NEW HAMPSHIRE

AGRICULTURAL

EXPERIMENT STATION,

HANOVER N. H.,

BULLETIN NO. 10.

CO-OPERATIVE

FERTILIZER EXPERIMENTS.

COMPARISON OF MANURE, PREPARED FERTILIZER, ASHES, AND CHEMICALS.

MARCH, 1890.

ORGANIZATION

— OF THE —

NEW HAMPSHIRE

Agricultural Experiment Station.

BOARD OF CONTROL:

Hon. Warren Brown, President,	Hampton Falls.
Rev. S. C. Bartlett. LL.D.,	Hanover.
Hon. S. B. Whittemore,	Colebrook.
Hon. G. A. Wason,	Nashua.
Prof. G. H. Whitcher, Secretary,	Hanover.

OFFICERS:

G. H. Whitcher,	Director.
A. H. Wood,	Supt. Dairy Dept.
H. H. Lamson,	Microscopist and Photographer.
F. W. Morse,	Chemist.
C. L. Parsons,	Asst. Chemist.
C. H. Pettee,	Meteorologist.
J. M. Fuller,	Station Farmer.
C. W. Whitcher,	Clerk.

CO-OPERATIVE FERTILIZER EXPERIMENTS.

It is commonly believed that experiments with fertilizers are of little use, except in the immediate locality in which they are made; some even advocating the idea that no two parts of the same farm have the same needs, and that the use of fertilizing materials is, and must be, from the nature of the case, a hap-hazzard undertaking, upon which study and investigation can throw little if any light.

I do not believe, however, that the case is as hopelessly involved in darkness as this view would lead us to conclude, and I am convinced that the feeding of plants will in time be placed on footing more nearly approaching that on which the feeding of animals now stands. It is not the purpose of this Bulletin to discuss this part of the subject but rather to present the results of a series of coöperative experiments carried on by direction of the Station on farms in various parts of the State.

OBJECT OF THE EXPERIMENTS.

The object was to determine, by field tests, the relative proportion of *Nitrogen*, *Phosphoric acid* and *Potash* which should form the most perfect *crop ration* for the soils and crops experimented on, and in connection with this, as a means of comparison, four plots in each set were left with no fertilizer of any kind, to determine the natural capacity of the soil; one plot had one of the best commercial fertilizers found in our market, one plot had ashes and concerning one plot, No. 6, no suggestion was made, the intention being for each farmer to use whatever he might have, either in the way of manures or commercial goods on this.

COST OF FERTILIZER.

In each case, except plot 8 where manure was used, the fertilizer or chemicals cost 50 cents per plot or $10.00 per acre; the manured plot had 30 bushels of farm yard manure, which is at the rate of about 7 cords per acre, the value of

which, on an average, may be placed at $20.00 (that is about twice the cost of the fertilizer, chemicals and ashes.) This amount of manure was used because it was believed to be about what our farmers would call a full average application for corn.

PARTIES WHO UNDERTOOK THE WORK.

The thanks of the Station and of the farmers of the State are due the following gentlemen who assisted in this undertaking: Hon. D. H. Goodell, Governor of the State, Antrim, N. H.; Hon. Warren Brown, Pres't Board of Control, Hampton Falls, N. H.; Hon. S. B. Whittemore, Member of Board of Control and of Board of Agriculture, Colebrook, N. H.; Alonzo Towle, M. D., Member Board of Agriculture, Freedom, N. H.; Charles McDaniel, Esq., Master State Grange, West Springfield, N. H.; F. T. Stanton, B. S., Strafford Corner, N. H.; C. C. Beaman, Esq., Cornish, N. H.; James Wood, Esq., Lebanon, N. H.; J. L. Gerrish, Esq., Mast Yard, N. H.; J. E. Whitcher, Esq., Strafford, N. H.

The last mentioned experiment was a continuation of a series commenced in 1888, and ruined by the early frost of that year, it cannot be compared with the other results since the plan was materially modified the past year.

PLAN OF FIELD.

The outside dimensions of the plowed field were to be 185 feet by 281 feet, this enabled one to lay off 20 plots each 33 feet by 66 feet, leaving an outside blank space four (4) feet wide all around the field and a space three (3) feet wide between each plot. Each plot was to have ten (10) rows with twenty (20) hills in each row or at the rate of 4000 hills per acre.

Table 1 is so arranged that the number of the plot is shown across the top, the kind of fertilizer used is shown in the left hand column; the number of pounds of any given substance used on a given plot will be found by looking opposite that substance, in the column marked at the top with the number of the plot, for example, if it is desired to know what the fertilizer on plot 13 was, we look in the column headed 13, following down this we come to 16½ pounds and looking at the left of this we see that this was dissolved bone black; 5 pounds of muriate of potash and 3½ pounds of sulphate of ammonia, make up the total application on that plot.

The lower three lines of figures in the table show the chemical composition of the material used on the various plots,

TABLE 1. FERTILIZERS USED IN CO-OPERATIVE EXPERIMENTS.

Kind and Amount of Fertilizer.	No. of Plot.																	
	1	3	4	5	8	9	10	12	13	14	15	16	18	19	20			
Dissolved bone-black.	lbs. 18½	lbs. 24½	lbs. 14	lbs. 17½	lbs.	lbs. 17½	lbs. 16½	lbs.	lbs. 16½	lbs.	lbs. 18½	lbs. 10½	lbs.	lbs.	lbs. 33⅓			
Muriate of potash.	33⅓	6				8¾	5		5		33⅓	9¾		22¼				
Sulphate of ammonia.	33⅓		7¼	23¼		1	3½	2	3½		33⅓	3¼	12½					
Ashes.					30					28								
Manure.																		
Prepared fertilizer.																		
Analysis of Fertilizer.																		
Phosphoric acid.	11.4	12.8	10.5	0.23	10.5	10.5	1.5	10.5	12.4	11.4	7.2							
Potash.	7	10	43.5	0.48	16	10	6.5	10	2	7	20.4		50		16			
Nitrogen.	2.8		6.8	2.8	0.48	0.7	2.8		2.8	2.5	2.8	2.8	20					

thus No. 13 had a mixture which by analysis showed 10.5% of phosphoric acid, 10% of potash and 2.8% of nitrogen.

TABLE 2. YIELDS OF HUSKED CORN AND FODDER PER ACRE.

		Stanton.	Goodell.	Baker.	Gerrish.	Wood.	Brown.	Beaman.	Average. Corn.	Average. Fodder.
1	C	52½	44½	**77.1**	**93**	68¼	32½	85	69.94	
	F	5200	1760		2635	2853	2800	5200		*3408*
2	C	37½	7½	13.6	69.7	18.1	65½	71	40.41	
	F	4200	520		1735	1220	3280	3000		2326
3	C	55	**93**	47½	**93**	**92.5**	*70*	63½	*73.50*	
	F	3600	2180		2635	4216	2900	4500		*3338*
4	C	**87.5**	45	20¼	**89.3**	76.4	66	76½	57.27	
	F	4000	1380		2480	1111	3160	3120		2542
5	C	**103.8**	33	30½	69.7	78.4	52½	50½	59.76	
	F	6500	1640		2170	4032	2700	4500		**3740**
6	C	65	**97.5**	**72 8**	67¾	*85.5*	*69 5*	62	*74.00*	
	F	3000	3080		1555	3600	3220	3000		2909
7	C	47½	40	9¾	35 8	184	*68.5*	54	39.13	
	F	3000	1480		1085	1584	3260	2860		2211
8	C	62½	**74**	**89.8**	**108.5**	**133.1**	67½	**112.5**	**89.69**	
	F	5000	2020		3150	5764	2500	4000		*3739*
9	C	72½	*54*	*67*	79.4	**161 8**	63	**106**	**77.66**	**3787**
	F	5200	1980		2635	4127	3080	4809		
10	C	61 3	34	*72.6*	77 5	*86.3*	35	*103*	*67.08*	
	F	5 000	1640		1850	3600	2300	5100		3250
11	C	50	20	11.6	42.6	19½	60	84½	41.17	
	F	000	940		1025	2016	1800	3000		2290
12	C	*80*	38½	15.4	62	80½	56	*95.5*	65.71	
	F	3200	1400		1705	3803	2560	4900		2795
13	C	**115**	*68*	*68.1*	73.6	*82.8*	23	94½	**75.00**	
	F	5200	2000		2325	4280	1480	4800		**3847**
14	C	70	36	58¼	69¾	55.6	67½	88	63.58	
	F	4500	1440		2015	2534	37 40	3000		2865
15	C	40	39	66¾	*83.3*	78.8	48	72	61.11	
	F	2400	1800		2325	3564	2880	4200		2861
16	C	30	41	54½	*89.1*	72.4	**82 5**	48½	59.70	
	F	2500	1860		2790	4298	3300	3900		3108
17	C	17½	27		54¼	26¾	**77**	60	43.66	
	F	1000	1080		1395	1886	3120	2860		1890
18	C	55	24		49½	21.1	**81**	**110.5**	56.85	
	F	2200	960		1240	1823	3060	36 0		2147
19	C	*75*	*46*		62	44.8	56½	*95*	63.21	
	F	3900	1380		1540	3510	2740	3900		2760
20	C	*85*	23		58.1	41¾	58	93	58.81	
	F	3100	1120		2100	3071	2280	3900		2608

CONDITIONS UNDER WHICH WORK WAS DONE.

The Station put up the fertilizers except for plots 8, 6, and 12, the farmer was to furnish use of land, was to lay out the plots, and plant according to directions, record certain observed facts on blanks furnished and to harvest and report weights. For this, no compensation, other than the fertilizer was given.

RESULTS OBTAINED.

While the results cannot be regarded as perfect, in fact fall far short of that, nevertheless it is believed that they are valuable. Seven of the ten farmers worked on corn which was husked, (one of these by reason of sickness did not report on weight of fodder) one planted corn for ensilage, one sweet corn for a canning factory, and one experimented on potatoes.

Table 2 gives the yield per acre of husked corn, 40 lbs. per bushel as husked, and of fodder, for each plot on each of the seven sets; plots 17, 18, 19 and 20, on Mr. Baker's acre, were destroyed by crows; the last two columns in the table give the average yield of corn and fodder from each plot, for the seven tests. In this table the THREE BEST YIELDS ARE PRINTED IN BLACK-FACED TYPE, *the next three best in italics.*

Taking this table as it stands and the best yield of corn is seen to be from manure, followed by plots 9 and 13, while the largest amount of fodder is found on plot 13, followed by 9 and 5.

If we select and average the three best plots, not including the one with manure, in each set, we can then compare the results from chemicals with those from manure, prepared fertilizer, and ashes, and by averaging the four plots with no fertilizer we have the data for determining the relative efficiency of each method of supplying plant food. This method of condensing results has been applied to table 2 and as a result we get table 3, the upper half being for *husked corn* the lower for *fodder.*

Table 3 shows us that the average yield of husked corn from manure was 89.69 bushels, from the best three combinations of chemicals 90.62 bushels, from prepared fertilizer 63.58 bushels, from ashes 65.40 bushels, and from plots not fertilized 41.00 bushels.

To the farmer these figures mean a great deal, provided that they are representative results; now as the cost of chemi-

cals, ashes, and prepared fertilizer are the same, any gain in product of one over the other represents profit, and we may

TABLE 3. COMPARISON OF MANURE, PREPARED FERTILIZERS AND CHEMICALS.

	Staunton.	Goodell.	Baker.	Gerrish.	Wood.	Brown.	Beaman.	Average.
	bu	bu.	bu.	bu.	bu	bu.	bu.	bu.
Manure,	62.5	74	89.75	108.5	113.1	67.5	112.5	**89.469**
	115	97.5	77.1	93	101.75	82.5	110.5	
Best three plots,	103.75	93	72.75	93	92.50	81	106	
	87.50	68	72.6	89.25	86.25	77	103	
	306.25	258.5	222.45	275.25	280.50	240.5	319.5	
Average,	*102.08*	*86.2*	*74.15*	*91.75*	*93.5*	*80.2*	*106.5*	**90.462**
Prepared fertilizer,	70	36	58.25	69.75	55.6	67.8	88	**63.58**
Ashes,	80	38.5	45.4	62	80.5	56	95.5	**65.4**
No fertilizer,	38.1	23.6	11.6	50.6	20.5	67.7	67.4	**41**
				FODDER.				
	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.
Manure,	5000	2020		3150	5764	2500	4000	**37539**
	6500	3080		2700	4932	4480	5200	
Best three plots,	5200	2180		2635	4208	3080	5100	
	5200	2000		2635	4280	3700	4800	
Average,	*5633*	*2420*		*2686*	*4502*	*4055*	*5033*	**4046**
Prepared fertilizer,	4500	1440		2015	2534	3700	3900	**2865**
Ashes,	3200	1400		1705	3863	2560	2900	**2595**
No fertilizer,	3050	1005		1325	1676	2845	3165	**2176**

well ask the question, Why do chemicals average a better yield than the prepared fertilizer?

The first step in answering this is to determine just what kind of plant food has been supplied in each case, and the proportion of the several kinds. If we take the fertilizers used on those plots which gave the three highest yields in each set, and average the per cent. of nitrogen, phosphoric acid and potash, we get the results given in table 4.

TABLE 4. COMPOSITION OF BEST CHEMICALS USED.

		Stanton.	Goodell.	Baker.	Gerrish.	Wood.	Brown.	Beaman.	Average.
On Corn.	Phosphoric acid, %	7	11.5	11.2	11.6	11.3	3 6	7.0	**9**
	Potash, %	17.8	7.6	6.3	5.6	10	10.2	8.7	**10.7**
	Nitrogen, %	4.1	1.8	2.7	3.2	1.9	11.4	7.8	**4.7**
On Fodder.	Phosphoric acid, %	7.3	11.5		10.5	5.9	11.1	10.8	**9.5**
	Potash, %	8 6	7.6		12 5	24.6	9 3	9 0	**11.9**
	Nitrogen, %	2 8	1 8		1.9	2 8	2 0	2.8	**2.3**

The upper half of this table shows what kind of a fertilizer proved best for the production of corn on each of the seven farms, the last column averages all of these. The lower half of the table shows the same thing for the production of fodder, consequently these results may be regarded as applicable where the design is to raise ensilage; combining these averages and we may fairly claim, so far as the teachings of these experiments are concerned, that the best results come from a fertilizer, with the following chemical composition: (beside it is given the average analysis of 18 fertilizers sold in N. H. in1889)

	Chemicals producing best results.	Average of fertilizers sold in N. H. in 1889.
Phosphoric acid	9.25	11.08
Potash	11.3	2.57
Nitrogen	3·5	2.45

The difference is very easily seen and we are forced to conclude that our prepared fertilizers are deficient in potash.

Or if we select from table 2 those three plots which yield highest in the average of *all* of the sets namely, 9, 13 and *6 the average composition is as below.

	Husked Corn.	Fodder.	Average of the two.
Phosphoric acid	10.7	7.	8.8
Potash	9.5	23.1	16.3
Nitrogen	2.	2.1	2.0

The best plots on fodder were 13, 9, 5.

*6 received a variety of fertilizers among the different experimenters.

These results are in no wise unusual; in our five years' work on the Station Farm, some of the results of which were reported in Bulletin No. 6, it has been found that the six combinations of chemicals which have given the highest income, on corn, per dollar invested have averaged:

Phosphoric acid	6.4
Potash	15.5
Nitrogen	2.5

EXPERIMENTS WITH ENSILAGE, SWEET CORN AND POTATOES.

The following are the results of experiments with the same combinations as for corn, on the crops above mentioned.

TABLE 5.

	Towle. Sweet Corn value per acre.	Whittemore. Potatoes. bu. per acre.	McDaniel. Ensilage. lbs. per acre.
1	**$68 60**	**172**	9120
2	28.40	110	6480
3	57.40	**180**	11160
4	19.60	110	*5460
5	*30.80	115	7680
6	*41.8	**160**	*12320*
7	35.40	80	7720
8	*40.40	*148*	*11520*
9	**57.80**	*150*	**13760**
10	*57.60*	*143.5*	11000
11	31.60	70	6200
12	*55 40*	71.5	**12400**
13	*50 20*	104	*11920*
14	**60.20**	128.5	10320
15	*41.20	127.5	11200
16	*42.60	90	10120
17	28.80	110	7000
18	32.60	16.3	7600
19	28.60	28	**12800**
20	48.20	98.5	9900

*A different variety of corn.

	Towle. Sweet Corn Value of crop *	Whittemore. Potatoes bu.	McDaniel. Ensilage lbs.
Manure,		148	11520
Average of best 3 plots of Chemicals,	$61.33	171	12986
Prepared fertilizer,	$60.20	128½	10320
Ashes,	$55.40	71½	12400
No fertilizer,	$31.05	87	6850

*An accidental changing of seed puts this plot in another series.

The superiority of chemicals over prepared goods is again demonstrated in these trials. The composition of the fertilizers giving best three yields is as follows:

	Towle.	Whittemore.	McDaniel.
Phosphoric acid %	10.8	11.6	4.0
Potash %	11.0	7.1	24.1
Nitrogen %	2.1	2.3	0.2

PLOT 6.

This plot, as before mentioned, had such fertilizers as each experimenter chose to apply.

Gov. Goodell applied 32½ pounds of Soluble Pacific Guano; unfortunately this was applied *in the hill* while all other fertilizers were broadcasted, comparison under this condition is impossible.

Mr. McDaniel used 4 bushels of hen manure on this plot; Mr. Gerrish 2 bushels of hen manure; Dr. Towle applied 28 lbs. of Quinnipiac fertilizer; Mr. Baker used 28 lbs. of Bradley's XL; Mr. Wood use 21½ pounds of ground bone and ½ bushel of ashes, Mr. Whittemore applied 28 pounds of Stockbridge Potato Manure.

COMPARISON OF COST AND PRODUCT.

Husked Corn.	bush.	Gain over no fertilizer bush.
Average yield with no fertilizer	41.00	
Average yield with Manure	89.69	48.69
Average yield with 3 Best Chemicals was	90.62	49.62
Average yield with Ashes	65.4	24.4
Average yield with Prepared fertilizers	63.58	22.58
Fodder.	lbs.	lbs.
Average of "nothing" plots	2176	
Average of Manured plots	3739	1563
Average of plots with Chemicals	4046	1870
Average of plot with Ashes	2595	419
Average of plot with Prepared fertilizer	2865	689

If we call the corn worth 25 cents per husked bushel and the fodder worth $5.00 per ton, we can find the value of the increased product, and, calling the manure worth $15.00 per acre, and all other plots $10.00 per acre, which is what the fertilizers would cost in any market, we can draw up the following exhibit of cost and income:

Corn	Cost of plant food per acre.	Value of increased yield	Value of increase per $1 invested in plant food
Manure	$15.00	$16.00	$1.07
Chemicals	10.00	17.08	1.71
Ashes	10.00	7.15	.71½
Prepared fertilizer	10.00	7.37	.74
Sweet Corn			
Chemicals	10.00	30.28	3.03
Ashes	10.00	24.35	2.43½
Prepared fertilizer	10.00	29.15	2.91½
Potatoes			
Manure	15.00	30.50	2.03
Chemicals	10.00	42.00	4.20
Ashes	10.00	Loss	——
Prepared fertilizer	10.00	20.75	2.07½

CONCLUSIONS.

1st. Chemicals when properly mixed can fully take the place of farm yard manure as a source of plant food, this is shown by the averages of the best plots in each set (see table 3)

2nd. Chemicals when properly mixed can and do give greater increase of crop than Commercial fertilizers (see table 3 and page 7.

4th. The average chemical composition of fertilizers for New Hampshire should be *Phosphoric acid*, 9 *to* 11 *per cent.*, *Potash*, 9 *to* 15 *per cent.*, *Nitrogen* 2 *to* 4 *per cent.*, whereas the fertilizers offered to us in the market average *Phosphoric acid*, 11%. *Potash* 2.5%, *Nitrogen*, 2.5%

To get such a fertilizer as the soil and plant demand farmers must buy crude chemicals and mix them in proportions which prove best by trial, until such time as the fertilizer manufacturers discard the present stereotyped 12—3—3 formula which does not and never did rest upon any basis either of theory or practice.

With increased confidence in their value and adaptation to New Hampshire conditions, I reprint a few of the combinations given in Bulletin No 6. The amounts are for one acre where no manure is used, and in all cases, with hoed crops, two-thirds of the mixture is to be sown broadcast and harrowed in, the remaining third to be put in the hill or drill.

I.

FOR CORN AND WHEAT.

Dissolved Bone black	325 lbs.
Muriate of Potash	100 lbs.
Sulphate of Ammonia	75 lbs.
	500

V.

OATS.

Dissolved Bone black	330
Muriate of Potash	105
Sulphate of Ammonia	65
	500

VII.

HAY.

Dissolved Bone black	225
Muriate of Potash	254
Sulphate of Ammonia	21
	500

IX.

POTATOES.

	(a)	or	(b)
Dissolved Bone black	340		300
Muriate of Potash	160		150
Sulphate of Ammonia			50
	500		500

It is hoped that this Bulletin will lead some of our farmers to test these combinations, using them side by side with Prepared fertilizers.

G. H. WHITCHER, *Director.*

The Bulletins of this Station are free to all farmers in the State who send a request for them to the Director.