	10.75	5.00	1:2.15
" No. 4,	....	....	....

From these data the following proportions of dry substance were assumed to be present in the material weighed back :

For cornfodder ; in quantities over 8 lbs., 1 : 1 ; from 4–8 lbs., 1 : 1.3 ; for less amounts, 1 : 1.4.

For hay : in quanties over 6 lbs., 1 : 1 ; in smaller quanties, 1 : 2.

Using these coefficients for correction, the following tables, VII–IX, show the amounts of food, and water taken daily by the steers of Set I, and their daily variations in weight, during the three periods, together with the record of stable temperatures for the same time :

TABLE VII.—*Weight Records, Set I, Period I, (Preliminary,) December 28, 1885–January 31, 1886.*

DATE.	STEER 1.							STEER 2.							STEER 3.						
	FOOD EATEN.			LIVE WEIGHT.				FOOD EATEN.			LIVE WEIGHT.				FOOD EATEN.			LIVE WEIGHT.			
	Fodder.	Cornmeal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Fodder.	Cornmeal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Fodder.	Cornmeal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
1885.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
December 28, .	11.00	11.00	22.00	1,025	1,060	35	. . . .	11.00	11.00	22.00	970	1,002½	32.5	. . . .	11.00	11.00	22.00	1,090	1,127½	37.5	. . . .
29, .	10.11	11.00	21.11	1,030	1,052	22	5.0	6.96	11.00	17.96	980	1,003	23.0	10.0	7.51	11.00	18.54	1,088	1,123	35.0	—2.0
30, .	10.29	11.00	21.29	1,017½	1,062½	45	—12.5	6.77	11.00	17.77	977½	1,010	32.5	—2.5	7.35	11.00	18.35	1,085	1,120	35.0	—3.0
31, .	10.11	11.00	21.11	1,030	1,072½	42.5	12.5	7.35	11.00	18.35	982½	1,015	32.5	5.0	6.58	11.00	17.58	1,082½	1,125	42.5	—2.5
1886.																					
January 1, .	9.75	11.00	20.75	1,035	1,072½	37.5	5.0	6.38	11.00	17.38	985	1,007½	22.5	2.5	8.50	11.00	19.50	1,090	1,145	55.0	7.5
2, .	10.29	11.00	21.29	1,035	1,075	40	0	7.73	11.00	18.73	980	1,020	40.0	—5.0	9.01	11.00	20.04	1,117½	1,152½	35.0	27.5
3, .	9.57	11.00	20.57	1,032½	1,032½	0	—2.5	7.15	11.00	18.15	995	1,015	20.0	15.0	9.04	11.00	20.04	1,112½	1,137½	25.0	—5.0
4, .	5.42	11.00	16.42	997½	1,060	62.5	—35.0	6.96	11.00	17.96	992½	1,020	27.5	—2.5	8.68	11.00	19.68	1,100	1,155	55.0	—12.0
5, .	2.00	9.75	11.75	1,017½	1,022½	5.5	20.0	7.35	11.00	18.35	985	1,010	25.0	—7.5	9.57	11.00	20.57	1,110	1,145	35.0	10.0
6, .	7.51	11.00	18.51	1,000	1,055	55	—17.5	6.96	11.00	17.96	985	1,005	20.0	0	9.39	11.00	20.39	1,102½	1,142½	40.0	—7.5
7, .	9.21	11.00	20.21	1,027½	1,072½	45	27.5	6.96	11.00	17.96	987½	1,030	42.5	2.5	8.86	11.00	19.86	1,110	1,155	45.0	7.5
8, .	9.75	11.00	20.75	1,040	1,082½	42.	12.5	6.38	11.00	17.38	1,002	1,017	15.0	14.5	9.21	11.00	20.21	1,117½	1,160	42.5	7.5
9, .	10.11	11.00	21.11	1,012½	1,072	29.	2.5	6.58	11.00	17.58	997½	1,025	27.5	—4.5	9.57	11.00	20.57	1,125	1,160	35.0	7.5
10, .	10.64	11.00	21.64	1,010	1,090	50	—2.5	8.50	11.00	19.50	1,005	1,032½	27.5	7.5	10.46	11.00	21.46	1,125	1,170	45.0	0
11, .	10.82	11.00	21.82	1,055	1,085	30	15.0	8.32	11.00	19.32	1,010	1,025	15.0	5.0	10.29	11.00	21.29	1,122½	1,172½	50.0	2.5
12, .	10.46	11.00	21.46	1,055	1,095	40	0	7.35	11.00	18.35	1,002½	1,032½	30.0	—7.5	10.11	11.00	21.11	1,130	1,170	40.0	7.5
13, .	10.46	11.00	21.46	1,065	1,090	25	10.0	7.92	11.00	18.92	1,010	1,045	35.0	7.5	10.46	11.00	21.46	1,135	1,175	40.0	5.0
14, .	10.46	11.00	21.46	1,065	1,090	35	—10.0	7.73	11.00	18.73	1,007½	1,030	22.5	—2.5	10.64	11.00	21.64	1,130	1,170	40.0	—5.0
15, .	9.75	11.00	20.75	1,055	1,090	35	0	6.77	11.00	17.77	1,005	1,040	25.0	—2.5	10.29	11.00	21.29	1,137½	1,190	52.5	7.5
16, .	9.93	11.00	20.93	1,060	1,095	35	5.0	6.77	11.00	17.77	1,005	1,040	35.0	0	10.29	11.00	21.29	1,147½	1,172½	25.0	10.0
17, .	10.46	11.00	21.46	1,055	1,095	40	—5.0	7.15	11.00	18.15	1,010	1,015	35.0	5.0	10.46	11.00	21.46	1,132½	1,182½	50.0	—15.0
18, .	10.11	11.00	21.11	1,050	1,090	40	—5.0	7.15	11.00	18.15	1,020	1,040	20.0	10.0	10.29	11.00	21.29	1,150	1,177½	27.5	17.5
19, .	9.93	11.00	20.93	1,052½	1,097½	45	2.5	6.58	11.00	17.58	1,010	1,030	20.0	—10.0	10.11	11.00	21.11	1,137½	1,180	42.5	—12.5
20, .	10.11	11.00	21.11	1,052½	1,097½	45	0	6.58	11.00	17.58	1,005	1,037½	32.5	—5.0	10.11	11.00	21.11	1,145	1,150	5.0	7.5
21, .	10.29	11.00	21.29	1,055	1,100	45	2.5	7.15	11.00	18.15	1,012½	1,032½	20.0	7.5	9.93	11.00	20.93	1,110	1,155	45.0	—35.0
22, .	10.46	11.00	21.46	1,065	1,102½	37.5	10.0	7.92	11.00	18.92	1,005	1,042½	37.5	—7.5	9.75	11.00	20.75	1,122½	1,190	67.5	12.5
23, .	10.46	11.00	21.46	1,065	1,102½	37.5	0	6.77	11.00	17.77	1,022½	1,030	7.5	17.5	9.21	11.00	20.21	1,145	1,190	45.0	22.5
24, .	10.46	11.00	21.46	1,065	1,100	35.0	0	6.96	11.00	17.96	1,010	1,050	4.00	—12.5	9.75	11.00	20.75	1,147½	1,195	47.5	2.5

25, .	10.29	11.00	21.29	1,067½	1,095	27.5	2.5	6.96	11.00	17.96	1,030	1,030	0	20.0	10.11	11.00	21.11	1,155	1,155	0	7.5
26, .	9.93	11.00	20.93	1,060	1,095	35.0	—7.5	6.38	11.00	17.38	1,005	1,040	35.0	—25.0	9.57	11.00	20.57	1,120	1,190	70.0	—85.0
27, .	9.75	11.00	20.75	1,070	1,070	0	10.0	2.75	11.00	13.75	1,007½	1,007½	0	2.5	9.39	11.00	20.39	1,150	1,182½	32.5	30.0
28, .	9.04	11.00	20.04	1,032½	1,092½	60.0	—37.5	5.81	3.50	9.31	982½	1,012½	80.0	—25.0	9.04	11.00	20.04	1,135	1,190	55.0	—15.0
29, .	7.15	11.00	18.15	1,057½	1,090	32.5	25.0	5.04	11.00	16.04	1,000	1,015	15.0	17.5	7.54	11.00	18.54	1,150	1,185	35.0	15.0
30, .	7.73	11.00	18.73	1,055	1,092½	37.5	—2.5	3.50	11.00	14.50	997½	1,015	17.5	—2.5	7.73	11.00	18.73	1,145	1,175	30.0	—5.0
31, .	10.29	11.00	21.29	1,062	1,102½	40.0	7.0	5.19	4.25	9.44	990	1,010	20.0	—7.5	8.32	11.00	19.32	1,130	1,180	50.0	—15.0
February 1, .	. . . .	. . .	. . . .	1,060	. . . .	. . . .	—2.0	. . . .	. . . .	. . . .	1,060	. . . .	. . . .	10.0	. . . .	. . . .	. . . .	1,140	. . . .	. . . .	10.0

TABLE VII—Continued.

Date.		Steer 4. Food eaten. Fodder.	Steer 4. Food eaten. Cornmeal.	Steer 4. Food eaten. Total.	Steer 4. Live weight. Before watering.	Steer 4. Live weight. After watering.	Steer 4. Water drunk.	Steer 4. Gain in weight.	Temperature of stable. 7, A. M.	Temperature of stable. 12, M.	Temperature of stable. 5, P. M.	Temperature of stable. Mean.	Weather notes.
	1885.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	F.°	F.°	F.°	F.°	
December	28,	11.00	11.00	22.00	1,072½	1,110	37.5	. . . . .	. . . . .	. . . . .	42.0	. . .	
	29,	10.64	11.00	21.64	1,067½	1,117½	50.0	—5.0	44.5	40.5	46.0	43.7	
	30,	10.64	11.00	21.64	1,077½	1,120	42.5	10.0	44.5	44.0	44.5	44.3	Fair.
	31,	10.64	11.00	21.64	1,075	1,125	50.0	—2.5	48.0	47.0	45.0	46.7	Rain.
	1886.												
January	1,	10.64	11.00	21.64	1,075	1,125	50.0	0	47.0	44.0	48.0	46.0	Cloudy.
	2,	10.82	11.00	21.82	1,070	1,160	90.0	—5.0	45.0	44.0	47.0	47.3	Fair.
	3,	10.64	11.00	21.64	1,060	1,125	65.0	—10.0	46.0	55.0	46.0	45.3	Rain.
	4,	10.64	11.00	21.64	1,090	1,135	45.0	30.0	53.0	49.0	56.0	54.7	"
	5,	10.82	11.00	21.82	1,095	1,125	50.0	—15.0	53.0	38.0	44.0	48.7	Cloudy.
	6,	10.82	11.00	21.82	1,067½	1,127½	60.0	—7.5	44.0	33.0	34.0	38.7	Snow.
	7,	10.82	11.00	21.82	1,085	1,130	45.0	17.5	38.0	34.0	38.0	36.3	Fair.
	8,	10.82	11.00	21.82	1,090	1,140	50.0	5.0	34.0	30.0	29.0	32.3	Freezing.
	9,	10.82	11.00	21.82	1,100	1,130	30.0	10.0	38.0	24.0	28.0	32.0	Snow.
	10,	11.00	11.00	22.00	1,090	1,122½	32.5	—10.0	26.0	24.0	23.0	24.3	High wind.
	11,	11.00	11.00	22.00	1,082½	1,132½	50.0	—7.5	25.0	26.0	19.0	22.7	Fair.
	12,	11.00	11.00	22.00	1,100	1,127½	27.5	17.5	28.0	24.0	26.0	26.7	"
	13,	11.00	11.00	22.00	1,097½	1,135	37.5	—2.5	24.0	26.0	24.0	24.0	"
	14,	11.00	11.00	22.00	1,090	1,125	35.0	—7.5	24.0	28.0	26.0	25.0	"
	15,	11.00	11.00	22.00	1,090	1,145	55.0	0	28.0	36.0	29.0	28.3	"
	16,	11.00	11.00	22.00	1,105	1,145	40.0	15.0	36.0	38.0	36.0	36.0	"
	17,	11.00	11.00	22.00	1,100	1,150	50.0	—5.0	40.0	38.0	36.0	38.0	High wind.
	18,	11.00	11.00	22.00	1,107½	1,140	32.5	7.5	39.0	44.0	38.0	38.3	Fair.
	19,	11.00	11.00	22.00	1,100	1,147½	47.5	—7.5	40.0	33.0	40.0	41.3	Snow.
	20,	11.00	11.00	22.00	1,110	1,150	40.0	10.0	41.0	44.0	39.0	37.7	Fair.
	21,	11.00	11.00	22.00	1,105	1,155	50.0	—5.0	40.0	44.0	41.0	41.7	Snow.
	22,	11.00	11.00	22.00	1,117½	1,157½	40.0	12.5	40.0	41.0	42.0	41.0	Fair.
	23,	11.00	11.00	22.00	1,120	1,160	40.0	12.5	38.0	34.0	33.0	35.0	Cloudy.
	24,	11.00	11.00	22.00	1,120	1,160	40.0	0	29.0	34.0	31.0	31.3	Snow.

	25,	11.00	11.00	22.00	1,132¼	1,165	32.5	12.5	33.0	34.0	32.0	33.0	"
	26,	11.00	11.00	22.00	1,117⅓	1,161	43.5	—15.0	42.0	44.0	42.0	42.7	Rain.
	27,	11.00	11.00	22.00	1,122⅓	1,162⅓	40.0	0	43.0	42.0	44.0	43.0	"
	28,	11.00	11.00	22.00	1,110	1,167⅓	57.5	—12.5	48.0	50.0	48.0	48.7	"
	29,	11.00	11.00	22.00	1,122	1,165	43.0	12.0	49.0	47.0	44.0	46.7	Cloudy.
	30,	10.82	11.00	21.82	1,112⅓	1,160	47.5	—9.5	48.0	43.0	38.0	43.0	Snow.
	31,	11.00	11.00	22.00	1,112⅔	1,167⅓	55.0	0	42.0	42.0	41.0	41.7	"
February	1,	. . . . .	. . . . .	. . . . .	1,120	. . . . .	. . . . .	7.5	37.0	36.0	35.0	36.0	Cloudy.

TABLE VIII.—*Weight Records, Set I, Period II, February 1–February 28, 1886.*

Date.	Steer 1.							Steer 2.							Steer 3.						
	Food eaten.			Live weight.				Food eaten.			Live weight.				Food eaten.			Live weight.			
	Fodder.	Mixed meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Fodder.	Cornmeal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Fodder.	Cornmeal.*	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
February 1, . . .	7.11	10.50	17.61	1,060	1,060	0	—2.0	4.73	14.00	18.73	1,000	1,030	30.0	10.0	6.57	7.75	14.32	1,140	1,180	40.0	10.0
2, . . .	7.11	10.50	17.61	1,025	1,100	75.0	—35.0	4.92	14.00	18.92	1,010	1,037½	27.5	10.0	6.01	0	6.01	1,140	1,175	35.0	0
3, . . .	7.64	10.50	18.14	1,065	1,100	35.0	40.0	4.73	14.00	18.73	1,015	1,010	25.0	5.0	6.39	0	6.39	1,140	1,157½	17.5	0
4, . . .	7.82	10.50	18.32	1,065	1,105	40.0	0	4.92	14.00	18.92	1,020	1,010	20.0	5.0	7.46	0	7.46	1,135	1,150	15.0	—5.0
5, . . .	7.82	10.50	18.32	1,075	1,110	35.0	10.0	4.73	14.00	18.73	1,020	1,050	30.0	0	7.46	0	7.46	1,130	1,150	20.0	—3.0
6, . . .	7.82	10.50	18.32	1,065	1,110	45.0	—10.0	3.96	14.00	17.96	1,025	1,045	20.0	5.0	7.64	0	7.64	1,110	1,155	45.0	—20.0
7, . . .	7.64	10.50	18.14	1,075	1,117½	42.5	10.0	4.54	14.00	18.54	1,025	1,055	30.0	0	7.64	14.00	21.64	1,130	1,160	30.0	20.0
8, . . .	7.82	10.50	18.32	1,075	1,115	40.0	0	3.96	14.00	17.96	1,030	1,055	25.0	5.0	6.75	14.00	20.75	1,135	1,155	20.0	5.0
9, . . .	7.46	10.50	17.96	1,075	1,075	0	0	5.50	14.00	19.50	1,037	1,060	23.0	7.0	6.75	14.00	20.75	1,120	1,157	37.0	—15.0
10, . . .	7.64	10.50	18.14	1,040	1,105	65.0	—35.0	5.32	14.00	19.32	1,035	1,052½	17.5	—2.0	6.57	9.25	15.82	1,120	1,135	15.0	0
11, . . .	7.82	10.50	18.32	1,070	1,115	45.0	30.0	5.32	14.00	19.32	1,035	1,065	30.0	0	3.67	10.25	13.92	1,090	1,157½	67.5	—30.0
12, . . .	7.64	10.50	18.14	1,077½	1,105	27.5	7.5	4.92	14.00	18.92	1,040	1,070	30.0	5.0	4.73	6.75	11.48	1,130	1,175	45.0	40.0
13, . . .	7.82	10.50	18.32	1,065	1,085	20.0	—12.5	4.35	14.00	18.35	1,045	1,070	25.0	5.0	5.68	8.75	14.43	1,145	1,170	25.0	15.0
14, . . .	7.46	10.50	17.96	1,050	1,105	55.0	—15.0	4.73	14.00	18.73	1,045	1,062½	17.5	0	3.96	5.00	8.96	1,140	1,165	25.0	—5.0
15, . . .	7.66	10.50	18.14	1,065	1,065	0	15.0	4.48	14.00	18.48	1,045	1,072½	27.5	0	5.08	14.00	19.08	1,125	1,125	0	—15.0
16, . . .	7.66	10.50	18.14	1,045	1,107½	62.5	—20.0	4.29	14.00	18.29	1,055	1,080	25.0	10.0	6.54	14.00	20.54	1,095	1,140	45.0	—30.0
17, . . .	7.32	10.50	17.82	1,065	1,115	50.0	20.0	4.09	14.00	18.09	1,055	1,075	20.0	0	6.36	14.00	20.36	1,122½	1,155	32.5	27.5
18, . . .	7.49	10.50	17.99	1,075	1,117½	42.5	10.0	4.48	14.00	18.48	1,045	1,077½	32.5	—10.0	5.99	14.00	19.99	1,120	1,165	45.0	—2.5
19, . . .	7.66	10.50	18.16	1,080	1,120	40.0	5.0	4.29	14.00	18.29	1,050	1,072½	22.5	5.0	5.81	14.00	19.81	1,135	1,170	35.0	15.0
20, . . .	7.66	10.50	18.16	1,085	1,110	25.0	5.0	4.29	14.00	18.29	1,055	1,070	15.0	5.0	7.27	14.00	21.27	1,135	1,162½	27.5	0
21, . . .	7.64	10.50	18.14	1,070	1,120	50.0	—15.0	4.54	14.00	18.54	1,045	1,070	25.0	—10.0	7.29	14.00	21.29	1,122½	1,16[illegible]½	40.0	—12.5
22, . . .	7.82	10.50	18.32	1,085	1,125	40.0	15.0	6.39	14.00	20.39	1,055	1,085	30.0	10.0	7.64	14.00	21.64	1,135	1,172½	37.5	12.0
23, . . .	7.82	10.50	18.32	1,090	1,120	30.0	5.0	5.32	14.00	19.32	1,062½	1,062½	0	7.5	7.16	14.00	21.61	1,132½	1,175	42.5	—2.5
24, . . .	7.64	10.50	18.14	1,090	1,117½	27.5	0	4.92	14.00	18.92	1,042½	1,085	42.5	—20.0	6.93	14.00	20.93	1,135	1,182½	47.5	2.5
25, . . .	7.82	10.50	18.32	1,080	1,125	45.0	—10.0	4.92	14.00	18.92	1,065	1,092½	27.5	22.5	6.75	14.00	20.75	1,140	1,185	45.0	5.0
26, . . .	7.82	10.50	18.32	1,100	1,120	20.0	20.0	5.32	14.00	19.32	1,065	1,095	30.0	0	7.11	14.00	21.11	1,150	1,180	30.0	10.0
27, . . .	7.82	10.50	18.32	1,085	1,130	45.0	15.0	4.92	14.00	18.92	1,070	1,095	25.0	5.0	6.93	14.00	20.93	1,142½	1,180	37.5	—7.5
28, . . .	7.82	10.50	18.32	1,090	1,135	45.0	5.0	4.73	14.00	18.73	1,075	1,100	25.0	5.0	6.75	14.00	20.75	1,155	1,192½	47.5	12.5
March 1, . . .	. . . .	. . . .	. . . .	1,110	. . . .	. . .	20.0	. . . .	. . . .	. . . .	1,080	. . . .	. . .	5.0	. . . .	. . . .	. . . .	1,153	. . . .	. . .	0

* Mixed meal until the 7th.

TABLE VIII—Continued.

DATE.	STEER 4. FOOD EATEN. Fodder.	Mixed meal *	Total.	LIVE WEIGHT. Before watering.	After watering.	Water drunk.	Gain in weight.	TEMPERATURE OF STABLE. 7, A. M.	12, M.	5, P. M.	Mean.	Weather notes.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	F.°	F.°	F.°	F.°	
February 1,	8.00	14.00	22.00	1,120	1,170	50.0	7.5	37.0	36.0	35.0	36.0	Cloudy.
2,	8.00	14.00	22.00	1,125	1,172½	47.5	5.0	39.0	35.0	34.0	36.0	Fair.
3,	8.00	14.00	22.00	1,125	1,170	45.0	0	34.0	33.0	30.0	32.3	Cloudy.
4,	8.00	14.00	22.00	1,130	1,175	45.0	5.0	30.0	26.0	26.0	27.3	High wind.
5,	8.00	14.00	22.00	1,140	1,170	30.0	10.0	25.0	26.0	24.0	25.0	Fair.
6,	8.00	14.00	22.00	1,130	1,175	45.0	—10.5	28.0	29.0	30.0	29.0	Snow.
7,	8.00	10.50	22.00	1,135	1,175	40.0	5.0	39.0	38.0	38.0	38.3	Fair.
8,	8.00	10.50	18.50	1,135	1,182½	47.5	0	42.0	44.0	45.0	43.7	"
9,	8.00	10.50	18.50	1,137½	1,175	37.5	2.5	43.0	47.0	48.0	46.0	"
10,	8.00	10.50	18.50	1,130	1,172½	42.5	—7.5	45.0	48.0	50.0	47.7	"
11,	8.00	10.50	18.50	1,130	1,172½	42.5	0	48.0	50.0	48.0	48.7	Rain.
12,	8.00	10.50	18.50	1,135	1,175	40.0	5.0	49.0	51.0	50.0	50.0	"
13,	8.00	10.50	18.50	1,127½	1,165	37.5	—7.5	51.0	50.0	48.0	49.7	Cloudy.
14,	8.00	10.50	18.50	1,120	1,170	50.0	—7.5	50.0	54.0	51.0	51.7	Fair.
15,	8.00	10.50	18 50	1,130	1,160	30.0	10.0	50.0	48.0	44.0	57.3	Cloudy.
16,	8.00	10.50	18.50	1,120	1,165	45.0	—10.0	42.0	39.0	39.0	40.0	High wind.
17,	8.00	10.50	18.50	1,125	1,165	40.0	5.0	40.0	38.0	39.0	39.0	Fair.
18,	8.00	10.50	18.50	1,120	1,170	50.0	—5.0	47.0	45.0	49.0	47.0	"
19,	8.00	10.50	18.50	1,127½	1,167½	40.0	7.5	52.0	46.0	49.0	49.0	Cloudy.
20,	8.00	10.50	18.50	1,132½	1,170	37.5	5.0	39.0	34.0	35.0	36.0	Windy.
21,	8.00	10.50	18.50	1,140	1,170	30.0	7.5	37.0	34.0	40.0	37.0	"
22,	8.00	10.50	18.50	1,130	1,165	35.0	—10.0	41.0	42.0	41.0	41.3	"
23,	8.00	10.50	18.50	1,130	1,170	40.0	0	48.0	47.0	44.0	46.3	Fair.
24,	8.00	10.50	18.50	1,132½	1,175	42.5	2.5	42.0	41.0	40.0	41.0	"
25,	8.00	10.50	18.50	1,135	1,177½	42.5	2.5	43.0	48.0	50.0	47.0	Snow.
26,	8.00	10.50	18.50	1,135	1,165	30.0	0	34.0	31.0	31.0	32.0	High wind.
27,	8.00	10.50	18 50	1,130	1,175	45.0	—5.0	28.0	31.0	30.0	29.7	Fair.
28,	8.00	10.50	18.50	1,135	1,177½	42.5	5.0	38.0	32.0	33.0	35.7	"
March 1,	.....	.....	.....	1,140	.....	.....	5.0	33.0	31.0	32.0	32.0	"

* Cornmeal until the 7th.

TABLE IX.—*Weight Records, Set I, Period III, March 1–March 29.*

DATE.	STEER 1.							STEER 2.							STEER 3.						
	FOOD EATEN.			LIVE WEIGHT.				FOOD EATEN.			LIVE WEIGHT.				FOOD EATEN.			LIVE WEIGHT.			
	Hay.	Mixed meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Hay.	Corn meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Hay.	Corn meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
March 1,	11.00	10.50	21.50	1,110	1,140	30.0	20.0	10.75	14.00	21.75	1,080	1,080	0	5.0	10.75	14.00	24.75	1,155	1,185	30.0	0
2,	11.00	10.50	21.50	1,100	1,140	40.0	—10.0	8.88	14.00	22.88	1,060	1,110	50.0	—20.0	9.75	14.00	23.75	1,152½	1,200	47.5	—2.5
3,	11.00	10.50	21.50	1,107½	1,145	37.5	7.5	9.00	14.00	23.00	1,080	1,115	35.0	20.0	9.38	14.00	23.38	1,162½	1,205	42.5	10.0
4,	11.00	10.58	21.50	1,115½	1,155	42.5	5.0	9.25	14.00	23.25	1,090	1,132½	42.5	10.0	8.75	14.00	22.75	1,170	1,220	50.0	7.5
5,	11.00	10.50	21.50	1,117	1,170	53.0	1.5	9.25	14.00	23.25	1,100	1,120	20.0	10.0	10.25	14.00	24.25	1,175	1,210	45.0	5.0
6,	11.00	10.50	21.50	1,120	1,170	50.0	3.0	9.25	14.00	23.25	1,085	1,110	25.0	—15.0	9.63	14.00	23.63	1,170	1,235	65.0	—5.0
7,	11.00	10.50	21.50	1,117½	1,165	47.5	—2.5	9.63	14.00	23.63	1,080	1,120	40.0	—5.0	9.88	14.00	23.88	1,185	1,235	50.0	15.0
8,	11.00	10.50	21.50	1,115	1,160	45.0	—2.5	8.63	14.00	22.63	1,090	1,130	40.0	10.0	8.88	14.00	22.88	1,185	1,236	51.0	0
9,	11.00	10.50	21.50	1,112	1,160	48.0	—3.0	8.75	14.00	22.75	1,097	1,130	33.0	7.0	8.63	14.00	22.63	1,182½	1,232½	50.0	—2.5
10,	11.00	10.50	21.50	1,117½	1,157½	40.0	5.5	10.13	14.00	24.13	1,097½	1,135	37.5	0.5	9.50	14.00	23.50	1,182½	1,240	57.5	0
11,	11.00	10.50	21.50	1,110	1,170	60.0	—7.5	9.38	14.00	23.38	1,105	1,140	35.0	7.5	9.75	14.00	23.75	1,185	1,242½	57.5	2.5
12,	11.00	10.50	21.50	1,120	1,160	30.0	20.0	9.63	14.00	23.63	1,105	1,142½	37.5	0	9.75	14.00	23.75	1,190	1,242½	52.5	5.0
13,	11.00	10.50	21.50	1,112	1,165	53.0	—18.0	8.88	14.00	22.88	1,105	1,140	35.0	0	10.38	14.00	24.38	1,192½	1,255	62.5	2.0
14,	11.00	10.50	21.50	1,125	1,180	55.0	13.0	9.75	14.00	23.75	1,105	1,150	45.0	0	10.25	14.00	24.25	1,202½	1,262	59.5	10.0
15,	11.00	10.50	21.50	1,135	1,177½	42.5	10.0	4.50	14.00	18.50	1,114	1,150	36.0	9.0	9.88	14.00	23.88	1,210	1,255	45.0	7.5
16,	11.00	10.50	21.50	1,137½	1,175	37.5	2.5	1.00	13.50	14.50	1,115	1,150	35.0	1.0	9.13	14.00	23.13	1,205	1,257½	52.0	—5.0
17,	11.00	10.50	21.50	1,132	1,170	37.5	—5.0	2.00	13.50	15.50	1,117½	1,130	12.5	2.5	9.88	14.00	23.88	1,207½	1,250	42.0	2.5
18,	11.00	10.50	21.50	1,125	1,167½	42.5	—7.5	1.25	11.50	12.75	1,105	1,130	25.0	—12.5	9.63	14.00	23.63	1,192½	1,250	57.5	—15.0
19,	11.00	10.50	21.50	1,125	1,175	50.0	0	8.38	13.75	22.13	1,105	1,105	0	0	9.13	14.00	23.13	1,200	1,252½	52.5	7.5
20,	11.00	10.50	21.50	1,127	1,177	50.0	2.0	10.50	6.50	17.00	1,090	1,132½	42.5	—15.0	10.00	14.00	24.00	1,202	1,255	53.0	2.0
21,	11.00	10.50	21.50	1,120	1,175	55.0	—7.0	10.13	14.00	24.13	1,110	1,145	35.0	20.0	10.00	14.00	24.00	1,195	1,260	65.0	—7.0
22,	11.00	10.50	21.50	1,130	1,175	45.0	10.0	9.66	14.00	23.66	1,122½	1,160	37.5	12.5	9.49	14.00	23.49	1,200	1,250	50.0	5.0
23,	11.00	10.50	21.50	1,132½	1,175	42.5	2.5	9.12	14.00	23.12	1,132½	1,162½	30.0	10.0	9.84	14.00	23.84	1,200	1,247	47.0	0
24,	11.00	10.50	21.50	1,130	1,185	55.0	—2.5	8.85	14.00	22.85	1,130	1,165	35.0	—2.5	10.19	14.00	24.19	1,200	1,252½	52.5	0
25,	11.00	10.50	21.50	1,140	1,190	50.0	10.0	9.52	14.00	23.52	1,130	1,165	35.0	0	10.53	14.00	24.53	1,202½	1,270	67.5	2.5
26,	11.00	10.50	21.50	1,145	1,145	0	5.0	7.91	14.00	21.91	1,130	1,170	40.0	0	10.65	14.00	24.65	1,217½	1,267½	50.0	15.0
27,	11.00	10.90	21.50	1,107½	1,177½	70.0	—37.5	9.25	14.00	23.25	1,133	1,170	37.0	3.0	10.30	14.00	24.30	1,220	1,272½	52.5	2.5
28,	11.00	10.50	21.50	1,142½	1,200	57.5	35.0	8.45	14.00	22.45	1,135	1,172½	37.5	2.0	11.00	14.00	25.00	1,210	1,270	60.0	—10.0
29,	. . . .	. . . .	. . . .	1,155	1,195	40.0	12.5	. . . .	. . . .	. . . .	1,137½	1,172½	35.0	2.5	. . . .	. . . .	. . . .	1,215	1,272½	57.5	5.0

TABLE IX—Continued.

Date.	Steer 4. Food eaten. Hay.	Food eaten. Mixed meal.	Food eaten. Total.	Live weight. Before watering.	Live weight. After watering.	Water drunk.	Gain in weight.	Temperature of stable. 7 A. M.	12 M.	5 P. M.	Mean.	Weather notes.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	F.°	F.°	F.°	F.°	
March 1,	11.00	10.50	21.50	1,140	1,165	25.0	5.0	33.0	31.0	32.0	32.0	Fair.
2,	11.00	10.50	21.50	1,120	1,175	55.0	—20.0	29.0	30.0	30.0	29.7	High wind.
3,	11.00	10.50	21.50	1,140	1,185	45.0	20.0	33.0	35.0	35.0	34.3	Cloudy.
4,	11.00	10.50	21.50	1,145	1,197½	52.5	5.0	40.0	39.0	38.0	39.0	"
5,	11.00	10.50	21.50	1,155	1,195	40.0	10.0	43.0	43.0	42.0	42.7	Fair.
6,	11.00	10.50	21.50	1,150	1,205	55.0	—5.0	43.0	43.0	42.0	42.7	"
7,	11.00	10.50	21.50	1,160	1,210	50.0	10.0	46.0	46.0	46.0	46.0	"
8,	11.00	10.50	21.50	1,162½	1,210	47.5	2.5	47.0	46.0	44.0	45.7	Snow.
9,	11.00	10.50	21.50	1,160	1,20 ½	47.5	—2.5	48.0	46.0	45.0	46.3	Cloudy.
10,	11.00	10.50	21.50	1,167	1,215	48.0	7.0	47.0	45.0	44.0	45.3	Snow.
11,	11.00	10.50	21.50	1,162½	1,12 ½	60.0	—4.5	45.0	44.0	46.0	45.0	Fair.
12,	11.00	10.50	21.50	1,175	1,215	40.0	12.5	48.0	50.0	51.0	49.7	Cloudy.
13,	11.00	10.50	21.50	1,167	1,20 ½	40.0	8.0	52.0	52.0	48.0	50.7	"
14,	11.00	10.50	21.50	1,165	1,217½	52.5	—2.0	46.0	48.0	49.0	47.7	Fair.
15,	11.00	10.50	21.50	1,177	1,231	54.0	12.0	45.0	54.0	56.0	51.7	"
16,	11.00	10.50	21.50	1,180	1,22 ½	47.5	—3.0	56.0	53.0	50.0	53.0	High wind.
17,	11.00	10.50	21.50	1,180	1,217	37.0	0	46.0	53.0	54.0	51.0	Fair.
18,	11.00	10.50	21.50	1,170	1,232½	62.5	—10.0	48.0	52.0	54.0	51.3	Cloudy.
19,	11.00	10.50	21.50	1,187½	1,230	42.5	17.5	49.0	52.0	51.0	50.7	"
20,	11.00	10.50	21.50	1,185	1,235	50.0	2.5	55.0	56.0	53.0	54.7	"
21,	11.00	10.50	21.50	1,177½	1,227½	50.0	—7.5	56.0	56.0	52.0	54.7	"
22,	11.00	10.50	21.50	1,192½	1,220	47.5	5.0	49.0	46.0	46.0	47.0	High wind.
23,	11.00	10.50	21.50	1,180	1,222½	42.5	7.5	45.0	44.0	43.0	44.0	Snow.
24,	11.00	10.50	21.50	1,177½	1,220	42.5	—2.0	43.0	45.0	46.0	44.7	Fair.
25,	11.00	10.50	21.50	1,172½	1,230	57.5	5.0	50.0	57.0	59.0	55.3	"
26,	11.00	10.50	21.50	1,185	1,235	50.0	12.5	53.0	53.0	52.0	52.7	Cloudy.
27,	11.00	10.50	21.50	1,185	1,227½	47.5	0	51.0	52.0	49.0	50.7	"
28,	11.00	10.50	21.50	1,175	1,235	60.0	—10.0	50.0	50.0	50.0	50.0	"
29,	. . . . .	. . . . .	. . . . .	1,187½	1,230	42.5	12.5	45.0	45.0	. . . . .	45.0	High wind.

(*i.*) RELATION OF WATER DRUNK TO VARIATIONS IN WEIGHT.

Before entering upon the discussion of the relative effects of the experimental rations, it may be well to consider the relation of the amount of water drunk to the daily gain or loss in weight, and to temperature.

The data for a single period will suffice for this purpose. The following table (X) shows the mean daily temperatures, the variations in the amounts of water drunk from the mean amount for the period, and the daily variations in live weight for Period I:

Table X.—*Showing Daily Variations in Weight, with Different Amounts of Water Drunk.*

Date.	Mean temperature.	No. 1. Water. Drunk.	No. 1. Water. Difference from average.	No. 1. Change in weight.	No. 2. Water. Drunk.	No. 2. Water. Difference from average.	No. 2. Change in weight.	No. 3. Water. Drunk.	No. 3. Water. Difference from average.	No. 3. Change in weight.	No. 4. Water. Drunk.	No. 4. Water. Difference.	No. 4. Change in weight.
	F.°	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1885.		Av.=37.0			Av.=25.2			Av.=40 4			Av.=45.8		
December 28, . .	. . . .	35.0	—2.0	. . . .	32.5	+7.3	. . . .	37.5	—2.9	. . . .	37.5	—8.3	. . . .
29, . .	43.7	22.0	—15.0	+5.0	23.0	—2.2	+10.0	35.0	—5.4	—2.0	50.0	+4.2	—5.0
30, . .	44.3	45.0	+8.0	—12.5	32.5	+7.3	—2.5	35.0	—5.4	—3.0	42.5	—3.3	+10.0
31, . .	46.7	42.5	+5.5	+12.5	32.5	+7.3	+5.0	42.5	+2.1	—2.5	50.0	+4.2	—2.5
1886.													
January 1, . .	46.0	37.5	+0.5	+5.0	22.5	—2.7	+2.5	55.0	+14.6	+7.5	50.0	+4.2	0
2, . .	47.3	40.0	+3.0	0	40.0	+14.8	—5.0	35.0	—5.4	+27.5	90.0	+46.2	—5.0
3, . .	45.3	0	—37.0	—2.5	20.0	—5.2	+15.0	25.0	—15.4	—5.0	65.0	+19.2	—10.0
4, . .	54.7	62.5	+25.5	—35.0	27.5	+2.3	—2.5	55.0	+14.6	—12.5	45.0	—0.8	+30.0
5, . .	48.7	5.5	—31.5	+20.0	25.0	—0.2	—7.5	35.0	—5.4	+10.0	50.0	+4.2	—15.0
6, . .	38.7	55.0	+18.0	—17.5	20.0	—5.2	0	40.0	—0.4	—7.5	60.0	+14.2	—7.5
7, . .	36.3	45.0	+8.0	+27.5	42.5	+17.3	+2.5	45.0	+4.6	+7.5	45.0	—0.8	+17.5
8, . .	32.3	42.5	+5.5	+12.5	15.0	—10.2	+14.5	42.5	+2.1	+7.5	50.0	+4.2	+5.0
9, . .	32.0	29.5	—7.5	+2.5	27.5	+2.3	—4.5	35.0	—5.4	+7.5	30.0	—15.8	+10.0
10, . .	24.3	50.0	+13.0	—2.5	27.5	+2.3	+7.5	45.0	+4.6	0	32.5	—13.3	—10.0
11, . .	22.7	30.0	—7.0	+15.0	15.0	—10.2	+5.0	50.0	+9.6	—2.5	50.0	+4.2	—7.5
12, . .	26.7	40.0	+3.0	0	30.0	+4.8	—7.5	40.0	—0.4	+7.5	27.5	—18.3	+17.5
13, . .	24.0	25.0	—12.0	+10.0	35.0	+9.8	+7.5	40.0	—0.4	+5.0	37.5	—8.3	—2.5
14, . .	25.3	35.0	—2.0	—10.0	22.5	—2.7	—2.5	40.0	—0.4	—5.0	35.0	—10.8	—7.5
15, . .	28.3	35.0	—2.0	0	25.0	—0.2	—2.5	52.5	+12.1	+7.5	55.0	+9.2	0
16, . .	36.0	35.0	—2.0	+5.0	35.0	+9.8	0	25.0	—15.4	+10.0	40.0	—5.8	+15.0
17, . .	38.0	40.0	+3.0	—5.0	35.0	+9.8	+5.0	50.0	+9.6	—15.0	50.0	+4.2	—5.0
18, . .	38.3	40.0	+3.0	—5.0	20.0	—5.2	+10.0	27.5	—12.9	+17.5	32.5	—13.6	+7.5

Table X.—Continued.

Date.	Mean temperature.	No. 1. Water. Drunk.	No. 1. Water. Difference from average.	No. 1. Change in weight.	No. 2. Water. Drunk.	No. 2. Water. Difference from average.	No. 2. Change in weight.	No. 3. Water. Drunk.	No. 3. Water. Difference from average.	No. 3. Change in weight.	No. 4. Water. Drunk.	No. 4. Water. Difference from average.	No. 4. Change in weight.
1886.	F.°	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
January 19.	41.3	45.0	+8.0	+2.5	20.0	—5.2	—10.0	42.5	+2.1	—12.5	47.5	+1.7	—7.5
20.	37.7	45.0	+8.0	0	32.5	+7.3	—5.0	5.0	—35.4	+7.5	40.0	—5.8	+10.0
21.	41.7	45.0	+8.0	+2.5	20.0	—5.2	+7.5	45.0	+4.6	—35.0	50.0	+4.2	—5.0
22.	41.0	37.5	+0.5	+10.0	37.5	+12.3	—7.5	67.5	+27.1	+12.5	40.0	—5.8	+12.5
23.	35.0	37.5	+0.5	0	7.5	—17.7	+17.5	45.0	+4.6	+22.5	40.0	—5.8	+2.5
24.	31.3	35.0	—2.0	0	40.0	+14.8	—12.5	47.5	+7.1	+2.5	40.0	—5.8	0
25.	33.0	27.5	—9.5	+2.5	0	—25.2	+20.0	0	—40.4	+7.5	32.5	—13.3	+12.5
26.	42.7	35.0	—2.0	—7.5	35.0	+9.8	—25.0	70.0	+29.6	—35.0	43.5	—12.3	—15.0
27.	43.0	0	—37.0	+10.0	0	—25.2	+2.5	32.5	—7.9	+30.0	40.0	—5.8	+5.0
28.	48.7	60.0	+23.0	—37.5	30.0	+4.8	—25.0	55.0	+14.6	—15.0	57.5	+11.7	—12.5
29.	46.7	32.5	—4.5	+25.0	15.0	—10.2	+17.5	35.0	—5.4	+15.0	43.0	—2.8	+12.0
30.	43.0	37.5	+0.5	—2.5	17.5	+7.7	—2.5	30.0	—10.4	—5.0	47.5	+1.7	—9.5
31.	41.7	40.0	+3.0	+7.0	20.0	—5.2	—7.5	50.0	+9.6	—15.0	55.0	+9.2	0
February 1.	36.0	.....	.....	—2.0	.....	.....	+10.0	.....	.....	+10.0	.....	.....	+7.5

Upon the consideration of these data the following facts are discovered:

1. The amount of water drunk each day varies greatly.

2. The immediate effect of the amount of water drunk in one day upon the live weight is extended over a greater period than twenty-four hours.

3. That the daily variations in live weight are mainly due to variations in the amounts of water drunk, and that, therefore, in discussing the effects of any rations upon the live weight, it is well to know the relation of the amount of water drunk on several preceding days to this weight.

4. Some other cause than a variation in the mean temperature of the stable seems to be principally chargeable with the variation in the amount of water drunk, since it is noticeable that the variation is not always in the same direction with the different steers at the same time.

The above data show how very far from conclusive must results be that are based solely upon live weights taken at infrequent intervals. They also indicate that a correction of the live weight by the addition or subtraction of the deficiency or excess in the amount of water drunk on the previous day, comparing it with the average amount for that portion of the period in which it occurs, will partially eliminate the error caused by an increase in live weight not due to real increase in the weight of carcass. When, however, as frequently happens, the amount of water drunk the second day previous to the weighing, has fallen far below or far exceeds the normal amount, and has, as is usual in such cases, been followed by a corresponding increase or decrease in the amount drunk on the next day, it would seem proper in making corrections to take into account the amounts drunk for several days preceding the date of the weighing to be corrected. It is, therefore, impossible to establish any rule of procedure which can always be followed with safety, and the experimenter must decide each case according to his knowledge of the influencing conditions.

(ii.) *Digestion Experiments.*

The method according to which these experiments were conducted, has already been given.

The following tables (XI and XII) show the amounts of food and water taken by each steer during the digestion experiments in the different periods, and also the amounts of dung and urine excreted during the same time. Tables XIII and XIV show the composition of the feeding stuffs, including that of the fodder and hay refused by the different steers in Periods II and III, and also that of the dungs.

TABLE XI.—*Food and Water Taken During Digestion Experiments.*

	Water.	Cornfodder.	Hay.	Cornmeal	Cottonseed meal.
Period I. (*Jan.* 25-29.)	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Steer 1,	155.0	46.16	....	55.00	....
2,	80.0	26.94	....	47.50	....
3,	192.5	45.65	....	55.00	....
4,	216.5	55.00	....	55.00	....
Period II. (*Feb.* 15-19.)					
Steer 1,	195.0	37.25	....	35.00	17.50
2,	127.5	18.00	....	70.00	....
3,	157.5	28.25	....	70.00	....
4,	205.0	40.00	....	35.00	17.50
Period III. (*March* 15-19.)					
Steer 1,	210.0	....	55.00	35.00	17.50
2,	108.5	....	17.13	66.25	....
3,	250.0	....	47.65	70.00	....
4,	243.5	....	55.00	35.00	17.50

TABLE XII.—*Weights of Dung and Urine Excreted During Digestion Experiments.*

DATE.	STEER 1.		STEER 2.		STEER 3.		STEER 4.	
	Dung.	Urine.	Dung.	Urine.	Dung.	Urine.	Dung.	Urine.
Period I.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
*January 26,	28.31	6.91	17.12	3.92	29.52	5.67	34.94	8.56
27,	22.25	4.02	17.19	11.55	34.28	5.53	25.00	12.45
28,	22.25	7.12	12.84	4.87	35.37	5.19	32.72	12.89
29,	14.78	3.50	8.23	5.73	32.03	4.01	30.94	11.19
30,	25.81	2.00	14.69	2.16	29.77	4.48	38.44	12.77
Total,	113.40	23.55	70.07	28.23	160.97	24.88	162.04	57.86
Period II.								
February 16,	18.64	6.19	19.11	3.11	18.09	6.23	28.25	15.62
17,	19.62	8.19	17.62	4.80	15.62	4.53	26.50	11.00
18,	25.62	7.75	21.25	4.83	25.59	4.78	26.16	11.31
19.	21.92	10.25	17.33	6.72	23.66	3.52	26.19	10.50
20,	21.83	5.91	13.85	4.55	29.52	3.53	23.37	12.86
Total,	107.13	38.29	89.16	24.01	112.48	22.61	130.47	60.79
Period III.								
March 16,	27.44	8.12	27.59	4.34	46.29	11.47	35.18	3.86
17,	31.94	11.80	25.06	3.69	46.59	3.02	33.19	12.69
18,	32.30	9.92	17.12	5.55	50.94	3.78	28.47	11.87
19,	24.28	9.78	18.50	4.92	52.28	4.36	31.19	12.58
20,	31.19	9.81	10.53	4.83	43.66	3.62	28.78	12.66
Total,	147.15	49.43	98.80	23.33	239.76	26.25	156.81	53.66

* These weights represent the amounts excreted from 12. M., of the day previous.

TABLE XIII.—*Composition of Feeding Stuffs Used in the Digestion Experiments.*

Index No.	Sample.	Loss in air drying.	Air-Dry Substance. Moisture.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein = N. × 6.25.	Crude ash.	Nitrogen.	Albuminoid nitrogen.	True albuminoids.
	Period I.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
165	Corn chop,	10.00	10.05	4.57	2.05	73.20	8.53	1.60	1.37	. . . . .	. . . . .
168	Fodder,	9.24	9.85	1.05	29.45	49.99	4.61	5.05	.74	.70	4.37
	Period II.										
249	Corn chop,	10.00	5.70	3.93	2.80	77.15	8.87	1.55	1.43	. . . . .	. . . . .
201	Cottonseed meal,	. . . . .	8.70	12.40	5.18	26.69	40.18	6.85	6.47	. . . . .	. . . . .
248	Fodder,	15.55	6.55	1.65	29.20	50.27	6.53	5.80	1.05	.80	4.96
255	" refused by Steer 1,	26.14	5.75	1.13	35.80	47.50	4.37	5.45	.70	.52	3.22
256	" " " " 2,	21.90	7.25	1.83(?)	28.30	50.71	6.26	5.65	1.01	.66	4.12
257	" " " " 3,	21.12	7.70	1.15	27.80	50.94	6.26	6.15	1.01	.74	4.61
	Period III.										
313	Corn chop,	10.00	9.45	4.30	2.00	72.31	10.44	1.50	1.68	. . . . .	. . . . .
	Cottonseed meal. Same as in Period II.										
306	Hay,	1.06	6.75	1.13	28.37	52.98	5.82	4.95	.95	.77	4.78
311	" refused by Steer 2,	1.13	7.80	1.45	26.15	53.38	6.12	5.10	.98	.91	5.65
312	" " " " 3,	1.13	7.45	1.70	32.03	48.81	6.26	3.75	1.01	.98	6.12

TABLE XIV.—*Composition of Dungs, Digestion Experiments.*

Index No.	Sample.	Loss in air drying.	Air-Dry Samples. Moisture.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein = N. × 6.25.	Crude ash.	Nitrogen.
	Period I.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
157	Steer 1,	81.03	8.60	2.53	19.00	46.02	12.35	11.50	1.98
158	" 2,	82.03	9.05	2.45	14.78	48.76	13.66	11.30	2.19
159	" 3,	85.50	9.05	3.87	15.83	48.36	11.74	11.15	1.88
160	" 4,	81.37	8.10	2.95	16.10	49.15	10.70	13.00(?)	1.71
	Period II.								
208	Steer 1,	78.89	7.50	5.05	19.00	41.22	14.53	12.70(?)	2.32
209	" 2,	78.83	7.80	4.73	11.18	53.42	13.92	9.00	2.23
210	" 3,	81.53	6.75	4.93	18.93	46.47	13.22	9.70	2.12
211	" 4,	83.82	7.95	2.25	17.65	46.00	14.35	11.80	2.30
	Period III.								
266	Steer 1,	81.02	6.75	4.77	21.05	43.56	13.92	9.95	2.23
267	" 2,	80.08	6.15	3.65	20.83	49.69	12.18	7.50	1.95
268	" 3,	85.78	6.35	3.97	23.50	49.23	10.00	6.95	1.60
269	" 4,	81.84	5.25	3.20	28.90	40.73	11.92	10.00	1.91

The ordinary methods of analysis were followed:

Moisture was determined by drying in an air oven, at 105° C.

Crude fat was determined by extraction with ether, and includes the wax and chlorophyll of the feeding stuffs, and some nitrogenous extractive matters in the case of the dungs.

Crude fiber was determined by the modification of the Weende method used in the laboratory of the United States Department of Agriculture: Successive heating, on the water-bath of 2 grams of substance, with 200 cc. of 5 per cent. hydrochloric acid, and 5 per cent. sodium hydrate, for two hours each, and careful washing with boiling water, ether, and alcohol, with final ignition.

Crude protein was obtained by multiplying the nitrogen, determined by the soda-lime method, by the factor 6.25.

Albuminoid nitrogen was determined by a modification of Stutzer's method, and *true albuminoids* obtained by multiplying by 6.25.

Crude ash was determined by very careful ignition in platinum crucibles under a cone.

Nitrogen-free extract, including starch, etc., was determined by difference.

Owing to the late date at which the above analyses were completed and tabulated for comparison, it has been impossible to repeat the determinations in several cases where it would be desirable. The chief discrepancies seem, however, to lie in the determinations of crude ash, and will, therefore, have little influence upon the matters of chief interest in these experiments.

In the following tables (XV–XVII,) are shown the amounts of the various proximate food constituents eaten, the amounts excreted as dung, and the amounts digested by each steer in the different periods, with their coefficients of digestibility, *i. e.*, the percentages of each digested out of the total amount eaten :

TABLE XV.—*Proximate Constituents Digested, Period I.*

	Water.	Dry substance.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein.	Crude ash.	Nitrogen.	Protein.*
STEER 1.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Eaten:—									
Fodder, (46.16 lbs.,)	8.392	37.768	.410	12.338	20.943	1.931	2.116	.310	1.831
Cornmeal, (55 lbs.,)	10.697	44.525	2.262	1.015	36.231	4.222	.792	.678	4.222
Water, ...	155.000								
Total, ...	174.089	82.293	2.702	13.353	57.177	6.153	2.908	.988	6.053
Excreted:—Dung, ...	92.731	19.669	.545	4.088	9.903	2.658	2.475	.426	
Digested, ...	. . . . .	62.624	2.157	9.265	47.274	3.495	.433	.562	
Coefficient of digestibility, . . .	. . . . .	76.1	79.8	69.5	82.7	56.8	14.9	56.8	
STEER 2.									
Eaten:—									
Fodder, (26.94 lbs.,)	4.898	22.042	.256	7.201	12.223	1.127	1.235	.181	1.069
Cornmeal, (47.5 lbs.,)	9.046	38.451	1.954	.876	31.293	3.627	.684	.586	3.627
Water, ...	80.000								
Total, ...	93.944	60.496	2.210	8.077	43.516	4.754	1.919	.767	4.696
Excreted:—Dung, ...	58.588	11.482	.309	1.861	6.139	1.720	1.423	.276	
Digested, ...	. . . . .	49.014	1.901	6.216	37.377	3.034	.496	.491	
Coefficient of digestibility, . . .	. . . . .	81.0	86.0	77.0	85.9	63.8	25.8	63.8	
STEER 3.									
Eaten:—									
Fodder, (45.65 lbs.,)	8.299	37.351	.435	12.202	20.712	1,910	2.092	.307	1.811
Cornmeal, (55 lbs.,)	10.697	44.525	2.262	1.015	36.234	4.222	.792	.678	4.222
Water, ...	192.500								
Total, ...	211.496	81.876	2.697	13 217	56.946	6.132	2.884	.985	6.033
Excreted:—Dung, ...	139.740	21.230	.903	3.695	11.280	2.740	2.603	.439	
Digested, ...	. . . . .	60.646	1.794	9.522	45.666	3.392	.281	.546	
Coefficient of digestibility, . . .	. . . . .	74.1	66.5	72.0	80.2	55.3	9.7	55.3	
STEER 4.									
Eaten:—									
Fodder, (55 lbs.,)	9.999	45.001	.524	14.701	24.951	2.301	2.521	.369	2.181
Cornmeal, (55 lbs.,)	10.697	44.525	2.262	1.015	36.234	4.222	.792	.678	4.222
Water, ...	216.500								
Total, ...	237.196	89.526	2.786	15.716	61.185	6.523	3.313	1.047	6.403
Excreted:—Dung, ...	138.765	23.275	.747	4.077	12.449	2.710	3.292(?)	.433	
Digested, ...	. . . . .	66.251	2.039	11.639	48.739	3.813	.021	.614	
Coefficient of digestibility, . . .	. . . . .	74.0	73.1	74.1	79.7	58.5	0.6	58.5	

* Or true albuminoids.

TABLE XVI.—*Proximate Constituents Digested, Period II.*

	Water.	Dry substance.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein.	Crude ash.	Nitrogen.	Protein.
STEER 1.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Eaten:—									
Fodder given, (40 lbs.,) . . .	8.433	31.567	.557	9.864	16.981	2.206	1.959	.355	1.675
" refused, (2.75 lbs.,) .	0.836	1.914	.023	.727	.965	.089	.110	.014	.065
" eaten,.	7.920	29.654	.534	9.137	16.016	2.117	1.849	.341	1.610
Cornmeal, (35 lbs.,)	5.296	29.704	1.238	.882	24.302	2.794	.488	.450	2.794
Cottonseed meal, (17.5 lbs.,) .	1.522	15.978	2.170	.907	4.671	7.031	1.199	1.132	7.031
Water, ...	195.000								
Total, ...	209.738	75.336	3.942	10.926	44.989	11.942	3.536	1.923	11.435
Excreted:—Dung, ...	86.207	20.923	1.142	4.298	9.323	3.287	2.873	.525	
Digested,.		54.413	2.800	6.628	35.666	8.655	.663	1.398	
Coefficient of digestibility, ...		72.2	71.0	60.6	79.3	72.5	18.7	72.5	
STEER 2.									
Eaten:—									
Fodder given, (40 lbs.,) . . .	8.433	31.567	.557	9.864	16.981	2.206	1.959	.355	1.675
" refused, (22 lbs.,) . .	6.064	15.936	.314	4.863	8.714	1.076	.971	.174	.708
" eaten, ...	4.175	15.631	.243	5.001	8.267	1.130	.988	.181	0.967
Cornmeal, (70 lbs.,)	10.592	59.408	2.576	1.764	48.604	5.588	.976	.900	5.588
Water, ...	127.500								
Total, ...	142.267	75.039	2.819	6.765	56.871	6.718	1.964	1.081	6.555
Excreted:—Dung, ...	71.754	17.406	.893	2.101	10.085	2.628	1.699	.421	
Digested..		57.633	1.926	4.664	46.786	4.090	.265	.660	
Coefficient of digestibility, . . .		76.8	68.3	68.9	82.3	60.9	13.5	60.9	
STEER 3.									
Eaten:—									
Fodder given, (40 lbs.,) . . .	8.433	31.567	.557	9.864	16.981	2.206	1.959	.355	1.675
" refused, (11.75 lbs.,) .	3.195	8.555	.107	2.577	4.721	.580	.570	.094	.427
" eaten,.	6.147	23.012	.450	7.287	12.260	1.626	1.389	.261	1.248
Cornmeal, (70 lbs.,).	10.592	59.408	2.576	1.764	48.604	5.588	.976	.900	5.588
Water.	157.500								
Total.	174.239	82.420	3.026	9.051	60.864	7.214	2.365	1.161	6.836
Excreted:—Dung,.	93.101	19.379	1.024	3.934	9.658	2.747	2.016	.441	
Digested..		63.041	2.002	5.117	51.206	4.467	.349	.720	
Coefficient of digestibility, . . .	. . .	76.5	66.2	56.5	84.1	61.9	14.8	61.9	
STEER 4.									
Eaten:—									
Fodder, (40 lbs.,)	8.433	31.567	.557	9.864	16.981	2.206	1.959	.355	1.675
Cornmeal, (35 lbs.,)	5.296	29.701	1.238	.882	24.302	2.794	.488	.450	2.794
Cottonseed meal, (17.5 lbs.,) .	1.522	15.978	2.170	.907	4.671	7.031	1.199	1.132	7.031
Water, ...	205.000								
Total, ...	220.251	77.249	3.965	11.653	45.954	12.031	3.646	1.937	11.500
Excreted:—Dung, ...	111.040	19.430	.475	3.725	9.710	3.029	2.491	.485	
Digested, ...		57.819	3.490	7.928	36.244	9.002	1.155	1.452	
Coefficient of digestibilily, ...		74.8	88.0	68.0	78.8	74.8	31.7	74.8	

TABLE XVII.—*Proximate Constituents Digested, Period III.*

	Water.	Dry substance.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein.	Crude ash.	Nitrogen.	Protein.
STEER 1.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Eaten:—									
Hay, (55 lbs.,).	4.256	50.744	.615	15.438	28.830	3.167	2.694	.517	2.601
Cornmeal, (35 lbs.,)	6.477	28.523	1.354	.630	22.778	3.289	0.472	.592	3.289
Cottonseed meal, (17.5 lbs.,) .	1.522	15.978	2.170	.907	4.671	7.031	1.199	1.132	7.031
Water, ...	210.000								
Total, ...	222.255	95.245	4.139	16.975	56.279	13.487	4.365	2.241	12.921
Excreted:—Dung, ...	121.103	26.047	1.332	5.880	12.168	3.888	2.779	.623	
Digested, ...	. . . . .	69.198	2.807	11.095	44.111	9.599	1.586	1.618	
Coefficient of digestibility, . . .	. . . . .	72.7	67.8	65.4	78.4	71.2	36.3	71.2	
STEER 2.									
Eaten:—									
Hay given, (55 lbs.,)	4.256	50.744	.615	15.438	28.830	3.167	2.694	.517	2.601
" refused, (37.87 lbs.,) . .	3.348	34.522	.543	9.791	19.987	2.291	1.910	.367	2.115
" eaten, ...	1.361	16.222	.072	5.647	8.843	.876	.784	.150	0.486
Cornmeal, (66.25 lbs., ...	12.260	53.990	2.564	1.192	43.115	6.225	.894	1.002	6.225
Water, ...	108.500								
Total, ...	122.121	70.212	2.636	6.834	51.958	7.101	1.678	1.152	6.711
Excreted:—Dung, ...	80.328	18.472	.718	4.100	9.781	2.397	1.476	.384	
Digested, ...	. . . . .	51.740	1.918	2.739	42.177	4.704	.202	.768	
Coefficient of digestibility, . . .	. . . . .	73.7	72.8	40.0	81.2	66.2	12.0	66.2	
STEER 3.									
Eaten:									
Hay given, (55 lbs.,)	4.256	50.744	.615	15.438	28.830	3.167	2.694	.517	2.601
" refused, (7.35 lbs.,) . . .	.624	6.736	.124	2.328	3.547	.455	.272	.073	.445
" eaten, ...	3.692	44.008	.491	13.110	25.283	2.712	2.422	.444	2.156
Cornmeal, (70 lbs.,)	12.954	57.046	2.708	1.260	45.556	6.578	0.944	1.184	6.578
Water, ...	250.000								
Total, ...	266.646	101.054	3.199	14.370	70.839	9.290	3.366	1.628	8.734
Excreted:—Dung, ...	207.843	31.917	1.353	8.009	16.778	3.408	2.369	.509	
Digested.	. . . . .	69.137	1.846	6.361	54.061	5.882	.997	1.119	
Coefficient of digestibility, . . .	. . .	68.4	57.7	44.3	76.3	63.3	26.2	63.3	
STEER 4.									
Eaten:—									
Hay, (55 lbs.,)	4.256	50.744	.615	15.438	28.830	3.167	2.694	.517	2.601
Cornmeal, (35 lbs.,)	6.477	28.523	1.354	.630	22.778	3.289	0.472	.592	3.289
Cottonseed meal, (17.5 lbs.,) .	1.522	15.978	2.170	.907	4.671	7.031	1.199	1.132	7.031
Water, ...	243.500								
Total, ...	255.755	95.245	4.139	16.975	56.279	13.487	4.365	2.241	12.921
Excreted:—Dung, ...	129.808	27.002	.912	8.235	11.606	3.396	2.849	.544	
Digested, ...	. . . . .	68.243	3.227	8.740	44.673	10.091	1.516	1.697	
Coefficient of digestibility, . . .	. . . . .	71.6	78.0	51.5	79.4	74.8	34.7	74.8	

For further convenience in discussion, the following tables have been added:

Table XVIII gives the proportions of water drunk to dry substance eaten, and the digestive coëfficients for each steer in the different periods.

Table XIX gives the *nutritive ratios* for each steer in the different periods. In the nutritive ratio, the amounts of digestible non-nitrogenous nutrients are compared with the amount of digestible nitrogenous nutrients; to get the real nutrient value of the fat, as compared with the other non-nitrogenous nutrients, the amount of fat digested is multiplied by 2½, (its heat-giving power as compared with starch,) and to the weight obtained are added the digestible crude fibre and nitrogen-free extracts, the sum representing the total digestible non-nitrogenous nutrients; comparing this with the digestible crude protein, the nutritive ratio is obtained.

It will be observed that in determining the nutritive ratio, all the nitrogen has been assumed to exist in the form of protein, containing 16 per cent. of nitrogen. But analysis shows that in some cases a very considerable proportion of the nitrogen exists in other forms of combination, as soluble amides, etc. It must, therefore, be admitted that the nutritive ratio calculated according to the method given, does not express the exact truth, but as no other generally accepted formula has yet been proposed as a substitute, it is still used, and will serve for comparison of the results of present experiments with those of the past stated in the same terms.

TABLE XVIII.—*Coefficients of Digestibility.*

	Proportion of water to dry substance.	Coefficients of Digestibility.						
		Dry substance.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein.	Crude ash.	Nitrogen.
Period I.								
Steer 1,	2.1 : 1	76.1	79.8	69.5	82.7	56.8	14.9	56.8
2,	1.6 : 1	81.0	86.0	77.0	85.9	63.8	25.8	63.8
3,	2.6 : 1	74.1	66.5	72.0	80.2	55.3	9.7	55.3
4,	2.6 : 1	74.0	73.1	74.1	79.7	58.5	0.6(?)	58.5
Period II.								
Steer 1,	2.8 : 1	72.2	71.0	60.6	79.3	72.5	18.7	72.5
2,	1.9 : 1	76.8	68.3	68.9	82.3	60.9	13.5	60.9
3,	2.1 : 1	76.5	66.2	56.5	84.1	61.9	14.8	61.9
4,	2.9 : 1	74.8	88.0	68.0	78.8	74.8	31.7	74.8
Period III.								
Steer 1,	2.3 : 1	72.7	67.8	65.4	78.4	71.2	36.3	71.2
2,	1.7 : 1	73.7	72.8	40.0	81.2	66.2	12.0	66.2
3,	2.6 : 1	68.4	57.7	44.3	76.3	63.3	26.2	63.3
4,	2.7 : 1	71.6	78.0	51.5	79.4	74.8	34.7	74.8

TABLE XIX.—*Nutritive Ratios.*

	Digestible fat × 2.5.	Digestible fiber.	Digestible extract.	Total digestible non-nitrogenous nutrients.	Digestible protein.	Nutritive ratio, protein = 1.0.
Period I.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
Steer 1,	5.392	9.265	47.274	61.931	3.495	1 : 17.7
2,	4.752	6.216	37.377	48.345	3.034	1 : 15.9
3,	4.485	9.522	45.666	59.673	3.392	1 : 17.6
4,	5.097	11.639	48.739	65.475	3.813	1 : 17.2
Period II.						
Steer 1,	7.000	6.628	35.666	49.294	8.655	1 : 5.7
2,	4.815	4.664	46.786	56.265	4.090	1 : 13.8
3,	5.005	5.117	51.206	61.328	4.467	1 : 13.3
4,	8.725	7.928	36.244	52.897	9.002	1 : 5.9
Period III.						
Steer 1,	7.017	11.095	44.111	62.223	9.599	1 : 6.5
2,	4.795	2.739	42.177	49.711	4.704	1 : 10.6
3,	4.615	6.361	54.061	65.037	5.882	1 : 11.1
4,	8.067	8.740	44.673	61.480	10.091	1 : 6.1

It has long been known that some of the nitrogenous ingredients of the dung are not directly derived from the food, but consist of unresolved biliary products, mucus, etc., and that, therefore, the apparent amount of digestible protein does not fully represent the actual amount digested. Lately, efforts have been directed toward the determination of the amounts of protein actually digested; it has been assumed that that portion of the dung insoluble in an artificial digestive fluid, representing the gastric and pancreatic juices, is the real indigestible residue of the food, and the difference between its amount of protein and the total amount in the food represents the amount actually digested. The amount of digestible protein in the dung has been found to vary closely in proportion to the total amount of dry substance in the food, and Stutzer* has proposed, as a result of his experiments, that 0.4 per cent. of the total dry substance digested, be added to the amount of digestible protein found by the old method. Later experiments indicate that this correction is, in many cases, insufficient, but no better empirical method has been proposed as a substitute. The changes made by the introduction of this correction may be seen in the following tabular statement:

*Zeit. physiol. Ch., 10, 574.

	Steer 1.		Steer 2.		Steer 3.		Steer 4.	
	Original ratio.	Corrected ratio.	Original ratio.	Corrected ratio.	Original ratio.	Corrected ratio.	Original ratio.	Corrected ratio.
Period I,	1 : 17.1	1 : 16.5	1 : 15.9	1 : 15.0	1 : 17.6	1 : 16.4	1 : 17.2	1 : 16.1
II.	1 : 5.7	1 : 5.5	1 : 13.8	1 : 13.0	1 : 13.3	1 : 13.0	1 : 5.9	1 : 5.7
III,	1 : 6.5	1 : 6.3	1 : 10.6	1 : 10.1	1 : 11.1	1 : 10.6	1 : 6.1	1 : 5.9

It will be observed that these changes effect no material variation in the relations of the nutritive ratios of the various rations; it will further be remembered that this correction is of comparatively recent introduction, and was not used in the experiments upon which the present German standards are based. For this reason this mention of the correction proposed is given to call attention to the real facts of the case, while the uncorrected ratios will be used for comparison with the standards.

Before proceeding to the discussion of the results of these digestive experiments, the following results, the means from a large number of careful experiments by German investigators, should be stated:

*"In round numbers, the normal amount of water (in food and drink together) may be stated at 4 pounds per pound of dry matter of the fodder for cattle."

Wolff † gives the following standards for fattening cattle, per day, and per 1,000 pounds live-weights:

	Total organic substance.	Nutritive (digestible) substances.				Nutritive ratio.
		Protein.	Extract and fiber.	Fat.	Total.	
First period,	27.0	2.5	15.0	0.50	18.00	1 : 6.5
Second period,	26.0	3.0	14.8	0.70	18.50	1 : 5.5
Third period,	25.0	2.7	14.8	0.60	18.10	1 : 6.0

A comparison of the amounts of water drunk shows that in all cases there was drunk a quantity of water much below the normal amount. Steer 2, especially, drank remarkably small quantities. It must, however, be remarked in this connection, that the mean temperature of the stalls was considerably below the normal temperature, and doubtless the quantity of water drunk was considerably diminished by reason of this condition. It will be of interest to compare the propor-

* Armsby, Manual of Cattle-Feeding, p. 136. † Cf., *ibid*, p. 492.

tional quantities of water drunk by the different steers during the experiment of Period I, when all were fed the same rations, with their respective coefficients of digestibility of dry substance. German experiments show that with an increase in the consumption of water there is an increase in the quantity of nitrogenous waste from the tissues of the body, and consequently a tendency to loss of flesh.

Taking the means of the weights of food eaten per day, and the nutritive ratios for the steers eating the same rations, the following results are obtained:

PERIOD.	Steers.	Ration.	Food eaten per day.	Nutritive ratio.
			Lbs.	
I,	1-4	Fodder and cornmeal,	12.458	1 : 17.1
II,	2 and 3	Fodder and cornmeal,	12.615	1 : 13.5
II,	1 and 4	Fodder and mixed meal,	11.935	1 : 5.8
III,	2 and 3	Hay and cornmeal,	12.533	1 : 10.8
III,	1 and 4	Hay and mixed meal,	14.339	1 : 6.3

Comparison with the German standard shows that a ratio composed of cornmeal alone, with fodder or hay, is far too wide, while those containing cottonseed meal approach the standard very closely. While it is noticeable from the figures of Tables XVIII and XIX, that there was quite a marked difference in the digestive power of the different steers when receiving the same ration, this was never sufficient to cause a material change in relations of the rations compared.

Comparing the coefficients of digestibility, given in Table XVIII, it is seen that not only an absolutely larger quantity of digestible nitrogen was found in the cottonseed meal ration, but also a greater proportion of that present was digested. The same statement is true for all the nutrients except the nitrogen-free extract, including starch, sugar, &c., of which the coefficient is greater in the ration containing only cornmeal.

With regard to the quantity of digestible dry substance eaten per day, it will be observed that in all cases it falls far below the amount prescribed by the German standard, the nearest approach to the latter occurring in the case of the mixed meal ration of Period III.

(iii) *Gain in Weight, and Cost of Increase.*

In studying the data to determine the relative effect of the rations upon the gain in weight, and the cost of that gain, it will be well to recall that experiments made on more than thirty steers in the course of the previous years' trials, failed to indicate at all conclusively any superiority of the more highly nitrogenous cottonseed ration over that composed of cornmeal alone, (not taking the coarse fodder into consideration), as far as its fattening power is concerned.

It must further be distinctly understood that the effort in this particular case was not to see how much *absolutely* of an increase of carcass can be produced with least cost, but rather to determine in detail the *relative* economy of the two sets of rations chosen for comparison. It will be readily understood that the necessary disturbance and discomfort to the animals subjected to experiment, especially to digestion experiment, tends to produce decided loss instead of gain in weight. At the same time, these disadvantages do not prevent any difference in effect between the two rations from being shown.

The following tables (XX–XXIII.) show the gain in live weights during the different periods, the amounts of food eaten, its cost, the daily gain, the daily consumption of food, the amount of food consumed for each pound of gain, and the cost of each pound of gain.

In calculating the effect of any ration, it must be remembered that it requires about seven days for the remains of any substance to be completely removed from the alimentary canal of cattle; therefore, the live weight one week after the beginning of each period is used as the starting point for the calculation. It will further be remembered that these weights are subject to correction for the variation in the amounts of water drunk on the days immediately preceding, from the average amount for that portion of the period.

Although the digestion week of each period was very trying, and sometimes unequally so, it seems difficult to eliminate the errors thus caused.

In estimating the cost of the food, the following prices were used:

Cornfodder, per ton, ...	\$5 00
Hay, mixed clover and timothy, loose, per ton, ...	13 00
Cornmeal, per ton, ...	18 00
Cottonseed meal, per ton, ...	30 00

TABLE XX.—*Gain and its Cost. Set I, Period I.*

	Steer 1.	Steer 2.	Steer 3.	Steer 4.
Number of days included, ...	28	28	28	28
Mean temperature of stable, 36 °5 F.				
Weight, January 4, ...	1,036 lbs.	989 lbs.	1,117 lbs.	1,067 lbs.
" February 1, ...	1,060 "	1,005 "	1,140 "	1,120 "
Gain, ...	24 "	16 "	23 "	53 "
" per day, ...	0.86 "	0.57 "	0.82 "	1.89 "
Weight of fodder eaten, ...	244.99 "	177.75 "	253.08 "	284.74 "
" cornmeal eaten, ...	284.75 "	278.50 "	286.00 "	286.00 "
Total weight of food eaten, ...	529.74 "	456.25 "	539.08 "	570.74 "
" " water drunk, ...	970.0 "	640.0 "	1,067.5 "	1,114.0 "
Weight of food eaten per day, ...	18.92 "	16.29 "	19.25 "	20.36 "
" " " per pound of gain, ...	22.07 "	28.52 "	23.44 "	10.77 "
" water drunk per day, ...	34.6 "	22.9 "	38.1 "	39.8 "
Cost of fodder, ...	\$0.612	\$0.444	\$0.633	\$0.712
Cost of cornmeal, ...	2.563	2.506	2.574	2.574
Total cost of food, ...	\$3.175	\$2.950	\$3.207	\$3.286
Cost per day, ...	0.118	0.105	0.115	0.117
Cost per pound of gain, ...	0.132	0.184	0.139	0.062

TABLE XXI.—*Gain and its Cost. Set I, Period II.*

	Steer 1.	Steer 2.	Steer 3.	Steer 4.
Number of days included,	21	21	15	15
Mean temperature of stable, 43.°1 F.				
Weight, February 8,	1,065 lbs.	1,057 lbs.	1,125 lbs.	1,130 lbs.
" March 1,	1,100 "	1,080 "	1,155 "	1,040 "
Gain,	35 "	23 "	30 "	10 "
" per day,	1.67 "	1.09 "	2.00 "	0.67 "
Weight of fodder eaten,	161.51 "	101.27 "	100.05 "	120.00 "
" cornmeal eaten,	157.00 "	294.00 "	201.00 "	105.00 "
" cottonseed meal eaten,	73.50 "	....	....	52.50 "
Total weight of food eaten,	392.01 "	395.27 "	301.05 "	277.50 "
" " water drunk,	722.0 "	578.0 "	537.5 "	600.00 "
Average weight of food eaten per day,	18.67 "	18.82 "	20.07 "	18.50 "
" " " " per pound of gain,	11.20 "	17.19 "	10.03 "	27.75 "
" " water drunk per day,	34.4 "	27.5 "	37.8 "	40.0 "
Cost of fodder,	$0.401	$0.253	$0.250	$0.300
Cost of cornmeal,	1.413	2.646	1.809	0.945
Cost of cottonseed meal,	1.102	....	....	0.787
Total cost of food,	$2.919	$2.899	$2.059	$2.032
Cost per day,	0.139	0.138	0.137	0.137
Cost per pound of gain,	0.083	0.126	0.069	0.203

TABLE XXII.—*Gain and its Cost. Set I, Period III.*

	Steer 1.	Steer 2.	Steer 3.	Steer 4.
Number of days included,	21	21	21	21
Mean temperature of stable, 48.°3 F.				
Weight, March 3,	1,115 lbs.	1,090 lbs.	1,185 lbs.	1,161 lbs.
" March 29,	1,145 "	1,138 "	1,212 "	1,185 "
Gain,	30 "	48 "	27 "	24 "
" per day,	1.43 "	2.29 "	1.29 "	1.14 "
Weight of hay eaten,	231.00 "	165.67 "	216.79 "	231.00 "
" cornmeal eaten,	147.00 "	282.25 "	294.00 "	147.00 "
" cottonseed meal eaten,	73.50 "	....	....	73.50 "
Total weight of food eaten,	451.50 "	447.92 "	510.79 "	451.50 "
" " water drunk,	966.0 "	701.0 "	1,138.0 "	1,026.5 "
Weight of food per day,	21.50 "	21.33 "	24.32 "	21.50 "
" " per pound of gain,	15.05 "	9.33 "	18.89 "	18.79 "
" water per day,	46.0 "	33.4 "	54.2 "	48.9 "
Cost of hay,	$0.577	$0.414	$0.542	$0.577
Cost of cornmeal,	1.323	2.542	2.646	1.323
Cost of cottonseed meal,	1.102	....	....	1.102
Total cost of food,	$3.002	$2.956	$3.188	$3.002
Cost per day,	0.143	0.141	0.152	0.142
Cost per pound of gain,	0.100	0.062	0.118	0.125

TABLE XXIII.—*Summary of Data on Gain and its Cost. Set I.*

	PERIOD I.		PERIOD II.		PERIOD III.	
	Steers 1 and 4.	Steers 2 and 3.	Steers 1 and 4.	Steers 2 and 3.	Steers 1 and 4.	Steers 2 and 3.
Daily gain in live weight,	1.37 lbs.	.69 lbs.	1.17 lbs.	1.54 lbs.	1.28 lbs.	1.79 lbs.
Food eaten per pound of gain,	16.42 "	25.98 "	19.47 "	13.61 "	16.92 "	14.11 "
Cost per pound of gain,	$0.097	$0.161	$0.143	$0.097	$0.112	$0.090

If the statement of Table XXIII can be accepted as conclusive, the evidence, as far as increase of carcass goes, seems to indicate the superiority of the cornmeal ration over the cottonseed mixture for this set of steers. This evidence is still stronger, if the fattening capacity of the steers during Period I be accepted as indicative of their capacity in that respect during the other periods; for it is seen that the amount of food consumed by steers 1 and 4, in Period I, to produce a pound of gain is a little more than half that required by the other pair, and the gain in weight is twice as great. A correction for this difference in fattening capacity would greatly increase the balance in favor of the cornmeal rations during Periods II and III.

It may, however, be well to observe that although the mean results for the different pairs of steers seem to lead in this conclusion, strong doubt is thrown upon the validity of this evidence when the results for the individual steers are studied. It is seen that there is no close agreement in the variations for steers of the same pair in passing from one ration to another, so that, in the absence of reasonably close agreement, the means for so small a number receiving the same treatment may justly be regarded as by no means fit for use as a basis upon which to establish decisive conclusions. This statement is more strongly emphasized by the fact that a large share of the unfavorable results shown by the means for steers 1 and 4, is due to the marked falling off of the latter steer, which never seemed satisfied with the amount of food supplied, especially during Periods II and III. Although considerable care was taken to get animals of the same general make-up, No. 4 was heavier boned and coarser haired than the other three, and therefore, would not be regarded as up to their average in general fattening quality, notwithstanding the testimony of Period I.

It is worthy of note that the rations of steers 2 and 3 became narrower in nutritive ratio from period to period, and that there is also a marked decrease from period to period in the cost per pound of gain in live weight. This is what would, within certain limits, be expected on theoretical grounds, and tends to support the German rules when applied to mixtures of different quantities of similar ingredients; while the results with cottonseed meal make it at least doubtful whether they can be invariably applied in mixing rations with widely different ingredients.

Examination of Tables XVI and XVII, shows that there is not as much difference in the amounts of nitrogen in the dung of the different steers as might be imagined from the difference in the amounts fed. Therefore, as the statements of Table XIX clearly show, the amounts of nitrogen digested by steers receiving the cottonseed ration are much greater than in the case of those receiving the cornmeal ration; this may be partly stored up as carcass, and may be partly excreted in the urine, or the whole may be excreted. Evidence seems to indicate that a large portion of that digested by steers 1 and 4 in these experiments was not stored up, but excreted. It will be remembered that the nitrogenous compounds in urine are more valuable than those in the solid dung, because more immediately available. In this case, however, this advantage in favor of the cottonseed ration, would not fully counterbalance the disadvantages.

It was remarked above that the total quantities of digestible nutrients taken daily by the different steers was little more than three fourths of the amount called for by the German standard. Prof. W. H. Jordan,* in discussing the reasons for the difference in results obtained by Dr. Armsby, of the Wisconsin station, and by himself in using cottonseed in rations for milch cows, states that Dr. Armsby added cottonseed to a ration already sufficiently rich, and obtained negative results; while he added cottonseed to a ration otherwise considerably below the standard, and obtained favorable results; the favorable results in the latter case being attributed to the relatively increased effect of the added cottonseed upon the nutritive character of the ration.

If this be the fact, and it is very plausible, it would seem that the rations compared in the experiments with which we are dealing, would afford an excellent opportunity for the display of the valuable qualities of the cottonseed, but the results seem rather to oppose the utility of cottonseed for fattening purposes.

The results of this year with three-year old steers, together with the indecisive results of previous experiments, leave the question open to further experiment in the same line; such experiments are now in progress at the Central Experimental Farm.

(b.) *Experiments with Two-year-old Steers.*

As in the case of the steers of Set I, the steers of this set were selected for their similarity in the physical characters which are indicative of good fattening capacity.

The general plan of the experiments with Set II differed from that for Set I. The general weighings were the same, but there were no digestion experiments. It was found difficult to arrange for bedding with saw-dust during the whole time of experiment, and straw was therefore used. Instead of digestion experiments, certain experiments were made to determine the value of the manure produced by the different rations. During a single week in each period, the steers were bedded with a certain quantity of saw-dust, of known composition, and the manure produced by each steer in the trial week was sampled for analysis.

At the end of the feeding experiments, the steers were butchered, and the proportions of different parts determined, the proportion of

* Annual Report of the Main Fertilizer Control and Agricultural Experiment Station, 1885-6, p. 76-78.

muscle, fat, etc., in a steak cut from the same portion of each, and also the amount of nitrogen it contained.

The rations fed daily to the different steers are as follows:

PERIOD I.

	Steers 5–8.
Cornfodder,	8 lbs.
Cornmeal,	6 "

PERIOD II.

	Steers 5 and 7.	Steers 6 and 8.
Cornfodder,	6 lbs.	6 lbs.
Cornmeal,	5 "	10 "
Cottonseed meal,	2.5 "	

PERIOD III.

	Steers 5 and 7.	Steers 6 and 8.
Hay,	9 lbs.	9 lbs.
Cornmeal,	5 "	10 "
Cottonseed meal,	2.5 "	

The data showing amounts of food and water taken daily by each steer, with the daily variations in live weight during the several periods, are shown in Tables XXIV–XXVI.

TABLE XXIV.—*Weight Records, Set II, Period I, December 28–January 31.*

Date.	Steer 5.							Steer 6.						
	Food.			Weight.				Food.			Weight.			
	Fodder.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Fodder.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
1885.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
December 28,	3.96	6	9.96	725	749	21	. . . . .	5.68	6	11.68	618	670	22	. . . . .
29,	6.39	6	12.39	713	750	37	—12	5.32	6	11.32	639	665	26	—9
30,	7.29	6	12.29	719	747	28	6	4.15	6	10.15	635	655	20	—1
31,	6.93	6	12.93	721	747	26	2	3.67	6	9.67	635	635	0	0
1886.														
January 1,	6.93	6	12.93	715	735	20	6	1.50	6	7.50	615	635	20	—20
2,	7.11	6	13.11	720	760	40	5	4.35	6	10.35	622	652	30	7
3,	6.57	6	12.57	735	772	37	15	4.92	6	10.92	613	655	12	21
4,	6.75	6	12.75	745	765	20	10	5.86	6	11.86	615	653	8	2
5,	6.75	6	12.75	735	770	35	—10	6.75	6	12.75	640	655	15	—5
6,	5.50	6	11.50	750	775	25	15	6.21	6	12.21	645	670	25	5
7,	6.75	6	12.75	750	765	15	0	7.11	6	13.11	647	675	28	2
8,	7.29	6	13.29	740	775	35	—10	6.57	6	12.57	645	675	30	—2
9,	5.50	6	11.50	760	775	15	20	5.50	6	11.50	645	661	19	0
10,	4.92	6	10.92	750	775	25	—10	6.93	6	12.93	645	685	40	0
11,	6.21	6	12.21	745	764	19	—5	7.29	6	13.29	650	670	20	5
12,	6.57	6	12.57	750	775	25	5	7.46	6	13.46	655	685	30	5
13,	7.11	6	13.11	730	745	15	—20	7.61	6	13.61	640	660	20	—15
14,	7.61	6	13.61	720	740	20	—10	7.61	6	13.61	635	660	25	—5
15,	7.29	6	13.29	730	750	20	10	7.29	6	13.29	640	663	23	5
16,	6.93	6	12.93	725	755	30	—5	6.93	6	12.93	615	675	30	5
17,	6.57	6	12.57	740	775	35	15	6.57	6	12.57	660	685	25	15
18,	6.21	6	12.21	745	775	30	5	6.21	6	12.21	660	685	25	0
19,	6.93	6	12.93	745	775	30	0	6.21	6	12.21	660	685	25	0
20,	7.29	6	13.29	716	770	24	1	6.93	6	12.93	650	680	30	—10
21,	7.29	6	13.29	748	785	37	2	7.64	6	12.64	660	685	35	10
22,	7.29	6	13.29	760	795	35	12	7.29	6	13.29	675	705	30	15
23,	6.93	6	12.93	760	760	0	0	6.57	6	12.57	660	665	5	—15
24,	7.29	6	13.29	715	780	65	—45	6.57	6	12.57	640	690	50	—20
25,	6.93	6	12.93	770	773	3	55	5.86	6	11.86	680	710	30	40
26,	7.29	6	13.29	735	775	40	—35	7.64	6	13.64	665	690	25	—15

TABLE XXIV—Continued.

DATE.	Steer 5. Food. Fodder.	Steer 5. Food. Meal.	Steer 5. Food. Total.	Steer 5. Weight. Before watering.	Steer 5. Weight. After watering.	Steer 5. Water drunk.	Steer 5. Gain in weight.	Steer 6. Food. Fodder.	Steer 6. Food. Meal.	Steer 6. Food. Total.	Steer 6. Weight. Before watering.	Steer 6. Weight. After watering.	Steer 6. Water drunk.	Steer 6. Gain in weight.
1886.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
anuary 27,	6.93	6	12.93	768	810	42	33	5.86	6	11.86	675	710	35	10
28,	6.93	6	12.93	770	815	45	2	4.92	6	10.92	670	695	25	—5
29,	7.29	6	13.29	770	805	35	0	5.86	6	11.86	670	700	30	0
30,	7.29	6	13.29	765	790	25	—5	7.29	6	13.29	640	690	50	—30
31,	7.64	6	13.64	750	775	25	—15	6.93	6	12.93	660	690	30	20
February 1,	.....	.....	.....	760	.....	.....	10	.....	.....	.....	670	.....	.....	10

TABLE XXIV.—Continued.

DATE.	STEER 7. FOOD. Fodder.	STEER 7. FOOD. Meal.	STEER 7. FOOD. Total.	STEER 7. WEIGHT. Before watering.	STEER 7. WEIGHT. After watering.	STEER 7. Water drunk.	STEER 7. Gain in weight.	STEER 8. FOOD. Fodder.	STEER 8. FOOD. Meal.	STEER 8. FOOD. Total.	STEER 8. WEIGHT. Before watering.	STEER 8. WEIGHT. After watering.	STEER 8. Water drunk.	STEER 8. Gain in weight.
1885.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
December 28,	6.75	6	12.75	644	666	22.0	. . . . .	6.04	6	12.04	573	595	22	. . . . .
29,	6 57	6	12.57	635	655	20.0	—9	5.68	6	11.68	569	585	16	—4
30,	6.67	6	12.57	630	663	33.0	—5	5.86	6	11.86	565	586	21	—4
31,	7.11	6	13.11	633	660	27.0	8	6.01	6	12.04	574	593	19	9
1886.														
January 1,	7.29	6	13.29	635	672	37.0	2	6.21	6	12.21	570	581	11	—4
2,	6.75	6	12.75	6 5	6 0	25.0	10	6.57	6	12.57	550	602	52	—20
3,	6.93	6	12.93	610	677½	37.5	—5	6.93	6	12.93	575	610	35	25
4,	6.57	6	12.57	619	675	26 0	9	6 39	6	12 39	585	600	15	10
5,	7.11	6	13.11	645	673	28.0	—1	7.11	6	13.11	570	610	40	—15
6,	6.75	6	12.75	660	685	25.0	15	6.75	6	12.75	615	620	15	35
7,	7.11	6	13.11	665	695	30.0	5	7.11	6	13.11	600	625	25	—5
8,	7.29	6	13.29	655	695	40.0	—10	6.75	6	12.75	595	628	33	—5
9,	6.57	6	12.57	675	710	35 0	20	6.04	6	12.04	600	610	10	5
10,	7.11	6	13.11	660	695	35.0	—15	7.11	6	13.11	590	615	25	—10
11,	7.29	6	13.29	660	692	32.0	0	7.29	6	13.29	592	620	28	2
12,	7.64	6	13.64	670	690	20.0	10	6.57	6	12.57	600	625	25	8
13,	7.64	6	13.64	643	670	27.0	—27	7.64	6	13.64	581	600	19	—19
14,	7.64	6	13.64	640	670	30.0	—8	6.93	6	12.93	565	595	30	—16
15,	7.64	6	13.64	641	671	30.0	1	7.46	6	13.46	578	603	25	13
16,	7.64	6	13.64	650	680	30.0	9	7.64	6	13.64	585	625	40	7
17,	7.64	6	13.64	670	700	30.0	20	7.64	6	13.64	600	625	25	15
18,	6 57	6	12.57	665	700	35.0	—5	6 93	6	12.93	600	630	30	0
19,	5.86	6	11.86	665	700	35.0	0	6.93	6	12.93	600	635	35	0
20,	6.93	6	12.93	660	695	35.0	5	7.29	6	13.29	595	630	35	—5
21,	7.29	6	13.29	660	687	27.0	0	7.64	6	13.64	600	638	38	5
22,	7.29	6	13.29	670	705	35.0	10	7.29	6	13.29	615	653	38	15
23,	6.57	6	12.57	665	665	0	—5	7.64	6	13.64	600	620	20	—15
24,	6.93	6	12.93	640	700	60.0	—25	7.29	6	13.29	600	650	50	0
25,	6.93	6	12.93	700	715	15.0	60	6.21	6	12.21	625	640	15	25
26,	6.93	6	12.93	675	700	25.0	—25	7.64	6	13.64	600	640	40	—25

TABLE XXIV—Continued.

DATE.	Steer 7. Food. Fodder.	Steer 7. Food. Meal.	Steer 7. Food. Total.	Steer 7. Weight. Before watering.	Steer 7. Weight. After watering.	Steer 7. Water drunk.	Steer 7. Gain in weight.	Steer 8. Food. Fodder.	Steer 8. Food. Meal.	Steer 8. Food. Total	Steer 8. Weight. Before watering.	Steer 8. Weight. After watering.	Steer 8. Water drunk.	Steer 8. Gain in weight.
18 6.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
January 27,	6.57	6	12.57	680	720	40.0	5	6.57	6	12.57	625	665	40	25
28,	6.21	6	12.21	675	705	30.0	—5	6.21	6	12.21	620	650	30	—5
29,	7.29	6	13.29	670	705	35.0	—5	7.29	6	13.29	620	660	40	0
30,	7.29	6	13.29	660	710	50.0	—10	7.64	6	13.64	620	640	20	0
31,	6.93	6	12.93	665	700	35.0	5	7.29	6	13.29	605	650	45	—15
February 1,	. . . . .	. . . . .	. . . . .	680	. . . . .	. . . . .	15	. . . . .	. . . . .	. . . . .	620	. . . . .	. . . . .	15

Table XXV.—*Weight Records, Set II, Period II, February 1–28.*

Date.	Steer 5, Food, Fodder.	Steer 5, Food, Meal.	Steer 5, Food, Total.	Steer 5, Weight, Before watering.	Steer 5, Weight, After watering.	Steer 5, Water drunk.	Steer 5, Gain in weight.	Steer 6, Food, Fodder.	Steer 6, Food, Meal.	Steer 6, Food, Total.	Steer 6, Weight, Before watering.	Steer 6, Weight, After watering.	Steer 6, Water drunk.	Steer 6, Gain in weight.
1886.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
February 1,	5.61	7.50	13.11	760	775	15	10	5.61	10	15.61	670	700	30	10
2,	5.29	7.50	12.79	760	795	35	0	4.93	10	14.93	680	710	30	10
3,	5.29	7.50	12.79	770	800	30	10	4.93	10	14.98	680	715	35	0
4,	5.82	7.50	13.32	782	812	30	12	4.93	10	14.93	695	715	20	15
5,	5.61	7.50	13.14	777	800	23	—5	5.29	10	15.29	670	700	30	—25
6,	5.61	7.50	13.14	770	810	40	—7	4.93	10	14.93	680	715	35	10
7,	4.93	7.50	12.43	775	815	40	5	4.57	10	14.57	680	715	35	0
8,	4.93	7.50	12.43	790	811	21	15	4.21	10	14.21	692	720	28	12
9,	5.29	7.50	12.79	780	815	35	—10	4.93	10	14.93	690	710	20	—2
10,	5.29	7.50	12.79	782	812	30	2	4.93	10	14.93	680	725	45	—10
11,	5.29	7.50	12.79	780	820	40	—2	4.93	10	14.93	695	715	20	15
12,	5.82	7.50	13.32	780	822	42	0	4.93	10	14.93	680	710	30	—15
13,	5.61	7.50	13.14	795	825	30	15	5.29	10	15.29	690	705	15	10
14,	5.82	7.50	13.32	780	825	45	—15	5.64	10	15.64	670	720	50	—20
15,	5.82	7.50	13.32	790	830	40	10	5.64	10	15.64	695	723	28	25
16,	5.82	7.50	13.32	785	800	15	—5	5.82	10	15.82	690	710	20	—5
17,	5.29	7.50	12.79	750	785	85	—35	3.86	10	13.86	690	720	30	0
18,	5.82	7.50	13.32	775	815	40	25	5.29	10	15.29	700	715	15	10
19,	6.00	7.50	13.50	780	812	32	5	5.61	10	15.61	685	720	35	—15
20,	5.61	7.50	13.14	785	805	20	5	5.64	10	15.64	695	720	25	10
21,	5.64	7.50	13.14	780	820	40	—5	5.29	10	15.29	690	715	25	—5
22,	5.64	7.50	13.14	800	825	25	20	3.86	10	13.86	690	715	25	0
23,	5.64	7.50	13.14	795	830	35	—5	4.57	10	14.57	690	715	25	0
24,	5.82	7.50	13.32	805	830	25	10	4.57	10	14.57	690	720	30	0
25,	5.64	7.50	13.14	790	825	35	—15	5.29	10	15.29	715	740	25	25
26,	5.29	7.50	12.79	800	830	30	10	3.50	10	13.50	695	720	25	—20
27,	5.61	7.50	13.14	810	850	20	10	4.57	10	14.57	700	720	20	5
28,	5.64	7.50	13.14	860	865	65	—10	4.12	10	14.12	700	751	51	0
March 1,	.....	.....	.....	810	.....	.....	40	.....	.....	.....	730	.....	.....	30

TABLE XXV—Continued.

Date.		Steer 7.							Steer 8.						
		Food.			Weight.				Food.			Weight.			
		Fodder.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Fodder.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
1886.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
February	1, ...	5.61	7.50	13.14	680	710	30	15	5.64	10	15.64	620	615	25	15
	2, ...	4.93	7.50	12.43	685	720	5	5	5.64	10	15.64	610	650	40	—10
	3, ...	5.29	7.50	12.79	690	730	40	5	5.29	10	15.29	620	660	40	10
	4, ...	5.64	7.50	13.14	700	735	35	10	5.29	10	15.29	625	665	40	5
	5, ...	4.93	7.50	12.43	680	715	35	—20	3.86	10	13.86	610	640	30	—15
	6, ...	4.93	7.50	12.43	690	725	35	10	4.93	10	14.93	620	645	25	10
	7, ...	5.29	7.50	12.79	685	740	55	—5	4.93	10	14.93	616	670	54	—4
	8, ...	4.57	7.50	12.07	710	730	20	25	4.57	10	14.57	615	660	15	29
	9, ...	4.57	7.50	12.07	688	720	32	—22	4.57	10	14.57	625	665	40	—20
	10, ...	4.93	7.50	12.43	690	725	35	2	4.93	10	14.93	635	660	35	10
	11, ...	5.29	7.50	12.79	685	725	40	—5	4.57	10	14.57	640	650	10	5
	12, ...	5.64	7.50	13.14	685	725	40	0	5.29	10	15.29	615	670	55	—25
	13, ...	5.29	7.50	12.79	690	715	25	5	5.64	10	15.64	635	660	25	20
	14, ...	5.64	7.50	13.14	675	755	80	—15	4.93	10	14.93	620	670	50	—15
	15, ...	5.64	7.50	13.14	715	730	15	40	4.93	10	14.93	640	670	30	20
	16, ...	5.64	7.50	13.14	690	720	30	—25	4.93	10	14.93	620	650	30	—20
	17, ...	5.64	7.50	13.14	690	725	35	0	2.54	10	12.54	610	660	50	—10
	18, ...	5.64	7.50	13.14	695	730	35	5	2.92	10	12.92	630	655	25	20
	19, ...	5.82	7.50	13.32	688	730	42	—7	3.86	10	13.86	622	660	38	—8
	20, ...	5.82	7.50	14.32	698	720	22	10	4.57	10	14.57	635	640	5	13
	21, ...	5.82	7.50	13.32	690	740	50	—8	2.92	10	12.92	600	635	35	—35
	22, ...	5.82	7.50	13.32	705	740	35	15	5.64	10	15.64	610	640	30	10
	23, ...	5.82	7.50	13.32	685	745	60	—20	5.29	10	15.29	615	640	25	5
	24, ...	5.64	7.50	13.14	685	735	50	0	4.57	10	14.57	605	670	65	—10
	25, ...	5.46	7.50	12.96	735	770	35	50	4.57	10	14.57	665	680	15	60
	26, ...	5.64	7.50	13.14	695	710	15	—40	3.86	10	13.86	635	660	25	—30
	27, ...	5.64	7.50	13.14	700	780	30	5	4.57	10	14.57	630	655	25	—5
	28, ...	5.64	7.50	13.14	695	765	70	—5	4.93	10	14.93	616	690	44	16
March	1, ...	. . . . .	. . . . .	. . . . .	740	. . . . .	. . . . .	45	. . . . .	. . . . .	. . . . .	680	. . . . .	. . . . .	31

TABLE XXVI.—*Weight Records, Set II, Period III, March 1 to the end of the Experiment.*

DATE.	STEER 5.							STEER 6						
	FOOD.			WEIGHT.				FOOD.			WEIGHT.			
	Hay.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.	Hay.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
1886.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
March 1,	8.63	7.50	16.13	840	845	5	40	7.00	10	17.00	730	740	10	30
2,	9.00	7.50	16.50	815	855	40	—25	8.00	10	18.00	720	750	30	—10
3,	9.00	7.50	16.50	820	865	45	5	8.50	10	18.50	715	745	30	—5
4,	9.00	7.50	16.50	820	860	40	0	8.75	10	18.75	710	735	25	—5
5,	9.00	7.50	16.50	820	870	50	0	8.50	10	18.50	720	750	30	10
6,	9.00	7.50	16.50	825	870	45	5	8.50	10	18.50	715	765	30	—5
7,	9.00	7.50	16.50	820	890	70	—5	8.00	10	18.00	715	750	35	0
8,	9.00	7.50	16.50	855	875	20	35	8.00	10	18.00	730	750	20	15
9,	9.00	7.50	16.50	825	880	55	—30	8.75	10	18.75	710	745	35	—20
10,	9.00	7.50	16.50	845	860	15	20	9.00	10	19.00	725	755	30	15
11,	9.00	7.50	16.60	830	865	35	—15	9.00	10	19.00	720	750	30	—5
12,	9.00	7.50	16.50	850	880	30	20	8.50	10	18.50	735	770	35	15
13,	9.00	7.50	16.50	845	880	35	—5	9.00	10	19.00	740	775	35	5
14,	9.00	7.50	16.50	835	892	57	—10	9.00	10	19.00	740	768	27	0
15,	9.00	7.50	16.50	860	900	40	25	8.50	10	18.50	740	780	40	0
16,	9.00	7.50	16.50	850	895	45	—10	9.00	10	19.00	765	775	10	25
17,	9.00	7.50	16.50	860	860	0	10	9.00	10	19.00	745	770	25	—20
18,	9.00	7.50	16.50	815	890	75	—45	9.00	10	19.00	730	763	33	—15
19,	9.00	7.50	16.50	860	865	5	45	9.00	10	19.00	740	770	30	10
20,	9.00	7.50	16.50	825	905	80	—35	9.00	10	19.00	740	775	35	0
21,	9.00	7.50	16.50	880	910	30	55	9.00	10	19.00	750	785	35	10
22,	9.00	7.50	16.50	865	900	35	—15	9.00	10	19.00	750	770	20	0
23,	9.00	7.50	16.50	860	900	40	—5	9.00	10	19.00	745	780	35	—5
24,	9.00	7.50	16.50	865	915	50	5	9.00	10	19.00	750	780	30	5
25,	9.00	7.50	16.50	865	915	50	0	9.00	10	19.00	747	790	43	—3
26,	9.00	7.50	16.50	865	900	35	0	9.00	10	19.00	750	784	34	3
27,	9.00	7.50	16.50	860	900	40	—5	9.00	10	19.00	760	780	20	10
28,	9.00	7.50	16.50	850	900	50	—10	9.00	10	19.00	755	800	45	—5
29,	9.00	7.50	16.50	865	905	40	15	9.00	10	19.00	760	800	40	5
30,	9.00	7.50	16.50	850	910	60	—15	9.00	10	19.00	760	790	30	0
31,	9.00	7.50	16.50	855	900	45	5	9.00	10	19.00	755	780	25	—5

TABLE XXVI—Continued.

DATE.	Steer 7.							Steer 8.						
	Food.			Weight.				Food.			Weight.			
	Hay.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight	Hay.	Meal.	Total.	Before watering.	After watering.	Water drunk.	Gain in weight.
1886.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
April 1,	9.00	7.50	16.50	860	910	50	5	9.00	10	19.00	730	770	40	—25
2,	9.00	7.50	16.50	870	910	40	10	9.00	10	19.00	750	795	45	20
3,	9.00	7.50	16.50	880	915	35	10	9.00	10	19.00	765	800	35	15
4,	9.00	7.50	16.50	875	925	50	—5	9.00	10	19.00	765	795	30	0
5,	9.00	7.50	16.50	885	920	40	10	9.00	10	19.00	760	790	30	—5
6,	9 00	7.60	16.50	880	910	30	—5	9.00	10	19.00	765	800	35	5
7,	9.00	7 50	16.50	890	920	30	10	9.00	10	19.00	765	805	40	0
8,	9.00	7.50	16.50	890	930	40	0	9.00	10	19.00	760	800	40	—5
9,	9.00	7.50	16.50	895	950	55	5	9.10	10	19.00	765	810	45	5
10,	9.00	7.50	16.50	900	935	35	5	9.00	10	19.00	765	810	45	0
11,	9.00	7.50	16.50	870	952	82	—30							
12,	9.00	7.50	16.50	890	930	40	20							
13,	9.00	7.50	16.50	890	920	30	0							
14,	9.00	7.50	16.50	870	930	60	20							
15,	9.00	7.50	16.50	900	950	50	30							
16,	9.00	7.50	16.50	880	960	80	—20							
17,	9.00	7.50	16.50	885	930	45	5							
18,	9.00	7.50	16.50	890	950	60	5							
19,	9.00	7.50	16.50	895	920	25	5							
20,	9.00	7.50	16.59	890	960	70	—5							
21,	9.00	7.50	16.50	900	975	75	10							
22,	9.00	7.50	16.50	860	945	85	—40							

TABLE XXVI.—*Weight Records, Set II, Period III, March 1 to the end of the Experiment.*

Date.	Steer 7. Food. Hay.	Steer 7. Food. Meal.	Steer 7. Food. Total.	Steer 7. Weight. Before watering.	Steer 7. Weight. After watering.	Steer 7. Water drunk.	Steer 7. Gain in weight.	Steer 8. Food. Hay.	Steer 8. Food. Meal.	Steer 8. Food. Total.	Steer 8. Weight. Before watering.	Steer 8. Weight. After watering.	Steer 8. Water drunk.	Steer 8. Gain in weight.
1886.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
March 1,	8.50	7.50	16.00	740	760	20	45	7.00	10	17.00	680	685	5	34
2,	8.75	7.50	16.25	720	765	45	—20	8.25	10	18.25	650	695	45	—30
3,	8.75	7.50	16.25	730	770	40	10	7.50	10	17.50	670	690	20	20
4,	9.00	7.50	16.50	730	770	40	0	6.75	10	16.75	660	690	30	—10
5,	8.50	7.50	16.00	725	775	50	—5	6.50	10	16.50	666	705	39	6
6,	8.50	7.50	16.00	735	780	45	10	7.00	10	17.00	665	690	25	—1
7,	8.50	7.50	16.00	725	777	52	—10	8.50	10	18.50	640	690	50	—25
8,	8.75	7.50	16.25	750	785	35	25	8.00	10	18.00	665	685	20	25
9,	9.00	7.50	16.50	710	780	40	—10	8.50	10	18.50	660	695	35	—5
10,	9.00	7.50	16.50	740	780	40	0	8.75	10	18.75	660	695	35	0
11,	9.00	7.50	16.50	730	770	40	—10	7.00	10	17.00	660	695	35	0
12,	9.00	7.50	16.50	750	800	50	20	8.00	10	18.00	680	695	15	20
13,	9.00	7.50	16.50	765	800	35	15	8.75	10	18.75	680	705	25	0
14,	9.00	7.50	16.50	750	800	50	—15	7.50	10	17.50	664	710	46	—16
15,	9.00	7.50	16.50	750	790	40	0	6.25	10	16.25	685	710	25	21
16,	9.00	7.50	16.50	765	805	40	15	8.50	10	18.50	680	705	25	—5
17,	9.00	7.50	16.50	770	800	30	5	7.50	10	17.50	685	710	25	5
18,	9.00	7.50	16.50	740	790	50	—30	8.00	10	18.00	675	700	25	—10
19,	9.00	7.50	16.50	750	785	35	10	8.50	10	18.50	665	670	5	—10
20,	9.00	7.50	16.50	740	794	54	—10	8.50	10	18.50	650	710	60	—15
21,	9.00	7.50	16.50	770	810	40	30	7.50	10	17.50	685	715	30	35
22,	9.00	7.50	16.50	760	800	40	—10	7.50	10	17.50	670	690	20	—15
23,	9.00	7.50	16.50	755	790	35	—5	7.00	9	16.00	670	700	30	5
24,	7.00	7.50	14.50	770	810	40	15	7.00	10	17.00	675	705	30	5
25,	8.00	7.50	15.50	775	800	25	5	1.00	10	11.00	680	715	35	5
26,	8.50	7.50	16.00	760	800	40	—15	8.50	10	18,50	680	715	35	0
27,	9.00	7.50	16.50	765	805	40	5	7.50	10	17.56	690	710	20	10
28,	8.50	7.50	16.00	760	825	65	—5	8.00	10	18.00	680	710	30	—10
29,	9.00	7.50	16.50	770	810	40	10	8.00	10	18.00	690	725	35	10
30,	9.00	7.50	16.50	770	805	35	0	8.50	10	18.50	680	720	40	—10
31,	9.00	7.50	16.50	765	810	45	—3	7.50	10	17.50	680	710	30	0

TABLE XXVI—Continued.

DATE.	Steer 7. Food. Hay.	Steer 7. Food. Meal.	Steer 7. Food. Total.	Steer 7. Weight. Before watering.	Steer 7. Weight. After watering.	Steer 7. Water drunk.	Steer 7. Gain in weight.	Steer 8. Food. Hay.	Steer 8. Food. Meal.	Steer 8. Food. Total.	Steer 8. Weight. Before watering.	Steer 8. Weight. After watering.	Steer 8. Water drunk.	Steer 8. Gain in weight.
1886.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
April 1,	9.00	7.50	16.50	750	810	60	—15	8.00	10	18.00	650	715	65	—30
2,	9.00	7.50	16.50	765	805	40	15	8.50	10	18.50	690	725	35	40
3,	9.00	7.50	16.50	770	800	30	5	9.00	10	19.00	685	725	40	—5
4,	9.00	7.50	16.50	760	805	45	—10	9.00	10	19.00	690	715	25	5
5,	9.00	7.50	16.50	780	810	30	20	9.00	10	19.00	685	715	30	—5
6,	9.00	7.50	16.50	775	815	40	—5	9.00	10	19.00	695	725	30	10
7,	9.00	7.50	16.50	780	825	45	5	9.00	10	19.00	700	730	30	5
8,	9.00	7.50	16.50	775	830	55	—5	8.00	10	18.00	695	740	45	—5
9,	9.00	7.50	16.50	800	840	40	25	8.50	10	18.50	710	753	43	15
10,	9.00	7.50	16.50	800	835	35	0	9.00	10	19.00	700	750	50	—10
11,	9.00	7.50	16.50	785	830	45	—15	9.00	10	19.00	695	750	55	—5
12,	9.00	7.50	16.50	790	820	30	5	9.00	10	19.00	710	730	20	—15
13,	9.00	7.50	16.50	775	820	45	—15	8.50	10	13.50	690	755	65	20
14,	9.00	7.50	16.50	775	820	45	0	9.00	10	19.00	680	740	60	—10
15,	9.00	7.50	16.50	780	850	70	5	8.50	10	18.50	690	765	75	10
16,	.....	.....	.....	.....	.....	.....	.....	9.00	10	19.00	690	760	70	0
17,	.....	.....	.....	.....	.....	.....	.....	9.00	10	19.00	700	745	45	10
18,	.....	.....	.....	.....	.....	.....	.....	9.00	10	19.00	680	775	95	—10
19,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	723	763	40	43

(i.) MANURE EXPERIMENTS.

The object of these experiments was to determine the comparative value of manure from the steers receiving the different rations, paying especial attention to their nitrogen content.

The litter was, as has already been stated, dry sawdust; a fresh quantity of known weight being used every day. The manure made by each steer during the five days of trial was thoroughly mixed and sampled after the end of each trial and submitted to analysis. A carefully taken sample of the sawdust used was also analyzed.

The results obtained are given in the following tables (XXVII–XXXII.):

TABLE XXVII.—*Weights of Dung, Set II.*

	Steer 5.			Steer 6.			Steer 7.			Steer 8.		
	Bedding.*	Manure.	Excreta.	Bedding.	Manure.	Excreta.	Bedding.	Manure.	Excreta.	Bedding.	Manure.	Excreta.
Period I.												
January 12,	22.00	46.50	24.50	23.25	49.50	26.25	22.00	57.00	35.00	22.75	55.50	32.75
13,	22.00	51.50	29.50	24.00	49.00	25.00	22.50	48.00	25.50	23.00	53.00	30.00
14,	22.50	48.50	26.00	23.00	54.00	31.00	22.50	59.50	37.00	22.00	54.00	32.00
15,	17.00	41.00	24.00	17.00	51.50	34.50	17.50	63.00	45.50	17.00	50.50	33.50
16,	18.00	38.00	20.00	17.50	40.50	23.00	18.00	46.00	28.00	17.00	40.00	23.00
Total,	101.50	225.50	124.00	104.75	244.50	139.75	102.50	273.50	171.00	101.75	253.00	151.25
Period II.												
February 16,	16.00	40.00	24.00	16.00	31.00	15.00	16.00	33.00	17.00	16.00	43.00	27.00
17,	16.00	50.50	34.50	16.00	44.00	28.00	16.00	50.00	34.00	16.00	43.00	27.00
18,	16.00	40.00	24.00	16.00	36.00	20.00	16.00	58.50	40.50	16.00	39.00	23.00
19,	16.00	46.50	30.50	16.00	42.50	26.50	16.00	50.00	34.00	16.00	42.00	26.00
20,	16.00	33.00	17.00	16.00	37.50	21.50	16.00	54.50	38.50	16.00	50.00	34.00
Total,	80.00	210.00	130.00	80.00	191.00	111.00	80.00	244.00	164.00	80.00	217.00	137.00
Period III.												
March 16,	15.00	50.50	35.50	15.00	45.50	30.50	15.00	66.50	51.50	15.00	40.00	28.00
17,	15.00	51.50	36.50	15.00	42.50	27.50	15.00	54.50	30.50	15.00	38.00	23.00
18,	15.00	42.00	27.00	15.00	44.00	29.00	15.00	54.00	39.00	15.00	42.00	27.00
19,	15.00	49.00	34.00	15.00	49.00	34.00	15.00	60.50	45.50	15.00	39.00	21.00
20,	15.00	44.00	29.00	15.00	42.00	27.00	15.00	51.00	36.00	15.00	34.00	19.00
Total,	75.00	237.00	162.00	75.00	223.00	148.00	75.00	286.50	211.50	75.00	193.00	118.00

* Bedding weighed out on the day previous to date.

TABLE XXVIII.—*Analysis of Manures of Set II.*

Index Number.	SAMPLE.	Loss in air-drying.	AIR-DRY SAMPLES. Moisture.	Crude fat.	Crude fiber.	Nitrogen-free extract.	Crude protein — N. × 6.25.	Crude ash.	Nitrogen.
	Period I.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
202	Steer 5,	54.32	5.05	2.38	45.07	35.04	2.61	9.85	.42
203	6,	54.72	5.30	2.78	39.65	33.37	5.65	13.25	.91
204	7,	56.47	4.85	1.85	37.88	29.75	3.92	21.85	.63
205	8,	58.28	5.50	2.00	38.13	31.50	5.82	17.05	.95
	Period II.								
251	Steer 5,	62.51	5.25	1.73	38.23	34.50	8.44	13.85	1.36
252	6,	60.15	5.00	1.10	37.58	34.46	6.96	14.90	1.12
253	7,	59.58	5.80	1.90	36.15	35.03	6.12	15.00	.98
254	8,	61.17	5.80	2.05	37.13	36.04	7.13	11.85	1.15
	Period III.								
307	Steer 5,	62.36	5.40	1.73	37.50	32.09	8.18	15.10	1.32
308	6,	61.53	5.85	2.03	39.83	32.49	8.75	11.05	1.40
309	7,	62.59	5.40	1.67	36.33	29.55	6.70	20.35	1.08
310	8,	64.04	5.55	2.57	34.10	35.06	7.57	15.15	1.22
134	Sawdust used as bedding,	38.18	9.30	5.83	64.58	18.18	.61	.90	.10

TABLE XXIX.—*Constituents of Manures, Set II. Period I.*

	Water.	Dry substance.	Nitrogen.	Crude ash.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Steer 5:—				
Manure, (225.5 lbs.,)	127.693	97.806	.433	10.146
Litter, (101.5 lbs.,)	44.965	56.535	.063	0.563
Excreta, (124.0 lbs.,)	82.728	41.271	.370	9.583
Steer 6:—				
Manure, (244.5 lbs.,)	139.658	104.842	1.007	14.669
Litter, (104.75 lbs.,)	46.405	58.345	.065	0.583
Excreta, (139.75 lbs.,)	93.253	46.497	.942	14.086
Steer 7:—				
Manure, (273.5 lbs.,)	160.711	112.789	.813	28.186
Litter, (102.5 lbs.,)	45.408	57.092	.063	0.570
Excreta, (171.0 lbs.,)	114.303	55.697	.750	27.616
Steer 8:—				
Manure, (253 lbs.,)	153.254	99.746	1.002	17.996
Litter, (101.75 lbs.,)	45.075	56.675	.063	0.566
Excreta, (151.25 lbs.,)	108.179	43.071	.939	17.430

TABLE XXX.—*Constituents of Manures. Set II, Period II.*

	Water.	Dry substance.	Nitrogen.	Crude ash.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Steer 5:—				
Manure, (210 lbs.,)	135.404	74.596	1.071	10.983
Litter, (80 lbs.,)	35.440	44.560	.049	.445
Excreta, (130 lbs.,)	99.964	30.036	1.022	10.538
Steer 6:—				
Manure, (191 lbs.,)	118.692	72.308	.852	11.341
Litter, (80 lbs.,)	35.440	44.560	.049	.445
Excreta, (111 lbs.,)	83.252	27.748	.803	10.896
Steer 7:—				
Manure, (244 lbs.,)	151.095	92.905	.967	14.794
Litter, (80 lbs.,)	35.440	44.560	.049	.445
Excreta, (164 lbs.,)	115.655	48.345	.918	14.349
Steer 8:—				
Manure, (217 lbs.,)	137.626	79.374	.969	9.985
Litter, (80 lbs.,)	35.440	44.560	.049	.445
Excreta, (137 lbs.,)	102.186	34.814	.920	9.540

TABLE XXXI.—*Constituents of Manures, Set II, Period III.*

	Water.	Dry substance.	Nitrogen.	Crude ash.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Steer 5:—				
Manure, (237 lbs.,)	152.610	84.390	1.178	13.470
Litter, (75 lbs.,)	33.225	41.775	.046	.417
Excreta, (162 lbs.,)	119.385	42.615	1.132	13.053
Steer 6:—				
Manure, (223 lbs.,)	142.250	80.750	1.201	9.477
Litter, (75 lbs.,)	33.225	41.775	.046	.417
Excreta, (148 lbs.,)	109.025	38.975	1.155	9.060
Steer 7:—				
Manure, (286.5 lbs.,)	185.108	101.392	1.158	21.811 (?)
Litter, (75 lbs.,	33.225	41.775	.046	.417
Excreta, (211.5 lbs.,)	151.883	59.617	1.112	21.394 (?)
Steer 8:—				
Manure, (193 lbs.,)	125.541	67.459	.871	10.821
Litter, (75 lbs.,)	33.225	41.775	.046	.417
Excreta, (118 lbs.,)	92.316	25.684	.825	10.404

TABLE XXXII.—*Summary of Data on Constituents of Excreta.*

	PERIOD I.		PERIOD II.		PERIOD III.	
	Steers 5 and 7.	Steers 6 and 8.	Steers 5 and 7.	Steers 6 and 8.	Steers 5 and 7.	Steers 6 and 8.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Dry substance,	45.454	44.758	39.130	31.281	51.116	52.229
Nitrogen,	.560	.940	.970	.861	1.132	.991
Crude ash,	18.569 ?	15.758	12.445	10.215	17.228 ?	9.782

It will be observed that the above results indicate, in spite of several doubtful determinations of crude ash, that, could not for lack of time be repeated, a decided superiority on the part of the steers receiving the cottonseed rations. This superiority is due not only to the greater quantities of nitrogen and mineral constituents contained in the dung, but also to the fact that that portion of the ash useful for plant food is present in somewhat larger proportion, if we may accept the results of other analysis. The low percentage of nitrogen found in the dung of steers 5 and 7, in Period I, is rather remarkable, and tends to increase the difference noticed between the two pairs in the later periods.

Another factor in producing the difference is the amount of excrement. It will be noticed that the *percentage* of nitrogen found in the manures was in Period III greater with the cornmeal ration than with the cottonseed, pointing to the presence in the dung of steers, receiving the latter ration, of a relatively larger quantity carbonaceous matter, which is also indicated by the figures of Table XXXII. The difference in favor of the steers receiving the cornmeal ration may, as has been suggested above, be more apparent than real, owing to the lower digestive capacity of steers 5 and 7 for protein observed during Period I. Nevertheless, the differences are not as great as might be expected, when the difference in the ration is considered.

(ii.) PROPORTION OF BUTCHERS' CARCASS, AND COMPOSITION OF FLESH OF STEERS OF SET II.

To place a more complete check upon the other work, the steers of Set II were slaughtered under my direction by a neighboring butcher, at such times as met his convenience, and the different portions of the body weighed. It was thought a matter of interest to dissect as carefully as possible a portion of the flesh selected so as to represent each animal, and note any difference in the proportion of fat to flesh, and in the percentages of nitrogen. For this purpose a slice 1½ inches thick was cut from the rump of each steer, at a point twenty inches above the hock. This was weighed and dissected as soon as possible, and the weights of bone, muscle, and fat, and connective tissue taken. A portion of the separated muscle was quickly dried and ignited with soda-lime. The following tables (XXXIII–XXXIV,) show the results obtained :

TABLE XXXIII.—*Slaughtered Weight of Steers of Set II.*

	Steer 5.	Steer 6.	Steer 7.	Steer 8.
Date of weighing,	April 22	April 10	April 15	April 19
Date of slaughter,	April 23	April 12	April 16	April 20
Live weight,	860 lbs.	765 lbs.	780 lbs.	723 lbs.
Dressed weight,	500 "	428 "	440 "	370 "
Per cent. of butchers' carcass,	58.14 "	55.81 "	56.41 "	51.17 "
Parts.				
Hind-quarter,	120 lbs.	104 lbs.	108 lbs.	88 lbs.
Fore-quarter,	130 "	110 "	112 "	97 "
Shins,	16 "	13.50 "	15 "	12 "
Heart,	10 "	13.75 "	10 "	7 "
Liver,	10 "	8 "	10.25 "	7 "
Lungs,	4 "	3.50 "	3.50 "	2.75 "
Stomach, intestines, and contents,	134 "	139 "	138 "	117 "
Omentum,	12.5 "	10 "	12 "	12.50 "
Head, hide, pancreas, spleen, kidneys, blood, &c., by difference,	173.5 "	149.25 "	151.25 "	194.75 "

TABLE XXXIV.—*Proportions of Muscle, Fat, and Connective Tissue, and Bone, in Fresh Rump Steak.*

	ABSOLUTE WEIGHT.				‡ PERCENTAGE OF PARTS.			
	Steer 5.	Steer 6.	Steer 7.	Steer 8.	Steer 5.	Steer 6.	Steer 7.	Steer 8.
	Grams.	*Grams.*	*Grams.*	*Grams.*				
Fresh weight,	1,198	890	1,228	827				
Weight after standing,	1,174	858	1,090	813				
Muscle,	945	692	*946	641	80.49	80.65	86.81	78.84
†Fat and connective tissue,	157	132	92	129	13.37	15.38	8.44	15.87
Bone,	72	34	42	48	6.14	3.97	4.75	5.39
Per cent. of nitrogen in fresh muscle,	.....	.....	.....	.....	2.50	2.50	2.62	2.88

† Including as much marrow as could conveniently be removed by a scalpel.

* Stood a day before it was dissected, hence a greater loss of moisture.

‡ Calculated after correcting for loss of moisture during dissection.

The figures of Table XXXIII show a large proportion of butchers' carcass for the steers receiving the cottonseed ration, as well as an absolutely larger weight of shins, liver, lungs, and omentum comparing the mean dressed weight for the two pairs, with the mean weight of the remaining portion of the steers we have the following figures :

	Steers 5 and 7.	Steers 6 and 8.
Mean dressed weight,	470 lbs.	399 lbs.
Mean weight of offal,	350 lbs.	345 lbs.

Taking into consideration the live weights of the animals at the beginning of this course of experiments, it seems evident that a portion of the difference in butchers' carcass in favor of the cottonseed rations, is in reality partially due to a difference in the original build of the steer.

It is furthermore noticeable, as shown by Table XXXIV, that the mean percentage of muscular tissue present in the rump steak was greater in steers 5 and 7 than in 6 and 8, while the fat was considerably less, as was also the percentage of nitrogen in the muscular tissue itself. Allowance must here be made for the admitted crudity of the results of dissection; but the results must remain practically in favor of steers 5 and 7, as far as the amount of muscular tissue is concerned. The increased quantity of albuminoids in the cottonseed ration does not seem to have increased the proportion of nitrogen in fresh muscle, but seems rather to have been spent in increasing the proportion of carcass.

(iii.) GAIN AND ITS COST.

As in the case of Set I, the gain has been estimated, together with its cost for each steer, in each period. The same rules and prices were adopted as in case of that set.

The following tables (XXXV–XXXVIII,) show the results:

TABLE XXXV.—*Gain and Its Cost, Set I, Period I.*

	Steer 5.	Steer 6.	Steer 7.	Steer 8.
Number of days included,	28	28	28	28
Weight, January 4,	740 lbs.	645 lbs.	642 lbs.	580 lbs.
Weight, February 1,	770 "	670 "	675 "	620 "
Gain,	30 "	25 "	33 "	40 "
Gain, per day,	1.05 "	0.89 "	1.18 "	1.43 "
Weight of fodder eaten,	191.31 "	187.53 "	203.23 "	198.29 "
Weight of cornmeal eaten,	168.00 "	168.00 "	168.00 "	168.00 "
Total weight of food eaten,	359.31 "	355.53 "	371.23 "	366.29 "
Total weight of water drunk,	770.0 "	763.0 "	875.0 "	831.0 "
Weight of food per day,	12.83 "	12.70 "	13.26 "	13.08 "
Weight of food per pound of gain,	11.98 "	14.22 "	11.25 "	9.16 "
Weight of water per day,	27.4 "	27.3 "	31.3 "	29.7 "
Cost of fodder,	$0.478	$0.469	$0.508	$0.496
Cost of cornmeal,	1.512	1.512	1.512	1.512
Total cost of food,	$1.990	$1.981	$2.020	$2.008
Cost per day,	0.071	0.071	0.072	0.072
Cost per pound of gain,	0.066	0.079	0.061	0.052

TABLE XXXVI.—*Gain and Its Cost, Set II, Period II.*

	Steer 5.	Steer 6.	Steer 7.	Steer 8.
Number of days included,	21	21	21	21
Weight, February 8,	780 lbs.	690 lbs.	690 lbs.	620 lbs.
Weight, March 1,	800 "	700 "	700 "	640 "
Gain,	20 "	10 "	10 "	20 "
Gain, per day,	0.95 "	0.48 "	0.48 "	0.95 "
Weight of fodder eaten,	117.22 "	102.61 "	115.59 "	94.60 "
Weight of cornmeal eaten,	105.00 "	210.00 "	108.33 "	210.00 "
Weight of cottonseed meal eaten,	52.50 "	....	54.17 "	
Total weight of food eaten,	274.72 "	312.61 "	278.09 "	304.60 "
Total weight of water drunk,	700.0 "	607.0 "	796.0 "	642.0 "
Weight of food per day,	13.08 "	14.89 "	13.24 "	14.50 "
Weight of food per pound of gain,	13.74 "	31.26 "	27.81 "	15.23 "
Weight of water per day,	33.3 "	28.9 "	37.9 "	30.6 "
Cost of fodder,	$0.293	$0.257	$0.289	$0.236
Cost of cornmeal,	0.945	1.890	0.975	1.890
Cost of cottonseed meal,	0.787	....	0.813	
Total cost of food,	$2.025	$2.147	$2.077	$2.126
Cost per day,	0.096	0.102	0.099	0.101
Cost per pound of gain,	0.101	0.215	0.208	0 106

TABLE XXXVII.—*Gain and Its Cost, Set II, Period III.*

	Steer 5.	Steer 6.	Steer 7.	Steer 8.
Date at the end of experiment,	April 21	April 9	April 14	April 18
Number of days included,	45	33	38	42
Weight, March 8,	825 lbs.	720 lbs.	740 lbs.	665 lbs.
Weight, end of experiment,	885 "	765 "	780 "	690 "
Gain,	60 "	45 "	40 "	25 "
Gain, per day,	1.33 "	1.38 "	1.05 "	0.51 "
Weight of hay eaten,	353.00 "	250.25 "	292.75 "	300.25 "
Weight of cornmeal eaten,	200.00 "	280.00 "	165.00 "	367.00 "
Weight of cottonseed meal eaten,	100.00 "	....	82.50 "	
Total weight of food eaten,	653.00 "	530.25 "	540.25 "	667.25 "
Total weight of water drunk,	1,824.0 "	1,057.0 "	1,378.0 "	1,484.0 "
Weight of food per day,	14.51 "	16.35 "	14.22 "	15.89 "
Weight of food per pound of gain,	10.88 "	11.78 "	13.51 "	26.47 "
Weight of water per day,	40.5 "	32.00 "	36.3 "	35.3 "
Cost of hay,	$2.294	$1.627	$1.903	$1.952
Cost of cornmeal,	1.800	2.520	1.485	3.303
Cost of cottonseed meal,	1.500	....	1.237	
Total cost of food,	$5.594	$4.147	$4.625	$5.255
Cost per day,	0.124	0.126	0.122	0.125
Cost per pound of gain,	0.093	0.092	0.116	0.210

TABLE XXXVIII.—*Summary of Data on Gain and Its Cost, Set II.*

	PERIOD I.		PERIOD II.		PERIOD III.	
	Steers 5 and 7.	Steers 6 and 8.	Steers 5 and 7.	Steers 6 and 8.	Steers 5 and 7.	Steers 6 and 8.
Daily gain in live weights,	1.11 lbs.	1.16 lbs.	.71 lbs.	.71 lbs.	1.19 lbs.	.94 lbs.
Amount of food eaten per pound of gain,	11.61 "	11.69 "	20.77 "	23.24 "	12.19 "	19.12 "
Cost per pound of gain,	$0.063	$0.065	$0.154	$0.160	$0.104	$0.151

These figures show that the pairs of steers agreed very closely during Period I, and that in Period II, with the same gain per day in live weight; the steers receiving the cottonseed ration made the gain with less food and at less cost than the other pair; while in Period III, the daily gain was considerably greater, and likewise produced with less consumption of food and less cost. It is but just to observe that in the last period a very considerable portion of the difference is due to the falling off of Steer No. 8, but taken as a whole, the experiments seem to be favorable to the cottonseed ration.

It will be remembered that the results on Set I led to the opposite conclusion. This fact emphasizes the statement made before, that further experiment on a larger number of steers is necessary to the settlement of this important question.

XXIII. MILK RECORDS.

During the past year a complete record of the morning and evening yield of milk was begun, taking each cow in turn as it calved. The weighings began six days after calving. The results are given in the following table.

MONTHS.	POLLY, full Jersey. Calved April 1, 1886.			MARY, Brindle, ¾ Jersey grade. Calved May 28.			BOSS, Short-horn grade. Calved September 19.			KATE, full Jersey. Calved September 24.			BERT,‡ Short-horn grade. Calved November 1.			BLACK, native, Calved November 24.		
	A. M.	P. M.	Total.	A. M.	P. M.	Total.	A. M.	P. M.	Total.	A. M.	P. M.	Total.	A. M.	P. M.	Total.	A. M.	P. M.	Total.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
*June,	187.6	228.0	415.6	168.2	179.8	348.0												
July,	222.2	233.9	456.1	223.7	236.7	460.4												
August,	237.2	218.3	455.5	133.8	216.4	359.2												
†September,	130.0	133.2	263.2	134.6	132.6	267.2												
October,	185.2	169.7	354.9	215.2	210.0	425.7	347.7	324.4	672.1	300.1	288.1	588.2						
November,	148.6	124.8	273.4	187.7	149.5	336.12	272.0	213.3	485.3	286.8	235.6	522.4	249.6	206.4	456.0			
December,	133.1	101.5	234.6	171.4	126.5	297.8	241.9	181.5	423.4	268.9	199.6	468.5	336.8	261,8	598.6	286.3	220.3	506.6

* Beginning June 9 with Polly, and June 8 with Mary Brindle.

† Omitting September 21–25.

‡ Beginning November 6.

In addition to the records of the weight of milk yielded by the several cows of the herd, a record is kept of the temperature of the stable at the time of milking, but these observations are reserved for later study.

XXIV. Meteorological Observations for 1885–1886.

For some years past the duty of taking the meteorological observations has devolved upon the Professor of Physics. Under present conditions it seemed preferable to have the observations taken at a point not far removed from the experimental plots, and to correlate the work as closely with the experimental work as the means at command would permit.

Accordingly a transfer was made during July, 1886, a louvre being fitted into the window of the eastern end of the farm-house at the Central Experimental Farm. As part of the apparatus previously used belongs to the equipment of the physical laboratory, it has been impossible to complete the usual record of meteorological changes. It is hoped, however, that the equipment may be completed during the present year, as the importance of the relations of meteorology to agriculture is fully appreciated.

The observations at the farm are taken by my assistant, Mr. H. J. Patterson; those prior to July, 1886, were taken by Prof. Osmond.

The barometric observations made previously, will not, for the present, be entered in the table.

The latitude is approximately 40°55 N, and the longitude, 77°51 W; the height above the sea, at Prof. Osmond's, 1,168.31 feet, at the Central Experimental Farm, 1,213.5 feet.

Meteorological Records, 1885.

MONTHS.	TEMPERATURE.						PRECIPITATION.			PREVAILING WIND.			CLOUDINESS.		
	7, A. M.	2, P. M.	9, P. M.	Daily mean.	Mean maximum.	Mean minimum.	Rain.	Snow.	Rain and melted snow.	7, A. M.	2, P. M.	9, P. M.	7, A. M.	2, P. M.	9, P. M.
	F. °	*F.* °	*F.* °	*F.* °	*F.* °	*F.* °	*Inches.*	*Inches.*	*Inches.*						
January,	21.15	27.55	21.11	24.33	31.66	13.59	Trace.	....	Trace.	W.	W.	W.	5.8	6.7	4.9
February,															
March,	19.55	22.42	18.21	19.59	26.91	4.81	....	....	....	W.	W.	W.	6.2	5.5	3.5
April,															
May,															
June,															
July,															
August,															
September,															
October,	43.55	56.96	47.89	49.07	58.35	36.44	....	....	3.81	S.	SW.	W.	6.8	5.9	5.3
November,	32.58	43.50	36.54	37.51	44.16	31.77	....	....	3.49	SW.	SW.	W.	7.3	7.4	7.4
December,	27.50	33.81	29.59	30.12	37.51	18.70	....	....	2.27	W.	W.	W.	6.3	5.1	5.7

Observations interrupted by illness of Prof. Osmond, January 28–March 5; March 27–September 30.

OTHER OMISSIONS:—March 6, 7, A. M.; March 14, 7, A. M., and 2, P. M.; March 26, 9, P. M.; October 6, 9, P. M.; October 9 and 10, 2, P. M., October 17, 2, and 9, P. M.; October 30, 2, P. M.; November 8, 2, and 9, P. M.; November 11, 9, P. M.; November 12 and 13, 2, and 9, P. M.; November 19 and 20, 2, and 9, P. M.; December 11, 18, and 21, 2, and 9, P. M.; December 19, whole day; December 26, 9, P. M.

Meteorological Records, 1886.

MONTHS.	TEMPERATURE.						PRECIPITATION.			PREVAILING WIND.			CLOUDINESS.		
	7, A. M.	2, P. M.	9, P. M.	Daily mean.	Mean maximum.	Mean minimum.	Rain.	Snow.	Rain and melted snow.	7, A. M.	2, P. M.	9, P. M.	7, A. M.	2, P. M.	9, P. M.
	F.°	F.°	F.°	F.°	F.°	F.°	Inches.	Inches.							
January,	18.60	26.95	21.3	21.95	27.56	10.30	....	....	6.38	W.	W.	W.	6.2	6.3	6.3
February,	20.11	30.88	25.88	25.69	32.80	12.11	....	....	1.78	SW.	W.	W.	6.5	5.8	4.8
March,	31.48	38.64	32.79	33.92	41.69	27.86	....	....	2.46	SW.	W.	NW.	6.5	6.4	5.6
April,	54.50	70.85	59.19	60.93	73.35	46.30	1.16	....	1.16	S.	SW.	SW.	5.1	4.4	4.7
May,	54.03	65.34	56.93	58.31	72.45	45.00	3.45	....	3.45	S.	S.	S.	5.5	5.6	5.0
June,	58.13	70.56	63.52	63.93	78.75	48.62	4.57	....	4.57	S.	SW.	SW.	4.8	5.2	4.8
July,	66.89	76.71	70.87	71.36	78.73	69.89	4.44	....	4.44	....	....	....	4.5	4.4	5.4
August,	65.29	77.43	66.80	69.08	81.00	68.36	2.02	....	2.02	....	....	....	5.4	4.3	4.2
September,	59.25	72.83	62.83	64.33	75.77	61.88	3.25	....	2.25	....	....	....	4.3	3.3	4.0
October,	45.59	61.11	50.98	52.17	65.06	40.76	1.19	....	1.19	....	....	....	5.2	4.2	3.3
November,	34.43	42.42	36.97	37.69	48.28	29.25	4.01	21.75	6.18	W.	SW.	SW.	5.8	5.3	5.2
December,	20.96	28.03	22.40	23.15	30.66	15.56	0.61	9.00	1.51	W.	W.	W.	6.0	6.1	4.2

OMISSIONS:—January 23, 2, P. M.: January 24, 9, P. M.; January 19, 9, P. M.; February 15 and 18, 9, P. M.; February 19, February 27, 2, and 9, P. M.; March 11, 2, P. M.; March 17 and 19, 9, P. M.; March 25, 2, and 9, P. M.; March 31, 2, P. M.; April 1–9, May 6, 2, P. M.; May 10, 2, P. M.; May 21, 9, P. M.; May 23, 2, and 9, P. M.; June 4 and 12, 7, A. M., and 2, P. M.; June 19, 21, and 22, 2, P. M.; June 25, 9, P. M.; July 1–12, (interval occurring at time of transfer of observatory.)

In addition to the above records, the following special data for the several months may be of interest:

1885.

January.

Highest temperature, 61° F., 9th inst.;
Lowest temperature, —5° F., 27th inst.;
Prevailing wind, W.

March.

Highest temperature, 40° F., 8th and 10th inst.;
Lowest temperature, —12° F., 5th inst.;
Prevailing wind, W.

October.

Highest temperature, 76° F., 1st. inst.;
Lowest temperature, 23° F., 30th inst.;
Number of days when rainfall exceeded 0.01 inch, 8;
Prevailing wind, S.W. to W.:
A little snow, occasional flakes, 30th inst.

November.

Highest temperature, 68° F., 7th inst.;
Lowest temperature, 5° F., 30th inst.;
Number of days on which rainfall exceeded 0.01 inch, 11;
Prevailing wind, S.W. to W.;
21st, ground nearly white with snow in A. M. for the first time;
23d, ground white with snow;
24th, snow about 10 inches deep, and much of it melted.

December.

Highest temperature, 49° F., 9th inst.;
Lowest temperature, —8° F., 8th inst.;
Number of days on which more than 0.01 inches of rain fell, 6;
Prevailing wind, W.

1886.

January.

Highest temperature, 54° F., 4th inst.;
Lowest temperature, —17° F., 13th inst.;
Number of days on which 0.01 inch, or more, of rain fell, 12;
Prevailing wind, W.;
1st, no snow on the ground, but on the mountains north and south;
4th, lightning in the evening.

February.

Highest temperature, 49° F., 8th, 10th, and 12th, insts.;
Lowest temperature, —17° F., 5th inst.;
Number of days on which 0.01 inch, or more, of rain fell, 6;
Prevailing wind, W.

March.

Highest temperature, 65° F., 15th inst.;
Lowest temperature, 0° F., 1st inst.;
Number of days on which 0.01 inch, or more, of rain fell, 8;
Prevailing wind, W. to N.W.;
18th, thunder about 5, P. M.; quite heavy for some time after 9, P. M.

April.

Highest temperature, 83° F., 22d inst.;
Lowest temperature, 36° F., 10th inst.;
Number of days on which 0.01 inch. or more, of rain fell, (including 1st–8th,) 13;
Prevailing wind, S.W.;
From 1st–8th, weather cloudy, with rain and snow almost continuously; temperature varying little from freezing point; during this interval 3.39 inches of rain and melted snow fell, making the total rainfall for the month 4.55 inches.
14th, very fine lunar halo, forming a complete circle.
20th, heavy thunderstorm during night, and continuous thunder P. M., in S.W. and W.

May.

Highest temperature, 85° F., 22d and 30th insts.;
Lowest temperature, 33° F., 26th inst.;
Number of days on which 0.01 inch, or more, of rain fell, 9;
Prevailing wind, S.;
8th, a distinct and quite permanent auroral arch, and at times a quite fine display of streamers; moonlight interfered.

June.

Highest temperature, 88° F., 13th and 29th inst.;
Lowest temperature, 34° F., 4th inst.;
Number of days on which 0.01 inch, or more of rain fell, 9;
Prevailing wind, S.W.

July.

Highest temperature, 88° F., 29th inst.;
Lowest temperature, 52.°5 F., 19th and 24th inst.;
Number of days on which 0.01 inch, or more of rain fell, 7.

August.

Highest temperature, 91° F., 28th inst.;
Lowest temperature, 48.°5 F., 19th inst.;
Number of days on which 0.01 inch, or more, of rain fell, 8.

September.

Highest temperature, 88° F., 10th inst.;
Lowest temperature, 40° F., 30th inst.;
Number of days on which 0.01 inch, or more of rain fell, 9.

October.

Highest temperature, 79° F., 13th and 14th insts.;
Lowest temperature, 24° F., 3d inst.;
Number of days on which 0,01 inch, or more, of rain fell, 10;
3d, heavy frost; ice ⅛ inch thick;
15th, at 2, P. M. wind had a velocity 20.9 miles per hour; at 5.50 P. M., a heavy shower lasting 15 minutes;
26th, continuous showers till 28th inst;
29th, heavy frost.

November.

Highest temperature, 69° F., 3d inst.;
Lowest temperature, 2° F., 27th inst.;
Number of days on which 0.01 inch, of rain fell, 14;
Prevailing wind, S.W.;
3d, thunder and considerable diffused lightning, beginning at 6, P. M., and lasting for three hours.
6th, a blowing snowstorm lasting from 6–8 P. M.;
Heaviest snow of month, 9.5 inches, 25th inst.

December.

Highest temperature, 59° F., 11th inst.;
Lowest temperature, 0° F., 6th inst.;
Number of days on which 0.01 inch or more of rain fell, 11;
Prevailing wind, W.;
4th and 5th, lunar halos, large on the 4th;
12th, rapid thaw, continuing all day and destroying the sleighing;
16th, snowfall of 4 inches.

APPENDIX.

Pennsylvania State College

AGRICULTURAL EXPERIMENTS.

[The earlier Bulletins issued by the College have long been out of print, and are here re-printed in response to numerous calls.]

PENNSYLVANIA STATE COLLEGE

BULLETINS.

The following account of one of the experiments conducted by Prof. W. H. Jordan on the college experimental farm during the past season, is printed for the information of farmers and others interested in agricultural science. It is believed that practical information distributed in this form will be of important service to the agricultural interests of the State, and it is designed to present, in a similar manner, from time to time, the results of other experiments or investigations. Additional copies may be procured by addressing THE PRESIDENT OR PROFESSOR OF AGRICULTURE, State College, Centre county, Pennsylvania.

Correspondence is invited.

No. 1. November 15, 1882.

The results of an Experiment showing the effect of various Fertilizers on the Quantity and Quality of the Wheat Crop.

The main consideration that leads farmers to adopt or reject any system of crop production, is that of profit. In particular, is the question of the economy of using commercial manures, lime, plaster, &c., carefully scrutinized. The decision as to what fertilizer or other substance is to be applied to the land, should be based on two points:

First. The effect on the quantity and quality of the crop.

Second. The effect on the future fertility of the soil.

It is safe to say that the former point is often kept in mind while the latter is utterly neglected. To obtain a crop for the present season, seems with many farmers to be the chief aim, regardless of what future years are to bring.

The system of field experiments now in progress on two of the experimental farms of the College, is intended to include the use of all the principal methods that are generally employed for the maintenance of fertility, and is to be continued for a number of years sufficient to determine the ultimate effect and value of the different methods of manuring employed. There is involved in these experiments a four years' rotation, corn, oats, wheat, grass, to be carried out on four parallel series of plots, each plot in a series to be treated the same way, year after year, and in the same manner that a corresponding plot in each of the other series is treated. It is hoped that we may thus obtain some facts of general interest with regard to the use of commercial and farm manures, of lime with and without yard manure, of plaster, &c.

In order to make intelligible the methods and aims of the experiments, a little explanation of the chemistry of fertilizers may be necessary.

Commercial fertilizers contain, among various ingredients, three that are especially valuable, and upon which the market prices of the fertilizers are based, viz: *nitrogen, phosphoric acid,* and *potash.* Some fertilizers contain one of these ingredients, some two, and some all.

Dissolved bone, dissolved bone-black, and *dissolved South Carolina rock* contain only *phosphoric acid,* excepting a small percentage of nitrogen in the dissolved bone. The chief source of *potash* is the *muriate* and *sulphate of potash* that are imported to this country from Germany, these salts containing no other valuable ingredient. *Wood ashes* also contain a great deal of potash, but are available only in certain sections of the country. *Nitrogen* is sold principally in *nitrate of soda,* (Chili saltpeter,) *sulphate of ammonia, dried blood, dried fish,* and various kinds of *meat scrap,* none of these substances containing anything of much value save the nitrogen.

The *superphosphates* that are found in the market contain phosphoric acid as the principal ingredient, accompanied usually by small percentages of nitrogen and potash. In compounding these superphosphates, manufacturers take some form of bone or South Carolina rock as the basis, adding a little nitrogen and potash, by using some of the materials mentioned above.

Of these three ingredients nitrogen is the most costly, the price ranging from 18 cents to 26 cents per pound, according to its source. Soluble phosphoric acid costs about 12½ cents per pound, while the insoluble form is sold at prices varying from 3 cents to 6 cents. Potash is worth 4½ cents in the muriate, and 6 cents in the sulphate.

All the elements of plant growth are found in yard manure, the percentages of nitrogen, phosphoric acid, and potash present depending upon the food from which the manure is made. Yard manure also contains a large amount of organic material that commercial manures do not, to which, however, we can assign no definite value.

The experiment here reported was conducted upon the Central Experimental Farm of the College, on land that is a limestone clay, and on plots that produced a crop of oats the preceding season, which was manured in exactly the same manner as the wheat, in this experiment.

The fertilizers were applied just before the wheat was sown, the yard manure being plowed under, and the commercial manures being harrowed in after the land had been plowed and harrowed once. Dissolved bone-black and muriate of potash were used as the respective sources of phosphoric acid and potash, and nitrogen was used in three different forms, viz: Dried blood, nitrate of soda, and sulphate of ammonia. The yard manure was produced from wheat-bran, corn-meal, corn-stalks, and hay, fed to milch cows and fattening steers, wheat straw being freely used as a litter. In all respects, except in the application of different fertilizers, the various plots were treated exactly alike. They are two hundred and sixty feet long, by twenty-one feet wide, each containing one eighth of an acre.

The following tabulation of results should be examined with certain questions in mind.

1. What ingredient or mixture of ingredients was most efficient?
2. What was the effect of a large application of nitrogenous material?
3. How do the results from commercial and farm-yard manures compare?
4. Did lime, ground limestone, or plaster increase production?
5. Did any of the fertilizers affect the quality of the wheat?

	Number of plot.	KIND OF FERTILIZER.	Quantity of fertilizer.	Cost of fertilizer.	Quantities of valuable ingredients: Nitrogen.	Phosphoric acid.	Potash.	Yield per acre: Wheat.	Straw.	Weight of a measured bushel at time of threshing.
			Lbs.		Lbs.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.
	1	Nothing,	....	....	...	...	...	7	420	52½
Valuable ingredients singly.	2	Dried blood,	320	$7 20	32	...	...	11.1	1,576	56
	3	Dissolved bone-black,	300	5 25	...	48	...	20.3	1,904	60
	4	Muriate of potash,	200	4 50	...	...	100	13.3	1,400	59½
Valuable ingredients two by two.	5	Dried blood, Dissolved bone-black,	240 300	10 05	32	48	...	22	1,520	61
	6	Dried blood, Muriate of potash,	240 200	9 90	32	...	100	7	984	54
	7	Dissolved bone-black, Muriate of potash,	300 200	9 75	...	48	100	19.3	1,840	61½
	8	Nothing,	....	....	...	...	...	16.6	1,720	61½
Complete fertilizer† with nitrogen in different proportions. Nitrogen furnished by dried blood.	9	Mineral fertilizers,* Dried blood,	500 210	15 15	24	48	100	21.6	2,464	61½
	10	Mineral fertilizers, Dried blood,	500 480	20 55	48	48	100	21.2	2,624	60½
	11	Mineral fertilizers, Dried blood,	500 720	25 95	72	48	100	25.3	2,880	60½
	12	Mineral fertilizers, Dried blood,	500 240	15 15	24	48	100	19.2	2,128	62
	13	Plaster,	320	1 00	...	...	...	11.7	1,176	55½
	14	Nothing,	....	....	...	...	...	12.4	1,776	59
Commercial fertilizers and yard manure compared.	15	Mineral fertilizers,	500	9 75	...	48	100	23.2	2,368	62
	16	Yard manure,	12,000	6 00	41	20	48	23.2	2,664	61
	17	Mineral fertilizers, Dried blood,	500 240	15 15	24	48	100	24	3,000	61
	18	Yard manure,	16,000	8 00	54	26	64	22.7	2,800	58
	19	Mineral fertilizers, Dried blood,	500 480	20 55	48	48	100	25.9	2,968	60
	20	Yard manure,	20,000	10 00	68	32	80	23.3	3,080	58
	21	Mineral fertilizers, Dried blood,	500 720	25 95	72	48	100	22.1	2,432	62
	22	Yard manure, Lime,	12,000 4,000	16 00	41	20	48	21.4	2,816	60
	23	Lime,	4,000	10 00	...	...	...	17.2	2,032	58½
	24	Nothing,	....	....	...	...	...	14	2,064	56
Complete fertilizers with nitrogen in different proportion. Nitrogen furnished by nitrate of soda.	25	Mineral fertilizers,	500	9 75	...	...	...	23.8	2,736	62½
	26	Mineral fertilizers, Nitrate of soda,	500 160	16 05	24	48	100	27	3,064	60½
	27	Mineral fertilizers, Nitrate of soda,	500 320	22 35	48	48	100	23.6	2,824	60
	28	Mineral fertilizers, Nitrate of soda,	500 480	28 65	72	48	100	25.2	3,048	59
Complete fertilizer with nitrogen in different proportions. Nitrogen furnished by sulphate of ammonia.	29	Mineral fertilizers,	500	9 75	...	48	100	22.8	2,392	61
	30	Mineral fertilizers, Sulphate of ammonia,	500 120	15 75	24	48	100	25.1	3,016	61
	31	Mineral fertilizers, Sulphate of ammonia,	500 240	21 75	48	48	100	26.1	2,912	61½
	32	Mineral fertilizers, Sulphate of ammonia,	500 360	27 75	72	48	100	24.3	2,504	60
	33	Plaster,	320	1 00	...	...	...	9.1	1,495	54
	34	Ground limestone,	4,000	10 00	...	...	...	10.1	1,760	51½
	35	Mineral fertilizers,	....	....	...	...	...	26.3	2,864	59½
	36	Nothing,	....	....	...	...	...	15.3	2,040	58

* "Mineral fertilizers" means a mixture similar to that applied to plot 7, viz: 300 pounds dissolved bone-black and 200 pounds muriate of potash. In plots 9 to 12, for instance, this mixture is used together with certain quantities of dried blood.

† A fertilizer containing nitrogen, phosphoric acid, and potash.

As several sets of plots in this experiment were treated practically in the same manner, averages of the yield from the plots receiving no fertilizer, and from the plots manured alike, are given in the next table. In this way errors resulting from natural differences of soil are largely eliminated. The former table shows that wherever phosphoric acid and potash are applied, 300 pounds of dissolved bone-black, and 200 pounds of muriate of potash were used, furnishing 48 pounds of phosphoric acid and 100 pounds of potash. Nitrogen is the only ingredient that was applied in varying quantities:

	YIELD PER ACRE.		INCREASE OF YIELD OVER PLOTS NOT MANURED.		Weight of a measured bushel.
	Wheat—bushels.	Straw—pounds.	Wheat—bushels.	Straw—pounds.	
Average yield of four plots receiving no fertilizer,	12.2	1,575			56.4
Yield of one plot receiving nitrogen,	11.1	1,576	....	....	56
Yield of one plot receiving phosphoric acid,	20.3	1.904	8.1	329	60
Yield of one plot receiving potash,	13.3	1.400	1.1	....	59.5
Yield of one plot receiving nitrogen and phosphoric acid,	22.0	1,520	9.8	....	61
Yield of one plot receiving nitrogen and potash,	7.0	984	....	....	54
Average yield of four plots receiving phosphoric acid and potash,	22.3	2,336	10.1	761	61.8
Average yield of four plots receiving phosphoric acid, potash, and 24 lbs. of nitrogen,	24.4	2,888	12.2	1,313	61
Average yield of four plots receiving phosphoric acid, potash, and 48 lbs. of nitrogen,	24.2	2,832	12.0	1,257	60.5
Average yield of four plots receiving phosphoric acid, potash, and 72 lbs. of nitrogen,	24.3	2,716	12.1	1,241	60.4
Average yield of four plots receiving yard manure,	22.6	2,840	10.4	1,265	59.3
Average yield of two plots receiving plaster,	10.4	1,336	....	....	54.8
Yield of one plot receiving ground limestone,	10.1	1,760	....	185	54.5
Yield of one plot receiving caustic lime,	17.2	2,032	5	457	58.5

A careful examination of the above tables makes evident the following facts in regard to this year's crop:

1. Phosphoric acid (from dissolved bone-black) was more efficient in increasing the crop than any other ingredient of the fertilizers used.

2. The addition of potash, and especially of both potash and nitrogen, to the phosphoric acid, gave a larger yield of both grain and straw, particularly of straw.

3. The use of the largest quantity of nitrogen (72 lbs.) with the mineral fertilizers, (phosphoric acid and potash,) resulted in no larger yield than the use of the smallest quantity (24 lbs.) of nitrogen. That is, increasing the nitrogenous fertilizer did not increase the crop.

4. The increase of crop from the use of yard manure was not so large as from the use of the complete commercial fertilizer.

5. Lime, ground limestone, and plaster had no appreciable effect on the crop.

6. The weight of a measured bushel of wheat was considerably larger wherever yard manure, or commercial fertilizers containing phosphoric acid, was used. On those plots receiving no manure, or only plaster, ground limestone, or caustic lime, the grain seemed shriveled, and was of less than standard weight.

7. In order to determine the effect of the different methods of manuring upon the composition of the grain, an analysis was made of samples taken from plots that were manured according to the various methods shown. Below are the results:

METHOD OF MANURING.	Water.	100 PARTS OF WATER-FREE SUBSTANCE CONTAINED—				
		Ash.	Albuminoids=N×6.	Crude fiber.	Other carbo-hydrates.	Fats.
No fertilizer, (average of 4 plots,)	13.33	2.35	12.53	3.19	79.63	2.30
Phosphoric acid and potash, (average of 4 plots,)	13.04	2.29	12.07	3.05	80 32	2.27
Phos. acid, potash, and 24 lbs. nitrogen, (average of 4 plots,)	13.16	2.34	12.85	2.89	79.73	2.19
Phos. acid, potash, and 48 lbs. nitrogen, (average of 4 plots,)	13.06	2.27	13.45	2.84	79.25	2.19
Phos. acid, potash, and 72 lbs. nitrogen, (average of 4 plots,)	12.59	2.09	13.38	2.89	79.44	2.20
Yard manure, (average of 4 plots,)	12.41	2.39	12.60	2.70	80.15	2.16

A small increase in the percentage of the nitrogenous portion of the grain seems to have resulted from the use of nitrogenous fertilizers, which is in accordance with facts previously known. The milling value of the wheat from the well manured plots is undoubtedly greater than where no fertilizer was applied.

8. No attempt has been made to determine the profit or loss involved in the use of the various fertilizers, as this cannot be done until one rotation has passed, and perhaps several. If simply this year's crop be considered, the plots receiving phosphoric acid alone, and phosphoric acid and potash combined, were the only ones where the increase of crop paid for the fertilizer. The prospects now are that the yield of grass next year will change the figures somewhat. These results, as well as those obtained in other parts of the country, make it seem doubtful whether the use of large quantities of nitrogenous fertilizers will, at present, be attended with profit. If, however, we adopt the policy of applying manure containing little nitrogen, the time will undoubtedly come when nitrogenous fertilizers will be more essential. The nitric acid and ammonia compounds coming from the air and from the decomposition of organic material in the soil, seem just now to be able to furnish us with a considerable portion of the nitrogen needed for plant growth. The length of time that this will continue to be the case can be determined only by experiment, and would probably vary largely with different soils.

Until we have more data from which to draw conclusions, probably the safest thing for the farmer to do, who wishes to use commercial manures, and has made no study of the needs of his soil, is to apply a fertilizer, containing phosphoric acid as the principal ingredient, accompanied by small percentages of nitrogen and potash. The superphosphates in the market answer the purpose very well, the chief objection to them being the small percentage of soluble phosphoric acid which they generally carry.

Does the solid matter of the wheat kernel increase after cutting, when the grain is cut before ripening?

The above question is one somewhat discussed by farmers. Some hold that when wheat is cut while still green the growth of the kernel is completed after cutting, in the same manner as when the wheat is allowed to stand until fully ripe. In order to get information on this point, samples of wheat were cut at various stages of growth, in each case the kernels of a portion of the sample being removed immediately upon cutting, the kernels of the remaining portion being allowed to dry on the stalk in the usual manner. After the wheat had become as dry as it would get in a warm dry room, two lots of 500 kernels each were counted from each sample, and then weighed. In this manner any appreciable growth on the part of the wheat dried on the stalk would be detected.

	FIRST LOT.				SECOND LOT.			
	Weight of 500 kernels.		Aver. weight of one kernel.		Weight of 500 kernels.		Aver. weight of one kernel.	
	Taken from stalk at cutting.	Dried on stalk.	Taken from stalk at cutting.	Dried on stalk.	Taken from stalk at cutting.	Dried on stalk.	Taken from stalk at cutting.	Dried on stalk.
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Cut June 24—in milk; kernel only partially developed; shriveled in drying, ...	4.099	5.261	.00820	.01052	4.137	5.302	.00827	.01060
Cut July 5—upper leaves green; lower leaves dead; head slightly turned; grain shriveled some in drying, ...	14.002	14.202	.02800	.02850	14.151	14.459	.02830	.02892
Cut July 10—stalk nearly all yellow; head tinted green; kernels beginning to turn brown, ...	16.834	16.697	.03367	.03339	17.222	16.915	.03441	.03389
Cut July 12—heads yellow; kernels colored brown, ...	17.270	17.259	.03454	.03452	17.204	17.249	.03441	.03450
Cut July 15—wheat crop cut same day, . . .	18.491	18.171	.03698	.03634	18.279	18.099	.03656	.03616

The increase in weight of the kernels after the wheat was cut appears to have been about 28 per cent., in the case of the partially developed kernels taken June 24. In all the subsequent samples the kernels dried on the stalk seem to be no heavier than those removed before drying and immediately after cutting.

No. 2. December 30, 1882.

I. The Results of Experiments with various Fertilizers on Corn and Oats.

II. An Examination of Agricultural Seeds.

The experiments here reported were conducted on the Central and Eastern Experimental Farms of the College, in each case occupying one of four series of plots on which are being conducted a system of experiments on corn, oats, wheat, and grass, in rotation. (See Experiment on Wheat, Bulletin No. 1.) The results of these experiments are, to a certain extent, negative in their character, which, however, constitutes no reason why they should be withheld, for honest experimenting demands that no facts or conditions shall be ignored. In the present case, while we cannot point to any remarkable or even satisfactory increase of crop from the use of any fertilizer, yet the results may serve to give some hints that will prove of value in farm practice. It is not claimed that complete rules of practice for general use can be derived from experimental work on two farms, or on twenty. The most that can be hoped for is the demonstration of principles that can serve for more or less general application, each farmer adapting them to his own peculiar conditions. However much experiment stations or industrial colleges may do for the farmer, each tiller of the soil must, to a certain extent, experiment for himself and form his own rules of practice, applicable to the special conditions with which he finds himself surrounded.

1. EXPERIMENTS ON CORN.

On both of the farms mentioned above, for two years (1881 and 1882,) considerable time and labor have been devoted to an experiment on corn, using on each farm, for each year, a different series of plots, the yearly number of plots on the Central farm being thirty-six, and on the Eastern farm twenty-two. The fertilizers used were for both years the same, in order, quantity, and kinds, as in the wheat experiment previously described. (See Bulletin No. 1.) In every case the fertilizers were applied to the plots in the spring, just previous to planting the seed, and shortly after breaking the sod. In 1881, they were sown broadcast on the land after it had been harrowed, but in 1882, they were spread while the land was lying in farrow or before harrowing, a deeper admixture of the soil and fertilizers being secured by the latter method than by the former. In both years the yard manure was spread on the sod, and plowed under. In planting, care was taken that there should be the same number of hills on each plot, and the same number of seeds in each hill. The rows and hills were such distances apart, that each plot contained at the rate of about 40,000 hills per acre—Eastern farm, 4ft. x 2.6 ft.; Central farm, 3.5 ft. x 3 ft.—and as three stalks were allowed to grow in each hill, the number of stalks per acre was about 120,000. The endeavor was made to complete on all the plots each operation in planting and cultivation on the same day that it was begun, so that no differences in the time of planting the seeds, &c., should cause differences in production. The corn was cultivated in the usual manner, all the plots being treated alike. The size of the plots on the Central farm is one eighth of an acre, being two hundred and sixty (260) feet long, and twenty-one (21) feet wide. On the Eastern farm they contain one twentieth of an acre, being one rod in width, and eight rods in length.

The results reached on each plot in each experiment are not shown here; only the average production of plots that were treated alike on both farms for both years being given. These averages, together with the methods of manuring, can be seen in the following table:

KINDS AND QUANTITIES OF FERTILIZERS APPLIED PER ACRE IN 1881 AND 1882, ON BOTH FARMS.*	Quantities of valuable ingredients contained in the fertilizers applied to an acre.			NUMBER OF PLOTS REPRESENTED IN THE AVERAGE YIELDS GIVEN.	Yield per acre.		Increase of yield due to the fertilizers.	
	Nitrogen, pounds.	Phosphoric acid.	Potash, pounds.		Corn, bushels.	Stalks, pounds.	Corn, bushels.	Stalks, pounds.
	Lbs.	*Lbs.*	*Lbs.*					
No fertilizer, ...	. . .	. . .	. . .	Average yield of 16 plots, .	34.3	2726		
Dried blood, 240 lbs.	24	. . .	. . .	Average yield of 4 plots, .	34.5	2792	.2	66
Dissolved bone-black, 300 lbs.	. . .	48	. . .	Average yield of 4 plots, .	37.0	2853	2.7	127
Muriate of potash, 200 lbs.	. . .	. . .	100	Average yield of 4 plots, .	32.6	3093	—1.7	367
Dried blood, 240 lbs. Dissolved bone-black, 300 lbs.	24	48	. . .	Average yield of 4 plots, .	40.2	2987	5.9	261
Dried blood, 240 lbs. Muriate of potash, 200 lbs.	24	. . .	100	Average yield of 4 plots, .	35.7	3413	1,4	687
Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	. . .	48	100	Average yield of 14 plots, .	37.6	3106	3.3	380
Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs. Nitrogenous fertilizer, † —	24	48	100	Average yield of 16 plots, .	36.3	3298	2.0	572
Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs. Nitrogenous fertilizer, ‡ —	48	48	100	Average yield of 14 plots, .	37.5	3245	3.2	519
Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs. Nitrogenous fertilizer, ‖ —	72	48	100	Average yield of 14 plots, .	36.6	3256	2.3	530
Yard manure, § 16,000 lbs.	54	26	64	Average yield of 10 plots, .	36.9	2700	2.6	— 26
Plaster, 320 lbs.	. . .	. . .	. . .	Average yield of 6 plots, .	34.6	2620	.3	—106

* The arrangement of the plots in detail is given in Bulletin No. 1.

† Either *dried blood*, *sulphate of ammonia*, or *nitrate of soda*, enough being used in any case to furnish 24 lbs. of nitrogen per acre. When dried blood was used, it required 240 lbs.; when sulphate of ammonia, 120 lbs.; and when nitrate of soda, 160 lbs. per acre.

‡ Either 480 lbs. of dried blood, 240 lbs. sulphate of ammonia, or 320 lbs. of nitrate of soda, containing 48 lbs. of nitrogen.

‖ Either 720 lbs. of dried blood, 360 lbs. of sulphate of ammonia, or 480 lbs. of nitrate of soda, containing 72 lbs. of nitrogen.

§ Composition assumed to be the average of fresh manure.

RESULTS OF THE EXPERIMENTS ON CORN.—It will doubtless be to many a matter of surprise, that the use of such liberal quantities of fertilizers on corn has failed to produce satisfactory results. In this respect, yard manure has proved to be no exception. For both years, and on both farms, the results have been similar. In 1881, they were ascribed to the severe drought that prevailed during the growing season. But as can be seen by the appended records of temperatures and rain-falls, the season of 1882 has been, so far as heat and moisture are concerned, fairly favorable for the growth of crops. It was thought that in 1881, the fertilizers might not have been mixed with the soil deep enough to exert the maximum effect, but the deeper admixture in 1882, caused an increase of crop no larger than that of 1881.

It does not seem possible that the ingredients of the fertilizers were not available to the growing plants, or that any needed element of growth was not supplied. The complete commercial fertilizer, in a majority of cases, consisted of dissolved bone-black containing over fourteen per cent. of soluble phosphoric acid, muriate of potash containing fifty per cent. of potash in a soluble condition, and sulphate of ammonia or nitrate of soda, containing large quantities of nitrogen in the most available form possible. Besides, the mixture contained sulphuric acid and lime, and small quantities of other ingredients that enter into plants. Certainly the yard manure was able to supply everything that the crop needed for growth, which the soil itself might fail to furnish, for it was made up of decomposed vegetable material, which is the most complete fertilizer possible.

The main and important fact with which we have to deal, is that the corn on the plots receiving no fertilizer, found sufficient material for growth to produce nearly as good a crop as where a large quantity of extra material was furnished in the manures; and, consequently, that the fertilizers were unprofitable, so far as the corn crop was concerned. One probable explanation of the fact that the various manures affected the yield so little is, that on both farms the corn was grown upon sod. In other words, a large quantity of roots and stubble decomposed in the soil during the time the corn was growing, furnishing, together with what came from the soil itself and from rain water, sufficient available material to nourish a fair crop.

It should also be remarked that corn makes its growth during that season of the year when the disintegration of the organic and mineral ingredients of the soil is the most active, and is, therefore, able to seize upon and utilize during a long period of growth, the material thus made available. So it is not strange that land in a hardly fair state of fertility should be able to nourish, without aid, an average crop of corn. And yet, as the yield on the plots receiving no fertilizer was in all cases rather below the average, this explanation hardly accounts for the fact that no form of fertilizer availed to secure more than moderate production. We are accustomed to think that below the limit of very large crops, the greater the supply of available plant food in the soil, the greater the production, unless some especially unfavorable condition prevails. But when on some plots, an amount of available material equal to that of the plots not manured, is supplemented by large additions from outside, and we see no especial increase of production, we are driven to the conclusion that other conditions besides the mere presence of plant food, place limitations upon a crop. The relation to crop production of the physical characteristics of the soil, such as coarseness or fineness, looseness or compactness, and of the degree of heat and moisture at particular seasons of growth, is but little understood. The whole question of the influence of the climate of each season and of each locality upon vegetable life, is one of which we have yet much to learn.

During the two years, sixteen plots receiving no fertilizer produced an average of 34.3 bushels of corn per acre, and on fourteen plots to which were applied a fertilizer containing enough of the principal ingredients of plant food for the growth of fifty bushels of corn per acre, the average yield was 36.6 bushels, a difference of only 2.3 bushels. Granting that the error arising from differences in the plots cannot be entirely eliminated: where the averages of so many plots are taken, this cannot be sufficient to account for the absence of a greater difference of production in the two cases cited. Beyond a statement of the fact that the corn was grown upon sod, and during the season of the most abundant production of plant food in the soil, we will not attempt here an explanation of the failure to receive satisfactory returns from the use of commercial fertilizers and of yard manure.* Certain phases of the whole question will be discussed more in detail in a future bulletin.

2. EXPERIMENTS ON OATS.

Experiments on oats have been conducted during the past season on both the farms mentioned above. On neither farm were the fertilizers applied directly to the oats, but in each case the crop was grown on plots that had been manured for corn the previous season,† after the plan already given in the account of the wheat experiment. (See Bulletin No. 1.) As the oats were the second crop removed after a single application of the various fertilizers, it would seem that the results from the different plots might give some indication both of the actual and of the relative effect of the several methods of manuring on the permanence of fertility.

The oats were cultivated on both farms in the ordinary manner. The plots were plowed in the spring, just previous to sowing the oats, were then harrowed, seed was sown at the rate of two bushels per acre, the land was harrowed again, and then rolled.

(*a*) EXPERIMENT ON THE CENTRAL FARM.—On this farm the land is a limestone clay, of good quality. The plots are one eighth of an acre in size, being of the same dimensions as the wheat plots, viz: two hundred and sixty feet long, by twenty-one feet wide. As before

* NOTE.—Since writing the above, there have come to hand some observations on the root development of corn, made by Dr. Sturtevant, of the New York Experiment Station, which seem to indicate that this cereal has larger feeding capacity than many other plants, and consequently can make good development where other crops would require aid in order to attain equal relative growth.

† The series of plots used in the experiment on corn in 1881.

stated, the fertilizers had been applied to the corn crop of the previous season, but none were used on the oats.

The following table shows the kinds and quantities of fertilizers applied to the corn in 1881, and the yield of oats in 1882. Only the average yields of plots manured essentially alike are given:

KINDS AND QUANTITIES OF FERTILIZERS APPLIED PER ACRE TO CORN IN 1881, BUT NONE TO THE OATS IN 1882.		Quantities of valuable ingredients contained in the fertilizers applied in 1881.			NUMBER OF PLOTS REPRESENTED IN THE AVERAGE YIELDS GIVEN.	Yield per acre in 1882.		Increase of yield due to the fertilizers the second season after their application.	
		Nitrogen.	Phosphoric acid.	Potash.		Oats—bushels.	Straw—pounds.	Oats—bushels.	Straw—pounds.
		Lbs.	*Lbs.*	*Lbs.*					
No fertilizer		...	...	...	Average yield of 5 plots,	39.6	2227		
Dried blood,	240 lbs.	24	...	...	One plot,	45.6	2532	6	305
Dissolved bone-black,	300 lbs.	...	48	..	One plot,	45.1	2448	5.5	221
Muriate of potash,	200 lbs.	...	...	100	One plot,	46.9	2648	7.3	421
Dried blood, Dissolved bone-black,	240 lbs. 300 lbs.	24	48	...	One plot,	45.9	2416	6.3	189
Dried blood, Muriate of potash,	240 lbs. 200 lbs.	24	...	100	One plot,	41.7	2656	2.1	429
Dissolved bone-black, Muriate of potash,	300 lbs. 200 lbs.	...	48	100	Average yield of 4 plots,	43.3	2183	2.7	—34
Dissolved bone-black, Muriate of potash, Nitrogenous fertilizer,*	300 lbs. 200 lbs.	24	48	100	Average yield of 5 plots,	44.4	2520	4.8	293
Dissolved bone-black, Muriate of potash, Nitrogenous fertilizer,*	300 lbs. 200 lbs.	48	48	100	Average yield of 4 plots,	44.5	2530	4.9	278
Dissolved bone-black, Muriate of potash, Nitrogenous fertilizer,*	300 lbs. 200 lbs.	72	48	100	Average yield of 4 plots,	46.3	2544	6.7	317
Yard manure,	16,000 lbs.	54	26	64	Average yield of 4 plots,	48.2	2828	8.6	601
Plaster,	320 lbs.	...	...	...	Average yield of 2 plots,	39.3	2364	...	137
Ground limestone,	4,000 lbs.	...	...	...	One plot,	37.1	2528	...	301
Caustic limestone,	4,000 lbs.	...	...	...	One plot,	45.9	2432	6.3	205

* See explanatory notes of previous table—page 247.

(*b*) EXPERIMENT ON THE EASTERN FARM.—Nearly the same conditions existed on this farm as on the Central farm, viz: The oats were grown on a series of plots that had produced a crop of corn since being manured, no fertilizers being put on the oats; the exceptions being that the plots contain only one twentieth of an acre instead of one eighth, and that the soil is of somewhat different character.

In the next table can be seen the same statement of facts for the Eastern farm that was made in the last preceding table for the Central farm.

Kinds and quantities of fertilizers applied per acre to corn in 1881, but none to the oats in 1882.		Quantities of valuable ingredients contained in the fertilizers applied in 1881.			Number of plots represented in the average yields given	Yield per acre in 1882.		Increase of yield due to the fertilizers the second season after their application.	
		Nitrogen.	Phosphoric acid.	Potash.		Oats—bushels.	Straw—pounds.	Oats—bushels.	Straw—pounds.
		Lbs.	*Lbs.*	*Lbs.*					
No fertilizer,		...	...	...	Average yield of 3 plots,	22	1100		
Dried blood,	240 lbs.	24	...	...	One plot,	22	980	...	—120
Dissolved bone-black,	300 lbs.	...	48	...	One plot,	26.6	1210	4.6	120
Muriate of potash,	200 lbs.	...	...	100	One plot,	25.5	1155	3.5	55
Dried blood, Dissolved bone-black,	240 lbs. 300 lbs.	24	48		One plot,	27.3	1140	5.3	40
Dried blood, Muriate of potash,	240 lbs. 200 lbs.	24	...	100	One plot,	26.6	1160	4.6	60
Dissolved bone-black, Muriate of potash,	300 lbs. 200 lbs.	...	48	100	Average yield of 3 plots,	29.1	1340	7.1	240
Dissolved bone-black, Muriate of potash, Nitrogenous fertilizer	300 lbs. 200 lbs. *—	24	48	100	Average yield of 3 plots,	28.9	1360	6.9	260
Dissolved bone-black, Muriate of potash, Nitrogenous fertilizer,	300 lbs. 200 lbs. *—	48	48	100	Average yield of 3 plots,	29.5	1622	7.5	522
Dissolved bone-black, Muriate of potash, Nitrogenous fertilizer,	300 lbs. 200 lbs. *—	72	48	100	Average yield of 3 plots,	28.9	1386	6.9	286
Yard manure,	12,000 lbs.	...	...	...	One plot,	23.3	1260	1.3	160
Plaster,	800 lbs.	...	...	...	One plot,	21.3	1080	—.7	—20

*See explanatory notes of first table, page 247.

RESULTS OF THE EXPERIMENTS ON OATS.

The appearance during growth, of the oats on the various plots as reported by the superintendent, together with the yields shown above, indicates that on the Eastern Farm the fertilizers had considerable influence on the second crop following their application. The growth of the oats on the plots receiving no fertilizers the previous season seemed much less vigorous than on the other plots.

On the Central Farm there is not so much evidence that the fertilizers had any effect the second season after their application. During the growth of the oats the thirty-six plots were uniform in appearance. Also, the production of the various plots was not so constantly in favor of the fertilizers as was the case of the Eastern farm. It is noteworthy that on the Central farm, where the land is in an average state of fertility, the use of liberal quantities of commercial fertilizers failed to produce any marked effect the second season on either the appearance or the quantity of a grain crop. But then, the yard manure did but little better. No single ingredient, or mixture of ingredients, seemed to produce any special effect. Nitrogenous fertilizers failed as signally as did the phosphatic or the potash manures, or even a mixture of these.

On the Eastern farm some of the fertilizers certainly caused considerable increase of growth the second season after the application, but the nitrogenous fertilizers either alone or combined with phosphoric acid and potash failed to have any effect.

GENERAL REMARKS.

The results of these experiments with oats, and especially those with corn, suggest the idea that when land is in condition to produce an average crop there is danger that the use of commercial fertilizers will fail to return a profit in the first one or two crops following their application. The profit comes in preventing the land from becoming exhausted, thus keeping up its capacity for crop production year after year. The same can be said of yard manure. On soils that are very much exhausted commercial manures very seldom fail to produce a marked effect, provided the right kind is used. It is well for farmers to be guarded in the purchase of nitrogen in fertilizers. As before stated, (see Bulletin No. 1,) our American lands seem able so far, in connection with the help they get from rain water, to furnish nearly all nitrogen that crops need.

The indications of the two years' experimental work with fertilizers on wheat, corn, and oats, are that at present the most profitable returns are to be obtained with wheat and the least profitable with corn. Also, that of the principal ingredients used, viz: nitrogen, phosphoric acid, and potash, phosphoric acid produces at present the most prominent effect.

TEMPERATURE AND RAINFALL.

The following is the record of temperature and rainfall during four months of the growing season (1882):

	CENTRAL FARM.		EASTERN FARM.	
	Temperature—Average.	Rainfall.	Temperature—Average.	Rainfall.
	Deg. Fahr.		*Deg. Fahr.*	
May,	....	....	61.9	4.88 inches.
June,	....	5.52 inches.	72.6	.97 "
July,	74.3	.34 "	81.1	1.32 "
August,	68.4	4.97 "	75.2	3.67 "

II. EXAMINATION OF AGRICULTURAL SEEDS.

Farmers often find that the seeds which they purchase in the markets fail to germinate, especially those for use in the kitchen garden. Such is undoubtedly very often the case with grass seed sown in the field, failures here being usually attributed, however, to other causes than the inferior quality or adulteration of the seed. The causes of inferior quality in seed are many. It may lack in vitality, because of not being fully ripe when gathered, from having been kept under improper conditions, or from having been kept too long. The mixing of old seeds with new is a favorite trick of some dealers. Seed may also be adulterated with material of less value or of no value at all, sometimes positively harmful.

The control of the quality of agricultural seeds has attracted considerable attention in this country since the establishment of experiment stations. With our present methods of testing the purity and germinating powers of seeds a very effectual safeguard can be established against frauds in their sale. This can be done most efficiently, however, only when legal enactment is joined with the work of an experiment station. A specimen of this kind of investigation is given in the work of Mr. Robert Tait, B. Ag., a graduate of the State College, in the Course in Agriculture, in the class of 1882. Mr. Tait made an examination of twenty (20) samples of seeds that were obtained by ordinary purchase from retail dealers.

The following table, taken from Mr. Tait's graduating thesis, clearly shows the importance of his results:

NAME OF SEED.	Percentage by weight of pure seed.	Percentage of pure seed capable of germinating.	Agricultural value of the seed on the scale of 100.	Weight of 1,000 seeds in grams.
Rough-stalked meadow grass,	99	4	4	.193
Kentucky blue grass,	82.3	1.8	1.5	.179
Sweet-scented vernal grass,	91.2	30.5	27.8	.523
Perennial rye grass,	99.7	62.5	62.5	1.770
Italian rye grass,	99.9	44.8	44.8	1.615
Crested dog's tail,	96.7	1.5	1.5	.384
Meadow fox tail,	89.6	9.5	8.5	.514
Hard fescue,	98.4	22	21.8	.534
Red clover,	99.8	71.5	71.5	1.521
Timothy,	99.5	92.3	92.3	.349
Lettuce,	.....	87	87	
Radish,	.....	92	92	
Cabbage,	.....	33.5	33.5	
Broccoli,	.....	46	46	
Kohl rabi,	.....	18	18	
Turnip,	.....	50	50	
Carrot,	.....	29.5	29.5	
Cauliflower,	.....	52	52	
Parsnip,	.....	13(?)	13(?)	
Celery,	.....	9(?)	9(?)	

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The Composition, Valuation and Purchase of Commercial Fertilizers.

Fifty years ago, *commercial* fertilizers were unknown. At the present time thousands of tons of various substances, designated by that general name, are consumed annually by the farmers of Pennsylvania.

The main inducement to invest in these fertilizers is the hope of profit; and the certainty of profit depends very largely upon the quality and cost of the material purchased. Two questions may then properly be considered in attempting to give farmers helpful information, viz: (1.) What should fertilizers contain, or by what standards do we judge of their quality? (2.) How can we determine whether the selling price of a fertilizer is a fair one? Concerning these and other related questions, the farming public has many vague, and often erroneous ideas, and it is the purpose of this bulletin to furnish such information as shall enable the farmers to protect themselves against fraud or mistake, and to purchase fertilizers with the same confidence as in the case of the most familiar commodities.

I. WHAT FERTILIZERS SHOULD CONTAIN.—Fertilizers should contain that which meets the farmers' demands; they should supply to the soil the needed elements of plant food. In brief, plants use from ten to fourteen elements in the process of growth. With few exceptions, three of these include all that the soil and air ever fail to furnish in abundance, and these are what the farmer must supply from some source outside the ones mentioned. Consequently, these three elements—one, two, or all of them—are the ones that fertilizers should contain, and which possess peculiar value.

II. THE VALUABLE INGREDIENTS OF FERTILIZERS.—The ingredients of fertilizers universally recognized as giving them their chief value are *nitrogen, phosphoric acid* and *potash*. The results of both scientific investigation and ordinary farm practice furnish the most direct and explicit evidence of the correctness of this view.

These three ingredients of plant food have especial value, for several reasons, viz: Plants use them in large relative quantities; the natural supply of them in the soil is sooner exhausted than is that of other substances, and the outside sources of supply are more limited than is the case with other less necessary material. Both the commercial and agricultural value of a fertilizer are based chiefly upon what it contains of nitrogen, phosphoric acid and potash. A superphosphate, for instance, contains, besides these, sulphuric acid,* lime,* magnesia, perhaps some iron, alumina, soda, chlorine and silica; but these ingredients are ignored in estimating the value of the fertilizer. If the farmer in exceptional cases needs to apply any of these substances to his soil, excepting nitrogen, phosphoric acid and potash, (most probably sulphuric acid, possibly lime or magnesia,) he can obtain them very cheaply from ample natural sources.

III. DIFFERENT FORMS OF THE VALUABLE INGREDIENTS.—Not only the presence and quantity of nitrogen, phosphoric acid and potash, but also their form of combination, must be taken into account in determining the value of a fertilizer. A pound of nitrogen in one fertilizer may have a very different value from a pound of the same ingredient in some other fertilizer. The same is true of phosphoric acid, and, to a limited extent, of potash. In nearly every case, however, the presence and quantity of these different forms can be determined, so that the estimation of the approximate value of any fertilizer is always possible.

* Combined as gypsum.

1. *Forms of Nitrogen.*—Nitrogen can be bought in three general forms: (*a.*) As nitric acid. Nitrogen is sold in this combination principally as nitrate of soda, (Chili saltpeter.) This (nitric acid) is the most costly form, and is generally considered the most efficient for immediate effect, it being the form in which the plant is believed to take up the principal part of its nitrogen. A good sample of nitrate of soda contains fifteen per cent. of nitrogen. (*b.*) As ammonia. Nitrogen combined as ammonia is furnished in sulphate of ammonia. It is nearly as costly here as in nitrate of soda, and is probably about as efficient, being very rapidly converted into nitric acid in the soil. A good sample of sulphate of ammonia contains at least twenty per cent. of nitrogen, and of course costs more by the ton than nitrate of soda. Both nitrate of soda and sulphate of ammonia can be adulterated by common salt, and other substances to which they bear close resemblance, and the adulteration not be detected by the ordinary methods of observation. (*c.*) As organic nitrogen. Nitrogen in the organic form is obtainable in a variety of materials, such as dried blood, dried fish, meat scraps, cotton seed meal, hoofs, horns, hair, wool refuse, &c. Organic nitrogen must first be converted by decay into nitric acid or ammonia before it can be used by plants to any great extent, and the rapidity with which the necessary decomposition takes place depends very much upon the nature of the organic substance. Consequently, organic nitrogen varies greatly in value, and therefore in price, according to the kind of material in which it is found. For example, dried blood acts almost as rapidly and efficiently as nitrate of soda or sulphate of ammonia, while horn shavings decompose slowly, and produce a very gradual effect.

This class of nitrogenous fertilizers may be adulterated in various ways, as with dirt, sand and worthless refuse, or may contain too much water, in either case causing a deterioration in quality. Nitrogen in the organic form is in no case so costly as when combined in nitric acid or ammonia, and its cheapest source is often some form of refuse animal material.

2. *Forms of Phosphoric Acid.*—Phosphoric acid exists in fertilizers in three general forms. It may be *soluble*, *reverted*, (precipitated,) or *insoluble*, the soluble and reverted sometimes being classed together as *available*. Soluble phosphoric acid is that which is readily soluble in water; the reverted is generally that which has once been made soluble, and has again become insoluble in water; and the insoluble is the form naturally existing in bone and in South Carolina rock. A fertilizer increases in both commercial and agricultural value in proportion as its phosphoric acid is rendered soluble. When bone or South Carolina rock is acted upon by sulphuric acid, (oil of vitriol,) the phosphoric acid becomes soluble, and in exact proportion to the quantity of sulphuric acid used, until the quantity of the latter comes to

be in excess of what is needed to act upon nearly all of the phosphate of lime present. The phosphoric acid in the bone or rock not acted upon remains in the insoluble form. Superphosphates, especially those of which South Carolina rock forms the basis, are liable to contain considerable reverted phosphoric acid, or that which, after being made soluble, has "reverted" to a condition intermediate between the soluble and insoluble. Of these three forms of phosphoric acid, the soluble is generally considered to have the greatest value, and the insoluble the least. The reverted form is held by some authorities to be as valuable as the soluble, and this opinion has much to support it. At present, however, a difference in value is recognized, and reverted phosphoric acid is generally given a place intermediate between the soluble and insoluble forms.

Soluble phosphoric acid has the same agricultural efficiency in all fertilizers, no matter what its source, whether from bone or from South Carolina rock. The same is true of the reverted. The insoluble form, or that which has never been acted upon by oil of vitriol, has a greater value in bone than in South Carolina rock. This is due to the fact that the disintegrating influences of the soil and air sooner and more rapidly bring the insoluble phosphoric acid of bone into condition for use than is the case with South Carolina rock. Either material, when not dissolved by oil of vitriol, varies in value according to the fineness with which it is ground, the finer the particles the better the distribution in the soil, and the more rapid the disintegration. This is true of any fertilizer which must be decomposed before it can be used by the plant.

3. *Forms of Potash.*—The different forms of potash vary less in agricultural efficiency than the different forms of nitrogen and phosphoric acid. In all the potash manures in the market the potash is soluble, and so is readily distributed in the soil. The principal source of this ingredient is the salts that come from Germany, mainly the chloride (muriate) and sulphate of potash. These two substances often have mixed with them considerable quantities of other compounds, such as common salt, (chloride of sodium,) and chlorides and sulphates of lime and magnesium. This is especially the case with kainite, which contains more of the compounds of soda, magnesia and lime than the salts of potash. None of these impurities do any harm, only so far as they increase the expense of handling the potash, excepting the chloride of magnesium, which has a poisonous effect on vegetation, and when present in considerable quantity in a fertilizer that is applied about seeding time is liable to affect the vitality of the seed. Potash is most costly in the sulphate, and least costly in the muriate, and except when needed for a few special purposes is most profitably purchased in the latter form.

IV. THE VALUATION OF FERTILIZERS.—This is the determination of their *market value*. It can be accomplished only by means of chemical analysis. It is obvious that field experiment can never be used to determine the *commercial* value of a fertilizer, for, by this method, a farmer in the Connecticut valley, on land sadly in need of potash, would pronounce the best possible phosphatic fertilizer to be worthless, while a majority of farmers in Chester county, Pennsylvania, would in the same way reject purely potash manures as having no value at all. The fact is both kinds of fertilizers have their consumers, and a price is paid for each that is governed by the condition of the market.

"Plaster, lime, stable manure, and nearly all the less expensive fertilizers have variable prices, which bear no close relation to their chemical composition; but guanos, superphosphates, and other fertilizers, for which thirty to eighty dollars per ton are paid, depend chiefly for their trade value on the three substances—*nitrogen*, *phosphoric acid* and *potash*—which are comparatively costly and steady in price. *The money value per pound of these ingredients is easily estimated from the market prices of the standard articles which furnish them to commerce.*"

The commercial value per pound of each of these ingredients in their various forms, as determined by, and in use at the Connecticut and New Jersey experiment stations in 1881, are given below, with a few omissions:

TRADE VALUES FOR 1881.

	Cents per pound.
Nitrogen in nitrates,	26
Nitrogen in ammonia salts,	22½
Nitrogen in Peruvian guano, fine steamed bone, dried and fine ground blood, meat and fish, superphosphates and special manures,	20
Nitrogen in coarse or moist blood, meat or tankage, in cotton-seed, linseed, and castor pomace,	16
Nitrogen in fine ground bone, horn, and wool-dust,	15
Nitrogen in medium bone,	13
Nitrogen in coarse bone, horn shavings, hair, and fish scraps,	11
Phosphoric acid, soluable in water,	12½
Phosphoric acid, "reverted," and in Peruvian guano,	9
Phosphoric acid, insoluble, in fine bone and fish guano,	6
Phosphoric acid, insoluble, in medium bone,	5
Phosphoric acid, insoluble, in coarse bone, bone-ash, and bone-black,	4
Phosphoric acid, insoluble, in fine ground rock phosphate,	3½
Potash in high-grade sulphate,	7½
Potash in low-grade sulphate and kainite,	5½
Potash in muriate or potassum chloride,	4½

"*These 'trade values' of the elements of fertilizers* are not fixed, but vary with the state of the market, and are, from time to time, subject to revision. They are not exact to the cent or its fraction, because the same article sells cheaper at commercial or manufacturing centers than in country towns; cheaper in large lots than in small; cheaper for cash than on time. These values are high enough to do no injustice to the dealer, and, properly interpreted, are accurate enough to serve the object of the consumer."

To determine the market value of a particular fertilizer, it is analyzed, and the amount *and forms* of nitrogen, phosphoric acid, and potash in it thus determined. By multiplying the pounds of each of these ingredients found in a ton by the price per pound, according to the form, and adding the products, we have a sum approximating very closely to the price at which the fertilizer should be sold, or what is called the "estimated value." The "estimated value" and the dealer's price should agree within two or three dollars per ton. When the dealer's charge is five dollars or more above the "estimated value," it is probable that the farmer can purchase some other fertilizer to better advantage. It is not claimed by any one that the "estimated" values represent to a cent what fertilizers should be sold for, but they are close enough to the true values to make the detection of fraud or overcharge a comparatively easy matter; and in the various States where farmers have availed themselves of this protection in a legalized manner, a saving to them of many thousands of dollars annually has undoubtedly resulted.

The agricultural value of fertilizers is by many supposed to be the same as the market value. This is a great and a harmful mistake. It is by no means the case that a sixty dollar fertilizer should be three times as profitable to a farmer as one costing twenty dollars. The twenty dollar fertilizer may be South Carolina rock, furnishing to the farmer phosphoric acid, this being, perhaps, the ingredient most necessary to apply to his soil, and, therefore, producing a marked effect on his crops. The sixty dollar fertilizer may be a fine sample of dried blood, chiefly valuable for its nitrogen, which his soil may not need. There are but few farms, so experiment seems to show, that will respond to an application of nitrogen alone in a manner that is at all in proportion to the cost of the nitrogen. Nevertheless, the fine sample of dried blood costs, and probably will continue to cost, from fifty dollars to sixty dollars per ton, while the South Carolina rock, which on most farms produces a much larger increase of crop than an equal quantity of dried blood, can be bought for less than twenty-five dollars per ton. When a farmer knows what class of fertilizers he can most profitably use, then he can safely assume that the value, to him, of the various fertilizers in that class will correspond nearly to the proper market price. Of two superphosphates, having nearly all their phosphoric acid soluble, one worth thirty dollars and the other twenty dollars, the former would certainly be as cheap as the latter; two hundred pounds of the one furnishing as much phosphoric acid as three hundred pounds of the other; the more concentrated fertilizer having the advantage, however, of supplying a given quantity of phosphoric acid to an acre, at the smaller cost of freight and handling.

V. FRAUDS IN FERTILIZERS.—Until within a few years, the fertilizer trade in this country undoubtedly offered an easy chance for the practice of fraud. That the chance was improved by some dealers is very certain. At the present time, fraud is more surely and quickly detected, especially in those States where the inspection of fertilizers is vigilant and active. Attempts at fraud are still made. The last Quarterly of the Pennsylvania Board of Agriculture shows one instance where a fertilizer worth forty-six cents per ton was selling for twelve dollars; and another worth five dollars was selling for twenty dollars. The report of the Connecticut Experiment Station, for 1881, gives several examples of fertilizers selling from ten dollars to twenty-three dollars per ton more than their real value. It is gratifying to know, however, that the majority of fertilizers now inspected have a value that compares favorably with the selling price. The last report of analyses, made under the direction of the Board of Agriculture, shows that out of one hundred and seventeen samples of fertilizers, the "estimated value" of sixty-nine either nearly equaled or exceeded the selling price, and in many other cases the selling price was only about five dollars too high. Many other of the fertilizers were found to be selling at prices much above their value, indicating the need of careful and constant inspection. In Connecticut, where an experiment station has for several years kept a close and extensive supervision of the fertilizer trade, farmers can buy commercial manures with a good degree of safety. The last published report from the New Jersey Station indicates that in that State, also, the same kind of supervision is securing the farmers against fraud. The advantages of such inspection, both to farmers and to all honorable dealers, is beyond question, and so far experience has shown that an experiment station is the most efficient organization for securing it.

SOME THINGS FOR FARMERS TO DO.—In the first place, they should see that all the brands of fertilizers coming into their neighborhoods are carefully sampled, and the samples sent to the proper authorities for analysis. They should carefully study the bulletins, which should be published frequently, giving the results of these analyses, and afterwards deal only with those persons whose wares stand the test of examination. If they again purchase fertilizers of dealers whose prices have been found to be considerable above the real value, these dealers should be required to sell at prices based upon what subsequent analysis of the samples purchased shows them to be worth. No form of organization can guard the interests of farmers in any direction unless aided by their active and intelligent coöperation.

VI. THE PURCHASE OF FERTILIZERS.—In the purchase of fertilizers, the aim should be to obtain, for a given sum of money, the largest possible quantity of the ingredient or ingredients that are needed. A large part of the fertilizers sold in Pennsylvania, as well as in all other

States, contain, as their basis, bone or South Carolina rock, a portion of the phosphoric acid of which is made soluble, and to which is added small quantities of both nitrogen and potash: blood, meat, fish, and often very inferior slaughter-house refuse furnishing the nitrogen, and muriate of potash or kainite, the potash. These fertilizers, quite a portion of which are the product of small manufactories, located in or near the farming communities where the fertilizers are used, have no standard composition as is the case with standard articles like dried blood, dried fish, dissolved bone, dissolved bone-black, dissolved South Carolina rock, and muriate of potash. Their composition may vary with each manufacturer and with each year. They are generally branded by the name of the company manufacturing them, or by some pretentious name, which has little or no significance. These "*manufactured*" articles are made, as before indicated, by the use of *standard* articles, and are in many cases so manipulated by the manufacturer that they do not offer to the farmer the same advantages that are found in the more concentrated materials which we have come to regard as *standard*.

Two very important objections can be urged against this large class of "manufactured" fertilizers, with few exceptions.

(1.) *They contain more comparatively worthless material than is necessary, and, consequently, smaller percentages than they should of the valuable ingredients, especially phosphoric acid.*

All fertilizers must contain some material of little value, but not to the extent that is the case with those under consideration. It may not be wise, in view of the needs of the average soil, to increase largely their percentages of nitrogen and potash, but many of them would much better contain more phosphoric acid, with a larger proportion of it soluble. It is not economy for the farmer to handle two tons of a fertilizer in order to apply to his soil two hundred and fifty pounds of available phosphoric acid, when it may just as easily be furnished in one ton. And it would not be economy for fair dealing manufacturers to sell low grade fertilizers, if farmers did not, through mistaken notions, seek to obtain those costing the least money without proper regard to what they contain. The more concentrated a fertilizer is, the more acres a ton of it will manure, and the smaller the cost of freight and handling.

(2.) *These "manufactured" fertilizers cost more in proportion to what they contain than do standard articles like dissolved bone-black, dissolved bone, dissolved South Carolina rock, muriate of potash, and some of the purely nitrogenous fertilizers.*

This is not necessarily so, but simply *is* so, as can be seen by the reports of experiment stations.

Both of the above points are illustrated by the figures given below, which are taken from the reports of the Connecticut and New Jersey Experiment Stations for 1881:

	Number of samples analyzed.	Nitrogen in 100 lbs.	Soluble phosphoric acid in 100 lbs.	Reverted phosphoric acid in 100 lbs.	Insoluable phosphoric acid in 100 lbs.	Potash.	*Estimated value, per ton.*	*Cost, per ton.*	Estimated value exceeds cost.	Cost exceeds estimated value.
Dried blood,	10	8.74	. . . .	. . . .	2.80	. . . .	$38 37	$38 70	. . . .	$0 33
Dried fish,	7	8.13	. . . .	. . . .	6 66	. . .	39 20	40 70	. . . .	1 50
Dissolved bone-black,	4	. . . .	14.37	2.80	.72	. . . .	41 92	38 00	$3 92	
Plain dissolved bone,	9	. . . .	14.96	1.49	1.15	. . . .	42 34	34 61	7 73	
Dissolved South Carolina rock,	8	. . . .	8.54	2.59	5.21	. . . .	29 41	27 63	1 78	
Muriate of potash,	10	. . . .	. . .	. . . .	. . . .	51.21	46 08	42 25	3 73	
"Manufactured" fertilizers, (Conn. Experiment Station,)	31	3.35	3.85	5.28	3.46	2.31	39 21	43 32	. . . .	4 11
"Manufactured" fertilizers, (N. J. Experiment Station,)	40	2.31	5.16	2.05	3.55	3.20	34 24	39 00	. . . .	4 76

The above table shows that the valuable ingredients are not sold so cheaply in the class of fertilizers designated as "manufactured," as in those standard articles, which generally contain these ingredients singly. It should be said, however, that this rule has many exceptions, and there is no good reason why plant-food should not be bought as cheaply in the one case as in the other.

A little calculation shows, nevertheless, that the purchase of one thousand pounds of dissolved bone-black, or of plain dissolved bone, six hundred and fifty pounds of dried blood, and one hundred and twelve pounds of muriate of potash, of the kinds, and at the prices shown in the above table, would furnish more available phosphoric acid and as much nitrogen and potash for $33 as was being bought in the average of the "manufactured" fertilizers for $41; the expense for freight and handling being less in the former case.

No attempt has been made in this bulletin to discuss the principles involved in the proper use of fertilizers in the production of crops. Only such facts are here presented as are necessary to proper knowledge of fertilizers in their commercial relations.

The table which follows gives the average composition of fertilizers of the various classes, and it is hoped that it may be instructive in showing how, and to what extent, commercial manures differ, thus enabling the farmer to purchase them more intelligently. It should be remembered that the figures given are averages, from which the composition of any one fertilizer may differ widely. For the most part, these averages were taken from the Farmer's Annual Hand-Book, edited by Armsby & Jenkins.

	No. of analyses.	Water.	Organic matter.	Ash.	*Nitrogen.*	Silica and insoluble.	Alumina and oxide of iron.	Lime.	Magnesia.	*Potash.*	Soda.	Sulphuric acid.	*Phosphoric acid*	Chlorine.	Carbonic acid.
Farm manure and factory refuse.															
Stable manure,	4	71.3	15.6	13.1	0.5	10.5	0.7	0.5	0.3	0.4	0.1	0.1	0.5	0.1	0.2
Hen manure,	3	58.0	16.3	25.7	0.8	20.7				0.4			0.5		
Night soil—poudrette,	6	32.2	26.1	41.7	1.4	14.9	2.2	3.5	0.6	0.3	0.3	6.7	2.2	0.1	
Swamp muck—fresh,	17	76.2	15.8	8.0	0.3	6.8	1.4	0.4							
Swamp muck—air-dry,	38	21.4	53.3	25.3	1.3	13.5	1.4	0.9							
Oyster-shell lime,	3	19.5				7.6	1.4	57.3	0.3	0.4	0.2	0.5	0.2	0.02	13.0
Gas lime,	7	4.4	10.5	85.1	0.3	5.1	3.4	40.9	11.0	0.6		4.1			25.0
Malt sprouts,	2	7.4	85.7	6.9	4.4	1.5	0.2	0.2	0.2	2.2	0.2	0.6	1.7		
Vegetable ivory,	2	18.8			0.5										
Ashes and lime manures.															
Wood ashes,	18	7.8				12.4	2.8	32.4	4.9	7.7	1.0	1.4	2.1	0.6	23.3
Leached wood ashes,	12	31.5				11.8	2.1	29.3	3.0	1.1	0.4	0.1	1.5	0.1	20.9
Lime-kiln ashes,	6	2.7				17.6	1.3	45.8	2.9	0.9	0.6		1.7		21.0
New Jersey green marl,	73	8.2				52.8	25.5	2.9	2.2	4.7	0.0	0.7	2.2		0.9
Land plaster (gypsum),	17					3.4		51.7				41.9			
Fertilizers chiefly valuable for their nitrogen.															
Nitrate of soda,	14	1.8			15.8									1.4	
Sulphate of ammonia,	13				19.7										
Dried blood,	47	16.0			9.4	3.0							5.0		
Dry fish guano,	88	15.7			7.8			7.0	0.7	3.0	1.0		6.9		
Half dry fish,	7	46.0			4.7					0.3			5.5		
Cotton-seed meal,	7	6.8			6.5					2.0			2.9		
Tankings and slaughter-house refuse,	13	20.2			5.9								8.4		
Hoof and horn shavings,	9	14.2			13.5								0.8		
Hair manures,	7	32.0			7.2								1.9		
Wool waste,	2	10.1			5.1										
Potash salts.															
Muriate of potash,	20									52.3	6.7			43.4	
Sulphate of potash—high grade,	10									40.5		46.5		1.0	
Sulphate of potash—low grade,	7									30.5		11.7		34.7	
Sulphate of potash—acid,	9	0.6				1.9		0.1	0.1	38.0	5.0	46.5		10.1	
Kainite,	13							4.2	8.8	13.1	17.2	15.9		26.3	

	No. of analyses.	Water.	Organic matter.	Ash.	*Nitrogen.*	Silica and insoluble.	Alumina and oxide of iron.	Lime.	Magnesia.	*Potash.*	Soda.	Sulphuric acid.	*Phosphoric acid.*	Chlorine.	Carbonic acid.
Phosphatic materials.															
Raw bone—undissolved,	110	9.6	...		3.3	...	...	...	...	...	...	...	21.7		
Bone-black—undissolved,	4	9.9	8.1	82.0	...	1 6	...		...	...	...	...	33 1		
Bone ash—undissolved,	2	5.0	...	...	...	4 5	...	44.9	...	...	...	...	35.3		
Canadian apatite—undissolved,	...	...	...	...	...	...	...	...	...	...	...	...	34.6		
South Carolina rock—undissolved,	...	...	...	...	...	...	...	...	...	...	...	...	26.0		

	No. of analyses.	Water.	Nitrogen.	Soluble phosphoric acid.	Reverted phosphoric acid.	Insoluble phosphoric acid.	Potash.
Peruvian guano, No. 1,	27	...	8.0	4.8	5.1	5.1	3.1
Dissolved bone black,	4	...	...	13.81	2.25	.64	
Dissolved bone—plain,	8	...	...	14.96	1.19	1.15	
Dissolved South Carolina rock,	12	...	.	8 16	2.66	5.31	
Low grade superphosphate (manufactured),*	71	...	2.76	4.57	3.46	3.51	3.02

*See previous remarks.

No. 4. May 10, 1883.

The Use of Commercial Fertilizers.

Bulletin No. 3 was devoted mainly to a discussion of the economical purchase of commercial fertilizers, rather than to questions involved in their economical use. The readers of that bulletin might well suggest that the consideration of first importance is to know the kind of fertilizer needed, and that the commercial relations are secondary in determining the farmer's profits in the use of this class of manures. This is true. It is absolutely essential for the farmer to understand the needs of his soil and of his crops before he can know what ingredient or ingredients of plant food to purchase. Farmers feel their need of exact knowledge concerning this matter, as is seen by the oft-repeated question, "Will you tell me just what I must apply to my farm in order to get good crops?"

The question is a very important one, and it would be very satisfactory if a definite answer could be given to every farmer in the land; so definite that all could secure the maximum profit from the use of commercial manures. This cannot be done in the present state of agricultural science. It is proposed, however, to present in this bulletin some suggestions that will aid in understanding the real situation, so that fewer misconceptions may exist as to just what science can do for farmers in this direction. Some attempt will also be made to point out the method by which each farmer may learn something definite concerning what is best in his own practice.

The object of the application of manure is to supply what the soil otherwise fails to furnish, and which it must be made to furnish, for the nutrition of growing crops. A soil in its virgin state seems to have no deficiencies of this kind—as. for example, the western prairies. These deficiencies, when they exist, are caused by the treatment which soils receive in the cultivation of crops during a series of years, and just what they have come to be in any case depends mainly upon three conditions, viz: (1.) The original quality of the soil. (2.) The kind of crops that have been grown. (3.) The kind and quantity of manure that has been applied.

Soils are formed from rock and decayed vegetable matter. The kind of rock, and the kind and amount of vegetable material from which any particular soil is formed, determine its composition. Granite soils, for example, differ essentially from limestone soils. The alluvial deposits of a river valley differ from the high land on either side.

All crops remove essentially the same kind of ingredients from the soil, but not in the same relative quantity. Continuous production of sugar beets, for instance, on the same land would bring it into very different condition from what would be reached by the continuous production of grain, provided the same kind and quantity of manure were used in both cases. So, also, differences in the kind and amount of manure applied to soils come after a time to produce noticeable differences in the capacity of these soils for crop production. It might have been possible, though very likely not profitable, to have so manured land with reference to the crops grown that no exhaustion would have taken place. As a matter of fact, many soils have so diminished in fertility that profitable crop growing is not possible without the aid of manure. It is evident from the above that the causes of infertility are very likely to be different in different cases, and that there is great difficulty in estimating what the cause is in any given case.

How, then, shall each farmer supply the needs of his soil?

In the first place, shall it be with commercial fertilizers? The idea seems to be somewhat prevalent that these are not manure in the same way that the excrement of animals is manure; in other words, that they do not add to the resources of the soil, but act merely as a stimulant, exciting the soil to unusual activity in supplying the wants of growing crops, and then leaving it in a condition of increased inactivity and weakness. This idea is erroneous. A superphosphate is as truly plant food, and may as truly add to the resources of the soil as would barn-yard manure. Many superphosphates contain six of the ingredients necessary for plant growth, and which the soil must furnish, and these are the same ingredients that mainly give efficiency to yard manure, and without which it would be worth little. The ash of the ordinary grains (the kernel) grown upon the farm contains from twenty-five to fifty per cent. of phosphoric acid, and from fifteen to thirty-five per cent. of potash, and a superphosphate is just as able to supply these substances as is yard manure.

A good superphosphate is no more of a stimulant to a worn-out soil than roast beef is a stimulant to a hungry man, for in both cases there is supplied that which is needed in order to do the work required. There may be objections to the uses of commercial manures alone, but to regard them as mere stimulants is a misconception of facts. Their effect may be more prompt, and not so long continued, as is the case with barn-yard manure, which is entirely another matter.

One important fact has been clearly brought out by experimental work in the United States during the past few years, a fact of prime importance in the use of commercial manures, which is, that the effect of any one ingredient, or combination of ingredients, varies greatly with different soils; and it has often been found to be the case that where one ingredient has failed to increase the crop, another has succeeded to a marked degree. It has also been found in some cases that a single ingredient—as, for instance, phosphoric acid—has alone been so efficient that it was not profitable to purchase either nitrogen or potash, or both, to apply with it. In other cases a mixture of two or all of these ingredients has seemed needful. These facts lead to several conclusions.

(1.) No one method of manuring with commercial fertilizers can be universally efficient, and at the same time return the maximum profit. A fertilizer containing nitrogen, phosphoric acid and potash in liberal quantities, with the usual amount of sulphuric acid and lime, would undoubtedly be universally efficient, as far as any commercial fertilizer can be so; but this would involve, in many cases, an expenditure of money for ingredients that could be left out of the fertilizer, and the crop be but little smaller. It is certainly true that on some soils an application of a moderate quantity of a single ingredient can be made with profit, where the use of other ingredients would increase the crop to an extent so slight, in comparison to the increase of expense, that loss would result instead of gain. The experience of many farmers has led them to the use of but one of the valuable ingredients. For instance, in the eastern part of Pennsylvania, South Carolina rock is largely used alone, containing phosphoric acid, while many farmers in the Connecticut Valley find that potash compounds have an efficiency that is not profitably increased by the addition of nitrogen and phosphoric acid. It is almost always true, however, that a complete fertilizer—one containing nitrogen, phosphoric acid and potash—produces a somewhat more luxuriant growth than a fertilizer containing only one or two of these ingredients.

There is one consideration of importance that is involved in the use of fertilizers containing but one or two of the three valuable ingredients. A certain soil may be deficient in available phosphoric acid; but when this deficiency is met, it may then be able to supply enough of other ingredients of plant food to support the growth of a good crop. To such land South Carolina rock is applied, and nothing else. The successive crops that are grown will remove from the soil not only phosphoric acid, but nitrogen and potash. While the fertilizer is making good the loss of one important ingredient (phosphoric acid) of plant food, no return is made for the loss of other substances equally important. Will not the soil in time come to be deficient in available nitrogen and potash, and these substances then have to be supplied in manure? Undoubtedly this is liable to take place after a length of time that will vary with the natural resources of different soils. It is very doubtful, however, if this constitutes a good reason for purchasing material for which there is no immediate use, especially if it be nitrogen, for the nitrogenous compounds of commercial fertilizers are liable to be leached from the soil to a considerable extent in the form of nitric acid and lost. It must be acknowledged, nevertheless, that because South Carolina rock, for example, is a fertilizer which contains but one of the three ingredients of which soils are likely to be, and so often are, exhausted, it can in this sense be said to be an incomplete fertilizer. The same is true of dissolved bone, muriate of potash, dried blood, or any fertilizer which does not contain nitrogen, phosphoric acid and potash. The situation seems to be about this: If the object is to get the largest possible return from a given expenditure of money, there are undoubtedly many cases where this object will only be reached, for a time at least, of a fertilizer containing but one or two of the ingredients mentioned above. If the desire is to hand over to a future generation land possessing unimpaired resources, then a complete fertilizer is the safest one to use.

There is no doubt, however, that it is poor economy to use any more of a nitrogenous fertilizer than will return an immediate profit on the investment. The farmer had better invest his money where it will be available for his descendants to use in the purchase of nitrogen, rather than expend it for that ingredient at a time when the resulting increase of crop will not pay the cost.

As is well known to many farmers, fertilizers are advertised that are compounded according to a formula or recipe, for which the claim is made that they are applicable to the needs of all soils. Special manures for special crops are also offered for sale. As we have seen, a universally economical commercial manure is not possible, and a special manure for potatoes or corn is full as likely to succeed well on wheat as on the crop for which it is compounded. It is true that the growing of roots on the same land for a series of years would create a demand for a certain ingredient of plant food sooner than would be the case in grain-growing, but the chief factor in determining what fertilizer will be profitable is the present condition of the soil rather than the composition of the crop.

It is fortunate, it may be remarked, that considering both cost and efficiency, the superphosphates ("manufactured" fertilizers of Bulletin No. 3,) which make up the chief bulk of commercial fertilizers used by farmers, are the safest commercial manures for farmers to purchase who do not know, and who do not take the trouble to find out, the special needs of their soils. These superphosphates contain chiefly phosphoric acid, combined with small percentages of nitrogen and potash, which probably corresponds to the average need more nearly than an other combination.

(2) Each farmer should determine for himself what are the special needs of his soil. How can this be done? One of the early ideas was that chemical analysis would indicate the deficiencies of a soil for crop production, but this idea was incorrect. Many soils incapable of producing a paying crop of wheat, upon analysis would be found to contain perhaps a hundred times the quantities of every ingredient of plant food that the soil would be required to furnish the crop. Much of this material is in a condition unfit for present use, and no chemical method now known can determine how much of the phosphoric acid or potash, or other ingredients, of a soil is available and how much is not. Each farmer can most surely determine the special needs of his

soil by experiments conducted on that soil. These experiments should not consist in comparing A's phosphate with B's or C's phosphate, for they are apt to be quite nearly alike, at least they would probably contain the same ingredients in somewhat different proportions. The only method by which the desired information can be secured is one involving the comparison of the effect of different ingredients. Let the farmer who has a worn-out field, upon which he wishes to use commercial manures for wheat growing, purchase of some reliable dealer sixty (60) pounds of dissolved bone-black, forty (40) pounds of muriate of potash, and eighty (80) pounds of dried blood, at a cost of less than four dollars. In experimenting with these substances let him proceed as follows: Lay off a piece of uniform ground eight rods square, and then divide this, after plowing and harrowing, into eight strips each one rod wide and eight rods long, and then apply the fertilizers according to the following plan:

Plot 1,	No fertilizer.	
Plot 2,	Dried blood, 20 lbs., containing nitrogen.	
Plot 3,	Dissolved bone-black, 15 lbs., containing phosphoric acid.	
Plot 4,	Muriate of potash, 10 lbs., containing potash.	
Plot 5,	Dried blood, 20 lbs., Dissolved bone-black, 15 lbs.,	Well mixed, containing nitrogen and phosphoric acid.
Plot 6,	Dried blood, 20 lbs., Muriate of potash, 10 lbs.,	Well mixed, containing nitrogen and potash.
Plot 7,	Dissolved bone-black, 15 lbs., Muriate of potash, 10 lbs.,	Well mixed, containing phosphoric acid and potash.
Plot 8,	Dried blood, 20 lbs., Dissolved bone-black, 15 lbs., Muriate of potash, 10 lbs.,	Well mixed, containing nitrogen, phosphoric acid and potash.

The fertilizers can be sown broadcast and harrowed in, and the wheat then be drilled in. By carefully watching the growth of the wheat, and then weighing the straw and grain harvested on each plot, such an experiment could undoubtedly be made profitable by many farmers.* No one should suppose that in this way the comparative profits can be estimated to a cent, for the errors resulting from natural differences in the various plots would prevent this. If any one ingre-

* The College would be glad to co-operate with any who desire to make such an experiment as the above, and would furnish such instructions, and give such aid in procuring the necessary fertilizers, as might be necessary, provided a sufficient number wish to make the experiments to render co-operation desirable.

dient or combination of ingredients should have a marked superiority of effect, which would probably not always be the case, the plan suggested would hardly fail to show it.

Several correspondents have made inquiries concerning fertilizers and their use, some of which have been answered by letter, and some of which have not. One correspondent desired to know just how much nitrogen and potash should be combined with phosphoric acid in order to get the best results. His answer will be found in the preceding part of this bulletin. The following is another inquiry: "Can it (nitrogen) be applied in any form so as to furnish plant food and yet not be so liable to be carried off by drainage and evaporation?" There is no nitrogenous fertilizer containing readily available nitrogen which is not subject to considerable loss by drainage, provided heavy rains occur. Nitric acid is the form in which loss of nitrogen takes place by leaching. If nitrates are applied to the soil, loss may very soon take place. If ammonia salts or organic nitrogenous compounds are used, then the nitrogen of these becomes gradually oxodized to nitric acid, the former most rapidly, and leaching can then occur. The nitrogen of yard manure probably remains in the soil more permanently than that which is ordinarily applied in commercial manures. It has frequently been stated that during a dry time ammonia compounds evaporate from the soil. This seems not to be the case. In fact, dry or moist earth, when left exposed to the air, gathers nitrogen instead of losing it.

"Would lime probably increase the product where there was little or no lime already in the soil, or where it might act as a corrective of previous acidity?" If a soil was so deficient in lime as not to be able to furnish what would be needed by an ordinary crop, then an application of lime would undoubtedly increase the product, for lime is a substance which is an essential constituent of all plants. But as a matter of fact, very few soils lack a supply of lime. We ordinarily do not apply lime to land in order to furnish a crop with that substance, but to so act upon the soil as to secure an increased supply of other needed material. That ordinary soils get to be acid is a popular fallacy. Acidity could only result from the presence of free acid and free acid could exist but a short time without being neutralized, in such soils as are ordinarily cultivated.

No. 5. August 10, 1883.

Results of Experiments on the Effect of Cutting Timothy and Clover Grass at Different Stages of Growth.

Farmers desire to secure from their grass a hay crop of maximum value. The main factors affecting the value of the hay crop are *quantity* and *quality*, and, as is well known, both these are influenced materially by the age at which the grass is cut. The proper time of cutting grass has been the subject of much discussion. Formerly, in many hay-producing regions, grass was allowed to stand until quite ripe. Later, many adopted the other extreme, and cut it when quite young. At present practice varies with different localities, though it is probable that a majority of farmers cut timothy when in bloom, or soon after. A great deal of clover, however, stands until the heads are partly or wholly dead. It seems to be quite generally held that grass in the last stages of maturity furnishes the maximum quantity of hay, but of a poorer quality than if it had been cut earlier. What is the golden mean where we secure the most profitable relation between quality and quantity?

Doubtless no one rule should be followed under all conditions of practice. The demands of other branches of farm work, the use for which the hay is intended, the kind of grass to be cut, these and other considerations determine what is wisest in each individual case.

The following facts concerning the cutting of grass, which have been obtained by the experiments of two years, will be made the basis of only such conclusions as each reader sees fit to draw for his own practice. Positive statements here will be confined strictly to matters of fact.

The figures given below were obtained in the following way: From one to two acres of grass, especially uniform in character and growth, were selected each year for each experiment. These carefully measured areas were divided into two or more equal plots, one or more plots being cut at each stage of growth. The grass was carefully cured, and the hay weighed when stored in the barn. After lying in the barn for five or six months, each lot of hay was reweighed, in order to determine the amount of "dry" hay from each cutting. Samples of each cutting have in every case been subjected to chemical analysis. Experiments have been conducted with timothy in 1881 and 1882, and with clover in 1882.

Experiments with Timothy.

These have been conducted on both the Eastern and Central farms. The grass has been cut in each experiment at only two stages of growth, viz: in full bloom and when approaching ripeness. The area of each cutting has been one acre, except on the Central farm in 1882, where it was one and one half acres.

In the following tables can be seen the results of the two years' experiments. The figures indicate pounds per acre:

	WEIGHT WHEN PUT IN BARN.		WEIGHT OF DRY HAY.	
	In bloom.	Nearly ripe.	In bloom.	Nearly ripe.
Eastern farm, 1881,	3 634	4,234	2,307	3,390
Eastern farm, 1882,	3,634	3 802	2,556	3,165
Central farm, 1881,	5,000	5,270	3 922	4,035
Central farm, 1882,	3,570	4,017	3,037	3,413
Average,	3,959½	4,331	2,955½	3,501¼
Increased yield,	.....	372	.....	546

The average time in the four cases which elapsed between the two cuttings was about sixteen (16) days.

The above figures show that during this time the average growth was sufficient to produce an increase of five hundred and forty-six (546) pounds of dry hay per acre, or an average increase of 18.5 per cent., after the period of bloom. This increase varied in the several cases from one hundred and thirteen pounds to one thousand and eighty-three pounds of dry hay per acre.

The shrinkage of the hay in weight after being stored in the barn is easily calculated from the above figures. The average shrinkage of the early cut hay (in bloom) was 25.7 per cent., and of the late cut (nearly ripe) 18.8 per cent., varying in the former case from 14.9 per cent. to 36.5 per cent., and in the latter case from 15 per cent. to 23.4 per cent. The average loss for all cases was 22.2 per cent.

The results of the analysis of samples of hay, carefully selected from the various cuttings, can be seen in the next two tables:

	Water.	100 PARTS OF WATER-FREE SUBSTANCE CONTAINED—				
		Ash.	Protein.	Crude fiber.	Other carbo-hydrates.	Fats.
1881. Eastern farm—In bloom,	9.53	5.03	8.06	36.89	47.57	2.48
Nearly ripe,	9.46	3.68	5.68	35.73	52.54	2.37
Central farm—In bloom,	10.27	4.80	5.83	37.71	49.39	2.27
Nearly ripe,	10.00	4.08	4.74	35.58	53.37	2.23
1882. Central farm—In bloom,	7.00	3.66	5.79	39.90	48.24	2.41
Nearly ripe,	7.00	3.55	5.25	35.90	52.78	2.52
Eastern farm—In bloom,	8.96	2.75	6.36	39.65	48.89	2.35
Nearly ripe,	8.88	3.07	5.83	35.89	52.36	2.85
Average of hay cut "in bloom,"	...	4.06	6.51	38.54	48.51	2.38
Average of hay cut "nearly ripe,"	.....	3.60	5.38	35.80	52.73	2.49

These averages give the composition of the dry substance of the hay. Dry timothy hay contains, on the average, about 12.5 per cent. of water, or one eighth its weight. Assuming this to be true of the hay when weighed, after lying in the barn, the average composition of the early and the late cut hay would be as follows: (A determination of the moisture in six samples of dry timothy hay, just as taken from the barns, gave the following figures: 11.43 per cent., 10.5 per cent., 10.75 per cent., 12.4 per cent., 13.23 per cent., and 15.14 per cent.; average, 12.24 per cent.:)

	Water.	Ash.	Protein.	Crude fiber.	Other carbohydrates.	Fats.
Average of hay cut "in bloom,"	12.5	3.55	5.70	33.72	42.45	2.11
Average of hay cut "nearly ripe,	12.5	3.15	4.71	31.33	46.13	2.18

The chief difference to be observed between the hays from grass in bloom and from grass nearly ripe is the larger percentage of protein in the former. The relative amount of crude fiber is also larger in the early cut hay, while of other carbohydrate material the late cut hay contains the greater relative quantity. It is generally true that the crude fiber (woody material) increases in relative proportion as grass grows older, and had there been analyzed samples of hay from grass cut during the younger stages of growth, this undoubtedly would have been found to be the case.

In the preceding tables we have all the data necessary for determining the nature of the growth that was made after the period of bloom—*i. e.*, to the growth of what constituents was due the increase in weight of dry substance. This can be done by multiplying the weight of the two kinds of hay by the percentage of the several constituents:

	Ash.	Protein.	Crude fiber.	Other carbohydrates.	Fats.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
2,955½ pounds of early cut hay contained,	104.9	168.4	996.4	1,254.4	62.4
3,501¼ pounds of late cut hay contained,	110.3	164.9	1,096.9	1 615	76.3
Increase,	6.4	3.5	105.9	360.6	13.9

After making due allowance for the amount of error necessarily involved in the above figures, it is still evident that nearly all the inincrease of weight was due to the growth of the non-nitrogenous constituents of the grass, or such compounds as cellulose, starch and allied substances, while the nitrogenous compounds (protein) increased none, or very little.

Experiments with Clover, 1882.

This experiment was conducted at the Central farm. A piece of especially uniform grass, nearly all clover, containing about six sevenths of an acre, or more exactly 37,701 square feet, was selected. This was accurately divided into six plots, each 213 feet long by 29½ feet wide. Two plots, not adjoining, were cut at each of three periods of growth, viz: The clover heads in bloom, partly dead, and nearly all dead, the dates of cutting being June 22, July 3, and July 19. As in the experiments with timothy, the hay was weighed when put in the barn, and then reweighed after five or six months, in order to know the yield of "dry" hay. The next table shows the yield of hay at the three periods of cutting:

	Yield of Two Plots.		Per cent. of loss in weight after storing.	Weight of dry hay per acre.	Per cent. of water in the dry hay.	Weight of water free substance per acre.
	Weight when stored.	Weight of dry hay.				
	Lbs.	Lbs.		Lbs.		Lbs.
June 22, head in full bloom,	2 110	1 215	42 4	4,210	12.60	3,680
July 3, some heads dead,	2 140	1 195	44.2	4 141	17.23	3 428
July 19, heads all dead,	1,520	1 130	25 7	3,915	15 15	3 381

Instead of an increased yield of hay from the late cuttings of clover there appears to be a decrease. The difference shown can hardly be due to lack of uniformity of the field of grass, for it was very uniform. It is not difficult to understand how hay from clover that is quite ripe may be inferior in quantity and quality to hay from clover in full bloom. After the period of bloom there is many years a quite rapid decay of the leaves, especially with heavy grass, and there is also much more loss of the finer parts of the plant in curing old grass than in curing it when cut in bloom.

In the case of grass which is a mixture of timothy and clover, with considerable less timothy than clover, it is suggested that some may make a mistake in allowing the grass to stand until the timothy is quite mature, for in most years the clover is by that time quite dead, and it is possible that the loss in quantity and quality of the clover may often much exceed the gain from the greater yield of timothy. There is one advantage, however, in letting grass stand untii quite ripe, it being then more easily and cheaply cured, and in a rainy harvest season much more safely cured.

The effect of letting the clover stand after the period of full bloom upon the composition of the hay is shown in the following results of analyses:

		100 PARTS OF WATER-FREE SUBSTANCES CONTAINED—				
	Water.	Ash.	Protein.	Crude fiber.	Other carbo-hydrates.	Fats.
May 24, heads beginning to form,	11 00	8 42	23.31	17.53	46.22	4.52
June 5, heads formed,	9.73	7.73	18.36	23 37	46.96	3 58
June 22, full bloom, (1.)	9.82	7 07	14.66	28.06	47.05	3 16
July 3, some heads dead, (2,)	9.05	6.60	13.69	36.40	40.23	3.08
July 19, heads all dead, (3,)	10.13	6 19	12.52	37.50	41.01	2.78

(1) First cutting. 2) Second cutting. (3 Third cutting.

The yield of dry substance per acre and the composition of this dry substance being given in the above tables, the yield per acre of the various constituents of the hay at the three stages of growth can now be calculated. This yield is shown in the next table:

	Yield of dry substance per acre.	YIELD PER ACRE OF—				
		Ash.	Protein.	Crude fiber.	Other carbo-hydrates.	Fats.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
June 22, heads in bloom,	3 680	260.2	539 5	1.032.6	1,731.4	116.3
July 3, some heads dead,	3 420	226.2	459 3	1 247.8	1.379.1	105.6
July 19, heads all dead,	3 381	208	420.7	1 260.3	1,378.3	93 7

It is shown by the above figures that in this experiment the youngest grass furnished the largest quantities of the most valuable ingredients of cattle food.

The reason for this is not that growth did not take place after the period of bloom, nor that there was a destruction of certain compounds in the plant. The true explanation of the decrease of the protein from 539.5 to 420.7 pounds per acre is undoubtedly due to the greater decay and loss of the finer parts of the plant, especially the leaves in the case of the old grass. The extent of this loss, or whether it occurs at all, depends very much upon the season.

The important facts involved in two years' experiments on grass are briefly as follows: (1) The average growth of timothy after the period of bloom in the four experiments recorded was 546 pounds of dry hay per acre, or 18.5 per cent. increase. (2) This increased growth was entirely of the non-nitrogenous constituents of the timothy. (3) The yield of hay from clover in full bloom was greater than at any succeeding stage of growth. (4) The composition of the clover hay from each period of growth indicates a constant decrease in total nutritive value after the grass passed the period of full bloom. (5) The loss in weight after storing the hay in the barn varied with the timothy from

15 per cent. to 36.5 per cent., averaging 22.2 per cent.; and with the clover varied from 25.7 per cent. to 44.2 per cent., averaging 37.4 per cent.

Experiments similar to the above will be continued, and it remains to be seen whether the above results are an indication of what generally occurs.

Summary of Meteorological Record, for January 1 to June 30, 1883, from Observations made at the State College, by Prof. Osmond.

DATE—1883.	BAROMETER.* Pressure of atmosphere. Means of observations. 7, A. M.	BAROMETER. Means of observations. 2, P. M.	BAROMETER. Means of observations. 9, P. M.	BAROMETER. Mean of daily means.	THERMOMETER—F. DEG. Temperature of air. Means of observations. 7, A. M.	THERMOMETER. Means of observations. 2, P. M.	THERMOMETER. Means of observations. 9, P. M.	THERMOMETER. Mean of daily means.	THERMOMETER. Means of. Daily max.	THERMOMETER. Means of. Daily min.	THERMOMETER. Difference.	HYGROMETER. Rel. humidity.† Means of. 7, A. M.	HYGROMETER. Means of. 2, P. M.	HYGROMETER. Means of. 9, P. M.	HYGROMETER. Mean.	PLUVIOMETER. Rainfall.‡ Inches.	PLUVIOMETER. No. of days rain fell.	CLOUDINESS. On scale of ten. 7, A. M.	CLOUDINESS. 2, P. M.	CLOUDINESS. 9, P. M.	WIND. Prevailing direction. 7, A. M.	WIND. Prevailing direction. 2, P. M.	WIND. Prevailing direction. 9, P. M.	WIND. Total miles per month.
January, . . .	28.45	28.40	28.16	28.13	18.9	25.5	22.5	22.41	31.19	5.42	25.77	88.4	82.9	81.2	81.42	3.69	12	9.6	8.0	6.7	W.	W.	W.	4,787
February, . .	28.57	28.51	28.52	28.51	21.5	31.5	27.8	28.00	37.07	18.47	18.60	85.6	74.4	78.5	79.10	3.53	10	7.8	7.0	5.8	W.	W.	W.	4,497
March, ...	28.29	28.23	28.28	28.27	27.9	36.6	30.6	31.69	43.45	20.22	23.23	76.2	63.4	72.3	70.42	1.90	5	5.6	5.0	3.2	S. W.	W.	W.	7,998
April, ...	28.31	28 28	28.30	28.30	42.7	56.6	46.0	47.29	55.35	35.19	20.16	75.4	59.8	73.9	66.53	2.08	8	7.2	6.0	4.6	W.	W.	W	3,390
May, ...	28.31	28.26	28.18	28.40	56.3	65.4	57.5	59.19	67.74	44.93	22.81	69.1	62.3	71.4	67.93	4.32	14	6.7	6.9	5.1	W.	W.	W.	3,374
June, ...	28.33	28 30	28.31	28.31	67.5	78.5	67.0	69.67	76.57	57.83	18.74	77.1	63.8	76.5	70.76	6.14	13	5.2	5.6	4.8	W.	W.	W.	2,556
Means, . . .	28.38	28.33	28.39	28.41	39.6	47.8	41.9	43.5	51.89	30.31	21.55	78.6	67.8	75 6	72.69	3.41	10.3	7.0	6.4	5.0	W.	W.	W.	4,434

* Reduced to 30° F., and instrumental error corrected by comparison with U. S. standard yard.

† 100 = saturation.

‡ "Rainfall" includes snow melted and measured.

No. 6. November 26, 1883.

Of the Bulletins published during the last year, three have been devoted to giving the result of various experiments and investigations conducted on the farms and in the laboratory of the College. All the experiments from which results have been reported during the past two years have been continued, and *several new and important ones* have been planned and put in operation during the present season. The purpose of these experiments and investigations is to throw light upon important questions pertaining to farm practice. The following is a brief summary of all the work that has been undertaken, and from which reports of progress will be made as fast as reliable results are reached:

1. *Experiments with various fertilizers*, involving the following points: (*a*) The use of incomplete, as compared with complete, commercial fertilizers. (*b*) The use of nitrogenous fertilizers. (*c*) The use of commercial fertilizers as compared with yard manure. (*d*) The use of lime with and without yard manure. (*e*) The best method of applying commercial fertilizers. (*f*) The relative efficiency of the various forms of phosphoric acid. (*g*) The most profitable quantity of any commercial fertilizer to use. These experiments with fertilizers involve the use of one hundred and eighty (180) plots on the Central Experimental farm, and sixty-six on the Eastern Experimental farm.

2. Experiments on the effect of cutting grass at different periods of growth, upon the quantity and quality of the hay.

3. Experiments with ensilage, including an investigation into the chemical changes that occur in the silo.

4. Experiments in feeding, growing, and fattening cattle. (*a*) With early and with late cut hay, and (*b*) with cornmeal and cottonseed meal.

5. Experiments by means of box-culture, including (*a*) a test of the relative effect of the different forms of phosphoric acid, and (*b*) an investigation into the effect of the various ingredients of commercial fertilizers upon the ash of certain plants.

It may be a long time before final conclusions will be reached in regard to any of the points under investigation. It should be understood distinctly that the results given in these bulletins are only reports of progress, and, for the present at least, any statements in the way of summing up results are only statements of facts that appear from time to time, and are not intended for general conclusions. The present bulletin reports, in part, the feeding experiments already made.

Feeding Experiments.

It has been the custom on the farms located at the College, to feed from fifty to seventy-five fattening steers each year during the winter months. This number of animals consumes yearly a large quantity of food, and it is essential to financial success that they be fed in the most economical manner possible. All cattle-feeders know that in fattening steers for the market the margin of profit, at best, is not large, and that the operation is often a losing one, unless the greatest care and economy are exercised.

In attempting to practice economy in feeding these animals at the College farms, questions have arisen for which no certain answers can be found. They are questions which farmers are asking everywhere, and which must be answered by experiment. Investigation in this direction is attended with peculiar difficulties, owing to the number and kind of factors involved in the processes of nutrition and growth. The kind, quality, and combination of the food given, the age, development, and individual peculiarities of the animals experimented upon, all have an important influence upon the results of any method of feeding.

The Germans have done a large amount of elaborate, scientific and practical work in order to ascertain the laws and facts that pertain to animal nutrition, and they have reached certain conclusions which are very valuable, but some of which still need to stand the test of practice before we shall be prepared to accept them without question, and in all their details.

The experiments conducted during the past two years have been, in part, an attempt to test the economy of a ration compounded according to a German feeding standard, as compared with a ration differing essentially from such a standard. The questions asked have not been answered as fully as was desired, but the results are reported as in the line of progress. The hints received in watching past experiments will serve, it is hoped, to make future ones more fruitful of results.

Farmers do not have uniform methods or standards of cattle feeding. Practice in this direction varies in the kind, combinations, and amounts of material fed. Cornmeal, however, is, in general, the principal ingredient of the rations fed to fattening steers. Some feed the cornmeal nearly pure, others mix with it considerable oatmeal or wheat bran to a limited extent, cottonseed and linseed meal. Opinions differ as to what food, or mixture of foods, is wisest. So far we have very little but opinion, if we except the experimental work of the Germans.

The German standards condemn a ration composed of cornmeal and cornstalks as not economical food for fattening cattle, on the ground that in such a ration there does not exist a proper relation between the digestible nutrients, viz: The albuminoids and carbohydrates.* The German feeding standard would call for an addition to this ration of some highly nitrogenous substance, like oil-cake or cottonseed meal.

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* All cattle foods contain four classes of substances, viz: Protein, (albuminoids,) carbohydrates, fats, and ash. The protein includes the nitrogenous compounds, like lean meat, gluten, &c.; the carbohydrates include sugar and starch, and bodies resembling these compounds. The fats or oils are very much like animal fats, and the ash is the mineral or non-combustible substances. Some foods are highly nitrogenous, like cottonseed and oil-cake. Others contain a small relative percentage of nitrogen, and a large relative percentage of carbohydrates, like turnips, potatoes, straw, cornstalks, &c.

It is certain that one practical inquiry is of great importance, viz: Can farmers profitably purchase the highly nitrogenous cattle foods that are for sale in our markets in order to combine them with the corn and coarse fodder produced on the farm? Theories based on scientific investigation would answer the inquiry in the affirmative, so far as it is a question of a proper combination of food ingredients, and so of an economical use of the material consumed. Of course, the variable prices of these different food-stuffs is something of which science can take no account, and the farmer must decide, from year to year, what he can afford to purchase. The great underlying principles in all practice in cattle feeding are those that determine the proper amounts and relation of nutrients in the ration, and these principles once understood it only remains for the farmer to purchase or to produce these nutrients in the cheapest possible form.

A large part of the experiments here reported have been devoted to testing the economy of a ration composed of cornmeal and cornstalks, as compared with one composed of cornmeal, cottonseed meal, and cornstalks. Cottonseed is used by English farmers to a great extent. Their supply comes from America, and it is a question worthy of attention, whether American farmers cannot use more of this material at home with profit.

Feeding trials have been conducted at both the Eastern and Central Experimental farms, and at both places the animals fed have been fattening steers. The trials were conducted with the utmost care, observing the methods and precautions indicated below.

At each farm, for each trial, four steers were selected, two being fed after one method, and the other two after the method with which it was desired to make comparison. The steers were selected so that in each lot of four, one pair should be as nearly like the other in size, weight, form, general appearance, and habit as possible. The selection at the Central farm of four steers was, in each case, from a large lot.

The rations to be tested were weighed to the animals each day, any material they did not eat also being weighed.

The weight of the steers was in no case recorded until the animals had been eating their rations for one week. The weighings were made weekly, at the same hour in the day, and always before drinking. In all things, except in what they ate, the steers were treated as nearly alike as possible.

The results of the experiments at the Eastern farm for 1881–2 are as follows:

FIRST PERIOD, (55 DAYS.)

	Steers 5 and 6. Cornmeal alone.	Steers 7 and 8. Mixture of cornmeal and cottonseed.
Date of first weighing,	December 15	December 15
Date of last weighing,	February 9	February 9
Weight of steers December 15,	2,110 lbs.*	2,110 lbs.*
Weight of steers February 9,	2,220 lbs.	2,336 lbs.
Total gain in weight,	110 lbs.	226 lbs.
Total quantity of cornfodder eaten,	674 lbs.	833 lbs.
Total quantity of cornmeal eaten,	1,660 lbs.	1,078 lbs.
Total quantity of cottonseed meal eaten,	....	431 lbs.
Average daily ration, Cornfodder,	12.3 lbs.	15.1 lbs.
Average daily ration, Cornmeal,	30.2 lbs.	19.6 lbs.
Average daily ration, Cottonseed,	....	7.8 lbs.

SECOND PERIOD, (42 DAYS.)

	Steers 5 and 6. Mixture of cornmeal and cottonseed.	Steers 7 and 8. Cornmeal alone.
Date of first weighing,	February 16	February 16
Date of last weighing,	March 30	March 30
Weight of steers February 16,	2,254 lbs.	2,368 lbs.
Weight of steers March 30,	2,404 lbs.	2,510 lbs.
Total gain in weight,	120 lbs.	152 lbs.
Total quantity of cornfodder eaten,	419 lbs.	524 lbs.
Total quantity of cornmeal eaten,	830 lbs.	1,245 lbs.
Total quantity of cottonseed eaten,	333 lbs.	
Average daily ration. Cornfodder,	10 lbs.	12.5 lbs.
Average daily ration. Cornmeal,	19.8 lbs.	29.7 lbs.
Average daily ration. Cottonseed,	7.9 lbs.	

A summary of the two periods shows the result to be as follows:

	Cornmeal alone.	Mixture of cornmeal and cottonseed.
Total quantity cornfodder eaten,	1,198 lbs.	1,252 lbs.
Total quantity cornmeal eaten,	2,905 lbs.	1,908 lbs.
Total quantity cottonseed eaten,	....	764 lbs.
Average daily ration for 97 days.† Cornfodder,	12.3 lbs.	16 lbs.
Average daily ration for 97 days.† Cornmeal,	30 lbs.	19.7 lbs.
Average daily ration for 97 days.† Cottonseed,	....	7.9 lbs.
Total gain in weight,	202 lbs.	376 lbs.
Cost of food,‡	$46 57	$47 04
Cost of food per pound of increase,	17.7 cents.	12.5 cents.

The superintendent of the Eastern farm stated in his report for 1881–2, that steers five and six were inferior in growing capacity to steers seven and eight. During the "first period," when the former lot was fed on the cornmeal ration, their gain was very unsatisfactory, and much inferior to the gain of steers seven and eight, that ate the mixture containing cottonseed. When, however, the rations were changed

* All the weights given in these tables refer to two steers.

† The quantities actually eaten.

‡ In estimating the cost of the food for 1881–2, the fodder was valued at $5 per ton, the meal at one and one half cents per pound, and the cottonseed at $30 per ton.

about, so that the poorer steers received the cottonseed and cornmeal, their increase in weight was equal to that of the better lot of steers receiving cornmeal alone.

The next table shows the result of the experiment at the Central arm for 1881–2:

	Steers No. 5 and 6. Cornmeal alone.	*Steers No. 7 and 8. Mixture of cornmeal and cottonseed.*
Date of first weighing,	Jan. 7	Jan. 7
Date of last weighing,	April 1	April 1
Weight of steers January 7,	1,835 lbs.	1,939 lbs.
Weight of steers April 1,	2,010 lbs.	2,200 lbs.
Total quantity of cornfodder eaten,	840 lbs.	1,436 lbs.
Total quantity of cornmeal eaten,	2,626 lbs.	1,344 lbs.
Total quantity of cottonseed eaten,	....	672 lbs.
Average daily ration for 84 days.* — Cornfodder,	10 lbs.	17 lbs.
Average daily ration for 84 days.* — Cornmeal,	31.3 lbs.	16 lbs.
Average daily ration for 84 days.* — Cottonseed,	....	8 lbs.
Total gain in weight,	175 lbs.	261 lbs.
Cost of food.†	$43 47	$38 15

In this case the rations were not changed about, so as to give the mixture of cornmeal and cottonseed to Nos. 5 and 6; but in order to determine the amount of error introduced by the different capacities for growth of the two lots of animals, the steers were fed alike for four weeks previous to beginning the experimental rations. Steers Nos. 5 and 6 gained 135 pounds during the four weeks, and steers Nos. 7 and 8 gained 194 pounds, or the two lots gained at the ratio of 100 to 144. While the experimental rations were fed, the gain of steers 5 and 6 was to the gain of steers 7 and 8 as 100 to 149; or the relative gain of the two lots was the same when fed alike, and when fed the rations that were put to a comparative test. One lot ate about thirty-two pounds of cornmeal per day, and the other lot only sixteen pounds of cornmeal and eight pounds of cottonseed.

The superintendent of both farms reported themselves as favorably impressed by the practical results of adding cottonseed meal to the ration.

Experiments similar to the above were continued at the Central Experimental farm in 1882–3. The general plan of operations was the same in these experiments as in those of 1881–2. The following is a summary of the results:

* The quantities actually eaten.

† See note on page 28.

	Steers 5 and 6. Cornmeal alone.	*Steers 7 and 8. Cornmeal and cotton-seed.*
Date of first weighing,	Jan. 13	Jan. 13
Date of last weighing,	March 3	March 3
Weight of steers, January 13,	2,315 lbs.	2,440 lbs.
Weight of steers, March 3,	2,505 lbs.	2,580 lbs.
Total weight cornfodder eaten,	345 lbs.	344 lbs.
Total weight cornmeal eaten,	1,764 lbs.	1,016 lbs.
Total weight cottonseed eaten,	. . . .	404 lbs.
Average daily ration for 49 days. Cornfodder,	7 lbs.	7 lbs.
Cornmeal,	36 lbs.	20¾ lbs.
Cottonseed,	. . . .	8¼ lbs.
Total gain,	190 lbs.	140 lbs.
Cost of food,*	$23 77	$20 44
Cost per pound of increase,	12_2 cents.	14.6 cents.

From March 3 to April 21 the cornfodder was replaced by a mixture of clover and timothy hay. The following table shows the results:

	Steers 5 and 6. Cornmeal alone.	*Steers 7 and 8. Cornmeal and cotton-seed meal.*
Date of first weighing,	March 10	March 10
Date of last weighing,	April 21	April 21
Weight of steers, March 10,	2,560 lbs.	2,600 lbs.
Weight of steers, April 21,	2,750 lbs.	2,770 lbs.
Total weight of hay eaten,	672 lbs.	672 lbs.
Total weight of cornmeal eaten,	1,512 lbs.	871 lbs.
Total weight of cottonseed meal eaten,	. . . .	347 lbs.
Average daily ration for 42 days. Hay,	16 lbs.	16 lbs.
Cornmeal,	36 lbs.	20¾ lbs.
Cottonseed meal,	. . . .	8¼ lbs.
Total gain,	190 lbs.	170 lbs.
Cost of food,	$22 94	$19 94
Cost per pound of increase,	12 08 cents.	11 66 cents.

In this last experiment the two lots of steers were fed alike for three weeks before the experiment was begun, and were weighed at the end of the second and third weeks. The daily ration for each steer was fifteen (15) pounds of cornfodder and ten (10) pounds of cornmeal. During the last two weeks the change in weight was practically nothing, steers five and six gaining ten (10) pounds and steers seven and eight losing five (5) pounds. It should be remarked that the steers fed in 1882–3 seemed older and more mature than those fed in 1881–2. The cornfodder was in all cases chopped before being fed, but the hay was not. The animals were allowed no exercise, except what they got while being watered once a day. The steers fed in 1881–2 at the Eastern farm were grown in the West, and those fed at the Central farm were grown in Central Pennsylvania. In 1882–3, the animals were also from the West.

The feeding trials have not given uniform results. The following is a brief review of the most important facts that appear:

* For 1882–3, the cornfodder is reckoned at $5 per ton, the hay at $10 per ton, the cornmeal at 65 cents per 50 pounds, and the cottonseed at $31 50 per ton.

1. In 1881–2 the outcome of the experiment was decidedly in favor of the mixed ration of cornmeal and cottonseed meal. In 1882–3 there was very little difference in the cost of production with the cornmeal alone, and with the mixture of cornmeal and cottonseed meal.

2. The only explanation of the difference in the results for the two years that suggests itself is the fact that the steers fed in 1882–3 were older, more mature, and fatter when the feeding was begun than was the case in 1881–2. The opportunity for growth was greater with the smaller and less mature animals. This, however, is only a suggestion; but is one that will be kept in mind in planning for future experiments.

3. The experiments do seem to indicate that if cottonseed meal is judicially combined with cornmeal, it can take the place of more than its own weight in cornmeal, and that, if the prices of the two kinds of food do not differ greatly, the cottonseed meal can be profitably purchased. This subject will be continued in the next bulletin.

No. 7. December 10, 1883.

Note on an Experiment with Native Potatoes.

By Prof. WILLIAM A. BUCKHOUT.

The potato crop is so important to farmers that anything which bears upon it has become of value and a good deal of interest attaches to all experiments in potato culture. It is well known that the potato is an American plant, found native, originally, in Chili, South America, and specimens supposed to be closely allied, if not absolutely the same, have been found at various times, within the past few years, in New Mexico and Arizona, where it grows spontaneously.

The occasional failure of the potato crop, its liability to disease, and the desire for new varieties have led experimenters at several times to procure seed—generally the tubers—directly from the native plants. The plants from such seeds have been crossed with the cultivated varieties, with the hope that the progeny would have increased vigor and producing power. It was believed that in some cases such was the effect. The careful series of experiments carried on by Rev. Chauncey Goodrich, and the results which followed from them, are well known. Ntaive potatoes from New Mexico have also been cultivated on the grounds of the Department of Agriculture, at Washington, but with what success has not been published. In the proceedings of the Academy of Natural Sciences of Philadelphia, for 1874, is given an account of a series of cultures carried on for eight years. The tubers originally taken were about the size and shape of a bullet, with thick skin, covered with many large, roughened spots. At the end of the time mentioned they had become oval, flattened, smoother and thinner-skinned, and some were nearly as big as a walnut.

On the experiment grounds of the *Rural New Yorker* they were cultivated the past year with substantially the same results which attended our own trial.

Within the past year tubers collected in Arizona in the fall of 1882 have been sent out to various applicants by Mr. J. G. Lemmon, of Oakland, California. We planted seven of these little potatoes in ordinary garden soil and gave them ordinary culture. One failed to grow; from the others one hundred and sixty seven tubers were produced. They averaged no larger than those planted, although several of them were about an inch in diameter. They are simply diminutives of the cultivated potato. All were flattened, globular, and had relatively large whitish spots. On exposure to the air they turn color in a few hours, and become of a dull ashen color. The skin is about twice as thick as in the domesticated varieties, and immediately beneath it is a colored layer, deep purple by reflected light, but when placed under the microscope and viewed as a transparent object it is a clear violet. The cells and starch grains are not appreciably different from those parts in the cultivated tubers. It was the intention to test their edibility, but they changed color almost as quickly as the cut surface of an apple when exposed to air and light, and, having delayed a day or two, we found them fully as bitter and unpleasant as our ordinary potatoes when they have become green by prolonged exposure to light. When cooked immediately after digging they are probably sweet and palatable, as they are often used by the Indians.

It is not at all likely that any immediate good result to the farmer will follow his cultivation of these native potatoes. Some persons appear to be under the impression that the first crop will show a considerable change in the size and in the quantity of the product and that cultivation a second year will fix and increase these desirable qualities still more, and so on, until within a few years they will become valuable for cultivation. But such quick results cannot be inferred from what we know of the origin of our cultivated plants, and our experiment fails to bear out the idea. That marked variations from the normal condition of a plant may appear spontaneously in some of its progeny is probably true; but such cases are not common, considering the number of individual plants under cultivation, and their occurrence cannot be indicated beforehand. Hence, for the practical cultivator these potatoes have as yet no value, but under the hands of the experimenter they may in time be so improved as to be worthy of general cultivation. This result may be secured either by crossing them with varieties now in cultivation, or, possibly, by developing some natural variations through prolonged and careful culture under various conditions. We shall endeaver to continue the experiments the coming year.

No. 8. April 25, 1884.

The Results of Experiments Showing the Effect of various Fertilizers on the Growth of Corn, Oats, Wheat, and Grass.

The system of field experiments now in progess on the experimental farms of the College, is intended to include the use of all the principal methods that are generally employed for the maintenance of fertility, and is to be continued for a number of years sufficient to determine the ultimate effect and value of the different methods of manuring employed. There is involved in these experiments a four years' rotation—corn, oats, wheat, grass—to be carried out on six series of plots. In four of these series, each plot is to be treated the same way, year after year, and in the same manner that a corresponding plot in each of the other series is treated. It is hoped that we may thus obtain some facts of general interest with regard to the use of commercial and farm manures, of lime with and without yard manure, of plaster, &c.

On the Central Experimental farm, one hundred and eighty (180) plots are under experimental treatment. One hundred and forty-four (144) of these plots are two hundred and sixty-one (261) feet long by twenty-one (21) feet wide, each containing one eighth of an acre. These plots are arranged in four (4) parallel tiers, thirty-six plots in each tier; and the plots of each tier run parlalel to one another, being separated by a strip of grass two feet wide.

The remaining thirty-six (36) plots are each one rod wide and eight rods long, containing one twentieth of an acre. These are arranged in two parallel tiers, eighteen plots in a tier, and are separated by a strip of land two feet wide, as in the case of the other plots.

The soil of the plots on the Central farm is a so-called limestone clay, and is formed from the decomposition of the surrounding and underlying rock, which is very largely magnesian limestone. This soil has the general appearance of a clayey loam. If worked at the proper time, it pulverizes very satisfactorily and forms a desirable home for the roots of plants. Its natural drainage is good, while it is sufficiently retentive of moisture to enable crops to withstand an ordinary drought.

The natural fertility of these plots is above the average, as is shown by the yield of the plots receiving no manure.

Dissolved bone-black and muriate of potash are used in these experiments as the respective sources of phosphoric acid and potash, and nitrogen is used in three different forms, viz: Dried blood, nitrate of soda, and sulphate of ammonia. The yard manure is produced from cottonseed meal, wheat-bran, cornmeal, cornstalks, and hay fed to milch cows and fattening steers, wheat straw being freely used as a litter. In all respects, except in the application of different fertilizers, the various plots are treated exactly alike. They are cultivated at the same time and in the same manner, and each has the same number of hills, with the same amount of seed to each hill. The rows are

3.5 feet apart, and the hills 3 feet, making about four thousand hills per acre.

The fertilizers are applied to the corn and to the wheat, or twice during the rotation. The yard manure is spread on the grass-sod and on the oat stubbles, and plowed under, and the commercial manures are spread on the land after plowing and before harrowing, and are then harrowed in. All the fertilizers are applied just before seeding.

As can be seen from an examination of the tables that follow, the various fertilizers used in these experiments include yard manure, commercial fertilizers of the very best quality, and certain substances as caustic lime, ground limestone, and plaster, which are not fertilizers in the full meaning of the term, because they do not so much supply plant food themselves as they cause its production from crude unavailable material in the soil.

The table which follows does not give in detail the yearly rate of yield of all the plots that have entered into this system of experiments on the Central Experimental farm during the past three years, but gives simply the average rate of yield of all those plots that have been treated in essentially the same manner. Following this table is a discussion of the data which it contains.

Table showing the Average Yield of all Plots Treated in the same Way, for the Years 1881, 1882, and 1883.

Kind and Quality of Fertilizers Used.	Average Yield per Acre. Corn. Shelled corn	Average Yield per Acre. Corn. Fodder.	Average Yield per Acre. Oats. Grain.	Average Yield per Acre. Oats. Straw.	Average Yield per Acre. Wheat. Grain.	Average Yield per Acre. Wheat. Straw.	Average Yield per Acre. Hay.	Increase of Yield per Acre over Plots not Manured. Corn. Shelled corn.	Increase. Corn. Fodder.	Increase. Oats. Grain.	Increase. Oats. Straw.	Increase. Wheat. Grain.	Increase. Wheat. Straw.	Increase. Hay.	Average total production in pounds.	Increase in lbs. of total production over plots receiving no manure.
	Bu.	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*	*Lbs.*		
1. Nothing,‖	37.5	2,791	41.9	2.355	19.3	1,840	3,500	....	....	....	....	....	....	....	37,712	
2. *Dried blood, 240 lbs.	39.4	2,965	44.3	2,457	20.2	2,240	3,800	1.9	171	2.4	102	0.7	400	240	40,436	2,694
3. *Dissolved bone-black, 300 lbs.	35.2	2,960	45.5	2,153	25.1	2,308	3,960	−2.3	166	3.6	98	5.8	488	460	40,384	2,642
4. *Muriate of potash, 200 lbs.	39.7	3,253	44.5	2,587	19.5	1,920	3,400	2.2	459	2.6	232	0.2	80	−160	40,736	2,994
5. * { Dried blood, 240 lbs. / Dissolved bone-black, 300 lbs. }	41.4	3.040	47.0	2,562	27.3	2,220	4,400	3.9	246	5.1	207	8.0	380	810	42,992	5,250
6. * { Dried blood, 240 lbs. / Muriate of potash, 200 lbs. }	39.7	3,453	43.1	2,395	18.5	1,952	2,720	2.2	659	1.2	40	0.8	112	840	39,792	2,050
7. † { Dissolved bone-black, 300 lbs. / Muriate of potash, 200 lbs. }	41.2	3,024	47.7	2,603	21.7	2,385	4,230	3.7	230	5.8	248	5.4	545	670	43,022	5,280
8. † { Nitrogenous fertilizers, containing 24 lbs. nitrogen,‡ / Dissolved bone-black, 300 lbs. / Muriate of potash, 200 lbs. }	40.0	3,263	51.0	2,923	27.4	3,071	4,740	2.5	469	9.1	568	8.1	1,231	1,180	46,712	8,970
9. † { Nitrogenous fertilizers, containing 48 lbs. nitrogen,‡ / Dissolved bone-black, 300 lbs. / Muriate of potash, 200 lbs. }	40.0	3,399	49.6	3,014	28.8	3,153	4,670	2.5	605	7.7	659	9.0	1,313	1,110	47,758	10,016
10. † { Nitrogenous fertilizers, containing 72 lbs. nitrogen,‡ / Dissolved bone-black, 300 lbs. / Muriate of potash, 200 lbs. }	39.3	3,317	51.0	3,051	29.1	3,160	4,800	1.8	553	9.1	696	9.8	1,320	1,240	47,936	10,194
11. Yard manure,§	41.8	2,794	47.6	2,701	28.3	3,141	3,680	4.3	....	5.7	316	9.0	1,301	120	44,291	6,549
12. Lime,	40.3	2,450	47.2	2,603	23.2	2,300	....	2.8	−344	5.3	248	3.9	460			
13. Ground limestone,	34.2	2,642	46.4	2,525	18.5	1,9-8	....	3.3	−152	4.5	170	−0.8	148			
14. Plaster,	37.3	2,826	43.4	2,441	19.7	2,101	....	−0.2	32	1.5	89	0.4	264			

* Average of two (2) plots with wheat and of four (4) with oats and corn.
‡ Furnished either by dried blood, sulphate of ammonia, or nitrate of soda.
‖ Average of fifteen (15) plots with corn and oats, and ten (10) with wheat.
† Average of eight (8) plots with wheat and of twelve (12) with oats and corn.
§ Average of six (6) plots with wheat and of nine (9) with oats and corn.

It requires careful study to see clearly the bearing of the results previously given upon the various points involved in the experiments. For the sake of clearness, each point will be considered separately in connection with such a restatement of experimental data as may be necessary.

The points upon which those experiments are intended to throw some light are as follows:

a. The comparative effect of the single valuable ingredients of commercial fertilizers.

b. The effect of complete, as compared with incomplete, fertilizers.

c. The comparative effect of different forms of nitrogen.

d. The necessary artificial supply of nitrogen.

e. The comparative effect of commercial fertilizers and yard manure.

f. Effect of lime, ground limestone, and plaster.

g. The permanancy of effect of the different fertilizers.

h. Effect of the various fertilizers upon the comparative growth of the different crops.

i. Effect of the various fertilizers upon the relation of grain to straw.

a. The Comparative Effect of Single Ingredients.

Constant observation of the wheat when growing and the results as seen in the previous table show that phosphoric acid was the ingredient having the greatest influence on the growth of the wheat, whether used alone or in combination with other ingredients. A combination of dissolved bone-black and dried blood has so far proved more efficient than a combination of the former with muriate of potash, indicating that the nitrogen has been of greater relative importance than the potash. Potash seems to be least needed at present on the limestone soil where these plots are located. It is probable that such will be found to be the case very generally in those regions in Pennsylvania where root-growing has not been practiced, but where wheat and corn have been grown and the larger part of the grain sold and the straw and fodder returned to the land. Stock-growing sends away from the farm very little potash. This is also true of dairying where only butter is sold, but when the whole milk is sold a loss of all three of the valuable ingredients is sustained. While phosphoric acid is now the most effectual ingredient, there are already indications in the growth of the last crop of wheat (1883) that those plots not receiving nitrogen will, after a time, fall very much behind in production. Prof. W. O. Atwater thus summarizes the results of experiments which he has conducted: "In brief, phosphoric acid took the leading place often, potash occasionally, and nitrogen very rarely."

b. The Effect of Complete as Compared with Partial Fertilizers.

A fertilizer containing nitrogen, phosphoric acid, and potash, with the necessarily accompanying ingredients, is said to be complete. A partial fertilizer is one not containing all these three ingredients.

If the growth of both straw and grain be considered, a complete fertilizer has proved the most efficient in increasing the growth of wheat. If only the growth of the grain is taken into account, the absence of potash did not materially diminish the production. Below is a table showing the comparative production of wheat with complete and with partial fertilizers. These figures also bear upon the discussion of the first point.

Valuable Ingredients Contained in the Fertilizer.	Average of	Average Yield of Wheat per Acre.		Increase of Yield of Wheat over Plots Receiving no Manure.	
		Grain. Bushels.	Straw. Pounds.	Grain. Bushels.	Straw. Pounds.
Nothing,	10 plots,	19.3	1,840		
Nitrogen alone,	8 plots,	20.0	2,240	0.7	400
Phosphoric acid alone,	2 plots,	25.1	2,308	5.8	468
Potash alone,	2 plots,	19.5	1,920	0.2	80
Phosphoric acid and potash,	8 plots,	24.7	2,385	5.4	545
Phosphoric acid and nitrogen,	2 plots,	27.3	2,220	8.0	380
Phosphoric acid, potash, and nitrogen.*	8 plots,	27.4	3,071	8.1	1,231

* Only twenty-four pounds of nitrogen per acre.

c. The Comparative Effect of Different Forms of Nitrogen.

Nitrogen exists in commercial manures principally in three forms, viz: As nitric acid in nitrates: as ammonia in ammonia salts: and as organic nitrogen in dried blood, dried fish, &c. There is very little doubt but that the plant takes in nearly all its nitrogen in the form of nitric acid—ammonia and organic nitrogen being oxidized to this form before becoming available.

Each of these three forms of nitrogen are used singly upon a number of plots in each series, being accompanied in every case by phosphoric acid and potash.

	Yield of Complete Fertilizer Containing 24 Lbs. of Nitrogen per Acre.		Yield of Complete Fertilizer Containing 48 Lbs. of Nitrogen per Acre.		Yield of Complete Fertilizer Containing 72 Lbs. of Nitrogen per Acre.	
	Grain. Bushels.	Straw. Pounds	Grain. Bushels.	Straw. Pounds.	Grain. Bushels	Straw. Pounds.
Nitrogen in dried blood.	26.7	2,996	27.1	3,162	[illegible]	[illegible]
Nitrogen in an ammonia salt,	29.9	3,152	28.9	3,140	29.4	[illegible]
Nitrogen in a nitrate,	26.0	3,200	30.2	3,148	30.8	[illegible]
Average,	27.5	3,106	28.7	3,150	29.2	3,194

Average yield of plots receiving no manure: Grain, 19.3 bushels; straw eighteen hundred and forty pounds.

Average yield of plots receiving phosphoric acid and potash: Grain, 24.7 bushels; straw, twenty-three hundred and eighty-five pounds.

It does not appear, from the above showing, that there has been any great difference in the activity of the three forms of nitrogen used, although each has considerably increased the yield, especially of straw.

d. The Necessary Artificial Supply of Nitrogen.

A glance at the last table given, and also at the second large one, shows that while a complete fertilizer containing twenty-four pounds of nitrogen to the acre, caused considerably more production than a fertilizer containing no nitrogen, increasing this nitrogen supply to forty-eight pounds, or even to seventy-two pounds per acre, has, so far, produced little additional effect. In the case of the crop from a complete fertilizer containing twenty-four pounds of nitrogen, the grain and straw, not including the roots, took up between sixty and seventy pounds of nitrogen per acre.

A great deal of nitrogen was supplied from natural sources, although the natural supply did not seem sufficient to meet the wants of a maximum crop. It would be interesting—as certainly it is important—to know what is the minimum partial supply of nitrogen that is necessary for the farmer to furnish to land that is continuously cropped.

e. The Comparative Effect of Commercial Fertilizers and Yard Manure.

Plots 15 to 21, inclusive, are alternately manured with yard manure and commercial fertilizers. The average yield of wheat on the commercial fertilizer plots, and the yard manure plots, is as follows:

Commercial fertilizers, ...	Grain, 27 bushels, ...	Straw, 2,850 pounds.
Yard manure, ...	Grain, 28.3 bushels, ...	Straw, 3,141 pounds.

There seems to be a slight difference in favor of the yard manure.

f. Effect of Lime, Ground Limestone, and Plaster.

An examination of the first two tables makes it evident that none of these substances produced anything more than a small increase of production. In those cases where these substances were applied to plots contiguous, or nearly so, to plots not manured, neither by the eye nor by the scales could much difference in production be detected.

g. The Permanancy of Effect of the Different Fertilizers.

As before stated, the fertilizers are applied to only two crops in the rotation, (corn and wheat,) and so a study of the growth of oats and grass on the various plots is necessary in order to determine the effect of the fertilizers the second year after their application.

The averages in the following table are made up from the yield of oats in 1882 and 1883 and grass in 1883:

Kind of Ingredients applied the Preceding Year.	Yield of Oats per Acre.		Yield of hay per acre—pounds.	Increase of Yield of Oats over Plots not Manured.		Increase of yield of hay over plots not manured—pounds.
	Grain. Bushels.	Straw. Pounds.		Grain. Bushels.	Straw. Pounds.	
Nothing,	43.1	2,258	3,560			
Dissolved bone black,	46.7	2,232	3,960	3.6	—26	450
Dissolved bone-black and muriate of potash,	45.6	2,214	4,230	2.5	—44	670
Dissolved bone-black, muriate of potash, and a nitrogenous fertilizer,	48.3 to 49.5	2,387 to 2,579	4,670 to 4,800	5.2 to 6.4	129 to 321	1,110 to 1,240
Yard manure,	47.8	2,572	3,680	4.7	314	120

It can hardly be doubted that the commercial fertilizers have caused an appreciable increase of the second crop following their application. This is especially the case with the grass, although with this crop the differences in growth represent somewhat the total difference of the results of three years' cropping with and without fertilizers.

h. The Effect of the Various Fertilizers upon the Comparative Growth of the Different Crops.

In considering this point it should be remembered that the corn has in every case been planted upon a sod containing the stubble and roots of clover and timothy.

This decomposing vegetable material has undoubtedly furnished a much greater quanty of food to the corn crop than has been available from similar sources to any succeeding crop in the rotation. For this reason it is fair to suppose that on the plots not manured the corn has attained a growth much nearer the maximum than was the case with the wheat; consequently the effect of the fertilizers is more evident with the wheat.

The various complete commercial fertilizers used increased the yield of the grain of the wheat forty-five to fifty per cent., and the weight of the straw sixty seven to seventy per cent. With the corn the highest increase of shelled corn was only eleven and one half per cent., and the highest increase of fodder twenty-four per cent. The influence of the fertilizers as seen during the various stages of growth of the corn and wheat was very prominent and unmistakable with the latter crop, but not so evident with the former. It seems very probable that wherever farmers adopt the same rotation that is followed in these experiments, wheat will return a greater profit than corn from a direct application of fertilizers of any kind.

i. Effect of the Various Fertilizers upon the Relation of Grain and Straw.

The figures given in the discussion of the last point show very plainly that the complete commercial fertilizers used caused, in the case of the wheat, a greater proportionate increase of straw than of grain. Below is given the relation of grain and straw in the several cases:

No manure,	One bush. of grain to each	95.3 lbs. of straw.
Dried blood,	" " " " " "	111. " " "
Dissolved bone-black,	" " " " " "	91.9 " " "
Muriate of potash,	" " " " " "	98.5 " " "
Dried blood and dissolved bone-black,	" " " " " "	81.3 " " "
Dried blood and muriate of potash,	" " " " " "	106. " " "
Dissolved bone-black and muriate of potash,	" " " " " "	96.5 " " "
Complete fertilizer with 24 lbs. of nitrogen,	" " " " " "	112. " " "
Complete fertilizer with 48 lbs. of nitrogen,	" " " " " "	111. " " "
Complete fertilizer with 72 lbs. of nitrogen,	" " " " " "	109. " " "
Yard manure,	" " " " " "	111. " " "
Average,	" " " " " "	101.1 " " "

In general, the greater the yield of wheat the more straw has accompanied a bushel of grain.

On the average, about one hundred and sixty (160) pounds of grain and straw together have threshed out a bushel of wheat.

As can be seen, the results obtained with the wheat are those that have been cited in pointing out the comparative effect of the fertilizers, for the results with the other crops have not been sufficiently marked in general to allow any satisfactory comparison.

It is not claimed that the results previously given show to the fraction of a bushel the comparative value of any given method of manuring. There is reason to be confident, however, that, as the figures given are, in nearly every case, the averages of two to three years and of several different plots each year, the results show, within small limits, the effect of the various methods of treatment.

No. 9. July 20, 1884.

The Results of Experiments Showing the Effect of Various Fertilizers on the Growth of Corn, Oats and Wheat.

Bulletin No. 8 is devoted to a statement of some of the results of experiments with fertilizers on the Central Experimental Farm of the College. The results of similar experiments on the Eastern Experimental Farm are presented here as corroborating in a marked manner some of the conclusions that seemed to be warranted by the figures given in that Bulletin. The experiments conducted on the two farms are similar in all their main features, and for information as to the plan, kind of fertilizing material used, &c., reference is made to the last Bulletin.

There is one important difference in the conditions existing in the two cases, which is that the soil of the experimental plots is much more exhausted at the Eastern than at the Central farm. This is plainly shown by the great difference in the natural yield of the unmanured plots in the two places.

The table on page 294 gives the yield of all the plots in the several series for three years :

	Quantity of fertilizer per acre.	Quantity of Valuable Ingredients per Acre.			1881.	1882.				1883.			
					Tier 1	Tier 1.		Tier 2.		Tier 1.		Tier 2.	
					Corn.	Oats.		Corn.		Wheat.		Oats.	
		Nitrogen—pounds.	Phosphoric acid—pounds.	Potash—pounds.	Shelled corn—bu.	Grain—bushels.	Straw—pounds.	Shelled corn—bu.	Fodder—pounds.	Grain—bushels.	Straw—pounds.	Grain—bushels.	Straw—pounds.
1. Nothing,	....	....	....	....	18	22	980	47.5	2,280	3.3	300	23.7	2,000
2. Dried blood,	240	21	....	....	18.3	22	980	48.8	2,680	3	180	25.6	1,780
3. Dissolved bone-black,	300	....	48	....	22.5	26.6	1,220	53.3	2,880	11.7	1,100	27.5	1,120
4. Muriate of potash,	200	....	....	100	15.7	25.5	1,130	42.5	2,800	8.8	210	25	1,240
5. Dried blood and dissolved bone-black,	510	24	48	....	22.8	27.3	1,110	58.2	3,010	15.7	1,460	25.6	1,740
6. Dried blood and muriate of potash, 200 pounds,	440	24	....	100	22	26.6	1,160	47	3,480	4.3	500	27.5	1,600
7. Dissolved bone-black, muriate of potash,	500	....	48	100	19.6	30.6	1,210	57	3,880	16.7	1,000	31.9	1,580
8. Nothing,	....	....	....	....	16.6	20	720	43.5	3,280	2.8	130	23.1	1,260
9. No. 7* and dried blood, 240 pounds,	740	24	48	100	16	29.3	1,160	51.5	3,680	20.7	1,360	32.4	1,740
10. No. 7 and dried blood, 480 pounds,	980	48	48	100	20.6	31.3	1,180	52	3,180	22.3	1,900	25	1,680
11. No 7. and dried blood, 720 pounds,	1,220	72	48	100	18	31.3	1,140	57.2	3,680	23.3	1,480	31.9	1,480
12. No. 7 alone,	500	....	48	100	17.8	29.3	1,010	50	3,680	17.3	800	32.4	1,500
13. No. 7 and nitrate of soda, 160 pounds,	660	24	48	100	17.4	30	1,260	55	3,680	18.7	900	31.3	1,400
14. No. 7 and nitrate of soda, 320 pounds,	820	48	48	100	20.4	29.3	1,182	72	3,680	21	2,010	30.6	820
15. No. 7 and nitrate of soda, 480 pounds,	980	72	48	100	21.1	29.3	1,640	69.5	3,700	22	2,680	31.9	1,380
16. Nothing,	....	....	....	....	18.5	24	1,600	60	3,080	4	1,060	28.1	1,200
17. No. 7 alone,	500	....	48	100	18.6	27.3	1,740	58.2	3,280	16.3	1,820	32.4	1,560
18. No. 7 and sulphate of ammonia, 120 pounds,	620	24	48	100	18.6	27.3	1,660	58.2	3,280	24	1,760	31.9	1,380
19. No. 7 and sulphate of ammonia, 240 pounds,	740	48	48	100	18	28	1,600	53.2	3,480	25.3	2,280	31.3	700
20. No. 7 and sulphate of ammonia, 320 pounds,	820	72	48	100	18.8	26	1,380	58	3,320	25.7	2,460	29	1,280
21. Yard manure,	12,000	....	....	....	18.8	23.3	1,280	45.2	2,680	10	1,200	22.5	960
22. Plaster,	320	....	....	....	17.4	21.3	1,080	47.2	2,520	10.2	420	25	600

No. 7 means the fertilizers of plot 7.

The following facts become evident upon a careful study of that table:

1. *Phosphoric acid* was the ingredient of the fertilizers having the predominating influence.

Alone, it produced a marked increase of crop, while nitrogen and potash, either alone or combined, had no appreciable effects.

2. *A complete fertilizer* proved more efficient than a partial fertilizer. The efficiency of the phosphoric acid was increased by adding to it both nitrogen and potash more than by adding either alone.

3. *The increased yield* due to the use of the fertilizers was many times greater with the wheat than with the corn. This was due, undoubtedly, as was stated in Bulletin No 8, in explanation of the same result on the Central farm, to the fact that the corn was planted in sod. It has uniformly been observed in all the experiments conducted on the College farms that where corn is planted in sod the fertilizers applied, even yard manure, have comparatively little effect in increasing the growth of the crop.

The Uniformity of the Natural Production of a Series of Plots, or the Necessary Error Involved in Field Experimentation.

There is scarcely any one interested in agricultural experiments who will not admit that the ultimate test of many theories must be found in field experimentation. While this is acknowledged, all who have conducted or watched field experiments by the plot method are aware that there is great difficulty in avoiding error, and that this is largely due to unavoidable differences in the yield of small plots, because of natural variations in the fertility of different parts of the same field. Some have gone so far as to assert that this difficulty cannot be overcome to a sufficient extent to admit of the use of the results of field experiments as a basis for reliable conclusions. Others believe that with proper precaution such experiments can be made to determine to quite a close approximation the comparative effect of different fertilizers, different methods of tillage, &c. It is certainly true that if a single plot is compared with some other plot in the series, the natural difference in production is sometimes as great as would be expected if one plot had been manured and the other had not. Even contiguous plots occasionally yield quite different results under the same treatment.

Notwithstanding these facts, it is the opinion of the writer, after conducting considerable many field experiments, and noting the results from a great many others, that it is possible to reduce the error of field experiments to such a small amount that it will not materially vitiate the reliability of the conclusions that may be drawn.

One of the experiments on the Central Experimental Farm during the summer of 1883 was the testing of the uniformity of production of thirty-six plots of land, which are now being used for various experiments. These plots are contained in two series or tiers, running parallel to each other. Each plot is one rod wide and eight rods long' containing one twentieth of an acre, and is separated from the contiguous plots by a strip of land two feet wide.* No fertilizer was applied to any of these plots, and they were treated exactly alike as to manner and time of cultivation and quantity of seed. The table on page 297 gives the yield of the individual plots in each series, the average yield for all the plots of each series, the variation of each plot from the average yield, and the average variation.

The next table shows the maximum and the mean variations from the average yield, for both series of plots:

	FIRST SERIES.						SECOND SERIES.					
	Grain.		Straw.		Total yield.		Grain.		Straw.		Total yield.	
	In bushels.	In per cent. of average yield.	In pounds.	In per cent. of average yield.	In pounds.	In per cent. of average yield.	In bushels.	In per cent. of average yield.	In pounds.	In per cent. of average yield.	In pounds.	In per cent. of average yield.
Maximum *above average yield*, . .	5.6	10.8	484	18.0	669	15.4	9.4	20.0	316	12.7	417	10.5
Maximum *below average yield*, . .	8.8	16.9	726	27.1	571	13.2	8.7	18.6	304	12.2	383	9.6
Greatest variation between any two plots, ...	14.4	27.7	1,210	45.2	1,240	28.7	18.1	38.7	620	24.9	800	20.1
Mean variation from the average,	3.6	6.9	209	7.8	209	4.8	3.2	6.8	122	4.9	182	4.6

This table shows that the mean variation from the average yield is in every case quite small, but it is very plain that the differences between plots, or even the variations of a few single plots from the average yield, are quite large. A closer examination of the first table shows, however, that the cases of large variation from the average yield are quite few. No one of twenty-nine plots out of the thirty-six varies in production of grain more than 8.2 per cent. from the average. With twenty-three plots the variation from the average yield of grain was less than the mean variation.

Nevertheless, it it quite evident that, although these plots were laid out on land of more than average uniformity in quality, the comparison of the yield of single plots for a single year, in order to determine the effect of different fertilizers or different methods of treatment, might be very misleading.

How, then, is it possible to avoid the errors thus arising? The method taken to accomplish this in the experiments with various crops, the results of which have previously been given,† is to treat several plots in each case in the same manner, these plots to be distributed through the series. For instance, in the experiments to which reference has been made, there are in each series five plots receiving no fertilizer,

* For description of the soil of these plots, see Bulletin No. 8.

† See Bulletin No. 8.

Table showing the Comparative Yield of small Plots of Land when treated alike.

	First Series.							Second Series.					
	Yield of oats per acre.			Variation from the average yield of all the plots of the series.				Yield of oats per acre.			Variation from the average yield of all the plots in the series.		
	Grain.	Straw.	Total yield.	Grain.	Straw.	Total yield.		Grain.	Straw.	Total yield.	Grain.	Straw.	Total yield.
	Bush.	*Lbs.*	*Lbs.*	*Bush.*	*Lbs.*	*Lbs.*		*Bush.*	*Lbs.*	*Lbs.*	*Bush.*	*Lbs.*	*Lbs.*
A, ...	43.8	2,900	4,300	—8.1	+224	— 31	A. 1	56.2	2,600	4,400	+9.4	+116	+417
B, ...	43.1	2,920	4,300	—8.8	+244	— 31	B. 1	45.6	2,740	4,200	—1.2	+256	+217
C, ...	52.5	2,720	4,200	+0.6	+ 44	—131	C. 1	47.5	2,380	3,900	+0.7	—104	— 83
D, ...	48.4	2,760	4,300	—3.5	+ 84	— 31	D. 1	44.4	2,480	3,900	—2.4	— 4	— 83
E, ...	50.6	2,880	4,500	—1.3	+204	+169	E. 1	47.5	2,380	3,900	+0.7	—104	— 83
F, ...	49.4	2,620	4,200	—2.5	— 56	—131	F. 1	50.6	2,180	3,800	+3.8	—304	—183
G, ...	48.4	2,460	4,000	—3.5	—216	—331	G. 1	39.0	2,360	3,600	—7.8	—124	—383
H, ...	50.0	2,700	4,300	—1.9	+ 24	— 31	H. 1	47.5	2,580	4,100	—0.7	+ 96	+117
I, ...	52.5	2,420	4,100	+0.6	—256	—231	I. 1	43.7	2,400	3,800	—3.1	— 84	—183
J, ...	50.0	2,900	4,500	—1.9	+224	+169	J. 1	38.1	2,480	3,700	—8.7	— 4	—283
K, ...	57.5	3,160	5,000	+5.6	+484	+669	K. 1	47.5	2,780	4,300	+0.7	+296	+317
L, ...	56.2	2,900	4,700	+4.3	+224	+369	L. 1	47.5	2,380	3,900	+0.7	—104	— 83
M, ...	55.0	2,740	4,500	+3.1	+ 64	+169	M. 1	50.6	2,480	4,100	+3.8	— 4	+117
N, ...	55.0	2,740	4,500	+3.1	+ 64	+169	N. 1	43.7	2,500	3,900	—3.1	+ 16	— 83
O, ...	56.2	2,300	4,100	+4.3	—376	—231	O. 1	44.4	2,380	3,800	—2.4	—104	—183
P, ...	55.6	2,420	4,200	+3.7	—256	—131	P. 1	50.6	2,380	4,000	+3.8	—104	+ 17
Q, ...	56.9	2,680	4,500	+5.0	+ 4	+169	Q. 1	49.0	2,440	4,000	+2.2	— 44	+ 17
R, ...	53.7	1,950	3,760	+1.8	—726	—571	R. 1	50.0	2,800	4,400	+3.2	+316	+417
Average, ...	51.9	2,676	4,331	3.6	209	209	. . .	46.8	2,484	3,983	3.2	122	182

and each of the principal methods of manuring are carried out on four plots. In all cases those plots which are treated alike are distributed as regularly as possible throughout the series to which they belong. Not only this, but there are four similar series, on each of which the experiments will be kept up for a number of years. It is believed that in this way the necessary error of the final results will be reduced to a small percentage. The following averages of the yields given in the last table but one, show how very probable it is that the average of four plots, regularly distributed through the series of eighteen, will vary but little from the average of all:

	FIRST SERIES. GRAIN.	SECOND SERIES. GRAIN.
Average yield of all plots,	51 9 bushels.	45 8 bushels.
Average yield of plots A, E, I and M,	50 5 "	49 5 "
Average yield of plots B, F, J and N,	49 4 "	44 5 "
Average yield of plots C, G, K and O,	53.5 "	44.6 "
Average yield of plots D, H, L and P,	52 6 "	47.5 "

The next table shows that even the average yield of three plots, quite widely separated in a series of eighteen, approximates very closely to the mean yield of all:

	FIRST SERIES. GRAIN.	SECOND SERIES. GRAIN.
Average yield of all plots,	51.9 bushels.	46 8 bushels.
Average yield of plots A, G and M,	49.1 "	48.6 "
Average yield of plots B, H and N,	49.4 "	45 6 "
Average yield of plots C, I and O,	53 7 "	45.2 "
Average yield of plots D, J and P,	51 3 "	44 4 "
Average yield of plots E, K and Q,	55.0 "	48.0 "
Average yield of plots F, L and R,	53.0 "	49.0 "

From all that precedes, it seems very probable that when several plots, distributed quite regularly throughout a series, are treated in the same manner, any considerable variation of their average production from the average production of several other plots similarly distributed but differently treated, can be credited largely to the difference of treatment. Of course, slight effects of fertilizers or methods of cultivation might fail to appear even by this method. If, however, more than one series of plots are used and the experiments are kept up for several years, the chances are almost entirely in favor of small errors.

The results given in this bulletin are published in order to show that accurate final conclusions about any method involved in farm practice can be reached only after the expenditure of much care, time and labor; and the desire is also to discourage the practice of drawing conclusions from the comparative yield of single plots for a single year. Farmers often do this. It is not intended, however, to discourage field experiments when properly conducted, or to to diminish confidence in the results that are obtained with the use of proper precautions.

How to Conduct Experiments.

The following are some of the rules that should be observed in experimenting with plots:

1. The land selected for the plots should be as level and as uniform in quality as possible.
2. The plots should be long as compared with their width.
3. When the surface of the land is all inclined one way, the length of the plots should extend up and down the inclination.
4. The treatment of the plots should vary in time and manner only in those plots which it is desired to test.
5. All the plots should be treated alike for at least one season in order to test the extent of their natural variations of fertility.
6. Each of the methods of manuring or of tillage which are to be tested, should be carried out on several plots well distributed in the series.
7. The experiments should be kept up for several years.
8. All possible precaution should be taken against errors of observation, as in measurements, weighings, &c.
9. The work should be honestly done, viz: No results should be excluded unless some error is known to have been introduced which render them worthless.

No. 10. January, 1885.

Feeding Experiments.

During the winter of 1883–4, the feeding experiments of the two previous years have been continued. The results reached previous to 1883–4 can be found in the Agriculture of Pennsylvania for 1883 and in Bulletin No. 6 issued by the College.

The following extract from Bulletin No. 6 states the

GENERAL PURPOSE AND PLAN OF THE EXPERIMENTS:

"In the practice of feeding farm animals questions have arisen for which no certain answers can be found. They are questions which farmers are asking everywhere and which must be answered by experiment. Investigation in this direction is attended with peculiar difficulties, owing to the number and kind of factors involved in the processes of nutrition and growth. The kind, quality and combination of the food given, the age, development and individual peculiarities of the animals experimented upon, all have an important influence upon the results of any method of feeding.

"The Germans have done a large amount of elaborate scientific and practical work in order to ascertain the laws and facts that pertain to animal nutrition, and they have reached certain conclusions which are very valuable, but some of which still need to stand the test of practice before we shall be prepared to accept them without question and in all their details.

"The experiments conducted at the College during the past three years have been, in part, an attempt to test the economy of a ration compounded according to a German feeding standard as compared with a ration differing essentially from such a standard. The questions asked have not been answered as fully as was desired, but the results are reported as in the line of progress. The hints received in watching past experiments will serve, it is hoped, to make future ones more fruitful of results.

"Farmers do not have uniform methods or standards of cattle-feeding. Practice in this direction varies in the kind, combination and amounts of material fed. Cornmeal, however, is, in general, the principal ingredient of the rations fed to fattening steers. Some feed the cornmeal nearly pure; others mix with it considerable oatmeal, or wheat bran to a limited extent, cottonseed and linseed meal. Opinions differ as to what food, or mixture of foods, is wisest. So far we have very little but opinion, if we except the experimental work of the Germans.

"The German standards condemn a ration composed of cornmeal and cornstalks as not economical food for fattening cattle, on the ground that in such a ration there does not exist a proper relation between the digestible nutrients, viz: the albuminoids and carbohydrates.* The German feeding standard would call for an addition to this ration of some highly nitrogenous substance, like oil-cake or cottonseed meal.

"It is certain that one practical inquiry is of great importance, viz: Can farmers profitably purchase the highly nitrogenous cattle foods that are for sale in our markets in order to combine them with the corn and coarse fodder produced on the farm? Theories, based on scientific investigation, would answer the inquiry in the affirmative, so far as it is a question of a proper combination of food ingredients, and so of an economical use of the material consumed. Of course, the variable prices of these different food-stuffs is something of which science can take no account, and the farmer must decide, from year to year, what he can afford to purchase. The great underlying principles in all practice in cattle feeding are those that determine the proper amounts and relation of nutriments in the ration, and these principles, once understood, it only remains for the farmer to purchase or to produce these nutrients in the cheapest possible form.

"The experiments here reported have been devoted largely to test-

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* All cattle foods contain four class of substances, viz: Protein, (albuminoids), carbohydrates, fats, and ash. The protein includes the nitrogenous compounds, like lean meat, gluten, &c.; the carbohydrates include sugar and starch, and bodies resembling these compounds. The fats or oils are very much like animal fats, and the ash consists of the mineral or non-combustible substances. Some foods are highly nitrogenous, like cottonseed and oil-cake. Others contain a small relative percentage of nitrogen and a large relative percentage of carbohydrates, like turnips, potatoes, straw, cornstalks, &c.

ing the economy of a ration composed of cornmeal and cornstalks as compared with one composed of cornmeal, cottonseed meal, and cornstalks. Cottonseed is used by English farmers to a great extent. Their supply comes from America, and it is a question worthy of attention whether American farmers cannot use more of this material at home with profit.

"Feeding trials have been conducted at the Central Experimental farm, the animals fed being fattening steers. The trials were conducted with the utmost care, observing the methods and precautions indicated below.

"For each trial four steers were selected, two being fed after one method and the other two after the method with which it was desired to make comparison. The steers were selected so that in each lot of four one pair should be as near like the other in size, weight, form, general appearance, and habit as possible.

"The rations to be tested were weighed to the animals each day; any material they did not eat was also being weighed.

"The weight of the steers was in no case recorded until the animals had been eating their ration for one week. The weighings were made weekly at the same hour in the day, and always before drinking. In all things, except in what they ate, the steers were treated as nearly alike as possible."

EXPERIMENTS IN 1883–4.

For these experiments twelve steers were in use, four being two years old at about the time the experiments closed, four three years old, and four about four years old. The animals were numbered as follows: Steers Nos. 1, 2, 3 and 4 were two years old (first lot); steers Nos. 5, 6, 7 and 8 were three years old, (second lot); and steers Nos. 9, 10, 11 and 12 were four years old (third lot).

For a time, the steers were fed preliminary rations in order to determine the relative aptitude for gain of the two pairs of steers in each lot when fed upon the same ration. The preliminary rations, which were fed from November 24 to December 29 were as follows, the quantities given being fed each animal daily:

First lot: Steers Nos. 1, 2, 3 and 4, ...	8 pounds	chopped cornfodder.
	6 "	cornmeal.
Second lot: Steers Nos. 5, 6, 7 and 8, ...	11 "	chopped cornfodder.
	11 "	cornmeal.
Third lot: Steers Nos. 9, 10 11 and 12, ...	12 "	chopped cornfodder.
	12 "	cornmeal.

From December 22 to December 29 two pounds more of meal were fed daily to each steer from No. 1 to No. 8, and three pounds more to steers No. 9 to 12. The weights of each pair of steers in each lot, before and after feeding the preliminary rations are given below:

	Steers 1 & 2.	Steers 3 & 4.	Steers 5 & 6.	Steers 7 & 8.	Steers 9 & 10.	Steers 11 & 12.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Weight—December 1,	1,480	1,435	2,345	2,345	2,590	2,570
Weight—December 29,	1,535	1,505	2,475	2,510	2,735	2,650
Gain,	75	70	130	165	145	80

On December 29, the steers began to eat the experimental rations, one pair in each lot receiving a mixture of cornfodder, cornmeal and cottonseed meal, and the other pair receiving a mixture of cornfodder and corn meal. The daily ration for each steer from December 29 to January 26 was as follows:

First lot, (2 yrs. old,)	Steers 1 and 2,	5 pounds cornfodder. 7 " cornmeal. 3 " cottonseed meal.
	Steers 3 and 4,	5 " cornfodder. 12 " cornmeal.
Second lot, (3 yrs. old,)	Steers 5 and 6,	7 " cornfodder. $10\frac{1}{2}$ " cornmeal. $4\frac{1}{2}$ " cottonseed meal.
	Steers 7 and 8,	7 " cornfodder. 17 " cornmeal.
Third lot, (4 yrs. old,)	Steers 11 and 12,	7 " cornfodder. $11\frac{1}{5}$ " cornmeal. $4\frac{4}{5}$ " cottonseed meal.
	Steers 9 and 10,	7 " cornfodder. 18 " cornmeal.

From January 26 to March 22, the quantities of cornmeal and cottonseed meal fed to each steer were not changed, but timothy hay was substituted for the cornfodder.

Steers Nos. 1 to 4 each received six pounds hay daily.

Steers Nos. 5 to 8 each received nine pounds hay daily.

Steers Nos. 9 to 12 each received ten pounds hay daily.

The table which follows gives the weight of several pairs of steers before and after the periods during which the different rations were fed, the total quantity of food actually eaten, the total cost, the cost per pound of gain, and the amount of gain per pound of food consumed for the steers of different ages:

	Steers 1 & 2.	Steers 3 & 4.	Steers 5 & 6.	Steers 7 & 8.	Steers 9 & 10.	Steers 11 & 12.
Weight January 5,	1,510	1,530	2,490	2,490	2,735	2,660
Weight January 26,	1,575	1,600	2,535	2,590	2,800	2,680
Gain,	65	70	45	100	65	20
Weight March 22,	1,835	1,815	2,780	2,775	3,080	2,835
Gain from January 26,	260	215	245	185	280	155
Total gain,	325	285	290	285	325	175
Total cornfodder eaten,	185	173	234	244	254	266
Total hay eaten,	672	672	1,008	1,008	1,120	1,120
Total cornmeal eaten,	1,078	1,848	1,617	2,618	2,772	1,724
Total cottonseed meal eaten,	462	. . . . .	693	. .	. . . . .	740
Total weight of material eaten,	2,397	2,693	3,552	3,870	4,146	3,850
Total cost of materials,*	$25.41	$28.92	$37.66	$41.25	$43.94	$40.82
Cost per pound of gain,	0.078	0.101	0.129	0.145	0.138	0.233
Pounds of food used for each pound of gain,	7.33	9.45	12.25	13.6	12.76	22.00

* The cornfodder is valued at $5 per ton, the timothy at $10 per ton, the cornmeal at 68 cents per fifty pounds, and the cottonsed meal at $30 per ton.

The average percentages of total and digestible ingredients in the cattle foods used in the experiments are as follows:

	Water.	Ash.	Protein. Nx6.25.	Crude fiber.	Other carbohydrates.	Fats.	DIGESTIBLES.		
							Protein.	Carbohydyates.	Fats.
Cornfodder,	15.	4.2	3.0	40.0	36.7	1.0	1.1	37.0	.30
Timothy hay,	13.5	3.87	6.16	28.94	45.85	1.68	3.5	45 9	.80
Cornmeal,	11.13	1.48	10.49	1.86	70.20	4.84	8.30	65.	4.10
Cottonseed meal,	7.70	7.04	42.79	6.36	19.76	16.85	36.4	18 8	14.4

The average quantities of digestible nutrients consumed daily by each animal would probably approximate quite closely to the following figures:

	Protein. Nx6 25.	Carbohydrates.	Fats.	Nutritive ratio.	DAILY NUTRIENTS PER 1,000 LBS. LIVE WEIGHT.			Daily gain for each animal.
					Protein. Nx6.25.	Carbohydrates.	Fats.	
Steers 1 and 2,	1.84	7.60	.76	1:5.	2.20	9.1	.90	2.1[illegible]
Steers 3 and 4,	1.16	10.2	.53	1:9.9	1.38	12.9	.40	1.85
Steers 5 and 6,	2.76	11.2	1.14	1:5.1	2.10	8.5	.90	1.88
Steers 7 and 8,	1.66	14.6	.79	1:10.	1.26	11.0	.60	1.85
Steers 9 and 10,	1.90	15.6	.80	1:9.3	1.81	10.8	.55	2.10
Steers 11 and 12,	2.95	12.6	1.21	1:5.3	2.15	9.2	.90	1.14
Average German fattening ration,	. . . . . .	. . . . . .	. . . .	1:5.7	2.7	14.9	.60	

RESULTS OF THE EXPERIMENTS FOR 1883–4.

Certain facts appear from these experiments, which are worthy of mention:

1. The effect of age in the cost of production is clearly seen in the fact that the youngest steers, (Nos. 1 to 4, which were not over two

years old when sold.) made a pound of gain from about three fifths the material, and at two thirds the cost required by the steers one and two years older.

2. The effect of substituting cottonseed meal for a portion of the cornmeal was to diminish the amount of material consumed for each pound of gain, and, at the prices ruling for the season of 1883–4, diminish the cost of production.

[The above statement is not true in the case of steers Nos. 11 and 12, but, as can be seen by the results of the preliminary feeding, these two animals were not thrifty, and on any less ration would not make an average growth.]

3. A wide departure from the standard German ration, both in actual quantities of nutrients consumed and in the nutritive ratio, diminished the amount of gain somewhat with the youngest steers, but none with the oldest. At the same time, it seems to be true that in the case of the more highly nitrogenous ration the use of material was more economical, a less quantity of total nutrients being required.

4. The above statements are made with a full knowledge that the possible errors in such work are quite large. But it seems extremely probable that where so many animals are used in an experiment, the error would not always be one way. In general results, the experiments of 1883–4 do not differ from those of the two previous years. As to the results of a departure from the German feeding standard, it may be said that if the effects of such a departure are not greater at the end of eleven weeks' feeding than the probable errors of weighing, they are of less importance than has been claimed, even if the errors were always one way.

5. The manurial residue of the food containing cottonseed was, without the slightest doubt, of greater value than the residue from the other rations, which is a point in favor of the cottonseed, independent of the food value.

No. 11. July 20, 1885.

EXPERIMENTS WITH FERTILIZERS, 1884.

a. Field Experiments at the Central Experimental Farm.

The plan and method of conducting these experiments have previously been described several times, and for information in regard to these points, also as to previous results, reference is made to the report of the Pennsylvania State College for 1883, as printed in the Agriculture of Pennsylvania for that year; also to Bulletins 1, 2 and 8.* The report made this year is but a continuation of results reached under the plan and with the plots previously described. The following table does not give the yield of all the plots in the four series, but only the average yield of those plots that are treated essentially alike.

* It should be borne in mind that fertilizers are not applied to the oats and grass in the rotation used in these experiments, but only to the corn and wheat.

Fertilizer per Acre.	Average Yield per Acre of Plots Treated Alike.							Increase of Yield per Acre over Polts not Manured.						
	Corn.		Oats.		Wheat.			Corn.		Oats.		Wheat.		
	Shelled corn.	Fodder.	Grain.	Straw.	Grain.	Straw.	Hay.	Shelled corn.	Fodder.	Grain.	Straw.	Grain.	Straw.	Hay.
	Bu.	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*	*Lbs.*
Nothing,	56.0	2,088	39.6	1,329	23.2	1,698	3,536							
Dried blood, 240 lbs.	60.5	2,040	38.9	1,200	20.0	1,600	2,880	4.5	— 48	— .7	—129	—3.2	— 98	—656
Dissolved bone-black, 300 lbs.	60.5	2,088	35.2	1,144	20.8	1,352	3,160	4.6	. . . .	—4.4	—185	—2.4	—346	—376
Muriate of potash, 200 lbs.	61.1	2,120	38.4	1,128	23.2	1,608	3,200	5.0	32	—1.2	—101	. . . .	— 90	—336
Dried blood, 240 lbs. Dissolved bone-black, 300 lbs.	62.5	2,280	40.8	1,296	25.1	1,856	3,280	6.5	12	1.2	— 83	1.9	158	—256
Dried blood, 240 lbs. Muriate of potash, 200 lbs.	48.0	1,880	38.7	1,200	27.1	1,936	3,280	— 7.0	—203	—0.9	—129	3.9	238	—256
Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	65.0	2,670	43.7	1,573	28.1	. . . .	3,970	9.0	582	4.2	244	4.9	. . . .	434
Nitrogenous fertilizer, containing 24 lbs. nitrogen,* Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	63.6	2,720	44.2	1,632	31.2	2,015	3,912	7.6	632	4.6	303	8.0	317	376
Nitrogenous fertilizer, containing 48 lbs. nitrogen,* Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	64.1	2,560	48.2	1,612	34.9	2,666	3,840	8.1	472	8.6	283	12.7	968	304
Nitrogenous fertilizer, containing 72 lbs. nitrogen,* Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	65.9	2,760	47.6	1,713	36.2	. . . .	3,690	9.9	672	8.0	384	13.0	. . . .	166
Yard manure,	66.9	2,490	38.6	1,331	30.4	2,466	3,906	10.9	402	—1.0	2	7.2	768	370
Lime,	51.0	1,840	41.1	1,368	22.8	1,592	3,400	— 5.0	—248	1.5	89	—0.4	—106	—136
Ground limestone,	68.5	2,320	44.5	1,304	25.5	1,672	2,720							
Plaster,	51.0	1,900	38.4	1,270	23.8	1,672	3,120							

* Nitrogen furnished either by dried blood, sulphate of ammonia, or nitrate of soda.

The above tables show some results that are in accord with those previously reached :

(1.) With the system of rotation adopted, even after the removal of the fourth crop, the application of fertilizers to corn that is planted upon sod causes very little increase of crop.

(2.) The maximum effect of the fertilizers is seen in the wheat.

(3.) On no previous crop of wheat, since the experiments began, have the nitrogenous fertilizers seemed to be so necessary as during the past season.

(4.) The yard manure, so far, shows no superiority with any crop over the complete commercial fertilizers.

(5.) The increase of crops from the use of the incomplete fertilizers is less than for previous years, and the predominating effect of any single ingredient is also less marked.

b. Field Experiments at the Eastern Experiment Farm.

On this farm, experiments conducted in a manner similar to that adopted on the Central Experiment farm gave the results shown in the next table:

	AVERAGE YIELD PER ACRE OF PLOTS TREATED ALIKE.					
	CORN.		OATS.		WHEAT.	
	Shelled corn.	Fodder.	Grain.	Straw.	Grain.	Straw.
	Bu.	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*
No fertilizer.*	36.7	2,113	26.	1,073	15.6	1,233
Dried blood, 240 lbs.,	47.2	2,320	26.	1,170	17.0	1,340
Dissolved bone-black, 300 lbs.,	59.5	2,600	26.6	1,120	21.3	1,520
Muriate of potash, 200 lbs.,	38.8	2,400	28.6	1,300	14.3	1,140
Dried blood, 240 lbs., and dissolved bone-black, 300 lbs.,	68.0	2,980	29.3	1,260	23.1	1,600
Dried blood, 240 lbs., and muriate of potash, 200 lbs.,	43.0	3,100	28.	1,120	15.00	1,100
Dissolved bone-black, 300 lbs., and muriate of potash, 200 lbs.,	59.5	2,466	33.	1,276	21.2	1,826
Nitrogenous fertilizer, containing 24 lbs. of nitrogen,† Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	*62.0	2,573	32.4	1,220	24.8	2,380
Nitrogenous fertilizer, containing 48 lbs. nitrogen,† Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	*63.5	3,066	34.1	1,163	27.	2,673
Nitrogenous fertilizer, containing 72 lbs. nitrogen,† Dissolved bone-black, 300 lbs. Muriate of potash, 200 lbs.	*63.6	2,060	34.6	1,110	30.4	3,097
Yard manure, 15,000 lbs.,	46.5	2,200	30.	860	20.1	1,990
Plaster, 320 lbs.,	35.5	1,800	23.	720	11.6	900

* Average of three plots.

† Furnished either by dried blood, nitrate of soda, or sulphate of ammonia.

In most respects, the results of the field experiments on the Eastern Experimental farm for 1884 agree with the results of former years. The effect of the fertilizers is more marked on this farm than on the Central Experimental farm, owing to the fact that the soil of the latter is in the more fertile condition.

The following points, as shown by a study of the last two tables, are worthy of notice:

1. The phosphoric acid, when not accompanied by either of the other valuable ingredients, had a marked effect in increasing the yield of both corn and wheat. Neither of the other ingredients (nitrogen and potash), when used alone, produced an increase of yield.

2. The complete fertilizers were more efficient than the partial, but not in proportion to the increased cost, especially where large quantities of nitrogen were used.

3. For the first time during the four years of experimenting on two of the College farms, have the fertilizers produced a large increase in the yield of corn. This can be explained, however. In every other instance the corn has been planted on sod; but in this case the corn was grown on plots from which a crop of wheat had been removed the previous summer, and on which no grass seed had been sown. There was, therefore, no grass-roots and stubble for the corn to feed upon, as in every other case in these experiments; and so the need for an application of a fertilizer was greater than under the ordinary conditions of the regular rotation where corn follows grass.

4. The effects of the fertilizers the second year after their application, as seen in the yields of oats given in the table, are appreciable, but not large.

c. Yield of Wheat with Different Quantities of Commercial Fertilizer.

The fertilizer used in this experiment consisted of a mixture of dissolved bone-black, muriate of potash and sulphate of ammonia, in the following proportions:

Dissolved bone-black, ...	72 pounds.
Muriate of potash, ...	8 "
Sulphate of ammonia, ...	20 "

The plots used in the experiments were Nos. A.1 to L.1 of the series occupied in 1883 in testing the "uniformity of the natural production of a series of plots." (See Bulletin No. 9.)

The plots were treated exactly alike, except in the quantity of fertilizer applied.

The results are given in the following two tables. In the first can be seen the yield of each plot; in the second is given the average corrected yiled of those plots treated alike:

NUMBER OF PLOT.	Pounds of fertilizer per plot.	Pounds of fertilizer per acre.	RATE OF YIELD PER ACRE.	
			Grain.	Straw.
			Bushels.	*Pounds.*
A.1,	6	120	20.	2,400
B.1,	12	240	24.3	2,440
C.1,	18	360	26.3	2,900
D.1,	24	480	27.3	2,960
E.1,	30	600	29.	2,860
F.1,	Nothing.	....	21.6	2,200
G.1,	6	120	23.6	2,200
H.1,	12	240	24.0	2,060
I.1,	18	360	27.6	2,740
J.1,	24	480	25.6	2,360
K.1,	30	600	30.0	2,700
L.1,	Nothing.	....	23.6	1,980

PLOTS.	Average yield of plots in 1883, with no fertilizer, and uniform treatment.		Average yield of plots treated alike, in 1884.		Correct average yield of plots treated alike, in 1874.		Quantity of fertilizer per acre, in 1884.
	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	
	Bush.	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Lbs.*	*Lbs.*
A.1 and G.1,	47.6	2,480	21.7	2,300	21.7	2,300	120
B.1 and H.1,	45.6	2,660	24.2	2,250	23.2	2,170	240
C.1 and I.1,	45.6	2,390	27.1	2,830	28.1	2,930	360
D.1 and J.1,	41.3	2,480	26.5	2,660	27.6	2,740	480
E.1 and K.1,	47.5	2,580	29.5	2,750	28.8	2,710	600
F.1 and L.1,	49.1	2,250	22.6	2,090	23.5	2,170	

d. **Yield of Wheat Sown at Different Depths with Different Quantities of Seed.**

In this experiment on part of the plots, the seed was sown at the depth ordinarily reached by drill-teeth in well-pulverized soil. The other plots were sown with a device attached to the teeth of the drill, which prevented the seed from reaching a depth of over two inches. Different quantities of seed were also shown by both methods. The treatment of the plots did not vary in any case, except in the depth of drilling and in the quantity of seed. The plots used were plots M. to R. of the series used in 1883, to test the uniformity of production of a series of plots when treated alike. Below are given the results:

NO. OF PLOT.	METHOD OF SOWING.	Quantity of seed.	YIELD PER ACRE.	
			Grain.	Straw.
		Bushels.	*Bushels.*	*Pounds.*
M,	Deep,	1	29	2,760
N,	Shallow,	1	28	2,620
O,	Deep,	1½	28.3	2,700
P,	Shallow,	1½	26.0	2,640
Q,	Deep,	2	26.6	2,500
R,	Shallow,	2	27.6	2,740

As can be seen, there is very little difference in the yield of the plots sown shallow and those sown deep. A more striking fact is that one bushel of seed produced as large a yield as the greater quantities, there being but very little difference in the yield from one, one and a half, and two bushels.

While there appears to be no difference in the yield from wheat sown shallow and that sown deep, there was a marked difference in the development of the plants in the two cases during the early stages of growth.

The wheat was sown on all the plots on September 11. On September 26, the wheat plants in plot N, P and R were just appearing; but none were to be seen on the other plots. On September 29, the plants on plots N, P and R were all up, and had made a very uniform growth. On the other plots, part of the plants had appeared and part had not.

About three weeks later, plants were taken from plots sown shallow and from plots sown deep, the earth being carefully removed from the roots, so as not to injure them. A striking difference was seen between the plants from the two methods of sowing. Those from the shallow sown seed were more stocky, with a much more abundant root develment, and were certainly in better condition to endure the vicissitudes of a severe winter than the smaller and less vigorous plants coming from the deeply-planted seed. It seems quite evident that the ultimate benefit to be derived from shallow sowing depends somewhat upon the nature of the winter season through which the plant must pass. While, as in the present case, there are seasons so favorable that all the plants live, there are others so trying to the life of young wheat-plants that only those of the most vigorous developments are able to survive. It is also true that the condition of the soil as to moisture should control, to an extent, the depth to which the seed should be covered, and that while in a moist season wheat should not be covered more than one or two inches, in a very dry season a greater depth may not only be beneficial, but absolutely necessary to germination. Such, indeed, was the case in many places the past season. (1884.)

No. 12. January 1, 1886.

FEEDING EXPERIMENTS.

During the winter of 1884–5 the feeding experiments begun in 1881 have been continued. The results of the previous experiments may be found in the Agriculture of Pennsylvania for 1883, and in Bulletins Nos. 6 and 10, issued by the College.

NOTE.—The experiment recorded in this number was conducted by Professor Jordan; but the preparation of the Bulletin is the work of Mr. William Frear, Ph. D., Assistant Professor of Agricultural Chemistry in the State College.

The following abstract from Bulletin No. 6 states the

General Plan and Purpose of the Experiments.

By reason of the many influences modifying the nutrient effects of food, investigations upon this subject are very complicated, and comparatively recent. In solving the problems of feeding, the German investigators have been most active, and, after many elaborate experiments, have established certain standards and laid down certain rules which have, to some degree, proven successful in practice.

American methods and standards of feeding are very far from uniform both as to kinds, combinations and quantities of food. Cornmeal is, however, the principal ingredient of the rations fed to fattening steers. This is sometimes fed nearly pure, sometimes in combination with oatmeal, wheat bran, cottonseed or linseed meal.

German standards condemn a ration of cornmeal and cornstalks, because the digestible albuminoids and carbo-hydrates* are present in such ratio to each other that they are not wholly utilized. According to the above standards, there should be added some highly nitrogenous material, as oil-cake or cottonseed meal.

While theories indicate that such an addition would be the most economical in material used, practical experiment is necessary to determine positively the relative value of the various rations made up from the feeding-stuffs referred to; and there must be considered, as factors in profit, not only the relative values of the rations for fattening purposes, but also their relative cost.

The experiments conducted during the past years have been, in part, an attempt to test the economy of a ration compounded according to a German feeding standard, as compared with a ration differing essentially from such a standard. The questions asked have not been answered as fully as was desired, but the results are reported as in the line of progress.

The experiments here reported were conducted at the Central Experimental farm, and have been devoted largely to testing the economy of a ration composed of cornmeal and cornstalks, as compared with one composed of cornmeal, cottonseed meal and cornstalks. Cottonseed is used by English farmers to a great extent. Their supply comes from America, and it is a question worthy of attention, whether American farmers cannot use more of this material at home with profit.

For each trial four steers were selected, two being fed after one method, and the other two after the method with which it was desired to make comparison. The steers were selected so that in each lot of

* All cattle foods contain four classes of substances, viz: Protein (albuminoids), carbo-hydrates, fats and ash. The protein includes the nitrogenous compounds, like lean meat, gluten, &c.; the carbo-hydrates include sugar and starch, and bodies resembling these compounds. The fats or oils are very much like animal fats, and the ash is the mineral or non-combustible substances. Some foods are highly nitrogenous, like cottonseed and oil-cake. Others contain a small relative percentage of nitrogen, and a large relative percentage of carbo-hydrates, like turnips, potatoes, straw, cornstalks, &c.

four one pair should be as nearly like the other in size, weight, form, general appearance and habit as possible.

The rations to be tested were weighed to the animals each day, any material they did not eat also being weighed.

The weight of the steers was in no case recorded until the animals had been eating their rations for one week. The weighings were made weekly, at the same hour of the day, and always before drinking. In all things, except in what they ate, the steers were treated as nearly alike as possible.

Experiments in 1884-5.

For these experiments there were selected four two-year-old steers (first lot), and four three-year olds (second lot.) The steers of the first lot were numbered 1, 2, 3 and 4, respectively; of the second lot 5, 6, 7 and 8.

A period of feeding, during which all the steers received the same kind of food (chopped cornfodder and cornmeal), and those of the same lot in exactly the same quantity, preceded the experiment proper. This served to place all under like conditions at the time of the beginning of the experiment, and to show the relative fattening capacity of the different pairs. This period extended from December 13 to January 24.

The weight of the several pairs of steers, before and after feeding the preliminary rations, are given below:

	Steers 1 & 2.	Steers 3 & 4.	Steers 5 & 6.	Steers 7 & 8.
Weight December 27,	1,415	1,410	2,100	2,165
Weight January 24,	1,490	1,510	2,210	2,255
Gain,	75	100	110	90

On January 24 the experimental rations were fed. The first pair of each lot received a mixture of cornfodder, cornmeal and cottonseed meal; the other, cornfodder and cornmeal only. The daily ration for each steer, from January 24 to February 28, was as follows:

First lot, (2 yrs. old.)	Steers 1 and 2,	6 pounds cornfodder. 5 pounds cornmeal. 2½ pounds cottonseed meal.
	Steers 3 and 4,	6 pounds cornfodder. 10 pounds cornmeal.
Second lot, (3 yrs. old.)	Steers 5 and 6,	8 pounds cornfodder. 7 pounds cornmeal. 3½ pounds cottonseed meal.
	Steers 7 and 8,	8 pounds cornfodder. 14 pounds cornmeal.

From February 28 to April 4, timothy hay was substituted for cornfodder, the ration being in other respects left without change.

Steers of the first lot (1–4) received 9 pounds of hay daily.

Steers of the second lot (5–8) received 11 pounds of hay daily.

In the following tables are given the weights of the several pairs of steers at the beginning and at the end of the periods during which different rations were fed, the amount of food actually consumed during each period by each pair, a statement of the total cost, the cost per pound of gain, and the amount of food consumed for each pound of gain :

First Period, (five weeks.)

	1 & 2.	3 & 4.	5 & 6.	7 & 8.
Weight, January 31,	1,510	1,550	2,215	2,305
Weight, February 28,	1,600	1,640	2,320	2,415
Gain,	90	90	105	110
Cornfodder eaten,	217	68	218	170
Cornmeal eaten,	280	560	392	784
Cottonseed meal eaten,	140	. . . . .	196	
Weight of food eaten,	637	628	806	954
Cost of materials,*	$5 16	$5 21	$7 01	$7 23
Cost per pound of gain,	0 057	0 058	0 067	0 066
Pounds of food used for each pound of gain,	7.78	6.98	7.68	8.67

* The valuation of the feeding-stuffs used is as follows: Cornfodder, $5 per ton ; hay (loose,) $10 per ton ; cornmeal, 45 cents per pound ; cottonseed meal, $30 per ton.

Second Period, (five weeks.)

	1 & 2.	3 & 4.	5 & 6.	7 & 8.
Weight, March 7,	1,615	1,670	2,350	2,470
Weight, April 4,	1,705	1,745	2,490	2,560
Gain,	90	75	140	90
Hay eaten,	504	478	616	6 6
Cornmeal eaten,	280	560	392	784
Cottonseed meal eaten,	140	. . . . .	196	
Weight of food eaten,	924	1,038	1,204	1,400
Cost of materials,	$7 19	$7 43	$9 55	$10 14
Cost per pound of gain,	0 080	0 099	0 068	0 118
Pounds of food consumed for each pound of gain,	10.27	13.73	8.60	15 56

Summary of Both Periods.

	1 & 2.	3 & 4.	5 & 6.	7 & 8.
Weight, January 31,	1,510	1,550	2,215	2,305
Weight, April 4,	1,705	1,745	2,490	2,560
Total gain,	195	195	275	255
Total cornfodder eaten,	217	68	213	170
Total hay eaten,	630	604	770	770
Total cornmeal eaten,	630	1,260	882	1,764
Total cottonseed meal eaten,	315	. . . . .	441	
Total weight of food eaten,	1,792	1,932	2,311	2,704
Total cost of materials,	$14 09	$14 53	$ 8 95	$20 15
Cost per pound of gain,	0 072	0 075	0 069	0 079
Pounds of food consumed for each pound of gain,	9.19	9.91	8.40	10.60

Results of the Experiments of 1884-5.

From the data gathered during this season's experiments, the following observations may be noted :

1. That this year's results, unlike those of earlier seasons, do not show that the younger animals have any advantage over the older in point of cost for the same gain. Let it be observed, however, that for both lots the cost per pound of gain is nearly the same as in the case of the two-year-olds of last year.

2. That, with this season's prices, the cost is practically the same for each ration.

3. The cottonseed rations will, as has been shown in earlier experiments, yield greater gain, pound for pound, than the other rations. When the relative fattening capacity is considered, it will be seen that Period I offers no marked exception to this rule. It will be at once remarked that the difference between the two rations is much increased during Period II, notwithstanding the fact that, as the hay contains a greater proportion of digestible nitrogenous matter than the cornfodder, the nutritive ratios of the two rations approach more closely than during Period I.

In the cases of the pairs of the second lot for Period II, it is to be observed that from February 28 to March 7 (the week immediately following the change of rations), while 5 and 6 gained thirty pounds, 7 and 8 gained fifty-five pounds, a difference which, in experiments for so short a period and open to so many sources of error, should doubtless be taken into consideration; and this would tend to diminish the great differences in weight shown in the latter weighing.

4. It will be noted that during the latter period there is a marked increase in the quantity of food required to produce one pound of gain, and, of course, a corresponding increase in cost.

5. As noted before in this connection, the cottonseed ration produces the more valuable manure.

6. As the experiments of other seasons have shown, indications are slightly in favor of the cottonseed ration; but this season's experiment, more than all earlier ones, shows that, under some conditions, a wide departure from the German standard may be made with but slight effects.

7. Nevertheless, the many sources of error in drawing deductions from mere live-weight results must cause conclusions to be taken with much reserve, and tentatively to those based upon more searching methods of investigation.

No. 13. February 1, 1886.

THE PENNSYLVANIA STATE COLLEGE.

COURSE IN MECHANIC ARTS.

(Combining Shop-Work and Study.)

The course was reorganized in September, 1884, and met with so much success during the following year that the trustees have found it advisable to construct and equip a new two-story building, 50x34 feet, which is now ready for occupancy. The building is divided into four main compartments—a carpenter shop and a wood-turning room on the second floor, and a forge room and a machine shop on the first floor.

In the forge room there is a small compartment for keeping iron and in the machine shop is a tool room. There is also a long sink with basins and with hot and cold water connections for washing purposes.

The equipment is the best modern machinery necessary to give the instruction as indicated in the accompanying schedule.

The course is designed to afford such students as have had the ordinary common-school education an opportunity to continue the elementary, scientific and literary studies, together with mechanical and free-hand drawing while receiving theoretical and practical instruction in the various mechanical arts.

The instruction in shop-work is given by means of exercises so planned as to cover, in a systematic manner, the operations in use in the various trades.

The object of the course being to give instructions in the use of tools, only such constructions are made as to cover principle without undue repetitions.

1. Bench Work in Wood.

The first instruction is in carpentering. The student is assigned a bench which he will find provided with one cross-cutting saw, one ripping saw, smooth plane, jack plane, jointer, set of firmer chisels, set of framing chisels, drawing-knife, back saw, set of Pugh's bits, bit-brace, mallet, oil-stone, try-square, screw-driver, hammer, hatchet, two-foot rule, mortise and scratch gauge, bevel and nail set. Besides fourteen sets, as given above, there is a good supply of other tools which may be passed around to the students as needed, a full set of iron planes, heading and matching planes, hollow and round planes, clamps, screw boxes, &c., &c.

Particular attention is given to laying out work. This is looked upon as important, since it requires the application of fixed principles, combined with care, thought and judgment. The first exercise in this is the use of the saw and plane in working wood to give dimensions, and a series of exercises follow in order, such as practice in making square joints, different kinds of dove-tails, the various tenons, roof trusses, panels, &c., &c. There are twenty-five such exercises.

2. Machine Work in Wood.

In this room are six turning lathes, a circular saw, and grind stone. The lathes are each provided with a complete set of gouges and chisels, parting tool, a pair of calipers and compasses and a two-foot rule. In wood turning it is desirable that one be able to judge accurately, by the eye alone, the proportions of details, so that small curves which are difficult to measure, can be produced in the work so nearly as not to be noticeably different from the detail in the drawing.

This course begins, after the last is thoroughly understood, with turning a plane cylinder, and ends, after twenty exercises, with a complicated vase.

3. Pattern Making.

The student is now familiar with wood-working tools and machines, and is supposed to possess a fair degree of skill in their use.

The work in this course is not so specifically laid down, as the range of applications for patterns is so great that there are an infinite number of exercises that would answer equally well, and in many cases the student will make patterns for some particular machine which he intends to build.

By changing this exercise a large variety of patterns is finally accumulated, and each student can see what others have made and thus become familiar with many more of the varied and peculiar forms which may arise in pattern making.

4. Iron and Steel Forging.

In the forge room are at present seven forges, provided with water and cooling tank, and each supplied with air blast from one of B. F. Sturtevant's steel-pressure blowers; also a self-feeding post-drill and two large vises.

With each forge is an anvil, tongs, punches, hot and cold chisels, heading tools, hammer, swedging tools, set hammers, flatters, fullers, &c., &c. In forging considerable time must be taken to acquire the elements of the work—in learning where, how and when a blow should be struck to give a desired result and to become able to keep the fire in good order. Being able to keep a good fire is essential to good results. After the twenty seven exercises in iron forging have been finished the student takes up steel forging. Having by this time acquired considerable skill in producing forms, his time is now mostly taken up in the hardening, tempering and annealing processes which are in common use. He now learns to make the various tools used in blacksmithing and engine lathe work, and is ready to prepare and dress his own tools when working in the machine shop.

5. Vise Work in Iron.

Eight vises are placed on substantial benches, around the sides of the machine shop, each fitted with a drawer in which the student keeps his work and the tools he may be using. In the tool room are eight complete set of tools, such as cold chisels, files, clipping hammers, file cards, calipers, squares, hand vises, &c. These are given out when needed and returned as soon as the student has finished using them, he being held responsible for them in the mean time. This course of twelve exercises is intended to give practice in the use of hand tools for metal and to teach the student how to keep them in order.

6. Machine Work in Metal.

The appliances for machine work are at present being purchased. One Harrington lathe, sixteen inch swing by six foot bed, one shaper, a speed lathe and a power grindstone, with a proper supply of chucks, cutters, drills, reamers, gauges, squares, calipers, &c., have already been received. It is expected to add several more lathes and a planer.

This course is designed to give the student a knowledge of the different machines and the methods of working them. After a few preliminary exercises, such as centering, squaring, straight-turning, polishing, tapering, chuck-boring, screw cutting, &c., some particular machine is constructed from drawings, patterns and castings which he has previously prepared.

Drawing.

The drawing of this course extends through the entire three years.

This work is looked upon as of the highest importance, and the effort is to make the instruction thorough, practical and of direct utility. Considerable time is devoted to free-hand drawing, as it is believed that it not only assists in mechanical drawing, but is of great service in after years, whatever one's occupation.

The mechanical drawing consists of a series of exercises, such being selected as will be of subsequent use. They are arranged in progressive order, beginning with geometrical constructions involving straight lines and circular arcs only, and ending with the more complex curves, such as the ellipse, helix, epicycloid, &c. Projection is next taken up. The instruction in this is from models, so that the student may have before him the actual object from which the projection is made, and not be obliged to depend upon his unaided conception. After completing this work he is required to draw parts of machines from actual measurements. For this purpose he is given some piece of mechanism to sketch and measure, and of which finally he is to make complete working-drawings.

In Mathematics the instruction covers Algebra, Plane and Solid Geometry, Plane and Spherical Trigonometry, Land Surveying, Mechanics and Mechanism, taught with special reference to this class of students, many practical applications being made.

Course of Instruction.

YEARS.	SESS.	STUDIES.	Hours per Week.	PRACTICULUMS.	Hours per Week.
FIRST YEAR.	Fall.	United States History.	3	Carpentering.	4
		Arithmetic.	4	Geometrical Free-hand Drawing.	5
		English Grammar.	5		
	Winter.	Algebra.	5	Carpentering and Joining.	8
		English Composition.	5	Model and Object Drawing.	5
		United States History.	5		
	Spring.	Algebra.	5	Wood-turning.	6
		English Composition.	5	Designing.	5
		Book-keeping.	4		
SECOND YEAR.	Fall.	Geometry.	2	Pattern-making.	4
		Algebra.	4	Geometrical Drawing.	4
		Physics.	4		
	Winter.	Geometry.	2	Foundry Work.	
		Algebra.	4	Orthographic Protection and Intersections.	
		Physics.	4		
		English.	2		
	Spring.	Geometry.	4	Forging.	
		Algebra.	5	Developing of Surfaces and Isometric Perspective.	
		Mechanics.	3		
		Civil Government.	2		
THIRD YEAR.	Fall.	Algebra.	3	Forging.	6
		Geometry.	3	Linear Perspective and Shades and Shadows.	9
		Mechanics.	4		
	Winter.	Geometry.	3	Vise Work.	6
		Trigonometry.	3	Detail Drawing.	9
		Rhetoric.	4		
	Spring.	Trigonometry and Surveying.	5	Machine Tool Work.	9
		Mechanism.	3	Machine Designing.	9

Requirements for Admission.

Candidates for this course must be at least fourteen years of age, and pass a satisfactory examination in the following subjects: Robinson's Complete Arithmetic (or its equivalent) to Ratio; English Grammar (Syntax and Etymology); Geography and Spelling.

General Information.

No charge whatever is made for tuition.

Each student is required to pay $17 a year for the fuel, lights, and care of the recitation and other public rooms, viz: $7 for the fall session, $5 for the winter, and $5 for the spring. This is the only charge made to pupils who do not room in the College. The charges to those who room in the College buildings are as follows: *Fall Session*—incidentals, $7; room rent, fuel and furniture, $11. *Winter Session*—incidentals, $5; room rent, fuel and furniture, $14. *Spring Session*—incidentals, $5; room rent, fuel and furniture, $8.

The charge for room rent, fuel and furniture is made on the basis of two persons to each room. In cases where a student rooms alone, he will be charged $4 additional per session.

By a resolution of the Board of Trustees, the Business Manager is required to collect from each student, before he is permitted to enter his name upon the College roll, an amount sufficient to cover all his college bills for the current session; or in case the student cannot pay immediately, to require a note, with sufficient security, for the payment at some future time, unless excused by the Executive Committee.

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The Winter Term opens January 6, 1886—12 weeks.

The Spring Term opens April 8, 1886—12 weeks.

The Fall Term opens September 8, 1886—14 weeks.

For Catalogues, or any further information, apply to

PROF. LOUIS E. REBER;
Or PRESIDENT ATHERTON,
STATE COLLEGE P. O.,
CENTRE COUNTY, PA.

No. 14. June 10, 1886.
THE GRASS CROPS OF 1885.

[The management of the experiments and the preparation of the results for publication are now in charge of Mr. William Frear, Ph. D., Assistant Professor of Agricultural Chemistry in the State College. It is believed that this present number will prove of more than usual interest and value from the fact that it summarizes results covering a considerable period of time.]

I. The General Fertilizer Experiments.

The results given below have been obtained in the continuation of the general fertilizer experiments with a four year rotation of wheat, grass, corn and oats, of which the wheat and corn receive an application of fertilizers. The experiments are made to ascertain the relative values of various single commercial fertilizers, the same compounded to form partial or complete fertilizers and yard manure. A full description of the plan of the experiment will be found in Bulletin No. 1 and in a programme just printed, which will be furnished on application.

The present grass crop was grown on the plots of Tier III, and completed the first experimental period of rotation. The grass was a mixture of clover and timothy, the timothy being drilled in with the wheat and the clover sown in the last part of the following March, two quarts of each seed being used. The grass was cut June 22, and stored June 24.

The growing season of 1885 was late and dry and very unfavorable for grass. The season of 1884 was also drier than usual.

In discussing the yield of hay from different plots, account must be taken of the fact that grass is the second crop removed after a single application of fertilizers, so that any variations it may show tend to indicate mainly the effects of the several fertilizers on the *permanance* of fertility. To gain a fair idea of the full effect of the various fertilizers it is necessary to consider also the preceding wheat crop and the combined weight of the two crops. In comparing the results from Tier III with the mean of those from Tiers I and II in preceding years it must be remembered that although a large part of any variation must be attributed to differences in the respective growing seasons, some part is probably due to differences in the soil of the different tiers.

In discussing the results the following points will be considered:

1. The comparative values of partial and complete fertilizers.

2. The comparative values of complete commercial fertilizers and yard manure.

3. The comparative values of the different nitrogen compounds of commereial fertilizers.

4. The comparative effects of different quantities of nitrogen.

[From the observations of this year (1886) it seems that the various fertilizers affect not only the total yield of grass, but also the proportion of clover contained in it. This will be made a subject of further notice in the proper place.]

5. Variations in the yield of grass in proportion to the combined crops.

6. The effect, if there be any, of a variation in the proportion of grain and straw upon the subsequent grass crop.

7. The variations due to the dryness of the season.

The following table gives the results from Tier III and the means of those from Tiers I and II; the average yields of all plots receiving essentially the same fertilizers are included, together with the average of those containing the same nitrogen compounds, those containing the same quantities of nitrogen and those treated with yard manure:

[*For table showing the effects of different fertilizers on wheat and grass crops, see pages 322 and 323.*]

An examination of these results shows the following facts:

1. Partial fertilizers, in general, produce little effect.

2. Complete commercial fertilizers surpass yard manure as far as the effects upon the two crops following a single application are concerned.

3. Dried blood is inferior, as a source of nitrogen, to nitrate of soda and sulphate of ammonia, the last two producing nearly the same effect in ordinary seasons; yard manure increases the yield of wheat more than dried blood, but the yield of combined crops is ordinarily less.

4. A marked increase is shown in the yield from the addition of forty-eight pounds of nitrogen over that obtained from plots receiving twenty-four pounds; but there seems to be no considerable further increase in yield from the use of a greater quantity, so that forty-eight pounds seems to be the highest addition which can profitably be made under existing conditions, including current prices; the average addition of yard manure (fifteen thousand pounds per acre) produces about the same increase of wheat as that produced by the addition of commercial fertilizer containing twenty-four pounds of nitrogen, but the increase of combined crops is ordinarily less.

5. Ordinarily, the high yields of grass are obtained from plots which have given large yields of wheat.

6. No marked relation seems to exist between the proportion of straw in the wheat crop and that of grass in the combined crops.

7. As variations from the effect produced upon the same crops in previous years, there be noted—

(*a*) The very low yields with partial fertilizers.

(*b*) The relatively increased value of sulphate of ammonia and yard manure.

(*c*) The increased yield of grass with the increase in the amount of yard manure applied.

(*d*) The much greater effect of plaster on the grass crop.

(*e*) The decrease in the yield of the plots receiving lime and the relatively greater value of ground limestone.

An examination of the yields of corn and oats grown upon Tier III seems to indicate that most of the above variations are, to a very considerable degree, due to the peculiarities of the soil of this tier; so that the present data are insufficient to indicate the precise effects of the season upon the action of the different fertilizers, as distinguished from the effects of the soil.

II. Experiments with Different Kinds of Phosphoric Acid.

These experiments have been made on plots A to L, of $\frac{1}{20}$ acre area, whose uniformity was tested by the unfertilized oats crop of 1883.* The experiments proper began with wheat in 1884.†

The grass received no fertilizer. The details of sowing and cultivation were identical with those of the general fertilizers series. The following table shows the kind and amount of fertilizers applied, the average yield of wheat and grass from the plots receiving the same fertilizer, after correction in accordance with the results of the uniformity test, and the weight of the wheat and grass crops combined:

Yield of Plots Fertilized with Different Kinds of Phosphoric Acid.

PLOTS.	KIND OF FERTILIZER.	Quantity of fertilizer ingredients per acre.	Quantity of fertilizer per acre.	WHEAT, 1884. Grain.	Straw.	Total wheat crop.	Grass, 1885—Hay.	Combined crops.
		Lbs	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
A and G,	Dissolved bone-black (phosphoric acid largely soluble)	200	640	1848	3400	5248	1550	6798
	Muriate of potash, ...	200						
	Sulphate ammonia, ...	240						
B and H,	Dissolved bone black (phosphoric acid all reverted), ...	200	640	2076	3486	5562	1611	7203
	Muriate of potash, ...	200						
	Sulphate of ammonia, ...	240						
C and I,	Fine ground bone, ...	150	590	2052	3430	5482	1500	6982
	Muriate of potash, ...	200						
	Sulphate of ammonia, ...	240						
D and J,	Ground South Carolina rock, ...	150	590	2070	3299	5369	1555	6924
	Muriate of potash, ...	200						
	Sulphate of ammonia, ...	240						
E and K,	Muriate of potash, ...	200	440	1704	2839	4543	1005	5548
	Sulphate of ammonia, ...	240						
F and L,	Nothing, ...	. . . .	. . . .	1452	2132	3584	1073	4657

The same remarks must be made concerning this year's grass as were applied to last year's wheat: that, under the conditions of the experiment, all the forms of phosphoric acid used caused an appreciable gain, which was nearly equal in all cases. This indicates an equality of effect on the permanence of fertility during the second year after the application of the fertilizer. Controlling conditions,

* See Bulletin No. 9.

† See College Report for 1883 and 1884.

Table Showing the Effects of Different

Number.	KIND OF FERTILIZER.	Quantity of fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	YIELDS PER — MEANS FROM TIERS I & II. — WHEAT. 1882-83. Grain.	Straw.	Total wheat crop.	Grass, 1885—Hay.	Combined crops.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1.	Nothing,	....	....	5	1116	1777	2893	3548	6441
2.	Dried blood,	240	240	1	1176	2184	3360	3340	6700
3.	Dissolved bone-black,	300	300	1	1452	2228	3680	3560	7240
4.	Muriate of potash,	200	200	1	1142	1878	3020	3300	6320
5.	Dried blood, Dissolved bone-black,	240 300	540	1	1564	2196	3760	3840	7600
6.	Dried blood, Muriate of potash,	240 200	440	1	1092	1928	3020	3000	6020
7.	Dissolved bone-black, Muriate of potash,	300 200	500	5	1445	2307	3752	4016	7768
8.	No. 7, Dried blood,	500 240	740	3	1445	2608	4053	4180	8233
9.	No. 7, Dried blood,	500 480	980	2	1544	3010	4554	4250	8804
10.	No. 7, Dried blood,	500 720	1,220	2	1598	2902	4500	4160	8960
11.	No. 7, Nitrate of soda,	500 160	660	1	1786	3136	4922	4300	9222
12.	No. 7, Nitrate of soda,	500 320	820	1	1724	3116	4840	4160	9000
13.	No 7, Nitrate of soda,	500 480	980	1	1748	3292	5040	3860	8900
14.	No. 7, Sulphate of ammonia,	500 120	620	1	1508	3072	4580	4240	8820
15.	No. 7, Sulphate of ammonia,	500 240	740	1	3804	3136	4940	4360	9300
16.	No. 7, Sulphate of ammonia,	500 360	860	1	1802	3180	4982	4164	9146
17.	Yard manure,	12,000	12,000	1	1656	2912	4568	3840	8408
18.	Yard manure,	16,000	16,000	1	1416	2704	3120	3912	8032
19.	Yard manure,	20,000	20,000	1	1536	2944	4480	3760	8240
20.	Yard manure, Lime,	12,000 4,000	16,000	1	1580	2920	4500	3900	8400
21.	Lime,	4,000	4,000	1	1304	1928	3232	4000	7232
22.	Ground limestone,	4,000	4,000	1	1070	1932	3002	3940	6942
23.	Plaster,	320	320	2	1045	1846	2801	3380	6271
	Average yield of plots receiving dried blood,	.....	....	7	1587	2807	4324	4280	8604
	Average yield of plots receiving nitrate of soda,	.....	....	3	1753	3181	4934	4107	9041
	Average yield of plots receiving sulphate of ammonia,	.....	....	3	1705	3129	4831	4255	9089
	Average yield of plots receiving 24 pounds of nitrogen,	.....	....	5	1525	2807	4332	4216	8548
	Average yield of plots receiving 48 pounds of nitrogen,	.....	....	4	1654	3068	4722	4255	8977
	Average yield of plots receiving 72 pounds of nitrogen,	.....	....	4	1686	3069	4755	4236	8991
	Average yield of plots receiving yard manure,	.....	....	4	1547	2870	4417	3875	8292

Fertilizers on Wheat and Grass Crops.

ACRE.					GAIN OVER UNFERTILIZED PLOTS.									
TIER III.					MEANS FROM TIERS I & II.					TIER III.				
WHEAT, 1884.			Grass, 1885—Hay.	Combined crops.	WHEAT, 1882-83.			Grass, 1883-4—Hay.	Combined crops.	WHEAT, 1884.			Grass, 1885—Hay.	Combined crops.
Grain.	Straw.	Total wheat crop.			Grain.	Straw.	Total wheat crop.			Grain.	Straw.	Total wheat crop.		
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1390	1697	3087	1384	4471										
1200	1600	2800	960	3760	60	407	467	—208	259	—190	— 97	— 287	—424	— 711
1248	1352	2600	760	3360	336	451	787	12	799	—142	— 345	— 487	—624	—1111
1392	1608	3000	800	3800	26	101	127	—248	— 121	2	— 89	— 87	—584	— 671
1506	1856	3362	1040	4402	448	419	867	292	1159	116	159	275	—344	— 69
1626	1936	3562	1160	4722	— 24	151	127	—548	— 421	236	239	475	—224	251
1724	*1822	3126	1436	4361	329	530	859	468	1327	334	125	459	52	391
1766	1968	3734	1427	5161	329	831	1160	632	1792	376	271	647	43	690
1854	2404	4258	1660	5918	428	1233	1661	702	2363	464	707	1171	276	1447
1979	2452	4431	1360	5791	482	1125	1607	912	2519	589	755	1344	— 24	1320
1998	2400	4398	1560	5958	670	1359	2029	752	2781	608	703	1311	176	1487
2256	2664	4920	1240	6160	608	1339	1947	612	2559	866	967	1833	—144	1689
2370	?	?	1560	?	632	1515	2147	312	2459	980	?	?	176	?
2070	1768	3838	1880	5718	392	1295	1687	692	2379	680	71	751	496	1247
2406	3192	5598	1920	7518	688	1359	2047	812	2859	1016	1495	2511	536	3047
2316	3416	5762	1840	7602	686	1403	2089	616	2705	956	1719	2675	456	3131
1830	2568	4398	1240	5638	540	1135	1675	292	1967	440	871	1311	—141	1157
1896	2104	4000	1440	5440	300	927	1227	364	1591	506	407	913	56	969
1962	2800	4762	2040	6802	420	1167	1587	312	1899	572	1103	1675	656	2331
1734	2104	3838	1040	4878	464	1143	1607	352	1959	344	407	751	—344	407
1368	1592	2960	720	3680	188	151	339	452	791	— 22	— 105	— 128	—661	— 791
1530	1672	3202	1760	4962	— 46	155	109	392	501	140	— 25	115	376	491
1428	1722	3150	2200	5350	— 71	69	— 2	—168	— 170	38	25	63	856	919
1852	2231	4083	1474	5557	471	1039	1431	732	2163	462	534	996	90	1086
2308	†2532	4840	1453	6112	637	1101	2911	559	2300	818	835	1572	69	1641
2274	2792	5066	1880	6945	589	1352	1941	707	2648	884	1095	1979	496	2475
1873	2014	3887	1544	5431	409	1030	1439	668	2107	483	317	800	160	960
2092	2666	4758	1625	6383	538	1291	1829	707	2536	702	969	1671	241	1912
2168	‡2773	4875	1530	6405	570	1292	1862	688	2550	778	1176	1788	146	1934
1855	2394	4249	1440	5689	431	1093	1524	327	1851	465	697	1162	56	1218

* Mean of four plots. † Mean of two plots. ‡ Mean of three plots.

other than the amount of available phosphoric acid present, seem to have been active in both years. The experiments serve to show that, with a good soil and under some other conditions not yet well known, "ground rock" may be as valuable a fertilizer as any other form of phosphoric acid. Further experiments must be made before any more definite statement can be warranted.

III. Experiments with Different Quantities of Commercial Fertilizer.

These experiments were made on plots A 1 to L 1, of $\frac{1}{20}$ acre area, whose uniformity was tested by oats in 1883. The fertilizers were applied to wheat in 1884, the plots being treated alike in ever other particular. The fertilizer was made according to the following formula:

Dissolved bone-black, ...	72 pounds.
Muriate of potash, ...	8 "
Sulphate of ammonia, ...	20 "

The points to be noted are the effect on the permanence of fertility as shown by this year's grass crop and the effect on the yield of the combined crops.

Table Showing Yields with Different Quantities of Commercial Fertilizer.

PLOTS RECEIVING THE SAME AMOUNT OF FERTILIZER.	Quantity of fertilizer per acre.	*WHEAT. 1884.			*Grass, 1885 —Hay.	Combined crops.
		Grain.	Straw.	Total wheat crop.		
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
A. 1 and G. 1, ...	120	1302	2300	3602	650	4252
B. 1 and H. 1, ...	240	1392	2170	3562	580	4142
C. 1 and I. 1, ...	360	1686	2930	4616	730	5346
D. 1 and J. 1, ...	480	1674	2800	4474	890	5364
E. 1 and K. 1, ...	600	1723	2710	4433	730	5168
F. 1 and L. 1, ...	Nothing.	1410	2170	3580	730	4310

* Corrected in accordance with the unifomity test.

The soil was so fertile that the addition of commercial fertilizer produced little increase. The results seem to favor the use of 360 to 480 pounds per acre. At current prices, the plots receiving the former amount were the only ones to yield an immediate profit.

IV. Experiments on the Deep and Shallow Planting and Thick and Thin Seedings of Wheat. The Effects Upon the Following Grass Crop.

The plots used were M to R, of the same tier as those used for the experiments wlth different kinds of phosphoric acid, and their uniformity was tested in the same way in 1883. The wheat* was sown by means of a common drill, using regulator attachment for the shallow sowing. The plots all received the same amount of fertilizers.

* See Bulletin No. 11 and the College Report for 1883 and 1884.

The following table gives the yields of wheat and grass and the weights of the combined crops from the different plots:

Yields of Wheat Sown at Different Depths and with Different Quantities of Seed, and the Following Grass Crop.

No. of plots.	METHOD OF SOWING.	Quantity of seed.	*WHEAT, 1884. Grain.	Straw.	Total wheat.	*Grass, 1885—Hay.	Combined crops.
		Bu.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
M	Deep,	1	1740	2760	4500	1200	5700
N	Shallow,	1	1680	2620	4300	1300	5600
O	Deep,	1½	1866	2960	4826	900	5816
P	Shallow.	1½	1674	2820	4494	1070	5564
Q	Deep,	2	1596	2500	4096	700	4796
R	Shallow,	2	1980	3280	5260	1320	6580

* Corrected according to the test of 1883.

1. That the shallow planting was best for the grass.

2. That the highest average yield of grass was obtained where the smallest amount of wheat seed was used.

Owing to the exceptional character of the season of 1885 the yield of the combined crops cannot be considered as fairly representative of those grown under ordinary conditions.

No. 15. October 30, 1886.

The Composition of Soiling Rye.

In consequence of the decrease in the area of cheap pasturage in the Eastern States, and the increased cost of maintaining interior fences, the soiling system of feeding milch cattle has of late attracted more general attention than formerly. In view of this fact, it is important to know the yields and food-values of the fodders obtained under this system, as compared with that obtained by pasturage. The following notes on the composition of soiling rye are preliminary to a more general study of the whole subject.

Table I gives the data showing the character, yield and amount of dry substance in samples taken at the Central Experimental farm; also, for comparison, the data given by Jenkins* as the mean of the analyses of five other American samples, and those obtained by Weiske at Proskaw,† from the examination of pasture-grass (clover and timothy mixed), plucked by hand thirteen times during four months of the growing season, and of the hay from a portion of the same field, mown twice in the same interval.

* Report of the Conn. Agric. Exp. Station, 1884, p. 114.

† Wolff, Ernahrung Landw. Nutzthiere, p. 108; Armsby, Manual of Cattle-Feeding, p. 296.

Table II gives the percentage composition of the dry substance of the same samples.

TABLE I.—*Yield per Acre.*

SAMPLE.	Height.	Soil.	Weight of fresh substance—lbs.	Weight of dry substance—lbs.	Per cent. of dry substance.
Soiling rye, No. 1,	18 inches.	Moderately manured,	14,917	2,468	16.52
Soiling rye, No. 2,	28 inches.	Heavily manured,	35,560	4,754	13.37
Soiling rye, No. 3,	52 inches.	Same as No. 2,	53,340	13,351	25.03
Mean of Nos. 2 and 3,			44,450	9,052	19.20
Jenkins' mean,			....	....	25.30
Pasture-grass,			....	3,699	
Twice mown hay,			....	5,914	

TABLE II.—*Percentage Composition of Dry Substance.*

	Crude fat.	Crude fiber.	Nitrogen - free extract.	Crude protein.	Ash.	Total nitrogen.	Albuminoid nitrogen.	Non albuminoid nitrogen.	Per cent. total N—non-alb. N.
Soiling rye, No. 1,	5.14	22.54	51.85	10.87	9.59	1.74	1.42	0.32	18.38
Soiling rye, No. 2,	5.07	26.21	39.26	17.06	12.41	2.73	1.76	0.97	35.77
Soiling rye, No. 3,	4.26	28.37	47.57	10.43	8.18	1.86	1.12	0.74	39.49
Mean of Nos. 2 and 3,	4.66	27.29	43.41	13.75	10.29	2.29	1.44	0.85	37.63
Jenkins' mean,	2.57	56.52	23.32	10.28	7.51				
Pasture-grass,	5.09	16.74	42.09	27.07	9.01				
Twice-mown hay,	3.69	27.14	49.69	13.42	6.06				

The early crop of rye, obtained by early sowing and heavy manuring, is best adapted for feeding when between the heights of two and four feet. A comparison of samples two and three, taken at the beginning and at the end of the feeding period, shows that there has been during the interval a rapid gain in dry substance, due mainly to the increase of the non-nitrogenous constituents. Of these, the nitrogen-free extract (starch, gums, &c.) gains much more rapidly than the crude fiber (cellulose). The crude protein drops far behind, and the crude fat (which includes chlorophyll or leaf-green and waxes as well as true fats) and ash are relatively diminished. There is a slight increase in the percentage of the total nitrogen present in a non-proteid form.

A comparison of No. 1, taken from a soil receiving a moderate amount of manure, with No. 2, taken from a much more highly manured plot, the plants being of nearly the same age, shows that No. 1 contains less moisture, a much higher percentage of nitrogen-free extract, and a much lower percentage of albuminoids. There is less crude fiber than in No. 2. There is also a much smaller proportion of the nitrogen present in a non-proteid form, so that the dry substance contains only two per cent. less of true proteids than the dry substance of No. 2. This is in full accord with Kellner's* observations on the

* Landw. Jahrb., 8, Supp. I, p. 243.

effect of high manuring on fodder plants. It must be remembered that the non-proteid nitrogenous bodies are not regarded as having a nutritive value equal to that of the true proteids.

It will be perceived that the means of other analyses given by Jenkins, when compared with the means of Nos. 2 and 3, show less fat, ash and protein, and very much less nitrogen-free extract, while the percentage of crude fiber is greatly increased. This would indicate that these samples were taken at a greater age.

Again, comparing the means of Nos 2 and 3 with pasture-grass, we note the following facts:

Soiling rye yields twenty tons per acre of green crop, pasture-grass seven and one half tons; soiling rye yields four and one half tons per acre of dry substance, pasture-grass two and three fourths tons. The percentages of crude fat, nitrogen-free extract and ash are nearly the same in both fodders; but soiling rye contains nearly twice as much crude fiber and only half as much protein as is present in pasture-grass. From Kellner's observations on early-cut meadow hay, it seems probable that the proportion of nitrogen* present in a non-proteid form is about the same in both substances.

From the preceding facts, we may conclude—

First. That, so far as chemical analysis can determine, soiling rye is much inferior to pasture-grass as an exclusive feed.

Second. That, fed with some nitrogenous bye-fodder, as malt-sprouts, oil-cake, etc., it may in many instances be more profitable on account of its much greater yield.

Third. That quite old soiling rye, such as sample No. 3, closely resembles the mean of first and second crop hay in composition, but is, of course, juicier, and has a yield which is greater by one half.

Fourth. That high manuring produces a crop of better nutritive quality and in very much greater quantity. We have observed no distinction shown by the cattle against the ranker growth.

No. 16. November 15, 1886.

The Composition and Food Value of Dessicated Apple-Pomace.

Every year millions of bushels of apples are converted into cider, and thousands of tons of pomace produced. How to utilize this by-product to the best advantage has been for years a mooted question among cider-makers, and from the lack of any decisive answer a large proportion of the product is annually wasted.

The general rule that a product should, if possible, be made to contribute, first, to the food-supply, and last to the manure-heap, coupled with the fact that apple-pomace has a very slight manurial value, would indicate that any method by which it could be profitably used for food should receive careful attention.

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* See above.

Two obstacles have prevented the general use of pomace for feeding purposes: First, the widely-extended belief that apples are not fit to fill a large place in a ration for horses or cattle, and, therefore, that the pomace certainly is not; and second, the ready fermentability of the pomace, by reason of which it is difficult to extend the period of its use.

There are two facts that should do much toward overcoming the prejudice against apples as a food supply: First, repeated experience has shown that farm animals can be fed on rations containing a large proportion of apples, not only without injury to health, but with positive advantage; the same has, in a more limited range of experience, been shown to hold true for the pomace. Second, the chemical composition of apples indicates that they are not inferior to turnips as a source of sugar, starch, and pectin, and that the pomace has a larger percentage of dry substance, which contains nearly as much nitrogenous matter and carbhydrates as the dry matter of sugar beets. Moreover, it has been found possible to avoid any injury arising from excess of free acid by sprinkling the pomace with chalk before feeding.

To obviate the difficulties caused by the fermentability of pomace, several methods have been proposed. Prof. F. H. Storer* says: "It would be interesting to determine by actual trial whether a process of preservation which is largely employed in Europe for keeping a variety of soft and juicy materials might not be available for the preservation of pomace." Prof. Storer refers to the "sour fodder" of the Germans—a kind of ensilage. This method is worthy of trial.

It has also been found possible to preserve pomace for a considerable time by freezing. In this state it forms an agreeable food for horses. Prof. S. W. Johnson has analyzed a sample of pomace prepared in this manner, and says: † "In respect to the quantities of the various food elements it contains, analysis shows that this pomace is superior to cornfodder, and to turnips, mangels, and all of our root crops except the potato, and that is but little inferior to the last-named tuber."

Some time ago Mr. Christopher Shearer, of Tuckerton, Pa., sent a sample of "dessicated apple-pomace" for analysis. He states that it can be prepared at slight expense, and that every ton of pomace yields several hundred bushels of the dessicated product.

The sample in question came in large, brown flakes, somewhat leathery in texture, but possessing an agreeable apple flavor and odor.

The following table gives the results of its analysis, together with the mean of several American analyses of fresh pomace, given by Dr. Jenkins,‡ and the analysis of frozen pomace by Prof. Johnson, for the sake of comparison:

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* On the Fodder Value of Apples, Bulletin of the Bussey Institution, Vol. I, p. 362.

† Conn. Agric. Experiment Station Report, 1881, p. 86.

‡ *Ib.* 1884, p. 117

SAMPLE.	Moisture.	Crude fat.	Crude fiber.	N.-free extract.*	Protein.†	Ash.	Free acid.‡
Dessicated apple-pomace,	8.47	4.87	18.81	60.82	5.19	1.84	1.17
Fresh apple-pomace,	74.10	1.90	5.20	16.70	1.40	0.70	
Frozen apple-pomace,	72.62	1.97	5.92	17.01	1.65	0.81	

* Including starch, sugar, pectose, &c.

† Including all the nitrogenous constituents = nitrogen × 6.25.

‡ Calculated as malic acid.

The dissicated pomace is seen to contain a very considerable amount of nitrogenous matter, and a proportion of carbohydrates (N.-free extract) nearly equal to that of wheat. The percentage of crude fiber is moderately high, but no greater than in palm-nut cake. The crude fat consists largely of wax and coloring matters.

According to chemical evidence, therefore, the dessicated pomace would seem to be a valuable source of carbonaceous food, to be fed with a generous admixture of nitrogenous foods, such as malt-sprouts, oil-cake, etc. The presence of so large a percentage of free acid may necessitate the softening of the pomace and subsequent treatment with small quantities of chalk before feeding. On the other hand, it may add to the appetizing qualities of a ration composed to a considerable extent of general feeding stuffs, such as hay or cornfodder.

It is possible that objections to this preparation may be found by actual experiment in feeding, but it certainly is worth a careful trial.

Seed Tests.

With a view of diminishing the loss suffered by Pennsylvania farmers from the use of poor seed, it has been decided to offer the opportunity for a free examination of their germinating power, under the following conditions:

I. That they be accompanied by a statement of—

1. Name or label of seed.
2. Name and address of producer or importer.
3. Name and address of dealer from whom they are purchased.
4. Date of taking the sample.
5. Selling price, per pound or bushel.
6. Known or reputed age of seed.
7. Number of packages from which the sample is taken.
8. Signature and post-office address of the person taking the sample.

Send with each sample any printed circular or statement that accompanies the seed or is used in its sale.

II. Seeds may be sent by mail or otherwise, but must in all cases be *prepaid*, and plainly addressed to the Professor of Agricultural Chemistry, State College, Centre county, Pa.

III. Great care should be taken in sampling seeds, by carefully mixing the contents of the bag, barrel, or other package in which they are contained and drawing samples from different parts, finally mixing these and taking the necessary amount for the sample to be sent.

Of the smaller seeds—red top, white clover, etc.—send two (2) ounces; of beets, turnips, etc., four (4) ounces; of grain, peas, beans, etc., eight (8) ounces.

For the present, it will be possible to examine the seed only with reference to its germinating power, as any further examination will involve more labor than can be performed under existing conditions.

As some time is required for the completion of these tests, a reply must not be expected in less than two or three weeks.

ERRATA.

Page 23, 3d line from bottom, for "*experiments*" read *experiment.*
" 26, 13th line, after "*farms*" insert a comma.
" 26, 14th line, after "*soil*" insert a comma.
" 27, 4th line, for "*preparations*" read *preparation.*
" 28, in the index add *five* to the number of the pages 84–107.
" 29, 15th line, for "*176*" read *175.*
" 32, 9th line, insert *144* in brackets.
" 43, 2d line from bottom, for "*crops*" read *crop.*
" 62, 18th line, for "*of*" read *when compared with.*
" 94, 13th line, after "*higher*" insert *yield.*
" 107, 4th line, before "*dried*" insert *complete fertilizers containing.*
" 131, 2d line, for "*thta*" read *that.*
" 131, 6th line from bottom, for "*Beaty*" read *Beauty.*
" 134, 8th line, for "*potash*" read *potatoes.*
" 144, 15th line from bottom, for "*Cambria*" read *Cambrai.*
" 149, 12th and 14th lines from the bottom, for "*McGehee*" read *McGhee.*
" 150, 6th line, *ib.*
" 160, 14th line from bottom, *ib.*
" 167, Table II, insert asterisk in 6th column from the right instead of the 2d.
" 170, 15th line, for "*acide*" read *acids.*
" 172, in table, 8th line, for "*McGehee*" read *McGhee.*
" 172, 20th line from bottom, after "*and*" insert *of.*
" 181, 17th line from bottom, for "*drank*" read *drunk.*
" 182, 6th line from bottom, for "*quanttiies*" read *quantities.*
" 203, 17th line from bottom, for "*unresolved*" read *unresorbed.*
" 213, column 2, 3d line, for "*6.67*" read *6.57.*
" 216, column 7, 2d line, for "*5*" read *35.*
" 220, column 11, 13th line, for "*13.50*" read *18.50.*
" 225, column 3, 1st line, for "*44.788*" read *44.784.*
" 225, 2d line below table, after "*that*" remove the comma.
" 230, column 5, 5th line, for "*215.2*" read *215.7.*
" 230, column 6, 7th line, for "*297.8*" read *297.9.*
" 233, column 10, 9th line, for "*2.25*" read *3.25.*
" 233, 1st line below table, after February 19 insert semicolon instead of comma.
" 233, 2d line below table, after April 1–9 insert semicolon instead of comma.
" 251, 3d column from right, 3d line, for "*1.210*" read *1.220.*
" 257, 15th line from bottom, for "*soluable*" read *soluble.*
" 257, 7th line from bottom, for "*potassum*" read *potassium.*
" 261, 6th column, for "*insoluable*" read *insoluble.*
" 263, 11th column, 4th line, for "*0.4*" read *0.04.*
" 270, 17th line, for "*oxodized*" read *oxidized.*
" 273, last table, 4th column, last line, for "*105.9*" read *100.9.*
" 277, column 3, 3d line, for "*28.28*" read *28.27.*
" 277, column 4, 3d line, for "*28.27*" read *28.28.*
" 284, 7th line from bottom, for "*Ntaive*" read *Native.*
" 286, 21st line, for "*parlalel*" read *parallel.*
" 298, Table II, last column, last line, for "*49.0*" read *49.4.*
" 302, Table I, last column, last line, for "*8*" read *80.*
" 305, column 2, 4th line, for "*61.1*" read *61.0.*
" 305, column 4, 7th line, for "*43.7*" read *43.8.*
" 305, column 9, 2d line, for "*4.6*" read *4.5.*

Page 305, column 9, 5th line, for "*— 7.0*" read *— 8.0.*
" 306, Table, column 3, 10th line, for "*2,060*" read *3,060.*
" 307, last line, for "*yiled*" read *yield.*
" 308, Table I, column 4, 3d line for "*26.3*" read *26.6.*
" 308, Table I, column 4, 7th line, for "*23.6*" read *23.3.*
" 312, 2d line below first table, for "*per pound*" read *per fifty pounds.*
" 312, Table II, column 4, 7th line, for "*186*" read *196.*
" 312, Table II, column 5, 10th line, for "*0.118*" read *0.113.*
" 314, second paragraph, 1st line, insert comma after instead of before "*iron.*"
" 314, 17th line from bottom, for "*instructions*" read *instruction.*
" 314, 16th line from bottom, "*as cover principle without undue repetitions*" read *as to cover principles without undue repetition.*
" 317, Table, first line, for "*Practiculums*" read *Practicums.*
" 317, Table, column 5, 15th line, for "*Protection*" read *Projection.*
" 319, 2d line from bottom, for "*commereial*" read *commercial.*
" 320, 3d line, for "*effect*" read *correspondence.*
" 320, 4th line, for "*upon*" read *with.*
" 322, column 6, 15th line, for "*3,804*" read *1,804.*
" 322, column 8, 18th line, for "*3,120*" read *4,120.*
" 322, column 9, 10th line, for "*4,160*" read for *4,460.*
" 323, column 8, 6th line from bottom, for "*2,941*" read *2,041.*
" 323, column 9, 19th line, for "*312*" read *212.*
" 323, column 13, 21st line, for "*128*" read *127.*
" 323, column 14, 24th line, for "*995*" read *996.*
" 324, 10th line, for "*ever*" read *every.*
" 325, table, column 6, 3d line, for "*900*" read *990.*
" 325, 4th line from bottom, for "*Proskaw*" read *Proskau.*
" 327–329, for "*dessicated*" read *desiccated.*