MINOR THESIS

THE CAUSE OF INJURY TO MAIZE BY WEEDS

Clement Ellis Craig, B. S.

1908

To Dr. T. L. Lyon, the author wishes to express his appreciation for the kindness in directing the investigation herein treated.

And to Dr. J. A. Bizzell, who made the chemical analysis of the soil solution.

THE CAUSE OF INJURY TO MAIZE BY WEEDS.

A MINOR THESIS

Presented to the

DEPARTMENT OF EXPERIMENTAL AGRONOMY CORNELL UNIVERSITY

For the Degree of

MASTER OF SCIENCE IN AGRICULTURE

by

Clement Ellis Craig, B. S.

June, 1908.

CONTENTS

CONTENTS

CONTENTS.

CONTENTS.

INTRODUCTION

That weeds cause injury to crops is a fact about which there is no difference of opinion. The exact cause of this injury, however, is not so well understood. Two reasons are usually assigned, namely, the loss of moisture and plant food. Some experimenters emphasize the former, while others lay greater stress on the latter. Some seem to consider the two causes as equally injurious. That weeds lower the moisture content is the common experience of farmers and there is also very conclusive experimental data on this point. The belief that injury results from loss of plant food seems to be based chiefly on reasoning from general principles and from the chemical analysis of weeds. Another cause assigned, based on experimental data, is the lowering of the soil temperature. One asserts that the lowering of the temperature hinders the efficiency of the roots and lessens the decay of organic matter. Shading of the crops is another cause assigned. Again root interference is proposed ; and the possibility of a toxic effect has been suggested.

Thus it will be seen that there are many explanations either singly or in combination, offered for the well-known

phenomenon, that weeds injure crops. Two of these causes, however, in the opinions of experimentalists stand pre-eminent ; namely, injuries due to loss of soil moisture, and to loss of plant food. The chief attention was, therefore, directed to these causes.

The thesis is divided as follows :

1. Historical
2. Experimental
3. Appendix.

In the historical part, the literature is reviewed and discussed.

In the experimental part, an account of the experiment is given, together with discussions chiefly in the light of the historical treatment.

In the Appendix, a limited study of the soil under experiment is made.

HISTORICAL

Effect of Weeds on Yield and Quality of Produce.

The Minnesota Station (Bul. 68, 588)"in 1898 planted corn in drills in two plats in a similar manner, the plats being run in duplicate. On one plat the corn was cultivated thoroughly, no weeds being allowed to grow, and a loose mulch of earth two or three inches deep was maintained throughout the early part of the summer. The other plat received but slight cultivation, the weeds being allowed to grow freely until July 21, when they were removed by hand and the soil cultivated." The weeds grown were mostly pigeon grass, and were mature when harvested. The results are shown in Table I.

Table I : Showing Effect of Weeds on Yield of Stover and Ear Corn, Rate per Acre.

Corn	Weeds	Ear Corn	Stover	Ear Corn and Stover	Total
Well cultivated		4824#	6703#	12762#	12762#
Poorly cultivated	3540#	2592#	3653#	6989#	10529#

A yield of 3540 pounds of weeds reduced the yield of corn fodder (stover and ear corn) 5773 pounds or 45 per cent ; the reduction in the yield of ear corn was 2232 ppunds or 46 per cent. The percentage of ear corn was nearly the same in both cases. The rate of reduction in yield due to weeds was 1.69 pounds corn fodder for each

pound of weeds. These results refer to weights at harvesting. Had dry matter been determined doubtless there would have been found a greater per cent of dry substance in the pigeon grass than in the corn. But the yield of corn fodder on the plats is comparable, and shows a marked reduction. The New Hapshire Station (Bul. 71, 54) compared two plats of corn, both cultivated ; but in one witch grass was allowed to grow, while in the other the grass was cut with a hoe. The results follow in Table II.

Table II : - Showing Effect of Witch Grass on Cultivated Corn - Results Rate per Acre.

Kind Culture	Stover	Shelled Corn
	lbs.	bus.
Hoed	11843	81.6
Not Hoed	9188	61.4

The grass caused a reduction in yield of both stover and shelled corn. The yield of stover in the plat not hoed was 77.6 per cent of that where hoed and the yield of shelled corn 75.2 per cent, thus showing a slightly greater reduction percentagely of shelled corn than of stover. The same Station (Bul. 71, 50) compared corn with no cultivation, weeds being permitted to grow, with corn cultivated. The results follow in Table III.

Table III : Showing Effect of Weeds on Yield of Corn

Kind of Culture	Stover lbs.	Shelled Corn bus.
No Culture, weeds growing	4420	17.1
Cultivation, frequent	12016	80.6
Cultivation, ordinary	11496	79.1

The weeds caused a great reduction in yield both of stover and shelled corn. The yield of stover where weeds grew was 38.4 per cent as much as where ordinary cultivation was given, and of shelled corn 21.6 per cent. Manifestly the quality of shelled corn was lowered.

The South Carolina Station (Bul. 61, 11) grew cowpeas in corn for two years with the results shown in Table IV.

Table IV : Showing Effect of Cowpeas on Yield of Ear Corn :

	1898 bu.	1899 bu.	Average bu.
Corn, no cowpeas	58.0	66.8	62.4
Corn, cowpeas in drills between rows	60.0	69.9	64.9
Corn, cowpeas broadcast " "	64.0	73.2	68.6

The corn was planted in rows four feet apart, one stalk to the foot in each case. Peas sown in drills showed an increase over no peas both years and peas broad-

cast showed a still greater increase. Whether the increase is due to peas being a leguminous crop or to some other cause is a question. The results seem to suggest the importance of distinguishing between "weeds" when studying their effect on either the soil or the crop.

At the Cornell Station during the summer of 1905, Cates conducted experiments to determine the effect of "weeds" on corn. The "Weeds" were rye, millet, and miscellaneous weeds. Table V is adapted from Cornell Bul. 247, 186, and shows the yield of both corn and "weeds". The table is arranged in series I, II, and III, and shows the effects of rye, millet, and miscellaneous weeds respectively. In each series, plats 1 and 4 are checks. In the column "Productive Capacity, Corn Fodder" is shown what presumably would have been the yield of corn fodder had no "weeds" been grown on the plats. These figures for plats 2 and 3 are calculated from the checks 1 and 4 where no "weeds" grew.

"Plats 1 and 4 were cultivated throughout the whole period of growth, viz., about once in ten days from June 14 to August 22. On June 14, plat 2 was cultivated when Series I was sown to rye, series II to millet, and series III allowed to grow to weeds without further cultivation. Plat 3 was cultivated June 14 and again June 27, when each

series was treated as plat 2."

Table V : Showing Yields per Plat of Corn and "Weeds"

	Green Weight					Field Cured		
	Series I Corn with Rye							
No. Plat	Productive Capacity Corn fodder lbs.	Corn Fodder lbs.	Rye lbs.	Total lbs.	Increase(+) Decrease (-) lbs.	Stover lbs.	Ear Corn lbs.	% Ear Corn to Fodde
1 ch	216.9	216.9		216.9		59	46.3	44
2	224.3	105.2	75	180.2	-44.1	38	21.5	36
3	231.7	131.1	78	209.1	-22.6	38	35.0	48
4 ch	239.0	239.0		239.0		63	48.0	43

	Series II Corn with Millet							
No. Plat	Productive Capacity Corn fodder lbs.	Corn Fodder lbs.	Millet lbs.	Total lbs.	Increase(+) Decrease (-) lbs.			
1 ch	122.5	122.5				38	33	46.5
2	125.1	49.1	100	149.1	+24.0	30	3	9
3	127.7	73.4	48	121.4	- 6.3	38	13	25.5
4 ch	130.2	130.2				40	38	49

	Series III Corn with Weeds							
No. Plat	Productive Capacity Corn Fodder lbs.	Corn Fodder lbs.	Weeds lbs.	Total lbs.	Increase (+) Decrease (-) lbs.			
1 ch	103.8	103.8		103.8		33	35	51.5
2	126.6	53.9	42	95.9	-30.7	26	11	30
3	149.4	104.1	45	149.1	- .3	42	32	43
4 ch	172.1	172.1		172.1		47	58	55

Series I, giving results with rye, shows a decided decrease in total green weight of produce, Series II with millet shows an increase, and Series III with weeds shows a decrease. Had dry matter been determined it is probable that, if the results had been averaged for the three series, the total produce where "weeds" were grown would have exceeded that of the checks. Allowing for the probable difference in dry matter between corn fodder and millet, the results in Series II show a very decided increase in total produce where millet was grown in the corn. The corn fodder as indicated by the green weight, suffered a much greater injury in this series than in series I and III.

Of field-cured stover where "weeds" grew the injury is not nearly proportionate to that of total fodder. The yield of plat 3, Series II is practically equal to that of the checks. But the yield of ear corn is much reduced in every case. The per cent of ear corn to field-cured fodder is less in every case where "weeds" grew except in plat 3, Series I. This reduction is most marked both in weight and per cent of ear maize in Series II where millet grew. There is less injury in every case to ear corn from the later sowing of "weeds" (Plat 3) than from the first sowing (Plat 2) : Manifestly, the lowering of the quality further emphasizes the injury.

While not directly applicable to corn, perhaps, some results from German and Scandinavian sources with miscellaneous crops will be helpful as indicating general principles. From an abstract in Fuhling's Landwirthschaftliche Zeitung, XLIV (1895), 355 is derived Table VI :

Table VI : Showing Effect of Weeds on Crops :

Kind	Part	No Weeds grms.	No Weeds % whole plant	With Weeds grms.	With Weeds % whole plant	Injury per cent
Peas	Grains	349	21.1	266	20.8	23.8
	Straw	1301		1016	.	22.4
Field Beans	Grains	850	37.9	470	34.1	44.7
	Straw	1390		910		34.6
Potatoes	Av. tuber	57.5		35.8		
	All tubers	27775		12775		54.0
Kohlrabi	Roots	16680	70.4	1816	64.4	89.1
	Leaves	7000		1000		85.7
Garden Beets	Roots	9000	79.4	338	50.7	96.3
	Leaves	2333		329		85.9

The number of potatoes where no weeds grew were 483 and with weeds were 357.

The injury in every case is marked being the most severe with the root crops. The percentage of injury was uniformally greater with the grain and roots than with the

straw and leaves.

From a Scandinavian source the results in Table VII are taken (E.S.R. 15, 683)

Table VII : Showing Effect of Weeds on Yield :

Results given in kilograms per Hretare.

Crop	Part	No Weeds	With Weeds Crop kilo	Weeds kilo	Crop and Weeds kilo	Total Decrease(-) kilo
Hay		6180	2890	1740	4630	-1550
Barley	Grains	2246	833		4975	-1066
	Straw	3795	2407	1735		
Potatoes	Tubers	22101	11330			

The decrease in yield of crops is marked in every case, a yield of 1740 pounds lowering the hay yield 3290 pounds. 1735 pounds of weeds lowered the yield of barley grain 1413 pounds, and of barley straw 1388, making a total of 2801. The percentage of injury to the grain was much greater than to that of straw. The decrease in total yield was also marked. This is especially interesting since it is usually supposed that both hay and barley have relatively large water requirements, as well as weeds.

The foregoing data, while giving unmistakable indications, would have been more valuable, especially for the purpose of a soil study, had dry matter been determined.

However, except where cowpeas were grown in the corn, the presence of "weeds" in every case lowered the yield of corn fodder ; and usually the percentage of ear corn to fodder was much reduced. The data showing the total yield if taken as reported, also usually show a decided decrease. But had dry matter been determined, the writer is of the opinion that the results would be very conflicting.

The effect of weeds on low-growing crops in Europe is more marked than on corn in this country. This may be due partially at least, to the greater shading. Where the yield of weeds are reported (p. 11) in these European tests, the total yield is much reduced.

<u>Effect of Weeds on Moisture.</u> Experimenters are agreed that one of the injurious effects of weeds on crops is the robbery of soil moisture. Warrenton states (Physical Properties of Soils, 125) that weeds are most injurious in a dry climate. It is further generally supposed that weeds require more moisture for the production of a given amount of dry matter than do most agricultural plants. Hays and Smith (Minn. 68, 588) in referring to pigeon grass (which was used in an experiment to determine their effect on corn) seems to voice the general belief as to all weeds by stating, that it is quite probable that these weeds use more water in producing a pound of dry matter than does corn.

The Minnesota Station (Minn. 68, 588) in the experiment just referred to (Also see p. 4) found that the moisture in the corn plat where no weeds grew varied from 36 to 20 per cent (data approximated from graphic table) while where weeds were growing in the corn the variation was from 49.5 to 7 % a difference between the minimum of 13 % against where weeds grew. These variations occurred between June 29 and July 28 just after the weeds were pulled. On August 5 the moisture in the weed-free plat reached 17 %, which was the lowest of the season. Assuming that this was about as lowest [illegible] which

the corn could extract the moisture from the soil, it appears that 10 % more moisture was available for the weeds than for the corn. The rapidity with which the weeds consumed the moisture is shown as follows :

Date	Rainfall	% Moisture (1)
July 7	1.44 in.	49.5
" 13		32.5
" 16		13.0
" 18	.55	
" 19		14.5
" 26		7.0

(1) Per cent moisture approximated from graphic statement.

Since the weeds were pulled July 21 the lowest moisture content was probably reached on that date. These moisture determinations were made by the electrical method.

King (Bu. Soils, 26, 44) determined the moisture content on the surface foot of two soils which were in weedy fallow. The results were averages from thirteen fields in each case. The Selma silt loam contained 6.83 % and the Goldsboro compact sandy loam, 3.64 % moisture.

At the Cornell Station (Bul. 247, 186) experiments were conducted with rye and millet, and weeds in corn. The data gives the average per cent of moisture taken at intervals between June 27 and August 15. Table VIII is quoted :

Table VIII : Percentage of Moisture on Cultivated and Weed Plats :

Plat	Treatment	Series I Maize with rye	Series II Maize with millet	Series III Maize with weeds
1	Cultivated	24.7	27.7	26.8
2	"Weeds" after June 14	22.0	24.8	21.3
3	"Weeds" after June 27	23.6	24.9	22.3
4	Cultivated	26.3	28.3	24.6

These results show a decrease in every case where "weeds" grew in corn. Had the season been dry and the data given in detail doubtless a greater variation against "weeds" at some periods would be shown.

Composition of Weeds, Corn, Millet, Soy Beans, and Cowpeas.

Cameron (Bu. Soils, 28, 6) observes, that "different crops and even the same crop under slightly varying conditions remove not only widely different amounts, but widely different proportions of mineral constituents from the soil."

Snyder (Soils and Fertilizers, 194) states that, "the amount of fertility removed in weeds is usually greater than that in agricultural plants because the weeds have a greater power of obtaining food from the soil." Again, the same author (Minn. Bul. 101, 244) says that, "weeds have large amounts of water and proteids. There is more protein in dry matter of purselane, pig weed, lambs quarter, cheese weed, and catnip, then in either alfalfa or clover. The drain on land by these weeds is because of the nitrogen they contain."

The Florida, West Virginia, and Minnesota Stations have made numerous analyses of weeds. Table IX, showing data on the composition of weeds as well as analyses of some agricultural plants for comparison, is as follows :

Table IX : Showing Composition of Weeds, Corn Fodder, Millet, and Soy Beans - Dry Matter.

Plant	Number Analysis		Authority	N. %	P_2O_5 %	K_2O %	Ash %
Weeds	49	Average	W. Va.19	1.62	.53	2.51	
Poke Weed	1	Max.Comp.	"	3.38	.65	8.00	
Broom Sedge	1	Min. "	"	.78	.21	.68	
Tall Ragweed	1		"	1.36	.41	1.79	
Weeds	15	Average	Minn.101 244	2.81			16.51
Pig Weed		Max. N	"	4.25			
Field Shuttle		Min. N	"	1.57			
Lamb's Quarter		Max. Ash					18.34
Goldenrod		Min "					6.89
Pigeon Grass				2.60			12.77
Purselane		Max. Comp.	Fla. 11	4.05			26.02
Cotton Head Weed		Min. "	"	.71			5.66
Corn Fodder	35		O.E.S. 11	1.25			4.7
Millet	1	Heads partly filled	" 11, 38	2.05			8.6
Millet	1	In bloom	" "	1.41			5.8
Millet	1		Minn.Rept. 1894, 134	1.18			10.17
Millet	12	Dry fodder	O.S.B. 11, 14	1.30			6.50
Cowpea	8	" Hay	"	2.98			8.50
Soy Beans	6	Green fodder	"	1.92			9.50
Soy Beans	1	Cut Aug. 30	"76	2.42			8.50

The table shows a wide variability in the composition of weeds. This strongly suggest the necessity of noting the characteristics of the particular weed with which any experiment is conducted to determine their effect on another crop. Further, it suggests possibilities in soil studies since by the proper selection of weeds to grow on the soil useful variations may be secured.

The nitrogen content of millet seems to be slightly higher than in corn fodder, and the ash content is decidedly higher. Doubtless the composition of millet varies as widely as does that of corn. Soy beans are decidedly higher in both nitrogen and ash than corn fodder and cowpeas.

Effect of Weeds on Fertilizing Constituents.

It has been noted above (p. 17) that many weeds possess a very high nitrogen and ash content. It would appear that they might cause injury by removing either nitrogen or the mineral elements. On land where phosphoric acid or potash or nitrogen is highly beneficial to crops, it would seem reasonable that a weed with a high ash and nitrogen content would cause injury by removing the deficient element or elements whatever they might be. But in the discussion under this head, nitrogen will receive the greatest share of attention, since nitrates cease to form after the soil moisture reaches a certain low limit, and since the nitrates in the soil show a greater variability than the other essential elements, Considerable attention will be paid to phosphoric acid, and but little will be given to potash. The potash requirement of soils is not so variable as either phosphoric acid or nitrates, and data is not so available.

Snyder (Soils and Fertilizers, 115) states, "Nitrification cannot take place in a soil deficient in moisture. As in all fermentation processes, so with nitrification, moisture is necessary for the chemical changes to take place. In a very dry time nitrification is arrested for the want of water."

Warrenton (Physical properties of Soils, 85) refers to experiments by Schloesing Jr. (Compt. rend. CXXV, 824)

upon the effect of amount of water on the nitrification of Ammonium sulphate. The experiments were made on artificial mixtures of sand and clay in various proportions, including a small quantity of chalk. The same percentage of water was added to each mixture for the main line of the experiment. A further variation was secured by adding more water to the more clayey mixtures. The rate of nitrification, where the same amount of water was added, was more rapid in the sand than in the clay. "By increasing the percentage of water in the soils containing the most clay, the rate of nitrification was raised to that observed in the sandy soils. He (Schloesing Jr.) concludes that the different rate of nitrification is mainly due to the different thickness and therefore availability of the water film coating the particles of the various mixtures."

Where weeds or any other crop rapidly lower the moisture in the soil, it would seem that there would be less nitrate formed than where the moisture condition is good.

King (Bu. Soils 26, 52) gives the variability of water soluble NO_3 and HPO_4 in the surface four feet in eight states as follows :

NO_3 varies in the proportion of 1 to 8

HPO_4 " " " " " 1 " 4

In each case 1 represents the smallest amount of the respective constituent found.

In another table (p.) is given the range found in eight soil types.

NO_3 varies in the proportion of	1	to	5.8
HPO_4 " " " " "	1	"	2.8
K " " " " "	1	"	2.4

Cameron and Bell (Bu. Soils 30, 67) state that "analyses of a number of extracts obtained from several types of soil of widely different origin and composition have yielded an average for potassium (K) of 27.3 parts, and for phosphoric acid (PO_4) 8.5 parts per million solution. The approximate uniformity of the individual results makes it appear improbable that a further accumulation of data would change these average figures materially."

In August and September (Bu. Soils 26, 49, 50,) thirty-two determinations were made of the water soluble acid radicles in the soil under corn. There was a wide variation of soil types, studied in various states. The data is the sum of results for four feet and is accordingly given in parts per four millions (pp4m) dry soil. The range of NO_3, pp.4 m was 3.17 to 334.32 , 12 ran below 10 pp.4 m. , 37% of the determinations showed less than 2.5 p.p.m. NO_3 per foot. The range in HPO_4 was 2.44 to 39.56 p.p.4m.

These show a wide variability for both NO_3 and HPO_4.

The acid radicals were determined for in the soil under cotton for the 1st, 2nd, 3rd, and 4th feet, in a Norfolk sandy soil (Bu. Soils 26, 39). The results follow in Table X.

Table X : Amount water Soluble NO_3 and HPO_4 in Soils under Cotton in Norfolk Sandy Soil, Goldstruo, N.C.

	Surface Foot			2nd Foot		
Month	H_2O	NO_3	HPO_4	H_2O	NO_3	HPO_4
April	10.13	28.70	18.20	16.42	30.01	11.30
May	9.06	50.00	10.56	13.01	9.03	4.28
June	6.95	37.58	9.86	11.39	4.18	7.33
July	3.41	2.99	10.21	7.29	1.74	8.82
August	5.26	2.54	.72	8.46	3.22	1.94
Sept.	3.74	1.30	2.88	8.93	.98	2.24

	3 rd Foot			4th Foot		
April	16.28	22.70	9.70	19.19	38.40	9.30
May	15.75	8.07	3.61	16.55	14.93	3.23
June	13.85	6.51	6.70	15.61	10.72	4.82
July	11.73	7.66	6.94	14.95	12.88	5.98
August	10.99	4.60	.77	14.16	12.30	.79
Sept.	12.61	4.88	1.55	14.81	14.76	2.39

These results show in a general way that the NO_3 lowers with the moisture. The results in the surface foot in May and June, however, show an increase, although there is a slight decrease in moisture. But for this period there is a decided decrease in NO_3 in the second and third feet. In July when the lower soil seems to be unable to permit any material amount of NO_3 to be transferred to the surface the fall in this radicle was extreme. The moisture for this period was very low. In August the moisture in the surface had increased considerably, but there was no corresponding increase in NO_3. In the fourth foot there was considerable reduction of NO_3, in May, and a slight reduction in moisture. After this period the amount of NO_3 was fairly constant with a slight decrease in moisture content. It is hardly probable that this was beneath the action of capillarity had there been sufficient moisture in the surface. The roots of the cotton plant doubtless penetrated somewhat into the third foot of soil, but did not reach the fourth foot. The data shows a valuable reserve in this soil beneath three feet, accumulated by leaching from the surface which under the proper conditions of capillarity would be of material advantage to the plant.

The HPO_4 was considerably higher the first month than later at each depth, and lowest in August. It has been noted that the moisture content was increased during thee

month and presumably the NO_3 should have been also. Was there an increase in NO_3 not shown in the table which caused a greater consumption of HPO_4? And HPO_4 being the less diffusible, is it improbable that for a short period it was the limiting factor rather than NO_3 ? In general the HPO_4 decreases with the depth, but would not seem to be a limiting factor except possibly in August.

The results (Bu. Soils 26, 47) on the Poccosan soil show a decided fall in NO_3 in the surface four feet, notwithstanding an increase in moisture as shown in Table XI.

Table XI: Moisture and NO_3 Content in Poccosan Soil Where Corn was Growing.

Date	Moisture %	NO_3 pp 4 m	HPO_4 pp. 4 m
May 30	1823	65.34	36.94
Aug. 27	2065	11.21	14.20

In a wooded tract of large trees on Goldsboro compact sandy loam, the NO_3 lowers very much more rapidly than the moisture in each of the surface four feet of soil (Bu. Soils 26, 45). The fourth foot, just referred to above, is drained as completely of its NO_3 as the surface foot. The difference to which the roots penetrate, perhaps at least is a factor in causing the variation. The HPO_4 is much

more abundant in the surface foot than below. While the minimum is not as low as in the Norfolk sandy soil, diffusion would seem to be less effective, which gives rise to the suspicion that HPO_4 may have been equally as difficult for the plant to secure as was NO_3. As in the Norfolk sandy soil, the lowest proportion HPO_4 in each of the four feet occurs on one date, which in this case is May 23.

The above series of data indicates the general variability of NO_3 and of HPO_4. The HPO_4, while doubtless deficient in some cases, does not generally seem to show the variability which NO_3 does. It would be expected, therefore, that any plant growth which made large demands on these substances, would make rapid and large changes upon the soil content of these radicles.

The effect of weeds growing alone upon the acid radicles as compared with those where crops were cultivated is shown by King (Bu. Soils 26, 44). The results which follow are given for the surface four feet :

Soil from	NO_3 p.p. 4 m.	HPO_4 p.p. 4 m.
Selma Silt Loam;		
Single field, best care	18.95	26.05
20 fields, less care, average	27.53	35.51
13 fields, weedy fallow, "	6.30	39.54
Goldsboro compact, sandy loam :		
Single field, best care	17.85	22.77
20 fields, less care, average	25.94	22.64
13 fields, weedy fallow, "	9.33	20.45
Wooded tract	17.54	23.23

While there may be a question about the results being strictly comparable, the poverty of NO_3 is very striking, and especially so if it remembered that these results are in parts per four million (pp 4 m.). The HPO_4 shows a dewided increase when weeds are growing in one case, and a very slight decrease in the other instance. It would seem clear that the NO_3 is entirely too low for proper plant growth.

The Cornell Station (247, 187) gives the total soluble salts and NO_3 recovered where rye grew in corn and NO_3 when millet was likewise grown. The following table shows the adapted results :

Table XII: Effect of "weeds" Growing in Corn on the Total Salts and NO_3 Content of the Soil.

No. Plat	Treatment	Series I, Corn with Rye: Total salts ppm June 27	Total salts ppm Aug, 25	NO_3 ppm Aug. 25	Series II Corn with Millet: NO_3 ppm Aug. 8
1	Cultivated, no "weeds"	600	329	160.0	23.0
2	(1) "Weeds" sown June 14	644	180	15.0	7.3
3	(1) "Weeds" sown June 27	551	226	29.0	7.4
4	Cultivated, no "weeds"	519	329	165.0	71.5

(1) "Weeds" refer to rye and millet respectively.

The total salts show a decrease on Aug. 25 as compared with June 27. In plats 2 and 3 where weeds grew the reduction was much more marked than on the checks, and of these more marked where the weeds were sown earlier in the season. Whether the essential elements varied to correspond with the total salts is a matter of conjecture. But the variation of the NO_3 due to "weeds" was very marked. The variation between the check plats is also great, due doubtless in a large measure to being taken at different dates. There was further a great difference in the NO_3 in the check plats, Aug. 8.

Hosford, under Professor Hunt's direction (Cornell 247, 190-192), approached the problem in a different manner. Sodium nitrate was applied to the end of a plat (462) Table XII, where millet was growing in corn. This part of the plat is designated as 462 N, after the fertilizer was applied. The growth on the whole plat was seriously checked as compared with the check plats where corn was growing alone and receiving cultivation. When the sodium nitrate was applied, the moisture in this plat, judging from the averages of soil moisture, was not low enough to cause the lack of growth, but the NO_3 in the soil was running very low. "Twice the amount of nitrate of soda necessary to supply 86 parts per million of dry soil to 2,000,000 of soil or to a depth of 8 inches was applied to 35 hills of the maize plat, known as 462 N.on July 6, 14, 21, and 27, or four applications in all. At the end of the first week or on July 14, both the maize and the millet were much greener than the rest of the plat (462) not so treated, but it could not be said with certainty that the growth was greater although it seemed a shade longer ; on July 18, however, the hills were distinctly larger than the other hills of the millet plat, and as green as the plants on the cultivated plat."

The water soluble nitrogen is shown in table XIII.

Table XIII: Variations in Water-soluble Nitrogen.

Date	461 Cultivated plat pp m	462 Millet in maize pp m	462 N End of 462 which was fertilized. pp m
May 31	56.4	40.0	
June 11	80.0	80.0	
June 22	73.9	60.9	
July 2	96.0	10.0	
July 8	68.5	11.5	21.8
July 19	52.7	7.5	48.0
July 30	12.3	3.8	160.0
Aug. 16	26.0	7.3	320.0
Aug. 21	10.5	9.6	218.2
Aug. 29	6.2	2.8	282.5

There can be little doubt that the increased size and vigor of the plants in plat 262 N was due to the increase of NO_3 in the soil.

Incidentally, it may be noted that the NO_3 in check plat 461 probably ran too low for good plant growth on Aug. 21 and 29.

TRANSPIRATION

The loss of water from the soil when plants completely cover the ground is chiefly through the plants. Generally, weeds lower the moisture more rapidly and to a lower limit than corn (see discussion above). Plants also vary in the amount of water required to produce a pound of dry matter. Warrenton (Physical Properties of Soils, 53) has collected data which follows in Table XIV :

Table XIV : Water Evaporated by Growing Plants for One Part Dry Matter Produced :

Results obtained by							
Lawes and Gilbert		Hellriegel		King		Wollny	
Beans	214	Beans	262	Maize	272	Maize	233
Wheat	225	Peas	292	Barley	393	Millet	416
Peas	235	Barley	310	Potatoes	423	Peas	477
Red Clover	249	Red Clover	330	Red Clover	453	Sunflowers	490
Barley	262	Wheat	359	Peas	477	Buckwheat	646
		Buckwheat	371	Oats	557	Oats	665
		Lupine	373			Barley	774
		Rye	377			Mustard	843
		Oats	402			Rape	912

Wide variations occur in the amount of water required to produce a given weight of dry matter in different plants. In the two columns where corn occurs, less water is required than for any other plants given. Millet occurs only in Wollny's results, and requires 74.25 % more water than corn. Peas, on which data is given in the table, shows 235, 292, 477, and 477 parts, respectively for one part dry mateer. The figures given by Lawes and Gilbert show a greater economy of water than the others. Is this economy due to the moist climate of England, to the manner of conducting the experiment, or to some other cause ? The results from the German investigators differ widely.

King (Bu. Soils, 26) conducted experiments on transpiration from the corn plant on four different soils. The soil was placed in barrels and a constant supply of water maintained one foot from the surface. Evaporation from the soil surface was included in the transpiration results. When the corn made a very poor growth, the proportion of water required was about three times as great as when the growth was good. Manifestly, where the evaporation is included in the results, the data is untrustworthy as showing the transpiration. Yet the data has practical value and supports King's general observation, that where the trans-

piration (including evaporation) is large, there is a larger proportion of dry matter produced than when the transpiration is small. The inclusion of evaporation from the surface with the transpiration by some experimenters, and its exclusion by others, together with different rates of growth would be sufficient without other varying factors to cause the difference observed by the investigators quoted.

King (Wis. 8 Rept, 126) calculated the amount of water required to produce a pound of dry matter under field conditions. Barley required 402, oats 501, and corn 301 pounds of water. Variations due to evaporation and capillarity were included in the data. Hays (Minn. 68) calculated that wheat under field conditions required 261 pounds to produce a pound of dry matter.

Warrenton (Physical Properties of Soils, 52) observes that, the relation in question (between transpiration and dry matter produced) appears to be fairly definite so long as certain conditions remain constant, but to vary under a wide range of circumstances. Further (p. 53) : "Two circumstances seem especially to influence the relation of water supply to produce :

1. The amount of water supplied
2. Its richness or poverty in plant food.

These two circumstances are relatively connected. When the soil contains little water, the solution in the soil is comparatively concentrated in character. When much rain has fallen, the supply of water in the soil may be ample, but it contains very little plant food. "The presence of much soluble saline matter in the soil is probably a check to a rapid transpiration of water by plants."

THE RELATION OF TRANSPIRATION TO PLANT FOOD TRANSFERRED TO THE PLANT.

There seems to be two means of transferring plant food to the plant, viz., diffusion, and the mechanical transfer in the stream of water. The older plant physiologists seem to lay a greater stress relatively on the former than do later investigators. Storer, conforming to the views of the older investigators, cites the Wardian case, and plants growing in the greenhouse where the air is moist, as showing the importance of diffusion. He assumes that transpiration is not sufficient to cause the required transfer of plant food. May not the passage of water through the plant due to root pressure be greater than is assumed ? And may not the plant food in the artificial soils usually employed under such circumstances be more abundant, thus, perhaps, requiring less water to produce a given amount of dry matter ? Referring to the mechanical transfer of plant food, Loew (Bu. Plant Industry 45, 11), states that, "the surplus of mineral matter found in plants, nutrient as well as indifferent compounds,- depends to a great extent upon the intensity of the current of transpiration, which explains

why herbaceous plants show a higher percentage of ash for the dry matter than do the leaves of woody plants." Warrenton (Physical Properties of Soils, 51) states, "The greater the evaporation (transpiration), the greater the transferrence of plant food from the soil to the plant."

CAPILLARITY

The writer under Professor Fippin's direction determined the capillary rise of water in four air dry soils of different textures. Soil 1 was secured by separating a coarse, sandy soil with a half m.m. sieve, that which failed to pass through being retained. Soil 2 was secured from that which was eliminated in securing Soil 1, and which failed to pass through a tenth m.m. sieve. Soil 3 was a silt loam, and was not passed through a sieve. Soil 4 was a caked clay loam, which was broken down with a roller and passed through a half m.m. sieve. Glass cylinders 40 c.m. internal diameter were prepared by firmly tying a dam of folded cheesecloth over one end. The soil was carefully placed in the tubes, avoiding the formation of air spaces. The cylinders were set in pans in which water was maintained at a depth of about two inches. The results in Table XV refer to rise above the water level.

Table XV : Capillary Rise in Soils of Different Textures - in Inches.

Capillary Rise at Different Periods

No Soil	10 mm.	1 hr.	2 das.	7 das.	13 das.	27 das.	48 das.
1	7	8.5	11.0	12.3	13.3	14.7	16.2
2	8.5	10.7	13.2	14.8	15.7	17.2	19.0
3	3.5	7.1	38.8	55.5	65.0	72.0 or top	
4		1.7	10.1	18.1	22.5	28.7	35.7

The coarse soils 1 and 2 show the most rapid rise in the beginning, but fall far behind toward the end of the experiment. Soil of medium texture permits the water to rise rapidly, diminishing toward the last, when it reached the top of the cylinder. Doubtless in time the rise would have been considerably higher had the column been longer. Soil 4 showed a slow rise, and judging from the results in capillary tests by the California Station, it is probable that it would never have reached above 48 inches. Had it been convenient to determine the rise in moistened soil, the capillary rise would have been greater and perhaps the comparative results would have been somewhat different. These differences, however, indicate the great variations in the capillary power of soils - differences which should be eliminated as far as possible in experimental work. When the soil is put under special stress, such as growing "weeds" in corn, the variations due to this cause might

reasonably be expected to very seriously modify results.

Warrenton (Physical Properties of Soils, 101), quotes experiments on capillarity made by King (Wisconsin Station) when the water was maintained at different depths beneath the surface. The results follow in Table XVI.

Table XVI : Rate of Capillarity, where Water was Maintained at Different Depths from the Surface.

Pounds per Square-foot Surface.

Soil	Distance Water Level Beneath Surface			
	1 ft.	2 ft.	3 ft.	4 ft.
Fine Sand	2.37 lbs.	2.07	1.23	.91
Clay Loam	2.05	1.62	1.00	.90

The evaporation or amount transferred to the surface by capillarity was sufficient where the water was four feet beneath the surface "for the most luxuriant growth."

These results, however, are not secured in the field since crops suffered with the water table within five feet of the surface. The roots would easily penetrate to within four feet of the water table. Warrenton assigns as a reason for this that in the laboratory the soils are usually screened so that the particles are of a fairly uniform size, while in the field there is a greater variation ; and that the water level in the field does not supply

moisture as readily as artificial supplies in the laboratory. The objection that the soils used in the laboratory are different from the field soils, however, does not apply to the Wisconsin results. The same author (p. 105) further states ; "The practical effect of capillary action in raising water to the surface of the soil to the level occupied by plant roots, has apparently been very much exagerated ; its influence on the distribution of water in the soil is nevertheless very large."

Some Florida trucking soils (Bu. Soils 13, 8, 9,) however, seem to possess a remarkable power of maintaining a sufficient, although very low, percentage of moisture. "The soil is a coarse white or yellow sand underlaid by a coarse sandy subsoil. It looks like a barren sea sand or a coarse sharp building sand, but that it is very productive is shown by the large and vigorous growth of pines, the luxuriant growth of grass, the great quantity of truck crops which can be produced during the season, and the enormous growth of beggar weeds which take possession of the land after the crop is removed." The surface is rolling, varying from 25 to 50 ft. Standing water is 15 to 20 feet beneath the surface. After a rain the surface inch or two is soon as dry as dust, but the moisture 3 to 6 inches beneath the surface never falls below 3 % and perhaps 4 %

to 5 % is optimum. At 6 % the soil is quite wet. No shoratge of soil moisture occurred during the period of observation, although there were periods of 15 to 20 days without rainfall. Mechanical analysis shows 94.87 % medium and fine sand in the surface soil, and 95.28 % in the subsoil, and most of the remainder was coarse sand. There is thus an unusual uniformity in the size of the soil particles, a condition which Warrenton suggests is favorable to capillarity Yet this author thinks possibly the remarkable results in this soil may be due to condensation. The fact that it is situated in a peninsula, together with the depth of the water table, would give credence to this supposition. But Whitney, in support of the theory that the result is due to capillarity, cites soils in dry climates of Southern California and Texas, where it is not unusual for crops to thrive for a period of five or six months without either rainfall or irrigation.

This difference in capillary power suggests an explanation for Hosford's results (Cornell 247, 189) where the largest yields of corn fodder were secured where the soil moisture was the lowest. The results are given in Table XVII, which is quoted as it occurs in the bulletin.

Table XVII : Influence of Texture of Soil upon Moisture Content and its Relation to Yield of Maize.

South Series		North Series	
Water per cent	Maize Fodder lb.	Water per cent	Maize Fodder
17.8	762	14.7	903
16.0	731	13.8	904
15.1	778	11.9	859
14.6	972	10.6	1001

Hunt, in discussing the results (p. 189) observes ; "The differences in the percentage of moisture in these plats are due to the character and perhaps the topography of the soil, the lower percentages being on the sandier and higher ground. In general the lower the percentage of moisture, the larger the yield of maize. It is extremely unfortunate that the proportion of water soluble nitrogen was not determined by these plats." While the amount of soluble nitrogen is suggested as an explanation of the difference in yield, the relative coarseness of the soil of plats producing the best yields, would in the light of results obtained in the laboratory, and observed in the Florida soils, indicate a higher capillary power.

The size of soil particles which have the greatest capillary power appears to be larger than is usually supposed.

RELATION OF CAPILLARITY TO TRANSFER OF FERTILIZING CONSTITUENTS.

King at the Wisconsin Station (see p.38), found that after evaporation experiments had run for some time, salts accumulated on the surface in sufficient amounts to hinder the loss of water. The same investigator, when discussing the high salt content in the upper four feet of some soils, observes ; "It is the writer's judgment that the relatively high salt content for the soils of Georgia and South Carolina are to a considerable extant due to a protracted drought, which had prevailed in the regions where the samples were taken, and which, through capillary rise and long and strong evaporation had concentrated the salts in the zone sampled."

Warrenton (Physical Properties of Soils, 191) states that, "salts may be concentrated in a solid form or as a strong solution at the surface ; this is especially the case after active nitrification, after drought, or especially and to the greatest extent after the application of a dressing of saline manure. Opposed to this tendency to accumulation at the surface we have the action of rain which tends to carry all soluble salts into the subsoil."

The alternate movement of the water upward and downward perhaps explains the sudden increase of soluble nitrogen noted at times late in the season. Where rain occurs after an accumulation on the surface of nitrates derived either from the soil or from an artificial application, the nitrates beneath the surface will increase. Probably if the soil sample includes the surface soil, such sudden fluctuations would not occur. There is, however, another possibility in a high rate of nitrification due to a good moisture and temperature condition. If the plants should cease to use soluble nitrogen some time previous to taking the soil sample, there would be an additional cause for an increase of this constituent.

DIFFUSION OF SOIL NUTRIENTS.

Warrenton gives the relative diffusion of salts as determined by Marignac, as shown in Table XVIII.

Table XVIII : Relative Diffusion Coefficients of Salts.

Relative Diffusibility of Acids		Relative Diffusibility of Basis			
Potassium Salts			Chlorides	Sulphates	Nitrates
Chloride	114	Potassium	1.56	1.46	1.55
Nitrate	100	Ammonia	1.25		
Sulphate	60	Soda	1.00	1.00	1.00
Carbonate	50	Calcium	.65		.66
		Magnesium	.55	.51	.64

There seems to be a discrepancy in the results in the relative diffusibility of the chloride and nitrate of potassium being in one case 1.14 and 1.00 respectively, and in the other 1.56 and 1.55. The table, however, shows that salts containing the bases potassium and ammonia and the acids chlorine and nitrogen are relatively highly diffusible.

When the salts are diffusing together, the rate is slightly different from that where diffusing separately. "The rate of diffusion of the more diffusible salts is generally very nearly what it would be if diffused alone,

while the rate of diffusion of the less diffusible salt is distinctly diminished. The relative diffusibility is also sometimes affected by the strength of the solution employed."

While phosphoric acid is not shown in the table, it probably has a low rate of diffusibility.

The abundance of the water greatly affects diffusion. In water cultures, proportions of plant food nutrients occur far below the amounts required, if they were only taken up by the plant in the proportions occurring in the solution. In sandy soils, therefore, the diffusion is better than in clayey soils on account of the greater thickness of the water film. The hindering effect of adhesion would also be relatively less in sandy soils. But it is found that in heavy soils, even, the nitrates are nearly completely taken up. King (The Soil, 117) states that "at the time the crops are growing, the roots remove the nitrates, where these roots are found, so thoroughly that the measured amounts at any one place is small, the plants tending to pick it up as rapidly as it may be formed." In the results of the same author (Bu. Soils 26), previously quoted, where weeds were growing on two types of soil the nitrates were almost completely removed. There is considerable water retained in field soils in all cases, hence,

by diffusion only, can the nearly complete removal of nitrates be accounted for. Usually the phosphoric acid does not fall relatively so low in soil as nitrates. This may be due to the slower diffusion, or to the continuous solubility either in the field or in the laboratory, or to all combined.

While the movement of soil nutrients for any considerable distance in a reasonable length of time is due to the mechanical transfer by the water of capillarity or percolation, the transfer to the rootlets after the root zone is reached is probably chiefly due to diffusion. Capillary water passing to the surface may by this means be largely or nearly wholly divested of the salts which the plants require. Under such circumstances the analysis of the surface soil for soluble plant food would give little indication of the nutrients used by the plant.

The amount of plant food nutrients in a soil sample may not even approximately represent the amount used by the plant. However, the amount of excess would probably in most cases be some indication. Where the amount was abundant, the plant would be well supplied, but the amount might run down to a certain fairly or equally low limit, and the plant be nearly or equally as well supplied.

The results of nitrogen determinations in drainage water (Bu. Soils 26 ; Rothamstead Memoirs, V. 91) from plats of wheat variously fertilized are interesting in this connection. This land responds abundantly to nitrogenous fertilizer. The NO_3 as nitric acid found in the drainage water and the yields are shown in Table XIX.

Table XIX : NO_3 as Nitric Acid in Drainage Water, and Yield of Wheat at The Rothanstead Station. The Amount NO_3 p.p.m. Arranged in Ascending Order.

NO_3 p.p.m.	Yield Wheat lbs.
3.9	1726
5.1	1988
8.5	3348
13.9	3587
14.0	5013
15.1	4498
15.3	3716
16.1	5304
17.4	4967
18.4	6920
19.2	4716

The increase in yield is correlated with the increase of NO_3 in the drainage water till 15.1 p.p.m. NO_3 is reached,

after which the results vary although the average is above that reached where there was 14.0 p.p.m. NO_3. (This statement is not strictly correct since the results were obtained from drainage water which passed through the subsoil some distance before entering the drain. Doubtless the amount of NO_3 given is smaller than would have been secured had the determinations been made where the roots were feeding ; but the comparative results would probably have not been far different.) The difficulty in securing soluble nitrogen when the amount of NO_3 in this soil is below 14.0 p.p.m. is indicated. Many factors would affect the limit below which plants would suffer for lack of soluble nitrogen, one of which would be the closeness of the roots of the plants. It is probably, the limit for corn would be higher than for wheat if the soil moisture, temperature, and other conditions were the same.

When any crop with a close root system is growing with corn, is not the corn at an increasing disadvantage as the limiting fertilizing constituent was lowered in the soil ?

DROUGHT LIMIT.

The drought limit, or the per cent of moisture in the soil, where plants cease to secure sufficient moisture for growth, varies widely with the soil and to a less degree with the plants.

The Bureau of Soils conducted evaporation experiments under uniform conditions upon different types of soil. The soils were artificially saturated and small amounts were used. The loss in weight was about uniform till the optimum moisture was reached, after which there was a progressive decrease in loss till the hygroscopic moisture was reached. There appeared to be no definite point at which the rate of evaporation changed till the soil became air dry. The drought limit, therefore, appears to be the relation between the needs of the plant and the progressively decreasing ability of the soil to supply moisture, rather than any definite point at which the soil fails to give up moisture.

Numerous determinations by King, Whitney, and others show the wide variation in the capacity of soils in the field to give up moisture to plants.

Heinrich (Physical Properties of Soils 63, 64) determined the wilting point of plants in different soils. The plants were grown in very small boxes till fully developed, and then placed under conditions of very little evapora-

tion till they begin to wilt. The soil was then mixed and the water determined. The air-dry soil was also placed in a saturated atmosphere to determine the hygroscopic moisture. The results follow in the adapted table XX.

Table XX : Wilting Point of Plants and Hygroscopic Moisture in Different Soils Employed.

Soil	Moisture per 100 Dry Soil: When Plants wilted	Moisture per 100 Dry Soil: Hygros. Moisture	%Wilting Point above Hygros. Moisture.
Coarse sandy soil	1.5	1.15	30.4
Sandy garden soil	4.6	3.00	53.3
Fine humus sand	6.2	3.98	55.8
Sandy loam	7.8	5.74	37.6
Peat	49.7	42.30	12.8

The wide variability of soils in their capacity to give up water to plants is shown, but the wilting point is much below that found by Whitney, King, and others under field conditions. The plant employed in the experiment would affect the results. There is a suspicion that the moisture content shown in these results is too low, due to the small containing boxes used, and to mixing the soil before determining the moisture. The soil above where the roots were feeding possibly approached the hygroscopic condition. The wilting point is much nearer the hygros-

scopic moisture than the results obtained by the California Station.

The drought limits for weeds is lower than for corn. (See discussion under Effect of Weeds on Moisture)

INTERRUPTION OF WATER BY PLANTS

Weber (Physical Properties of Soils, 119) estimated that in the forests of Switzerland, Prussia, and Bavaria trees interrupted the falling moisture as follows :

Larch	15 per cent
Birch	19 " "
Spruce Fir	24 " "
Scotch Pine	30 " "

When weeds cover the surface, and the rainfall is in small amounts, the loss from this source may at times be very material. Even when the rainfall is considerable the amount intercepted may overbalance the protection against evaporation.

Effect of Weeds on Light, Warmth, and Protection from Air Currents.

In a German experiment (E. S. R. 16, 883 ; Fuhling's Landw. Ztg. 53) weeds growing in potatoes, beans, and maize lowered the temperature 2° to 4° C. through "shading and transpiration."

The results of an experiment at the Minnesota Station (Bul. 68, 585), where the temperature of the soil where no vegetation was growing was compared with that where wheat was growing though not strictly comparable with weeds growing in crops, would nevertheless be of some value for this purpose. Where the wheat was growing the temperature was about 5° lower than where the ground was bare.

Manifestly where weeds growing in corn exclude the light from the lower leaves, the efficiency of this part would be lessened. Since soil bacteria require absence of light, is it possible that nitrification will occur closer to the surface than where weeds are not growing in corn, providing the moisture content remains the same ?

Suppose a few small weeds were growing in corn, but having a large shading capacity for the plant food and water consumed ; would the surface soil have a better moisture condition for nitrification ? In ordinary field conditions the scant moisture for much of the growing season hinders

nitrification on the immediate surface.

If a limited amount of small weeds under the same conditions should cause an increase in nitrates, will there be a sufficient increase to more than balance the amount of nitrates consumed by them ? There would be probably less temporary loss of food constituents by accumulation on the surface.

It would seem, on the other hand, that the lessening of the temperature of the soil might be detrimental, but this seems to be uncertain. If detrimental in a northern latitude, will it necessarily be true farther south ?

Shade by lowering the temperature lessens evaporation from the surface of the soil. Corn while lessening evaporation does not accomplish this result as well as when weeds are growing with it. Weeds likewise assist the corn in hindering the movement of the air over the surface, thereby lessening evaporation from the surface. King, (Wis. Rpt. 11, 309) found that less water was evaporated from a pan when placed to the leeward of an oak grove, hedge, and clover field. This was probably due both to the lessening of the velocity of the wind, and to the atmosphere acquiring some moisture from the windbreaks.

Effect of Weeds in Producing a Toxic Substance.

According to an old theory recently revived, plants produce in soils a substance which is injurious to plant growth. The work by the Bureau of Soils seems to strongly indicate the correctness of the theory. It is claimed that plants vary greatly in the toxicity produced and that soils have different capacities in overcoming this unfavorable condition. If the theory be true, is it not reasonable that some weeds would cause toxicity for a cultivated plant ?

Clark and collaborators (Cornell Bul. 247, 198) found that soils denominated "poor spots" on account of the poor crops produced, contained a high content of nitrates. This soil when transferred to the greenhouse and pulverized, produced better plant growth than that denominated "good soil". "Good soil" refers to the soil which produced good crops under field conditions. Was the poor production in the field due to a toxic substance which was eliminated by aeration or some other agency when transferred to the greenhouse ? Was there any relation between the conditions producing high nitrogen content and the injurious influence ?

Effect of Weeds by Root Interference.

Paunnel (E.S.R. X, 1048 ; Ia. 39, 52) states that "some weeds are injurious because the network of roots prevents the full development of the roots of the grain crop." Other observers have assumed such injurious effects, but so far as the writer is aware no conclusive experiments have been conducted.

Effect of Scraping on Soil Moisture.

Warrenton (Physical Properties of Soils, 108) states that during six winter months, (October to March) the evaporation from a water surface near London was 4.8 inches, and from a bare field at Rothamstead was 4.8 to 5.2 inches. During the six summer months the evaporation was 15.9 inches from the former and 11.1 to 11.5 inches from the latter.

At the Wisconsin Station (Rept. 8, 105) the difference in moisture was determined between rolled and cultivated plats. The land was plowed in the spring and the plats alternated. The results follow in Table XXI.

Table XXI : Comparison in Moisture Content between Rolled and Cultivated Land ; First Foot.

Date	Rolled %	Cultivated %
May 29	15.4	17.2
June 9	13.6	16.9
June 17	12.0	16.0
June 20	15.0	19.0
July 17	11.8	14.1

The second and third feet showed a difference in favor of the cultivated plats but was less marked than in the first foot.

Snyder (Soils and Fertilizers) determined the difference in Soil moisture in corn where given shallow cultivation and where not cultivated. The results follow in Table XXII.

Table XXII : Moisture in Corn Field :

	With shallow surface cultivation	No cultivation
Soil, depth 3 to 9 in.	14.2 %	8.2 %
" " 9 " 15 "	17.2 %	12.38 %

The difference in favor of cultivation is marked.

Effect of Scraping on Yield of Corn.

The South Carolina Station (Bul. 44,2) compared corn cultivated with corn not cultivated. All plats were planted on the level. The results are shown in Table XXIII.

Table XXIII : Comparison of Yield Ear Corn Cultivated and Not Cultivated.

Treatment	Sound Corn bu.	Total bu.
Cultivated, level and shallow	51.1	58.6
Cut in ridges throughout	52.7	60.0
Not cultivated, weed and grass, cut with hoe	49.7	56.5

There is but a slight decrease in yield where the plat was scraped. The percentage of sound corn is about the same.

The Illinois Station (Bul 13, 419) compared the effects of scraping with cultivation for three successive years. The land was black prairie loam twenty inches deep, underlaid with yellow clay. In 1887 (the year before the experiment began) crimson clover was grown on the land. The surface was scraped at the usual time for cultivation as follows : First year five times ; second year three times ; and the third year four times. The last scraping was given on July 24, July 16, and June 25 and 26 for the respective years. Care was taken to disturb the soil as little as possible when removing the weeds. The results

follow in Table XXIV.

Table XXIV : Effect of Scraping on Yield of Corn :

No. Plat	Kind of cultivation	Yield per acre 1888 bu.	1889 bu.	1890 bu.	Average bu.
1	Hoed, ordinary	96	72.8	69.4	81.1
2	None, weeds scraped from surface	90	72.1	69.1	78.7
3	Shallow, once after tasseling	94.1	83.8	66.4	81.4
4	Deep, " " "	85.2	79.3	59.3	74.9
5	Shallow, ordinary	93.8	84.6	66.8	81.7
6	Deep, "	84.9	74.2	60.8	73.3
7	Shallow, frequent	94.6	80.9	71.1	82.2
8	Deep, "	84.3	68.8	69.4	74.2

(For a continuation of these experiments, see Bul. 25 and 31)

The results are consistent for plat experiments. The scraped plat shows but a slightly less yield than the best plats. Doubtless some weeds grew in the intervals between scraping, and after "laying by". Should we assume that some weeds grew and that a small amount of weeds are detrimental according to their quantity, it would be easy to conclude that this injury would be sufficient to cause the slight decrease in yield when compared even with the best yielding plats. If the soil moisture was lowered in

this plat to correspond with that on bare land and in corn above noted, it would seem that the yield is not correllated with the moisture in the soil where plats are scraped. It would further seem to indicate some compensating factor or factors.

It is usually supposed that cultivation favors nitrification. Snyder, (Soils and Fertilizers), 114) states that "cultivation, particularly of clay soils favors nitrification increasing the supply of oxygen in the soil." If this be true, were the Illinois and South Carolina soils sufficiently rich in nitrates under the supposedly unfavorable conditions for the nitrates not to be a limiting factor ?

Effect of Mulching.

The Geneva Station (7 Rept. 180) compared moisture a in duplicate plats not growing plants as follows : Weeds pulled, cultivated different depths, and mulched. The results follow in Table XXV.

Table XXV : Effect of Pulling Weeds, Cultivation and Mulching on Soil Moisture where no Plants Grew.

	Untouched Weeds pulled	Cultivated 1/2"	2"	4"	Mulch 1 in. short oat straw
	%	%	%	%	%
Average May 5-Oct 3	16.19	17.10	17.41	18.00	19.37
Aug. 8	14.2	15.1	16.1	16.1	19.0

The mulched plats show an excess of moisture over the cultivated plats, which in turn show an excess over the untouched plats. The difference is more marked during the dry weather.

Ebermeyer (Physical Properties of Soils, 111) found that the evaporation from artificially saturated soil within the forest covered by litter was during the six summer months only 46 per cent as much as where no litter was employed. It is possible that under certain circumstances the mulch applied about crops by tending to prevent the soil moisture reaching such a low status may maintain a condition by which capillarity may be more active. After the moisture reaches below a certain limit there may not only

be a lack of upward capillarity but loss may occur from percolation.

On the other hand a mulch intercepts moisture and should therefore not be too thick. This would apply with especial force if the rainfall is in small amounts.

-- EXPERIMENTAL --

PURPOSE OF EXPERIMENT

In the experiment herein treated it was not proposed to study all the possible causes of injury which weeds produce when growing in corn. The chief efforts were confined to the effects of weeds on the soil moisture and the fertilizer contents of the soil. Further variations were produced in the experiment by scraping and mulching the surface of the soil. As the experiment progressed other variations than those included in the plan developed. Although a consideration of some of these other factors may not be strictly in line with the purpose of the experiment, their inclusion is nevertheless believed to be warrented.

GENERAL PLAN OF THE EXPERIMENT

The plan of the experiment included the following comparisons:

Fertilization	vs	No fertilization
"Weeds"	"	No "Weeds"
Small growth of "Weeds"	"	Larger growth of "Weeds"
Cultivation	"	Mulch
Cultivation	"	Scraping of surface

Nitrate of soda, acid phosphate, and sulphate of potash were applied to plats singly. For weeds millet was used in the main line of the experiment. Soy beans were used as a variation. One plat was mulched and one merely had the weeds cut at the surface of the ground, taking care to leave no mulch.

The moisture and fertilizer contents of the soil were determined weekly on the ends of the plats where no corn grew, and, at longer intervals, within the corn.

No. Plat	--DETAILED OUTLINE OF EXPERIMENT--
(1)	Corn, cultivated all season; check.
(2)	Corn, plat scraped.
(3)	Corn, plat mulched.
(4)	Corn, cultivated all season; check.
(5)	Corn; millet sown at first cultivation.
(6)	Corn; Millet sown when corn was two feet high.
(7)	Corn, cultivated all season; check.
(8)	Corn; millet sown when corn four feet high.
(9)	Corn; soy beans sown at first cultivation.
(10)	Corn, cultivated all season; check.
(11)	Corn; soy beans sown when corn was two feet high.
(12)	Corn; soy beans sown when corn four feet high.
(13)	Corn, cultivated all season; check
(14)	Corn, fertilized with $Na NO_3$; cultivated all season, check.
(15)	Corn, " " " ; millet sown after corn two feet high.
(16)	Corn, no fertilizer, cultivated all season; check.
(17)	Corn, fertilized with $NaNO_3$; millet sown when corn four feet high.
(18)	Corn, fertilized with acid phosphate, cultivated all season.

(19) Corn, cultivated all season; check.

(20) Corn, fertilized with acid phosphate; millet sown when corn two feet high.

(21) Corn, fertilized with acid phosphate; millet sown after corn four feet high.

(22) Corn, cultivated all season; check.

(23) Corn, fertilized with potassium sulphate, cultivated all season.

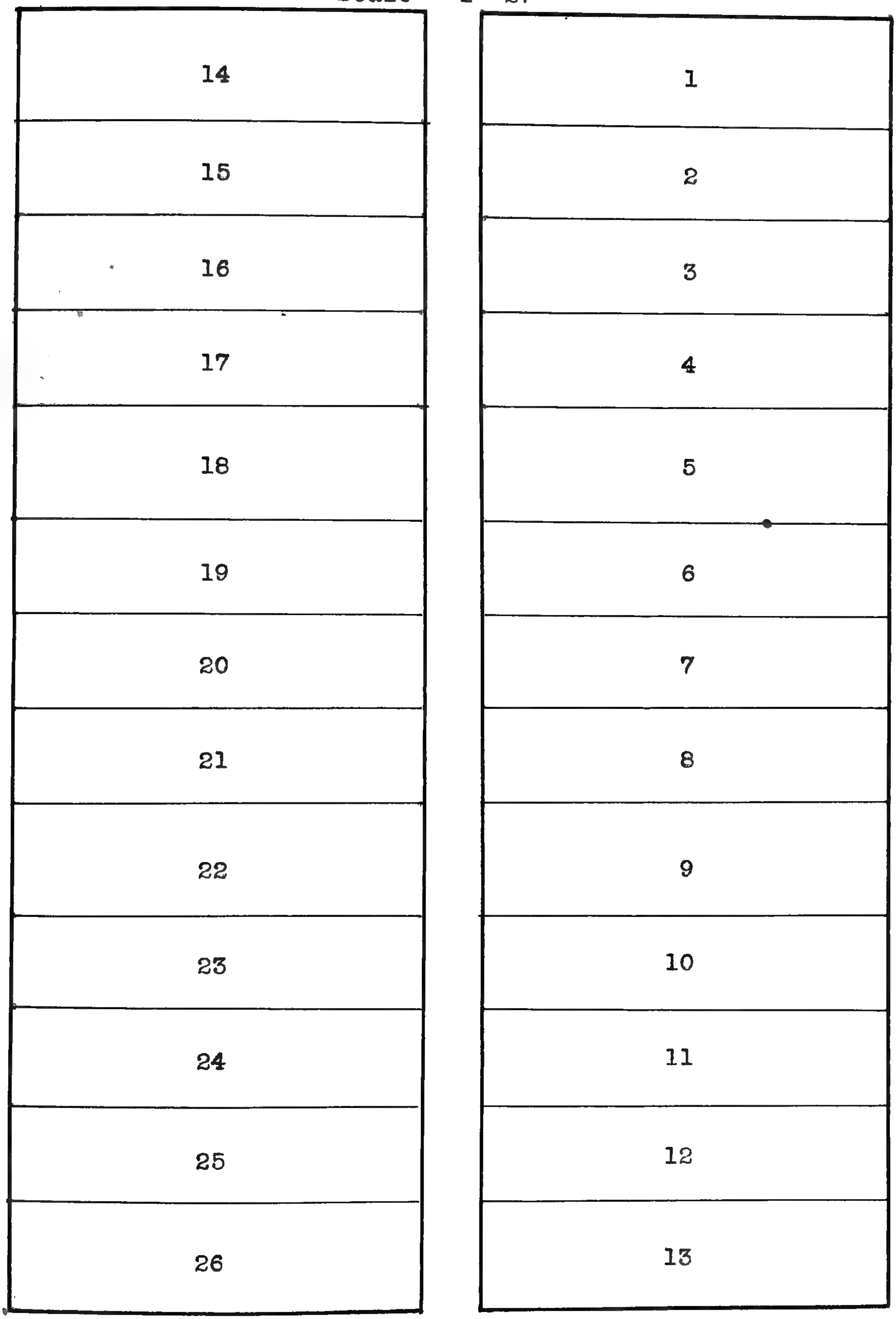
(24) Corn, fertilized with potassium sulphate; millet sown after corn two feet high.

(25) Corn, cultivated all season; check.

(26) Corn, fertilized with potassium sulphate; check; millet sown after corn four feet high.

-- MAP OF PLATS --

Scale-- 1"=27'



-- DESCRIPTION OF PLATS --

The land selected for the experiment had been in corn two or three years previously. It was gently rolling, and appeared to be fairly uniform. Slight variations, where occurring appeared to be gradual changes. The highest point was on the northeast part, from which it fell gently away to the southwest. There was a slight depressinn in the southeast portion. The northwest edge bordered grass land which fell away more abruptly. The extreme difference in elevation of the experimental ground was perhaps fifteen feet.

The plats extended from north to south in two series. The north series included plats 1 to 13, and the south series plats 14 to 26. The plats were 18' by 75'. 45' in the middle was occupied by corn, 15' on each end bare or occupied by millet or soy beans. A strip of 15' was left between the series extending the whole length of the experimental ground from east to west. The corn was planted in hills three feet apart, five kernals to the hill to the better secure a uniform stand of three stalks. Thus each plat contained six rows of 16 hills each. The spaces were left at both ends rather than at one end only, to the better secure composite samples which would be comparable to the soil in the corn.

Every third plat was reserved as a check.

-- FERTILIZERS APPLIED --

The fertilizers were applied to the whole plat as fol-

lows:* Nitrate of soda at the rate of 775 pounds per acre to plats 14, 15, & 17; acid phosphate at the rate of 775 pounds to plats 18, 20 and 21; and sulphate of potassium at the rate of 388 pounds to plats 23, 24, and 26. The essential ingredients applied were thus approximately of nitrogen and phosphoric acid (P_2O_5) 125 pounds, and of potash(K_2O) 174 pounds. Calculated in the terms in which the statement of fertilizer constituents are made (Table "A", Appendix)

	The nitrogen equals		554	pounds	NO_3
P_2O_5	Phosphoric Acid	=	167	"	PO_4
K_2O	Potash	=	145	"	K

* It was intended to apply 640 pounds each of nitrate of soda and acid phosphate, and 320 pounds of sulphate of potash, but because of a change in the length of the plats an error was made.

-- PREPARATION OF LAND ---- PLANTING AND CULTIVATION

The land had been plowed in the early spring seven to eight inches deep thoroughly turning under the corn stubble. On May 17th., after three days of moderate temperature, the land was in fair condition for working, although rather moist. It was prepared, fertilized, and planted according to the plan. The continued cold weather succeeding planting and a washing rain June 18th. made replanting necessary June 22nd. It was not necessary, however, to replant a large per cent of the corn

Crows took up some of the corn on plats 10, 11, 12 and 13, which made it necessary to again replant these plats. On June 18, Soy beans were sown on plat 9 at the rate of one and one half bushels per acre. The stand not being good the plat was replanted with a hand planter at the same rate July 3rd.

June 18th. millet was sown at the rate of one bushel per acre on plat 5. A washing rain occurring before they were cultivated in, the sowingwas repeated June 22nd.

July 24th. soy beans were sown in plat 11, and millet on plats 6, 15, and 20.

August 6th. soy beans were sown on plat 12, and millet on 17, 21 and 26. In all cases soy beans were sown at the rate of one and one half bushels per acre and millet one bushel per acre. Where millet and soy beans were sown, the ends of the plats as well as the part in corn were occupied.

The plats were given shallow cultivation June 22nd, July 5th. and July 30th. As it was dry after this and the mulch seemed efficient it was not deemed advisable to again disturb the soil. The cultivation could only be given in one direction. The ridges between the hills in the row were cut down as needed and the plats where corn only grew were kept free from weeds. Plat 2 was frequently scraped on the surface only, taking care to leave no mulch, and plat three had about a two inch mulch of straw after becoming compacted. The plats on which "weeds" were grown were cultivated until the millet and soy beans were sown.

-- MOISTURE DETERMINATION --

All samples for moisture and fertilizer determination were a composite of six borings taken to the depth of 7 inches till July 30th. After this date the surface two inches was discarded. The soil augur was used in sampling, serving the purpose well except when the soil became extremely dry in the "weedy" plats 5 and 9, where it was difficult to get good samples. This difficulty, however, would seem not to affect the value of the results, since if there were any variation from the proper results it would be on the side of conservatism There would be a tendency to secure a higher moisture and perhaps also of nitrogen content on these plats than the actual amount.

Regularity was observed in the locations at which borings were made. The samples in the corn were taken in the center of the square between the hills in the first, third, and fifth middles. The first borings were made in the second cross middle from each end, the second from the third, etc. At the ends the first boring was made three feet from the corn, the second four feet, etc. Care was taken not to walk on the part, where the future borings were to be made. Where slight ridges occurred the boring was made between the furrow and ridge.

The samples were taken to the laboratory where the moisture was determined and estimated on the basis of dry soil.

-- FERTILIZER ANALYSIS --

(All chemical analyses of the soil solution given in)
(this thesis were made by J. A. Bizzell, Ph.D.)

The fertilizer constituent was determined from the samples used for moisture estimation. Nitrogen (NO_3) was determined for plats 1 to 17; phosphoric acid (PO_4) for plats 17 to 22; and potassium (K) for plats 22 to 26 inclusive. These were estimated in parts per million (p.p.m.) dry soil.

** Plat 22 being a check served for comparison for both PO4 and K_2O content.

-- WEATHER CONDITIONS --

Rainfall from May 1st. to September 30th., 1907.

Date	Inches
May 3rd.	.02
" 4th.	.15
" 6	.08
" 7	.39
" 9	.46
" 10	.20
" 11	.11
" 15	.01
" 16	.33
" 18	.02
" 19	.10
" 26	.53
" 27	.11
	2.83
June 2	.05
" 4	.05
" 5	.35
" 6	.29
" 7	.02
" 13	.11
" 18	2.44
" 19	.15
" 20	.22
June 23	.05
" 24	.33
" 25	.15
" 26	.10
" 29	.10
" 30	.74
	5.15
July 1st.	.32
" 2	.02
" 7	.04
" 11	.90
" 12	.30
" 19	.01
" 20	.18
" 26	.17
" 31	.01
	1.95
Aug. 1st.	.91
" 5	.21
" 16	.01
" 20	.02
" 21	.36
" 23	.01
" 27	.12
	1.64
Sept. 1	.10
" 2	.12
" 3	.33
" 4	.14
" 5	.39
" 6	.02
" 8	.11
" 9	1.06
" 10	.04
" 11	.22
" 18	.07
" 19	.01
" 20	.02
" 21	.06
" 23	.36
" 24	.03
" 27	.02
" 28	.06
" 29	.70
" 30	.10
	3.96

- TEMPERATURE MAY 1ST. TO SEPTEMBER 30th. -

	Mean	Departure from normal	highest	lowest
May	50.3° F.	-6.7° F	85° F	27° F
June	62.9	-3.3	93	41
July	69.7	-0.9	89	43
August	66.6	-0.6	93	44
September	63.2	+2.6	86	42

The rainfall from May 17th. when the corn was planted till September 20th. was 12.11 inches. The latter part of May and the first half of June were dry. Rain was abundant the latter half of June and fair through the first half of July. From July 18th. till in the first part of September, when numerous showers occurred, there was only one rain of consequence, that being August 1st. when .91 inches fell. The rainfall was good through September.

The temperature through May and June was considerably below normal; the remainder of the season was about normal.

--GROWTH--

The dryness during the early crop period prevented rotting of the planted corn while the low temperature seriously retarded germination and growth. Through July growth was fair. In August a severe drought occurred but fair growth was made through September.

After the second sowing of millet and soy beans was

made, July 24th., dry weather occurred which so hindered the growth of "weeds" that the experiment was seriously impaired. There was a poor stand of soy beans in all cases although they were covered a fair depth and showed good viability in the laboratory.

-- INJURIES SUSTAINED --

Besides the unfavorable season curtailing growth and injuring the stand, a severe wind-storm broke off some plants and cattle injured the plats as follows: 12 and 13 were so severely injured as to throw them out of the experiment; 26 was nearly as badly injured; 15, 14 and 25 were injured less than 26; some others were slightly injured.

-- HARVESTING --

The injuries above noted made the harvesting a much more tedious process than usual in order to secure dependable results. All hills in which there was an injured stalk, and all that were clearly replant, were discarded. Record was made by rows of the number of hills harvested with 3 stalks, 2 stalks, and one stalk respectively. The rows were weighed separately. The "weeds" in the corn and at the ends of the plats were harvested separately. In the corners two representative middles at each end of the plats were harvested. At the ends the edges were discarded and the surface harvested carefully measured.

The harvesting was done September 20th. to 24th. The

variation in time resulted from the tediousness of the task, the lack of a fully matured plan, and unfavorable weather.

-- EFFECT OF STAND ON THE WEIGHT OF THE STALKS --

Since there were about eight per cent of the hills which contained but two stalks, an attempt was made to determine whether estimating yield on the basis of the number of stalks was justified. Accordingly the stalks growing two in a hill where three or more such hills were in a row were carefully weighed. These were compared with the stalks in the same row growing three in a hill. The results follow in Table XXVI.

TABLE XXVI SHOWING COMPARATIVE WEIGHTS WHERE TWO AND THREE STALKS GREW IN THE HILL

No. Plat	No. Row	Two Stalks No. Hills	Two Stalks Wt. per stalk	Three Stalks No. Hills	Three Stalks Wt. per stalk.
			Lbs.		Lbs.
1	1	3	1.33	3	1.03
	4	3	1.21	8	1.07
2	4	5	1.07	5	1.05
3	5	4	1.53	10	1.58
7	6	3	1.72	8	1.73
8	1	6	2.21	8	1.53
10	4	3	1.58	9	1.49
	5	3	1.25	4	1.62
11	3	3	1.33	6	1.04
14	1	3	1.37	2	1.25
	5	4	1.22	10	1.35
17	4	4	1.44	12	1.28
	6	3	1.21	13	1.14
18	1	3	1.54	11	1.13
	4	4	.94	12	.71
	5	5	.82	10	.74
	6	3	.96	13	.81
19	1	3	1.04	13	.68
	2	3	.46	13	.71
	5	4	1.16	11	.79
	6	5	1.07	11	.97
20	2	3	1.12	11	1.00

(TABLE CONTINUED) (XXVI)

No. plat	No. Row	Two stalks No. Hills	Wt. per stalk	Three stalks No Hills	Wt. per stalk
	4	4	.83	12	.86
	5	3	.96	10	1.07
21	3	3	1.08	11	1.05
22	1	5	.85	8	.90
	2	7	.73	6	.87
	4	3	.87	8	1.01
	5	5	.75	5	1.03
	6	3	1.08	12	.99
24	1	3	1.42	10	1.66
	3	7	1.75	8	1.63
	5	3	2.12	8	1.55
25	3	3	1.42	6	1.44
26	4	3	1.37	3	2.14
	6	3	1.17	2	1.58

Those plats showing a larger weight per stalk where only two stalks grew were 1, 8, 11, 17, 18, and 19; those showing about the same or varying comparative weights were 2, 3, 7, 10, 14, 20, 21, 24, and 25; those showing a smaller weight where two grew in the hill were 22 and 26. Plat #22 the north end of which was markedly the poorest part of the whole ground contained five rows with three or more hills with two stalks in a hill. In four of these rows the stalks were heavier where three grew in the hill and in the other row there was but little difference. 20 and 21 showed about the same weights for stalks growing under the different conditions, while 18 and 19 clearly showed an advantage, where only two stalks grew in the hill. The comparative uniformity of results in plat 22, together with the gradual change in comparative weights as the plat is approached from the west would seem to indicate a correlation. But a glance at 26, where two rows were weighed and where the growth was good shows a much more marked difference in weights in the other direction. Conclusions are, therefore, not warranted.

The weight per stalk where two grew in a hill averaged 3.64 per cent more than where three grew in a hill. There was considerable variation. A comparatively few hills had but one stalk. These showed a great variation in

weight. But since the average per stalk where two grew in a hill was not far different from where three grew, and since the number where two grew were not a large per cent of the whole, it seemed hardly worth the trouble to correct for this error. Suppose ten per cent of the hills had two stalks, weighing ten per cent more per stalk than where three grew, the error would be but one per cent. This would fall far below the range of experimental error. Under same conditions doubtless correction should be made where the number of hills with a smaller number of stalks are any considerable per cent of the whole. The writer is informed that at one station it is estimated that a hill with two stalks is calculated to yield 80%, and one with one stalk 42 per cent as much as where three occur.

TABLE XXVII--YIELD OF CORN FODDER BY ROWS---GREEN WEIGHT
*RATE PER 100 STALKS

No. Plat	No. Row	** No. Stalks Harvested	Wt. rate per 100 Stalks	Average Wt. rate per 100 stalks	Extreme variations from average	*** Extreme variations.
1	1	15	115.0 lbs.	lbs.	%	%
	2	17	114.7			
	3	27	101.0		-10.6	
	4	30	110.0			
	5	27	113.0			
	6	35	124.3	113.0	+10.0	20.6
2	1	32	114.1			
	2	30	138.3		+18.3	
	3	35	117.1			
	4	25	104.8		-10.4	
	5	33	117.4	116.9		
	6	36	109.7			28.7
3	1	38	144.8		-8.8	
	2	27	170.4		+7.3	
	3	28	170.4			
	4	29	147.4			
	5	38	157.2			
	6	35	162.9	158.8		16.1

* The weights of each row are not here given but the rates shown are the rates per 100 stalks. The normal number of stalks is the same in each row. This method affords an easy method of comparison.

** Column shows number of stalks harvested, out of a possible 48.

*** Per cent calculation on basis of average.

TABLE XXVII CONTINUED						
No. Plat	No. Row	No. Stalks harvested	Wt. Rate per 100 stalks	Average Wt. rate per 100 stalks	Extreme variations from average.	Extreme variations.
			Lbs.	Lbs.	%	%
4	1	29	148.3			
	2	23	158.7		+10.1	
	3	29	124.1		-13.9	
	4	32	154.7			
	5	38	145.4			
	6	38	133.8	144.2		24.0
5[2]	1	23[3]	76.1			
	2	24	55.2			
	3	18	38.9		-34.8	
	4	19	39.5			
	5	17	42.6			
	6	22	105.7	59.7	+77.1	111.9
6	1	37	144.6			
	2	45	144.4			
	3	47	142.5		-4.4	
	4	39	157.7			
	5	48	146.9			
	6	33	158.3	149.1	+6.2	10.6
7	1	33	151.6			
	2	31	151.6			
	3	37	138.5		-11.9	

2 North End.

3 Number of stalks out of a possible 24.

TABLE XXVII CONTINUED						
No. Plat	No. Row	No. Stalks Harvested	Wt. Rate per 100 stalks	Average Wt. rate per 100 stalks	Extreme Variations from average	Extreme Variations.
			lbs	lbs	%	%
7	4	35	166.4			
	5	32	162.8			
	6	30	172.5	157.2	+9.7	21.6
8	1	36	175.7			
	2	40	163.7			
	3	45	176.7			
	4	34	156.6			
	5	37	199.3		+24.6	
	6	34	88.2	160.0	-44.9	69.5
*9	1	**23	80.4		+32.9	
	2	23	78.3			
	3	23	62.0			
	4	24	47.9			
	5	24	52.1			
	6	19	42.1	60.5	-30.4	63.3
10	1	32	143.8			
	2	42	141.1			
	3	36	128.3		-11.9	
	4	33	150.8			
	5	18	151.4			
	6	26	158.7	145.7	+8.9	20.8

*Only the middle four rows of the north part taken.

**Stalks harvested out of a possible 24.

TABLE XXVII CONTINUED

No. Plat	No. Row	No. Stalks Harvested	Wt. Rate per 100 Stalks	Average Wt. rate per 100 stalks	Extreme variations from average	Extreme Variations
			lbs	lbs	%	%
11	1	29	128.4		+14.3	
	2	30	107.5			
	3	24	111.5			
	4	34	119.9			
	5	31	112.9			
	6	16	93.7	112.3	-16.6	30.9
14	1	12	131.2			
	2	32	116.4		-9.3	
	3	31	125.0			
	4	33	132.6			
	5	34	132.2			
	6	42	133.3	128.4	+3.8	13.1
15	1	46	137.0			
	2	48	134.4			
	3	46	141.3			
	4	48	139.6		+2.5	
	5	41	134.1			
	6	47	130.9	136.2	-3.9	6.4
16	1	43	129.1		+11.7	
	2	44	123.9			
	3	41	117.7			

TABLE XXVII CONTINUED

No. Plat	No. Row	No. Stalks harvested	Wt. Rate per 100 stalks	Average Wt. rate per 100 stalks	Extreme varia- tions from average	Extreme varia- tions
			lbs	lbs	%	%
16	4	34	130.1			
	5	41	100.6			
	6	44	92.0	115.6	-20.4	32.1
17	1	43	93.0		-24.9	
	2	46	148.1		+19.6	
	3	46	129.9			
	4	44	131.2			
	5	47	125.5			
	6	45	115.0	123.8		44.5
18	1	39	119.2		+33.3	
	2	48	91.7			
	3	44	90.9			
	4	44	75.0		-16.1	
	5	40	76.2			
	6	45	83.3	89.4		39.4
19	1	45	72.8			
	2	45	67.8		-21.2	
	3	35	92.9			
	4	40	97.5			
	5	41	86.0			
	6	43	99.4	86.12	+15.4	36.6

TABLE XXVII CONTINUED

No. Plat	No. Row	No. Stalks harvested	Wt. Rate per 100 stalks	Average Wt. rate per 100 stalks	Extreme Variations from average	Extreme variations
			lbs	lbs	%	%
20	1	46	90.8			
	2	39	101.9			
	3	43	107.0			
	4	42	85.7		-17.4	
	5	36	104.9			
	6	37	131.8	103.2	+27.1	44.5
21	1	33	114.4		+9.9	
	2	26	114.4			
	3	39	105.8			
	4	39	94.2			
	5	40	103.7			
	6	41	92.1	104.1	-11.5	21.4
22	1	34	88.2			
	2	32	81.2			
	3	34	77.9		-13.1	
	4	30	98.3			
	5	25	92.0			
	6	42	100.0	89.6	+11.6	24.7
23	1	44	119.3			
	2	29	144.8		+9.4	
	3	24	141.7			

TABLE XXVII CONTINUED

No. Plat	No. Row	No stalks harvested	Wt. rate per 100 stalks	Average Wt. rate per 100 stalks	EXtreme variations from average	Extreme variations
23	4	26	137.5			
	5	32	109.4		-17.3	
	6	36	141.0	132.3		26.7
24	1	36	161.8		-2.6	
	2	37	171.6		+3.5	
	3	38	167.3			
	4	33	162.1			
	5	30	166.6			
	6	33	167.4	166.1		5.9
25	1	23	176.1		+31.0	
	2	26	121.2			
	3	24	143.7			
	4	28	142.9			
	5	25	114.0			
	6	23	108.7	134.4	-19.2	50.2
26	1	15	135.0			
	2	28	126.8			
	3	19	145.0		+8.0	
	4	15	116.6		-13.1	
	5	14	144.6			
	6	12	137.5	134.2		21.1

After eliminating the first and sixth rows from the north ends of plats 5 and 9, the north ends only were taken, since the data from the south ends were not dependable due to injuries sustained. The variation was as follows: For plat 5, Minimum 11.6%, maximum 25%, and extreme variation 36.6%; for plat 9, minimum 20.3%, maximum 30%, and extreme variation 50.3%.

The table shows an extreme variation in green weight of stalks between the rows of the same plat from 5.9 per cent in plat 24, to 111.9 per cent in plat 5. Eliminating plats 5 and 9, the maximum extreme is 65.9%, occurring in plat 8, and the average variation is about 28 per cent. The number of stalks harvested in the row seems to have little influrnce in the variation.

Rows 1 and 6 of plat 5 being on the edges of the plats, where conditions for growth were better, should clearly not be counted in final yields. To secure comparable results rows 1 and 6 of plat 9 were also eliminated. Row 6, plat 8, being next to plat 9, is clearly not representative. Rows 5 and 6, plat 16, and row 1 plat 17 were markedly poor; but row 4 plat 16 and row 2 plat 17 were markedly good. The yields by rows indicate that the south series beginning with plat 14 improved in productiveness to about the middle of plat 15, from whence a gradual reduction is shown till the border between plats 16 and 17 is reached. A few rows beyond this show an increase, after which there

is a decided fall. No part, however, was eliminated in calculating yields except in plats 5 and 9, as above stated.

The variability noted throughout the table, and especially in this apparently uniform land from plats 14 to 20 inclusive, where we believe no one not seeing the growing crop would suspect the lack of uniformity, indicates the extreme caution which should be exercised in conducting plat experiments.

--DETERMINATION OF DRY MATTER--

For the determination of dry matter representative samples were taken. Of the corn, two hills of three stalks each were taken from plats 2,3,5, and 10. Of millet and soy beans composite samples were taken; millet from plats 5 and 6, and soy beans from plats 9 and 11. The samples, while rather small for the purpose are believed to give fairly approximate results.

TABLE XXVIII SHOWING DRY MATTER

No. Plat	Kind of Crop	Dry Matter
		%
2	Corn	21.42
3	"	21.58
5	"	24.69
5	Millet	33.71
6	"	17.50
9	Soy beans Weeds & Grass	25.59
10	Corn	19.99
11	Soy Beans	21.02

In Table XXIX, which follows, the weights in dry matter are given. For the plats where dry matter was determined, the per cents shown in the above table were used in correcting from green weight. For the remaining corn plats except plats 9 and 11, the average of plats 2, 3, and 10 were taken. Plat 9 was calculated the same as plat 5, and plat 11, the same as plat 10. The remaining millet was calculated the same as the millet in plat 6.

In the column, "Production capacity of corn" the weights for the check plats are the actual yields. The intermediate figures given refer to what the corresponding plat presumably would have yielded had it been treated as a check. It is assumed that the change in productive capacity of the

soil was gradual between the check plats. The calculation is made by taking one third of the difference between the consecutive check plats and adding or subtracting according to the trend of the variation. The productive capacity for plat 11 was calculated on the assumption that the same variation occurring between check plats 7 and 10 continued through plat 11; and plat 15 was similarly calculated from check plats 16 and 19. This method would appear less reliable than where a check plat is in each side of the plat for which the correction is made.

TABLE XXIX: YIELD-CORN, MILLET AND SOY BEANS.---

No. Plat	Per cent Stand corn harvested	Variation between rows	Production Capacity of corn
		%	lbs.
1	52.43	20.6	3522
2	66.32	28.7	3800
3	68.06	16.1	4079
4	65.97	24.0	4357
*5	85.42	36.6	4497
6	86.46	10.6	4637
7	69.44	21.6	4776
8	78.82	69.5	4581
*9	94.44	50.3	4386
10	65.97	20.8	4190
11	56.94	30.9	3995
12			
13			
14	65.28	13.1	
15	96.18	6.4	3828
16	86.81	32.1	3522
17	94.10	44.5	3216
18	90.63	39.4	2910
19	86.46	36.6	2605
20	84.72	44.5	2671
21	76.74	21.4	2737
22	70.83	24.7	2803
23	66.32	26.7	3233

TABLE XXIX: YIELD -- CORN, MILLET and SOY BEANS

No. Plat	Per cent Stand corn harvested	Variation between rows	Production capacity of corn
		%	Lbs.
24	72.22	5.9	3663
25	51.74	50.2	4093
26	36.11	21.1	

* The four middle rows of the north half only taken, as South end was damaged by cattle.

TABLE XXIX : YIELD -- CORN, MILLET AND SOY BEANS

--Yield, Rate per acre--

No. Plat	Corn	Millet In Corn	Millet Ends	Soy Beans In Corn	Soy Beans Ends
	lbs	lbs	lbs	lbs	lbs.
1	3522				
2	3643				
3	4952				
4	4357				
5	1609	3932	4999		
6	4528	2180	2026		
7	4776				
8	4913	191	772		
9	2145			2090	3700
10	4190				
11	3310			534	894
12					
13					
14	3922				
15	4155	222	2182		
16	3522				
17	3735	negligible	369		
18	2722				
19	2605				
20	3143	219	1610		

TABLE XXIX : YIELD -- CORN, MILLET AND SOY BEANS

-- Yield, Rate per acre--

No. Plat	Corn	Millet In Corn	Millet Ends	Soy Beans In corn	Soy Beans Ends
	lbs	lbs.	lbs		
21	3163	Negligible	740		
22	2803				
23	3991	"	310		
24	5069	201	2665		
25	4093				
26	4075	Negligible	1156		

TABLE XXIX: YIELD -- CORN, MILLET AND SOY BEANS

Plat No.	Total excluding ends.	Increase + or Decrease - of total	Increase + or Decrease - of corn
1	3522	check	check
2	3643		-157
3	4952		+873
4	4357	check	check
5	5321	+1044	-2888
6	4708	+ 71	- 109
7	4776	check	check
8	5104	+523	+332
9	4235	-151	-2241
10	4190	check	check
11	3844	-151	-685
12			
13			
14	3922		+286
15	4377	+549	+327
16	3522	check	check
17	3735		+519
18	2722		-188
19	2605	check	check
20	3362	+691	+472
21	3163		+426
22	2803	check	check

TABLE XXIX: YIELD -- CORN, MILLET AND SOY BEANS

Plat No.	Total excluding ends	Increase + or Decrease - of total	Increase + or Decrease - of corn
	lbs	lbs	lbs
23	3991		+758
24	5270	+1607	+1406
25	4093	check	check
26	4075		

TABLE XXX SHOWING AVERAGE MOISTURE CONTENT FOR DIFFERENT PERIODS. PER CENT DRY SOIL (DEDUCED FROM TABLE "A" APPENDIX)

No. Plat	July 9th., 16th. 24th. & 30th. Ends	Aug. 5th, 19th, 26th, & Sept. 16 Ends	In Corn.
	%	%	%
1	22.6	21.1	18.0
2	21.3	18.2	15.0
3	26.0	25.0	17.9
4	20.1	18.2	13.7
5	17.9	9.8	9.7
6	20.4	17.0	13.1
7	18.5	17.7	14.1
8	19.4	17.4	14.7
9	14.8	10.0	9.3
10	16.5	15.2	12.3
11	15.7	13.0	11.5
12	14.4	13.0	14.1
13	15.9	14.7	13.7
14	24.6	23.1	19.0
15	24.4	21.3	16.9
16	23.2	22.5	17.5
17	22.5	21.5	15.4
18	21.1	20.4	15.3
19	20.7	19.9	16.7
20	20.0	17.4	14.6

TABLE XXX SHOWING AVERAGE MOISTURE CONTENT FOR DIFFERENT PERIODS, PER CENT DRY SOIL (DEDUCED FROM TABLE "A" APPENDIX)

No. Plat	July 9th. 16th. 24th. & 30th. Ends	Aug. 5th, 19th, 26th Ends	& Sept. 1 In Corn.
21	20.9	19.6	14.5
22	19.6	17.9	14.6
23	21.0	19.5	14.6
24	20.3	16.0	12.9
25	19.3	17.5	13.2
26	19.1	16.3	12.7

TABLE XXX SHOWING AVERAGE MOISTURE CONTENT FOR DIFFERENT PERIODS, PER CENT DRY SOIL (DEDUCED FROM TABLE "A" APPENDIX)

			August 19th and 26th	
No. Plat	Difference %	Ends %	In Corn %	Diff. %
1	3.1	19.8	14.9	4.9
2	3.2	16.1	11.8	4.3
3	7.1	24.2	13.8	10.4
4	4.5	16.9	10.3	6.6
5	0.1	5.9	5.7	0.2
6	3.9	15.1	9.7	5.4
7	3.6	16.3	11.2	5.1
8	2.7	16.6	12.0	4.6
9	0.7	7.1	6.2	0.9
10	2.9	14.6	10.5	4.1
11	1.5	12.4	9.7	2.7
12	1.1	12.5	13.4	-0.9
13	1.0	14.3	13.2	1.1
14	4.1	21.3	15.8	5.5
15	4.4	18.0	13.3	4.7
16	5.0	21.0	13.9	7.1
17	6.1	19.6	12.1	7.5
18	5.1	18.7	11.5	7.2
19	3.2	18.3	13.7	4.6
20	2.8	14.4	11.5	2.9

TABLE XXX SHOWING AVERAVE MOISTURE CONTENT FOR DIFFERENT PERIODS, PER CENT DRY SOIL (DEDUCED FROM TABLE "A" APPENDIX)

No. Plat	Difference %	August 19th and 26th Ends %	In Corn %	Diff. %
21	5.1	18.3	11.0	7.3
22	3.3	16.5	11.6	4.9
23	4.9	18.3	11.2	7.1
24	3.1	12.5	9.0	3.5
25	4.3	16.3	10.5	5.8
26	3.6	15.6	9.5	6.1

TABLE XXXI SHOWING DIFFERENCES IN MOISTURE CONTENT OF SOIL FOR DIFFERENT PERIODS, BETWEEN THE ENDS, AND WHEN CORN GREW ALSO THE VARIATIONS IN YIELDS

No. Plat	August 5, 19, 26 and Sept. 16		August 19 and 26th.		Increase + or Decrease -
	Calculated from checks	Found	Calculated from checks	Found	
	%	%	%	%	%
1		3.1		4.9	
2	3.6	3.2	5.5	4.3	-1.2
3	4.1	7.1	6.1	10.4	+4.3
4		4.5		6.6	
5	4.2	0.1	6.1	0.2	-5.9
6	3.9	3.9	5.6	5.4	- .2
7		3.6		5.1	
8	3.4	2.7	4.8	4.6	- .2
9	3.2	0.7	4.5	0.9	-3.6
10		2.9		4.1	
11	2.3	1.5	3.1	2.7	- .4
12	1.7	-1.1	2.1	-0.9	-3.0
13		1.0		1.1	
14		4.1		5.5	
15		4.4		4.7	
16		5.0		7.1	
17	4.4	6.1	6.3	7.5	+1.2
18	3.8	5.1	5.5	7.2	+1.7
19		3.2		4.6	
20	3.2	2.8	4.7	2.9	-1.8

TABLE XXXI SHOWING DIFFERENCES IN MOISTURE CONTENT OF SOIL FOR DIFFERENT PERIODS, BETWEEN THE ENDS, AND WHEN CORN GREW ALSO THE VARIATIONS IN YIELDS

No. Plat	August 5, 19, 26 and Sept. 16		August 19 and 26th.		Increase or Decrease
	* Calculated from checks	Found	Calculated from checks	Found	
21	3.2	5.1	4.8	7.3	-2.5
22		3.3		4.9	
23	3.6	4.9	5.2	7.1	+1.9
24	3.9	3.1	5.5	3.5	-2.0
25		4.3		5.8	
26		3.6		6.1	

* In this calculation it is assumed that changes occur gradually between the checks. To illustrate the method take plat #2. One third the difference between checks 1 and 4 added to 1 gives 3.6, which is supposed to be the difference between the moisture between the ends and in corn had to be treated as a check.

TABLE XXXI SHOWING DIFFERENCES IN MOISTURE CONTENT OF SOIL FOR DIFFERENT PERIODS, BETWEEN THE ENDS, AND WHEN CORN GREW ALSO THE VARIATIONS IN YIELDS

No. Plat	Per Cent Stand	Dry Matter Increase + or decrease - Corn	Total
1	52.43	check	
2	66.32	-157	
3	68.06	+873	
4	65.97	check	
5	85.42	-2888	+1044
6	86.46	- 109	+ 71
7	69.44	check	
8	78.82	+ 332	+ 523
9	94.44	-2241	- 151
10	65.97	check	
11	56.94	- 685	-151
12			
13			
14	65.28		
15	96.18	+ 327	+ 549
16	86.81	check	
17	94.10	+519	
18	90.63	- 188	
19	86.46	check	
20	84.72	+472	+ 691

TABLE XXXI SHOWING DIFFERENCES IN MOISTURE CONTENT OF SOIL FOR DIFFERENT PERIODS, BETWEEN THE ENDS, AND WHEN CORN GREW ALSO THE VARIATIONS IN YIELDS

No. Plat	Per Cent Stand	Dry Matter Increase + or decrease - Corn	Total
21	76.74	+426	
22	70.83	check	
23	66.32	+758	
24	72.22	+1406	+1607
25	51.74	check	
26	36.11		

TABLE XXXII SHOWING AVERAVE FERTILIZER CONTENT FOR DIFFERENT PERIODS--PARTS PER MILLION OF DRY SOIL (DEDUCED FROM TABLE "A" APPENEIX)

No. Plat	July 9, 16,24,30. Ends	Aug. 5, 9,26, & Sep. 16. Ends	Aug. 5, 9,26, & Sep. 16. In Corn	Aug. 19 & 26 Ends	Aug. 19 & 26 In Corn
	NO_3	NO_3	NO_3	NO_3	NO_3
1	80.1	90.4	53.0	70.8	16.7
2	97.1	90.6	71.5	52.8	52.5
3	68.2	85.7	29.5	97.5	23.3
4	97.0	123.7	24.3	87.9	16.5
5	48.5	2.0	3.6	1.7	2.2
6	86.0	60.5	17.1	50.6	10.7
7	81.8	93.2	29.6	66.9	9.6
8	85.7	89.4	33.7	88.8	24.8
9	63.4	5.9	5.8	2.5	5.0
10	56.0	89.5	24.8	59.9	22.3
11	51.8	77.9	26.2	55.0	27.2
12	52.4	58.4	55.4	61.8	62.1
13	57.3	96.8	36.1	73.9	35.6
14	200.1	77.1	205.6	157.8	143.7
15	240.6	229.8	166.7	150.9	148.5
16	140.2	160.4	110.7	127.5	80.1
17	208.0	254.8	181.2	174.3	166.3
	PO_4	PO_4	PO_4	PO_4	PO_4
18	8.9	9.3	8.3	10.2	8.6
19	8.2	8.4	8.5	9.3	8.5

TABLE XXXII SHOWING AVERAGE FERTILIZER CONTENT FOR DIFFERENT PERIODS--PARTS PER MILLION OF DRY SOIL (DEDUCED FROM TABLE "A" APPENDIX)

No. Plat	July 9, 16, 24, 30 Ends	Aug. 5, 9, 26, & Sep. 16 Ends	Aug. 5, 9, 26, & Sep. 16 In Corn	Aug. 19 & 26 Ends	Aug. 19 & 26 In Corn
	PO_4	PO_4	PO_4	PO_4	PO_4
20	8.6	8.4	8.2	8.2	8.1
21	7.9	8.9	8.7	8.1	7.6
22	7.3	8.8	7.7	9.6	7.0
	K	K	K	K	K
22	9.1	6.8	5.7	5.1	3.9
23	8.5	10.4	7.8	9.6	5.7
24	8.7	7.6	7.2	6.0	5.5
25	10.6	8.4	5.7	6.3	4.7
26	12.9	9.8	10.7	10.9	10.9

DISCUSSION OF RESULTS

First sowing of "Weeds"

Plat 5 Yield

On Plat #5 millet was sown at the first cultivation June 18th.

TABLE XXXIII THE RATE OF YIELD PER ACRE OF BOTH CORN FODDER AND MILLET

	Corn		"Weeds" End.		"Weeds" In Corn		Corn & "Weeds" In Corn	
	Green Wt.	Dry Wt.	Green Wt.	Dry Wt.	Green Wt.	Dry. Wt.	Green Wt.	Dry Wt.
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs.
Normal Productive Capacity	21413	4497	14829	4999				
Yield	6515	1609	14829	4999	11011	3932	17526	5541
Increase + or Decrease -							-3887	+1044

Calculated on the basis of green weight the total yield of corn fodder and millet was 3887 pounds less than the productive capacity of the green corn fodder; but calculated on the basis of dry matter the yield was 1044 pounds greater. The percentage of dry matter in the corn was 21% while in the millet it was 35.71%.

TABLE XXXIV MOISTURE, CALCULATED ON THE BASIS OF DRY SOIL, PLAT 5

	Ends		In Corn		
	July 9,16,24 30.	Aug. 5,19,26 & Sep. 16	Aug. 19 & 26	Aug. 5,19, 26 &Sep 16	Aug. 19 &
	%	%	%	%	%
Calculated from checks	19.6	18.0	16.7	13.8	10.6
Actual	17.9	9.8	5.9	9.7	5.7

The decrease in the moisture content is marked. The millet grew rapidly during the early period of growth. When it is remembered that the moisture in the checks was too low much of the time for best results, the poverty of moisture in plat 5 is emphasized.

TABLE XXXV NITROGEN (NO_3) PARTS PER MILLION (P.P.M.) DRY SOIL (AVERAGE FOR DATES GIVEN) PLAT 5

	Ends		In Corn		
	July 9, 16, 24, & 30	Aug. 5, 19,26 & Sept. 16	Aug. 19 & 26	Aug. 5,19 26 &Sep16	Aug.9 & 26
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m
Calculated from checks	92.0	113.5	80.9	26.1	14.2
Actual	48.5	2.0	1.7	3.6	2.2

There is shown a speedy reduction of nitrogen both on the ends and in the corn to a point which would seem to seriously limit if not prohibit plant growth.

XXXVI COMPARISON OF THE REDUCTION OF MOISTURE AND NO_3, PLAT 5

	Ends			In Corn	
	July 9,16 24 & 30	Aug. 5,19,26 A Sep. 16	Aug.19 & 26	Aug.5,19 26 &Sep.16	Aug. 19 &26
Moisture	%	%	%	%	%
Normal calculated from checks	19.6	18.0	16.7	13.8	10.6
Actual Amt.	17.9	9.8	5.9	9.7	5.7
Nitrogen	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
Normal Amt. calculated from checks	92.0	113.5	80.9	26.1	14.2
Actual Amt.	48.5	2.0	1.7	3.6	2.2

The summarized comparison shows a much more speedy diminuition of the nitrogen than of the moisture. The nitrogen contents lowers with the moisture not only in this plat, but holds true on the part of all plats where crops were grown. (See Table "A" Appendix) But the nitrogen lowers relatively much more rapidly when a large crop of "weeds" were grown. It is interesting to note that the nitrogen content of the corn grown on this plat was only

.84 per cent, dry matter.

PLAT #9 YIELD

On Plat #9 soy beans were sown at the first cultivation June 18th. and was later replanted, July 5th. The stand was not sufficient to prevent the growth of weeds and grass. The soy beans, perhaps, constituted half of the weeds harvested. No nodules were found on the roots.

TABLE XXXVII THE RATE OF YIELD PER ACRE OF BOTH CORN FODDER AND "WEEDS"

	Corn		"Weeds"				Corn & "Weeds"	
			End.		In Corn		Corn & "Weeds"	
	Green Wt.	Dry Wt.	Green Wt.	Dry Wt.	Green Wt.	Dry Wt.	Green Wt.	Dry Wt.
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Productive Capacity	20886	4386	14461	3700				
Actual	8689	2145	14461	3700	8167	2090	16856	4235
Increase+ or Decrease-							-4030	-151

Calculated on the basis of green weight the total yield of corn fodder and "weeds" was 4030 pounds less than the productive capacity of green corn fodder. On The basis of dry matter the yield was 151 pounds less. Or, to state it differently, the production of 2090 pounds of dry matter in "weeds" reduced this yield of dry matter

in corn fodder 2241 pounds. Here as in plat 5 the statement of results in green weight would have been entirely misleading.

TABLE XXXVIII MOISTURE CALCULATED ON THE BASIS OF DRY SOIL, PLAT 9

	Ends			In Corn	
	July 9,16,24 & 30	Aug. 5,19,26 & Sep. 16	Aug. 19 & 26	Aug. 5,19, 26, &Sep.16	Aug. 19&26
	%	%	%	%	%
Calculated from checks	17.2	16.0	15.2	12.9	10.8
Actual	14.8	10.0	7.1	9.3	6.2

The reduction in the soil moisture as compared with the checks where corn only grew was very marked even early in the season. It was evident during the greater part of the season that the moisture content was too low for normal growth.

TABLE XXXIX NITROGEN (NO_3) CALCULATED PARTS PER MILLION (P.P.M.) DRY SOIL (AVERAGE FOR DATES GIVEN), PLAT 9

	Ends			In Corn	
	July 9,16 24, & 30	Aug. 5,19,26 & Sep. 16	Aug. 19 & 26	Aug. 5,19, 26 & Sep.16	Aug. 19 & 26
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
Calculated from checks	64.6	90.7	62.2	26.4	18.1
Actual	63.4	5.9	2.5	5.8	5.0

Here, as in plat 5 is shown a much more rapid diminuition of nitrates than occurs in the checks.

TABLE XXXX COMPARISON OF THE REDUCTION OF MOISTURE AND NITROGEN PLAT 9

	Ends			In Corn	
	July 9,16 24 & 30	Aug. 5,19,26 & Sep.16	Aug. 19 & 26	Aug. 5,19 26 & Sep16	Aug.19 &26
	%	%	%	%	%
Moisture Calculated from checks	17.2	16.0	15.2	12.9	10.8
Actual	14.8	10.0	7.1	9.3	6.2
Nitrates NO_3 Calculated from checks	64.6	90.7	62.2	26.4	18.1
Actual	63.4	5.9	2.5	5.8	5.0

Here as in Plat 5 a much more rapid reduction of nitrates occurs than of moisture.

SECOND SOWING OF "WEEDS"

A drought succeeded the sowing of the second crop of"weeds" July 24th., which seriously injured this part of the experiment. Millet was sown on plats 6,15, 20 and 24, and soy beans on Plat 11. The soy beans in the corn grew as tall or taller than at the ends of the plats.

TABLE XXXXI SHOWING RESULTS OF SECOND SOWING OF "WEEDS PRODUCTIVE CAPACITY CALCULATED FROM CHECKS. RESULTS IN DRY MATTER

No. Plat	Productive Capacity Corn lbs.	Yield in Corn: Corn lbs.	Millet lbs.	Soy Beans lbs.	Increase(+) Decrease(-) Corn lbs.	Total lbs.
6	4637	4528	180		-109	+71
15	3828	4155	222		+327	+549
20	2671	3143	219		+472	+691
24	3663	5069	201		+1416	+1607
11	3995	3310		534	-685	-151

TABLE XXXXII SHOWING RESULTS OF SECOND SOWING OF WEEDS. THE PRODUCTIVE CAPACITY CALCULATED FROM CHECKS, CORRECTED FOR EFFECT OF FERTILIZER. RESULTS GIVEN IN DRY MATTER.

No. Plat	Productive Capacity Corn lbs.	Yield in corn: Corn lbs.	Millet lbs.	Soy beans lbs.	Increase (+) Decrease (-) Corn lbs.	Total lbs.
6	4637	4528	180		-109	+71
15	3922	4155	222		+233	+455
20	2483	3143	219		+660	+879
24	4421	5069	201		+648	+849
11	3995	3310		534	-685	-151

In Table XXXXI the comparison is made with the productive aapacity calculated from the checks. The method, however, is not logically correct for plats 15, 20, and 24 since these were fertilized with sodium nitrate, acid phosphate and potassium sulphate respectively. Plats 14, 18, and 23, were fertilized to correspond with the above plats in the order named to dertermine the effect of fertilizers. An attempt was made to correct the calculated productive capacity from the checks by correcting for the effect of fertilizer. (TABLE XXXXII) The actual yield of 14 was taken for comparison with plat 15.

The number for comparison with plat 20 is secured by subtracting 188 pounds, which is the loss apparently due to the acid phosphate in plat 18, from the normal productive capacity (2671# - 188# = 2443#) .

The number for comparison with plat 24 is secured by adding 758 pounds which is the gain apparently due to the potassium sulphate in Plat 23, to the normal productive capacity (3663# + 758# = 4421#)

The results from the two methods are about the same except by the latter method (Table XXXII) the increase in plat 24 is less marked.

When millet was sown in plats 15, 20 and 24, there was an increase in corn fodder, Plat 6 showed a

decrease in corn but an increase in the total weight. Where soy beans were sown on plat 11, the total showed a decrease.

It should be remembered that while the yield of weeds was small, young plants have a relatively large proportion of roots, and a smaller proportion of that above ground can be harvested. If this is considered probably every plat showed an increase in total yield.

But was the increase due to any beneficial effect from the light growth of "weeds", or to the calculated productive capacity being too small? It will be very difficult to determine the effect of a light growth of weeds in plat experiments since the weight of a light growth may easily come within the range of experimental error.

THIRD SOWING OF "WEEDS"

The third sowing of "weeds" made August 6th. failed to grow sufficiently for harvesting except plat 8. The millet gave a yield of 191 pounds dry weight (Table XXIX). Compared with the productive capacity the corn gave an increase of 332 pounds of corn alone, making a total increase of 523 pounds. Thisis in line with the results obtained from the second sowing of "weeds".

EFFECT OF MULCHING

Plat #3 was mulched both in the corn and in the

ends. Weeds were not permitted to grow. The increase in dry matter over the normal productive capacity calculated from the checks was 873 pounds.

TABLE XXXXIII COMPARING THE MOISTURE AND NO_3 CONTENT

	Ends			In Corn	
	July 9,16, 24 & 30	Aug. 5,19, 26. & Sep.16	Aug. 19 & 26	Aug. 5,19, 26, Sep.16	Aug.1[illegible] & 26
	%	%	%	%	%
Moisture Normal Calculated from checks	20.9	19.2	17.9	15.1	11.8
Actual	26.0	25.0	24.2	17.9	13.8
NO_3	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m
Normal Calculated from checks	85.7	101.5	76.5	33.9	16.5
Actual	68.2	85.7	97.5	29.5	23.3

On the ends of the mulched plat the moisture ran considerably higher than on the checks. In the corn during the dry weather, the moisture content ran nearly as low as the calculated normal. There was thus considerably more water used by the plants, which was reflected in the larger yield. During the most trying period of the drought the corn on this plat seemed to suffer nearly as severely as on any of the plats. The nitrogen content was greatly lowered, as well as the moisture.

It was noted in the early season during a wet and rather cool period that the plants on this plat were growing more vigorously than on the cultivated plats near it. Presumably the soil under the mulch was cooler and contained less air than where there was no covering.

EFFECT OF SCRAPING

Plat 2 was not cultivated after planting but the weeds were prevented from growing by cutting them off at the surface of the ground, taking care to leave no mulch. The yield of corn fodder, dry matter, was 157 pounds less than normal as calculated from checks.

TABLE XXXXIV SHOWING THE MOISTURE AND NO_3 CONTENT OF PLAT 2

	Ends			In Corn	
	July 9,16,24 & 30	Aug. 5,19,26 & Sep. 16	Aug. 19 & 26	Aug.5,19 26 & Sep16	Aug.19 & 26
	%	%	%	%	%
Moisture Normal Calculated from checks	21.8	20.1	18.8	16.6	13.4
Actual	21.3	18.2	16.1	15.0	11.8
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
NO_3 Normal Calculated from checks	91.4	101.5	76.5	43.4	16.6
Actual	97.1	90.6	52.8	71.5	52.5

The moisture was somewhat lower than the checks. The nitrogen on the ends was not materially different except during the drought (Column Aug. 19 & 26) when it materially lowered. The nitrogen where the corn grew was much higher than in the checks. Since this can not be accounted for by a sufficiently decreased yield, what is the explanation? It is usually supposed that cultivation favors nitrification. Was nitrification more rapid in this plat than in the checks, or were more nitrates brought up from an accumulated reserve below? The nitrogen content of the soil, Sept. 16, when considerable rain had fallen gives some indication that this latter view may at least partially account for the phenomenon.

(See Table A, Appendix)

In the early part of the season the growth on the scraped plat appeared to be considerably poorer than on the checks, yet the final yield was but 157 pounds, or 4.1% less than the calculated normal yield. It is probable that the calculated normal yield is slightly low, but even then there is not the diminuition in final yield that was indicated by the early growth. It would thus seem possible that on the scraped plat the moisture available was made more efficient by an abundance of available nitrogen in the soil.

-- COMPARISON OF MULCHED AND SCRAPED PLATS --

TABLE XXXXV SHOWING DEPARTURE FROM NORMAL AS CALCULATED FROM CHECKS, IN YIELD, AND MOISTURE, AND NITROGEN (NO_3) content in SOIL

No. Plat	Treatment	Moisture & Nitrogen	Ends Jul.9,16 24 & 30	Ends Aug. 5,19 26,Sep.16	Ends Aug. 19 & 26	In Corn Aug.5,19 26,Sep16	In Corn Aug.19 & 26	Yield
			%	%	%	%	%	#Lbs
2	Scraped	Moisture	- 0.5	- 1.9	-2.7	-1.6	-1.6	-157
3	Mulched	"	+ 5.1	+ 5.8	+6.3	+2.8	+2.0	+873
			p.p.m.	p.p.m.	P.p.m.	p.p.m.	p.p.m.	
2	Scraped	NO_3	- 0.3	-10.9	-23.7	+28.9	+35.9	
3	Mulched	"	-17.5	-15.8	+21.0	-4.4	+6.8	

There was a greater difference between the moisture of the ends and in the corn in the mulched than in the scraped plats. There are many varying factors, among which are evaporation and capillarity.

The NO_3 where corn was growing, is much more abundant in the scraped than in the mulched plat. Was this due to the moisture in the soil not being sufficient to permit sufficient growth to use the available nitrogen?

-- VARIATIONS IN FERTILIZER CONSTITUENTS --

(See Table XXXVI)

The nitrates varied greatly. In general they lowered with the moisture. This was very marked in plats 5 and 9 where the first sowing of "weeds" was made. In these

plats the soluble nitrogen lowered much more rapidly than did the moisture. While the moisture soon ran so low in these plats as to limit plant growth it is a question whether the poverty in nitrogen was not equally, or even more, the limiting factor. Can the plant, by lowering its content of this constituent continue growth if moisture is available? That this can be done is indicated by the nitrogen of the corn fodder on plat 5 being only .84%, while this constituent in the corn fodder of three other plats determined was nearly double this amount. Had the moisture and nitrates of the soil been equally limiting factors we would expect the content of this constituent to be about the same as in the other plats.

In the other plats of the north series during the drought (see column Aug. 19 & 26) a great variation was noted even in the checks (plats 1, 4, 7, 10, & 13). Plat 7 is notably low. Plat 1 has a moderate amount. This is the heaviest soil of this series. Diffusion being hindered in consequence, what is the limiting amount for growth of corn or for checking the accumulation of nitrogen by the plant? Plat 2 (scraped) is high in nitrates. Plat 16, which is a check in the second series is the highest in nitrate content of any unfertilized plat where the NO_3 was determined.

Plats 14, 15, and 17 fertilized with a heavy application of sodium nitrate, failed, at least, to give

any material increase in the crop. Evidently the lack of nitrates in these plats can not account for the low yields. But the moisture ran low, which was doubtless one of the causes, or the cause, for the low yields. It appears, therefore, that the lack of nitrates in the soil was probably a limiting factor, at least, in the amount of nitrogen accumulated by the plants in some cases while in others no such effect occurred from this cause.

A very interesting feature of the table (XXXII) is the variation of NO_3 in the checks. Is it improbable that plat 7, for instance, is too low to supply the optimum amount of nitrates to the plant if the moisture and other conditions were favorable? What effect would this have on the composition of the plants? Sodium nitrate applied to timothy on the Mitchel Farm gave a decided increase in Yield (Cornell Bul. 241, 7)

The PO_4 content in the soil was about the same throughout the season, and is but slightly lower in the corn than at the ends. There was but little effect on the yields. This corresponds with the fact that acid phosphate gives but slightly increased yields on the Mitchel Farm. T

The Potassium (K) in the soil seems to show a slight tendency to lower on the ends with the moisture,

while in the corn there is, percentagely, considerable decrease. Where potassium sulphate was applied it seemed to be somewhat reflected in the yields. This corresponds with the increase in yield when applied to timothy, to which reference is made above.

-- YIELD OF NITROGEN IN CROPS --

A chemical analysis was made of corn fodder from plats 2, 3, 5, and 10, of millet from plats 5 and 6, and of soy beans, weeds, and grass from plat 9, and soy beans from plat 11. Care was taken to select what appeared to be representative samples. Two hills of corn with three stalks each and small composite samples of millet and soy beans were taken. In each case the sample of millet and soy beans consisted of about equal parts taken from the ends and in the corn. It will be noted that the samples were rather small for the purpose. The calculated results for the above plats, together with other plats taken for comparison, are given in Table XXXXVI.

TABLE XXXXVI SHOWING NITROGEN REMOVED BY THE CROPS ON SOME PLATS. AND THE NITROGEN IN THE SOIL 2 - 7 INCHES SEPT. 16. YIELD AND NITROGEN CONTENT OF CROPS GIVEN IN DRY MATTER

No. Plat	Crop In Corn	Crop Ends	Yield Rate per acre Lbs.	Nitrogen %
2	Corn fodder		3643	1.49
3	" "		4952	1.39
4	" "		4357	*1.38
5	" "		1609	.84
5	Millet		3932	1.16
5		Millet	4999	1.16
6	Corn fodder		4528	*1.38
6	Millet		180	3.04
7	Corn fodder		4776	*1.38
8	" "		4913	*1.38
8	Millet		191	**3.04
9	Corn fodder		2145	*** .84
9	****Soy beans		2090	1.49
9		Soy beans	3700	1.49
10	Corn fodder		4190	1.37
11	" "		3310	*1.38
11	Soy beans		534	3.43

*Average per cent nitrogen content of plats 3 and 10 taken.
**The same per cent nitrogen employed as for millet in plat 6.
***" " " " " " " " corn " " 5.
****Soy beans constituted about 50%, weeds and grass constituting the remainder.

TABLE XXXXVI SHOWING NITROGEN REMOVED BY THE CROPS ON SOME PLATS AND THE NITROGEN IN THE SOIL 2 - 7 INCHES SEPT. 16. YIELD AND NITROGEN CONTENT OF CROPS GIVEN IN DRY MATTER. (Continued)

No. Plat	Nitrogen removed by crop. Rate per acre	Total Nitrogen removed by crop rate per acre	Nitrogen in Soil 2 - 7" Sept.16.
	Lbs.	Lbs.	Lbs.
2	54.28	54.28	41.6
3	68.84	68.84	10.8
4	60.13	60.13	4.2
5	13.52		
5	45.61	59.13	1.8
5	58.00	58.00	.6
6	62.49	62.49	
6	5.47	67.96	2.4
7	65.91	65.91	10.0
8	67.80		
8	5.80	73.60	5.0
9	17.16		
9	31.14	48.30	1.7
9	55.13	55.13	2.8
10	57.40	57.40	8.5
11	45.67		
11	18.32	64.01	4.9

The manner of securing the results are clearly open to objection, but they may show some indications. Plats 5 and 9, when compared with the whole,show a decrease in nitrogen in the crop, but when compared with plats 4 and 10 respectively, the decrease is but slight except where corn grew in Plat 9. The corn in this plat is calculated the same as in Plat 5, which is probably too low since the corn yield was 33% greater in Plat 5. Allowing for this probable error, there appears to be about the same yield of nitrogen in the ends as in the corn on these two plats.

The nitrogen in 2 to 7 inches of soil is lower in these plats than any of the others. Plat 2, which was scraped, shows the highest amount of nitrogen in the soil of any of the plats, but the total nitrogen in the crop was low.

-- CAPILLARITY --

For the study of the differences in the capillary power of the soil the results from plats 1 to 13 were used, since the greatest variations in texture occurred in these plats. The variations from the approximate normal for the different plats, and between the ends and in corn is shown in Table XXXXVII.

TABLE XXXXVII PER CENT AVERAGE MOISTURE, NORTH SERIES, (PLATS 1 TO 13) CALCULATED ON THE BASIS OF AVERAGE MOISTURE CONTENT ENDS OF PLATS JULY 9TH. & 16TH.

No. Plat	July 9 & 16	Aug. 5, 19, 26, & Sep. 16.		Aug. 19 & 26.	
	Ends	Ends	In Corn	Ends	In Corn
	%	%	%	%	%
1	23.95	88.2	75.4	82.9	62.3
2	22.55	81.0	66.6	71.50	52.7
3	26.3	95.2	68.0	92.1	52.5
4	21.4	85.2	64.1	79.3	48.2
5	20.8	47.3	46.5	28.3	27.4
6	21.3	80.0	61.8	71.0	45.6
7	20.05	86.0	70.2	81.4	56.0
8	20.45	85.0	71.8	81.4	88.9
9	16.65	60.2	56.2	42.9	37.2
10	17.1	88.9	71.6	83.7	61.8
11	16.35	79.6	70.4	76.2	59.6
12	14.9	87.3	94.7	84.0	90.0
13	16.3	90.4	84.0	88.0	81.4

For the basis of calculation the average moisture content of the ends for July 9 and 16 when the moisture was presumably not far from the optimum was taken. This was some too low for plats 5 and 9, but the error due to this cause is not material.

The most interesting features of this table are the results from plat 12, where there was only a very light growth of soy beans in the corn. Not only was the percentage of the optimum moisture higher than on any of the other plats, but was higher in the corn than in the ends. These averages can not be due to any aberrent determinations for an examination of the detailed data (Table "A" Appendix) shows that for each determination the same differences are shown. Some of these determinations were made before any soy beans were above ground. This is the more interesting on account of this being the highest plat of the whole experimental area. Had this been a heavier soil there would be a possibility of a water coming to the surface where the corn was growing from higher ground, but even under this circumstance the very slight difference between the elevation of this plat and the level of the land above would make such an explanation improbable. It appears, therefore, to be due to strong capillary action. The protection against evaporation by the corn appears to conserve more moisture than is transpired by the plants.

Table A: Showing Moisture and Nitrogen, (NO_3) in Soil.

Plats, 1-13. Corn Planted May 17, 1907.

No. Plat,	Treatment,	ENDS, July 9 Moisture % dry soil,	NO_3 ppm.* dry soil,	NO_3 ppm. moisture,
1	Cultivated all season,	24.5	79.6	325
2	Scraped,	21.7	116.6	537
3	Mulched,	25.7	73.9	288
4	Cultivated all season,	22.1	98.0	443
5	Millet sown June 18,	20.6	84.8	412
6	Millet sown July 24,	21.2	79.0	373
7	Cultivated all season,	19.9	99.1	498
8-	Millet sown Aug. 6,	20.7	100.0	483
9	Soy Beans sown June 18.	16.2	98.6	609
10	Cultivated all season,	17.4	54.4	313
11	Soy Beans sown July 24.	16.5	53.0	321
12	Soy Beans sown Aug. 6	14.9	54.8	367
13	Cultivated all season,	16.5	57.5	349

*ppm, is the abbreviation for parts per million.

Table A(Cont.): Showing Moisture and Nitrogen, (NO_3) in Soil Plats, 1-13. Corn Planted May 17, 1907.

No.	ENDS, July 16.			ENDS. July 23.		
Plat,	H_2O % d.soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.	H_2O % d.soil,	NO_3 ppm. d.soil,	NO_3 ppm. H_2O.
1	23.4	84.5	361	21.3	78.0	366
2	23.4	91.0	389	21.6	97.0	449
3	26.9	39.0	145	26.7	84.0	315
4	20.7	88.4	427	19.8	110.0	555
5	21.0	72.0	347	17.8	29.9	168
6	21.4	78.0	365	19.9	113.7	571
7	20.2	81.0	405	18.7	78.4	419
8	20.2	61,7	305	19.1	101.4	531
9	17.1	60.3	353	15.0	75.6	504
10	16.8	33.6	200	16.2	84.0	519
11	16.2	26.4	163	15.5	73.8	476
12	14.9	34.2	230	14.0	75.6	540
13	16.1	30.0	186	15.7	81.6	520

Table A(cont.): Showing Moisture and Nitrogen, (NO_3) in Soil Plats, 1-13. Corn Planted May 17, 1907.

	ENDS, July 30.			ENDS, Aug. 5		
No. Plat,	H_2O % d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.	H_2O % d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.
1	21.2	78.4	370	21.1	90.0	427
2	18.7	84.0	449	18.3	84.0	458
3	24.7	76.0	308	25.8	61.7	240
4	17.9	91.8	513	18.1	111.0	612
5	12.1	6.6	55	12.8	2.2	17
6	19.3	73.4	380	19,8	135.0	701
7	15.3	67.8	443	18.0	96.0	533
8	17.6	79.8	453	17.3	135.0	780
9	11.1	19.2	173	11.6	8.8	76
10	15.5	52.2	337	15.6	73.1	468
11	14.5	54.0	373	13.6	56.6	416
12	13.9	45.1	325	12.8	66.0	515
13	15.2	60.0	395	14.4	56.1	390

Table A(cont.): Showing Moisture and Nitrogen(NO_3) in Soil.

Plats, 1-13. Corn Planted May 17, 1907.

	In Corn, Aug. 5			ENDS. Aug. 12.		
No. Plat,	H_2O % d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.	H_2O.% d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.
1	19.6	51.9	362	20.6	90.0	436
2	16.7	37.2	223	17.1	75.6	442
3	21.8	32.4	149	24.5	101.4	416
4	16.5	49.2	298	17.5	96.0	548
5	12.8	3.3	26	8.2	6.5	79
6	17.3	58.2	337	16.6	81.6	491
7	16.6	63.0	380	17.1	84.0	490
8	17.9	67.2	375	17.2	111.0	646
9	11.6	6.6	57	8.4	4.0	47
10	13.4	23.6	176	14.9	62.1	418
11	14.1	33.0	234	16.5	75.0	454
12	14.7	28.6	194	12.5	72.1	577
13	13.6	18.1	133	14.1	78.6	557

Table A(cont.): Showing Moisture and Nitrogen (NO_3) in Soil Plats, 1-13. Corn planted May 17, 1907.

	ENDS		Aug. 19	IN CORN		
No. Plat,	H_2O % d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.	H_2O. % d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.
1	20.0	72.0	359	15.3	18.6	122.5
2	16.1	51.6	320	11.3	24.7	219
3	24.1	97.5	404	14.6	6.6	45
4	17.2	84.0	439	10.4	16.5	159
5	6.2	1.5	24	5.5	2.0	36
6	16.0	60.0	375	11.0	11.5	105
7	16.5	54.0	328	11.9	8.8	74
8	16.8	84.0	500	13.2	24.7	187
9	7.0	3.0	43	5.3	5.5	104
10	14.7	50.5	344	10.6	13.7	129
11	12.1	55.0	455	9.2	22.0	239
12	12.7	55.0	433	14.2	66.7	469
13	14.7	78.6	535	12.9	29.7	230

Table A(cont.): Showing Moisture and Nitrogen (NO_3) in Soil Plats, 1-13. Corn Planted May 17, 1907.

IN ENDS.				Aug. 26 IN CORN		
No. Plat,	H_2O% d. soil,	NO_3 ppm. d. soil,	NO_3 ppm. H_2O.	H_2O % d. soil,	NO_3 ppm. d, soil,	NO_3 ppm. H_2O.
1	19.6	69.6	355	14.5	14.8	102
2	16.1	54.0	336	12.4	80.3	670
3	24.4	97.5	400	13.0	40.1	309
4	16.7	91.8	548	10.2	16.5	162
5	5.6	2.0	36	5.9	2.5	42
6	14.2	41.2	290	8.4	10.0	119
7	16.2	79.8	492	10.6	10.5	99
8	16.5	93.6	567	10.9	25.0	230
9	7.3	2.0	27	7.1	4.5	62
10	14.5	69.3	477	10.5	31.0	295
11	12.8	55.0	430	10.3	32.5	315
12	12.3	68.7	559	12.6	57.5	455
13	14.0	69.3	495	13.6	41.6	305

Table A(cont.): Showing Moisture and Nitrogen (NO_3) in Soil.

Plats, 1-13. Corn Planted May 17, 1907.

No. Plat	ENDS Sept. 2 H_2O % d. soil	NO_3 ppm. d. soil	NO_3 ppm. H_2O.	ENDS. Sept. 16 H_2O % d. soil	NO_3 ppm. d. soil	NO_3 ppm. H_2O.
1	18.9	69.6	369	23.8	130.0	547
2	16.7	45.0	270	22.3	172.9	775
3	23.9	117.0	491	25.6	86.2	336
4	17.0	96.0	565	20.8	208.0	1000
5	6.0	1.0	17	15.2	2.2	14
6	13.5	25.3	187	18.8	6.0	32
7	16.6	73.8	444	20.1	143.0	712
8	16.3	66.0	405	19.0	45.0	237
9	7.1	2.0	28	14.2	10.0	70
10	14.9	87.6	588	16.1	165.0	1024
11	11.8	52.2	442	13.6	145.0	533
12	14.3	90.0	630	14.1	44.0	312
13	14.7	90.0	613	15.7	183.1	1168

Table A(cont): Showing Moisture and Nitrogen (NO_3) in Soil.

Plats,1-13. Corn Planted May 17,1907.

IN CORN Sept.16

No. Plat,	H_2O % d.soil,	NO_3 ppm. d.soil,	NO_3ppm. H_2O.
1	22.6	126.7	560
2	19.5	150.0	768
3	22.3	39.0	175
4	17.7	15.0	85
5	14.5	6.6	45
6	15.9	8.8	55
7	17.2	36.0	209
8	16.7	18.0	108
9	13.4	6.1	46
10	14.5	30.8	212
11	12.5	17.5	140
12	15.0	68.7	457
13	14.8	55.0	372

Table A: Showing Moisture and Fertilizer in the Soil.

Plats 14-26. Corn Planted May 17,1907.

ENDS. July 9

No. Plat,	Fertilizer	Treatment	H_2O % d.soil	Fer.ppm.* d.soil	NO_3 ppm H_2O
14	775# Nit.Soda	Cult.all season,	27.2	238.8	878
15	775# " "	Millet sown July 24	25.3	267.1	1056
16	None	Cult. all season,	24.0	91.0	379
17	775# Nit.Soda	Millet sown Aug 6	23.5	240.5	1023
18	775# Acid Phos.	Cultivated all season,	22.2	PO_4 9.7	---
19	None,	" " "	21.7	7.8	---
20	775# Acid Phos.	Millet sown July 24	20.5	7.1	---
21	775# " "	" " Aug 6	22.6	7.1	---
22	None	Cult.all season,	21.3	6.5	---
22	"	" " "	21.3	K 10.4	---
23	388# Sul.Pot.	" " "	22.9	9.1	---
24	" " "	Millet sown July 24	21.6	10.2	---
25	None,	Cult.all season,	20.6	11.2	---
26	388# Sul.Pot.	Millet Sown Aug.6	20.3	19.5	---

* Fer.ppm, abbreviates Fertilizer parts per million.

Table A(cont): Showing Moisture and Fertilizer in the Soil.

Plats 14-26. Corn Planted May 17-1907.

No. Plat	ENDS July 16: H_2O % d. soil	ENDS July 16: Fer. ppm. d. soil	ENDS July 16: NO_3 ppm H_2O.	ENDS July 2[illegible]: H_2O % d. soil	ENDS July 2[illegible]: Fer. ppm. d. soil	ENDS July 2[illegible]: NO_3 ppm H_2O.
14	24.8	162.5	655	23.9	221.0	925
15	24.5	195.0	796	24.6	247.0	1004
16	23.2	130.0	560	23.7	162.5	686
17	23.3	195.0	837	22.1	227.5	1294
		PO_4			PO_4	
18	22.1	11.0		21.1	7.1	
19	21.5	9.7		21.1	8.3	
20	21.0	13.0		19.7	8.3	
21	21.6	8.4		21.4	7.8	
22	19.5	7.8		19.3	7.1	
		K			K	
22	19.5	7.1		19.3	14.3	
23	21.4	5.2		20.7	11.0	
24	20.6	8.4		20.0	8.4	
25	20.0	14.9		18.9	7.8	
26	20.0	9.7		18.7	9.7	

Table A(cont.): Showing Moisture and Fertilizer in the Soil.

Plats 14-26. Corn Planted May 17,1907.

	ENDS July 30			ENDS Aug 5.		
No. Plat	H_2O % d.soil	Fer.ppm d.soil	NO_3ppm. H_2O.	H_2O % d.soil	Fer.ppm. d.soil	NO_3ppm. H_2O.
14	22.5	178.0	780	23.5	235.5	1000
15	23.1	253.5	1097	23.7	227.5	960
16	21.8	177.4	814	22.2	146.2	666
17	21.0	169.0	805	21.3	295.7	1388
		PO_4			PO_4	
18	18.9	7.8		19.6	7.2	
19	18.5	7.2		19.5	6.0	
20	18.8	6.0		19.2	6.6	
21	18.2	8.4		19.3	8.4	
22	18.3	7.8		18.0	7.2	
		K			K	
22	18.3	4.5		18.0	7.8	
23	19.1	9.0		19.2	10.8	
24	19.2	7.8		18.6	12.0	
25	17.6	8.4		17.3	10.2	
26	17.3	12.6		16.7	10.2	

Table A(cont.): Showing Moisture and Fertilizer in the Soil.

Plats 14-26. Corn Planted May 17,1907.

	In Corn Aug.5			ENDS Aug.12		
No. Plat	H_2O % d.soil	Fer.ppm. d.soil	NO_3ppm. H_2O.	H_2O % d.soil	Fer.ppm. d.soil	NO_3 ppm. H_2O.
14	21.8	210.1	965	22.6	208.0	920
15	20.3	240.0	1182	20.8	159.0	764
16	20.1	120.0	596	21.3	151.8	710
17	18.1	282.0	1560	21.0	180.0	858
		PO_4			PO_4	
18	18.2	7.8		19.3	6.0	
19	18.4	7.2		18.9	7.2	
20	17.4	9.0		16.4	7.8	
21	17.0	9.6		19.6	6.6	
22	15.8	7.2		17.2	7.2	
		K			K	
22	15.8	9.6		17.2	4.8	
23	16.9	12.0		19.4	6.6	
24	16.4	13.2		15.6	7.2	
25	14.7	8.2		16.9	5.4	
26	14.6	13.4		17.0	9.6	

Table A(cont.): Showing Moisture and Fertlizer in the Soil

Plats 14-26 Corn Planted May 17,1907

	ENDS Aug.19			InCorn Aug.19		
No. Plat	H_2O % d.soil	Fer.ppm. D.soil	NO_3ppm. H_2O.	H_2O % d.soil	Fer.ppm. d.soil	NO_3 ppm. H_2O.
14	21.5	156.0	725	16.3	150.0	920
15	18.8	126.0	675	14.0	132.0	934
16	21.3	120.0	564	14.1	66.7	472
17	19.8	165.0	834	12.2	129.2	1060
		PO_4			PO_4	
18	18.8	---		11.2	8.2	
19	18.5	9.6		13.6	7.1	
20	14.8	7.7		11.5	7.7	
21	19.1	7.2		11.3	7.7	
22	16.6	----		11.8	6.0	
		K			K	
22	16.6	4.2		11.8	3.8	
23	18.6	9.6		11.1	6.0	
24	14.0	6.0		9.3	4.5	
25	16.2	6.0		10.3	4.4	
26	15.6	11.0		9.5	6.5	

Table A(cont.): Showing Moisture and Fertilizer in the Soil.

Plats 14-26 Corn Planted May 17,1907.

	Ends Aug 26			InCorn Aug 26		
No. Plats	H_2O % d.soil	Fer.ppm d.soil	NO_3 ppm. H_2O.	H_2O % d.soil	Fer.ppm. d.soil	NO_3ppm. H_2O.
14	21.1	159.6	756	15.3	137.5	895
151	17.3	175.8	1014	12.7	165.0	1300
16	21.1	135.0	640	13.7	93.5	685
17	19.5	183.6	942	12.0	203.5	1692
		PO_4			PO_4	
18	18.6	10.2		11.8	9.0	
19	18.1	9.0		13.9	9.9	
20	14.0	8.8		11.6	8.5	
21	17.6	9.0		10.9	7.5	
22	16.5	9.6		11.4	8.0	
		K			K	
22	16.5	6.0		11.4	4.0	
23	18.1	9.6		11.3	5.8	
24	11.1	6.1		8.7	6.5	
25	16.4	6.6		10.7	5.0	
26	15.6	10.8		9.6	15.3	

Table A(cont.): Showing Moisture and Fertilizer in the Soil

Plats 14-26 Corn Planted May 17,1907.

	ENDS Sept.2			ENDS Sept.16		
No. Plat	H_2O % d.soil	Fer.ppm. d.soil	NO_3ppm. H_2O,	H_2O % d.soil	Fer.ppm. d.soil	NO_3ppm. H_2O.
14	21.1	182.0	870	26.4	357.5	1350
15	16.5	126.0	768	25.5	390.0	1530
16	20.9	143.0	684	25.5	240.5	940
17	20.2	151.4	750	25.5	375.0	1470
		PO_4			PO_4	
18	18.8	9.0		24.7	10.4	
19	18.3	9.6		23.6	9.1	
20	12.8	7.0		21.7	10.4	
21	18.2	10.2		22.6	11.0	
22	16.9	9.6		20.4	9.7	
		K			K	
22	16.9	8.4		20.4	9.1	
23	17.7	10.2		22.1	11.7	
24	8.8	6.5		20.5	6.5	
25	16.4	9.0		20.1	11.0	
26	15.3	11.4		19.6	7.2	

Table A(cont.): Showing Moisture and Fertilizer in the Soil.

Plats 14-26 Corn Planted May 17,1907

In Corn Sept.16

No. Plat	H_2O % d.soil	Fer.ppm. d.soil	NO_3ppm. H_2O.
14	22.6	325.0	1440
15	20.5	130.0	634
16	22.2	162.5	733
17	19.2	210.0	1090
		PO_4	
18	19.9	8.4	
19	20.8	9.7	
20	18.0	7.8	
21	18.9	10.8	
22	19.3	9.6	
		K	
22	19.3	5.4	
23	19.0	7.8	
24	17.4	4.8	
25	17.0	5.4	
26	15.8	7.7	

-- FURTHER STUDIES OF THE SOIL --

Some further studies were made of the soil in different plats. Pore space, specific gravity, and rate of evaporation were determined. It was thought possible that a correllation might be shown between variations in some of these properties and the variations in yield, and that some changes might have occurred as a result of variations in treatment. There were also opportunities for some other observations.

-- PORE SPACE AND SPECIFIC GRAVITY --

Soil to the depth of 7 inches was taken in cylinders 7 inches deep by 6 inches in diameter. The capacity of the cylinders was carefully measured with water. Two series were obtained, the first November 20th. just after a thaw and the second November 21st.

Unless otherwise stated the first series was taken at the north end of each plat just beyond where the corn grew, and the second near the middle of the plat. 22a refers to the north end of Plat 22, which was clearly the poorest spot of the field, and 22 refers to the middle of the plat where the soil was gradually changing to the decidedly better part of the plat on the south end. No freeze or precipitation occurred between the taking of the samples. Both series were weighed and the moisture was determined from the samples taken on the side of holes from which the cylinders of soil were taken.

The series taken November 21st. was also immersed in water for three hours, letting the water rise from beneath, removed and immediately weighed in a scale pan. The pore space for the series taken November 20th.(Table "B" Column 8) and November 21st. (Table "C" Column 8) was calculated according to the following formula.

$$(1)\quad \frac{\text{Capacity Cylinder (c.c.)} - \dfrac{\text{Wt. dry soil(gm)}}{\text{Sp. Gr.}}}{\text{Capacity Cylinder (c.c.)}} = \text{Per Cent Pore Space}$$

The pore space for the series taken November 21st. (Table "C" Column V) was also calculated by the following formula:

$$(2)\quad \frac{\text{Moisture in soil when taken(gm)} + \text{Water of Saturation (gm)}}{\text{Capacity of Cylinder (c.c.)}} = \text{Per cent Pore Space}$$

The specific gravity was determined with a pyknometer from the samples used for moisture determination in both series. The results from each series correspond closely so the average of the two is used in the tables which follow:

TABLE "B" SHOWING MOISTURE, PORE SPACE AND SPECIFIC GRAVITY. SAMPLE TAKEN NOV. 20TH.

I	II	III	IV	V	VI	VII	VIII
No. Plat	Capacity Cylinder	* Moisture in soil	Wt.Dry soil	Sp. gr.	Volume Soil	Pore Space c. c.	%
	c.c.	%	gms.		c.c.	c.c.	%
1	3220	23.50	4457	2.64	1688	1532	47.5
4	3255	20.56	4319	2.63	1642	1613	49.6
7	3220	17.16	4398	2.64	1666	1554	48.3
10	3225	13.76	4187	2.67	1568	1657	51.4
16	3240	26.85	4137	2.62	1579	1661	51.3
19	3240	25.02	4131	2.63	1571	1669	51.5
22	3220	23.02	4425	2.65	1670	1560	48.3
25	3235	22.46	4343	2.62	1658	1577	48.7
2	3225	21.39	4399	2.63	1673	15.52	48.1
3	3240	24.25	4564	2.63	1735	1505	46.5
3	3230	24.18	4240	2.63	1612	1618	50.1
5	3195	20.34	4516	2.63	1717	1478	46.2
9	3245	13.97	4678	2.64	1772	1473	45.4
23	3245	23.91	4017	2.62	1533	1712	52.8

* The moisture here as in all other cases is calculated on the basis of dry soil unless otherwise stated.

TABLE "C" SHOWING MOISTURE, PORE SPACE AND SPECIFIC GRAVITY, SAMPLES TAKEN NOVEMBER 21ST.

I No. Plat	II Capacity Cylinder	III Moisture in soil	IV Wt. Dry Soil	V Sp. Gr.	VI Volume Soil.	VII C.C.	VIII Pore *1 %	IX Space **2 C.C.	X %
	C.C.	%	gms.		C.C.	C.C.	%	C.C.	%
1	3220	27.46	4061	2.64	1535	1685	52.33	1595	49.53
4	3255	23.89	4058	2.63	1543	1712	52.60	1660	51.00
7	3220	22.11	4000	2.64	1515	1705	52.95	1668	51.80
10	3225	15.20	4489	2.67	1681	1544	47.88	1520	47.13
16	3240	28.07	3962	2.62	1512	1728	53.33	1702	52.53
19	3240	27.22	3945	2.63	1500	1740	53.70	1659	51.23
22	3230	23.75	4240	2.65	1600	1630	50.46	1529	47.34
25	3235	23.04	4133	2.62	1577	1658	51.25	1569	48.50
2	3225	26.87	4110	2.63	1563	1662	51.53	1644	50.98
3	3240	25.29	4296	2.63	1633	1607	49.60	1593	49.17
25	3195	24.96	4056	2.63	1542	1653	51.73	1612	50.45
9	3245	16.36	4389	2.64	1662	1583	48.78	1577	48.60
22a	3230	23.18	4225	2.65	1594	1636	50.65	1527	47.28
23	3245	24.13	4005	2.62	1529	1716	52.88	1681	57.80

*Calculated according to formula 1, page 147

**Calculated according to formula 2, page 147.

TABLE "D"

COMPARISON OF PORE SPACE

	November 20		November 21		
No. Plat	Location of sample	Pore Space %	Location of Sample	Pore Space By formula #1 %	By formula #2 %
I	II	III	IV	V	VI
1	No.end of plat	47.5	Middle of plat	52.33	49.53
4	"	49.6	"	52.60	51.00
7	"	48.3	"	52.95	51.80
10	"	51.4	"	47.88	47.13
16	"	51.3	"	53.33	52.53
19	"	51.5	"	53.70	51.23
22	"	48.3	"	50.46	47.34
25	"	48.7	"	51.25	48.50
2	"	48.1	"	51.53	50.98
3	"	46.5	"	49.60	49.17
5	"	46.2	"	51.73	50.45
9	"	45.4	"	48.78	48.60
23	Middle of plat	52.8	"	52.88	51.80
3'	Near middle of plat	50.1			
22a			North end of plat	50.65	47.28

The tables show inconsistencies indicating that the samples should be composite. Some of the differences might have been eliminated by determining the moisture content from the soil in the cylinders rather than from that from the side of the holes from which the samples were taken.

The Specific Gravity (Tables "B" and "C" shows an irregular tendency to slightly increase from plats 1 to 13. Plats 10 and 22, which represented almost the extremes in production capacity and presumably of texture, had a slightly higher specific gravity than any of the other plats. There seems to be no correlation either direct or the reverse between the specific gravity and the productive capacity.

The pore space column X Table "C" is uniformly smaller than that in column VIII. While column X was calculated by the more direct method (formula 2, page 147) it seems that some of the water was lost by transferring the sample to the scale pan.

Comparing the samples taken November 20th. and 21st. (Table "D", III and V) both calculated by the indirect but more dependable method, it will be noted that those taken November 20th. at the end of the plats immediately after a thaw had less pore space than those taken the next day from the middles of the plats. Since no

crops grew on the ends of the check plats, it would seem that the phenomena might possibly be due to the influence of the crop. But plats 5 and 9 show the same differences, and the ends of these plats produced practically the same crop as their middles.

The moisture content November 21st.(Table "C",III) was contrary to appearances higher than on November 20th. (Table "B", III). No precipitation or freeze occurred between the taking of the samples. On November 20th. the surface was sticky. The soil cylinders were sunk one fourth to one half inch beneach the surface, thus eliminating this portion, but the soil beneach this was also notably more sticky than the day following, when it worked fairly well. It would seem that the freeze localized the moisture, and after the thaw it was redistributed. There would seem to be a correllation between this and the increase in pore space noted above.

On the whole, the plats which were not cultivated (Plats 2, 3, 5, and 7) show less pore space than the others. Had the samples been taken earlier in the season, perhaps the difference would have been more marked. Plat #2 has a higher per cent pore space than any of the other uncultivated plats. The mulch had been removed from Plat #3 previous to taking the samples. Further correllations do not seem to exist.

-- SUGGESTIONS FOR DETERMINING PORE SPACE --

In the light of the experience gained in securing

the pore space here tabulated a few suggestions are made. It appears that getting total weight and determining moisture and specific gravity, and from this data calculating the pore space, is more dependable than the direct method by adding water. Only one cylinder is needed thus obviating errors due to lack of exact measurements. Since the variability is small it is essential that errors be eliminated as far as possible. Composite cylinders of soil should be weighed in the field and the sample for moisture and specific gravity determination taken from the whole of the samples after thoroughly mixing. If striking variation occurs probably this should be eliminated, as any compacting factor, such as the step of a horse, for instance, would cause a sample not to be comparable; If this elimination is not resorted to a larger number of samples should be taken from the plats when much variation occurs.

-- RATE OF EVAPORATION AND LOSS FROM DRAINAGE --

Rate of evaporation from platinum dishes

Soil from samples taken for moisture determination Nov. 20th. (Table "B") was used. Platinum dishes were filled, packed by jarring uniformly, and struck. The samples were placed in a room a few feet from the radiator. The results follow in table "E":

TABLE "E" LOSS OF WATER BY EVAPORATION FROM PLATINUM DISHES

No. Plat	Wt. Dry Soil	Moisture		Rate loss per day for 3 days	3 - 7 days	7 - 10 days	10 - 13 days	13-17 days	H_2O at end 17 da.
	gms.	gms.	%	gms.	gms.	gms.	gms.	gms.	gms.
I	II	III	IV	V	VI	VII	VIII	IX	X
1	211.99	49.82	23.50	6.58	4.40	2.23	.89	.06	2.85
4	213.29	43.86	20.56	6.47	3.96	1.78	.42	-.01	2.01
7	192.92	33.11	17.16	5.65	2.70	1.20	.11	-.01	1.47
10	208.20	28.58	13.73	5.30	2.28	.66	.05	-.01	1.43
16	200.16	53.73	26.85	6.12	5.72	2.53	.86	.02	2.21
19	172.32	43.11	25.02	5.74	4.47	1.81	.24	.00	1.89
22	201.13	46.30	23.02	6.93	4.22	1.89	.35	-.01	1.93
25	191.96	43.12	22.46	5.82	4.21	1.97	3.6	-.02	1.90
2	204.61	44.76	21.39	7.03	3.49	1.97	.54	.01	2.11
3	196.23	47.59	24.25	6.78	4.16	2.12	.69	.00	2.16
23	187.42	44.91	23.91	6.23	4.35	1.90	.40	.00	1.91
3	186.18	45.01	24.18	6.43	3.96	2.07	.19	.00	2.07
5	198.48	40.38	20.34	6.26	3.43	1.84	.24	-.01	1.65
9	200.64	28.04	13.97	5.62	3.14	-.93	.13	-.08	1.35

The rate of evaporation diminished fairly uniformly till the hygroscopic moisture was reached. The "drought limit" for corn appears to have been reached before the first weighing was made at the end of three days. The data would have been more valuable had the weighings been made at closer intervals.

-- RATE OF DRAINAGE AND EVAPORATION FROM CYLINDERS OF SOIL --

The cylinders of soil taken November 21st. (Table "C") for the determination of pore space were used. Immediately beneath the soil was cheese cloth, the whole being supported by galvanized wire netting one sixth inch mesh. The cylinders with accessories were supported on sticks in pans, allowing a free access of air beneath. Covers of glazed paper and boards were used, thus practically eliminating the loss of moisture to the bottom of the cylinders.

They were placed in the room used for evaporation from platinum dishes under what appeared to be uniform conditions. The results follow in Tables F, G, & H:

TABLE F ORIGINAL DATA ON DRAINAGE AND EVAPORATION FROM CYLINDERS OF SOIL

No. Plat	No. Cylinder	Capacity Cylinder	Wt. Cylinder	Wt. wire and Cin	Total Weight Soil as taken from field	Moisture in field	Total Wt. saturated cylinder
			gms.	gms	gms.	%	Gms.
I	II	III	IV		V	VI	VII
1	1	3220	414.5	56.	5647	27.46	6127
4	4	3255	412	"	5495	23.89	6186
7	7	3220	415	"	5355	22.11	61 39
10	10	3225	410	"	5637	15.20	6475
16	16	3240	392	"	5522	28.07	6112
19	19	3240	411	"	5485	27.22	6071
*22	24	3230	411.5	"	5715	23.75	6237
25	25	3235	421.5	"	5563	23.04	6180
2	2	3225	411	"	5682	26.87	6221
3	3	3240	415.5	"	5855	25.29	6361
5	5	3195	415.5	"	5540	24.96	6140
9	9	3245	419.5	"	5583	16.36	6442
22a	22	3230	412	"	5672	23.18	6220
23	23	3245	415.5	"	5440	24.13	6155

* 22a was taken from the north end of the plat where the poorest soil of the field ocurred, while 22 was taken from near the middle of each plat as was done with all the other samples.

TABLE "F"CONTINUED ORIGINAL DATA ON DRAINAGE AND EVAPORATION FROM CYLINDERS OF SOIL.

	Weight after							
No. Plat	1 Hour	2 Hours	24 Hrs.	3 Days	6 3/4 days	9 3/4 days	13 days	17 days
	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.
I	VIII	IX	X	XI	XII	XIII	XIV	XV
1	5905	5895	5828	5722	5615	5547	5487	5411
4	5898	5892	5823	5716	5539	5466	5403	5325
7	5856	5840	5782	5691	5510	5399	5322	5234
10	6296	6284	6209	6101	5907	5791	5704	5612
16	5890	5870	5800	5684	5515	5440	5362	5276
19	5862	5851	5784	5675	5508	5430	5352	5289
22	6007	5992	5933	5820	5697	5625	5550	5470
25	5995	5984	5903	5790	5604	5527	5450	5372
2	5974	5964	5884	5773	5654	5586	5424	5445
3	6137	6127	6050	5940	5820	5755	5697	5626
5	5906	5895	5817	5704	5549	5481	5411	5338
9	6254	6247	6172	6065	5868	5738	5640	5547
22a	6013	6003	5931	5804	5648	5577	5496	5401
23	5885	5864	5803	5704	5524	5425	5352	5280

TABLE "F" CONTINUED ORIGINAL DATA FOR DRAINAGE AND EVAPORATION FROM CYLINDERS OF SOIL

Weight After

No. Plat	22 Da.	27 Days	34 Days	41 Days	48 Days	57 Da.	67 Da.
	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.
I	XVI	XVII	XVIII	XIX	XX	XXI	XXII
1	5313	5214	5092	4987	4930	4847	4785
4	5219	5129	5027	4942	4888	4811	4757
7	5131	5050	4944	4867	4822	4745	4696
10	5507	5421	5318	5253	5210	5142	5095
16	5173	5066	4937	4855	4796	4714	4655
19	5145	5044	4923	4834	4773	4691	4633
22	5362	5264	5140	5045	4990	4913	4864
25	5274	5182	5069	4994	4945	4866	4812
2	5347	5254	5136	5043	4987	4905	4849
3	5538	5455	5328	5230	5167	5077	5015
5	5233	5148	5042	4963	4910	4831	4773
9	5433	5335	5232	5165	5117	5052	5005
22a	5294	5198	5080	4994	4928		4818
23	5187	5095	4987	4894	4836	4758	1702

TABLE "G" SHOWING RATE OF LOSS OF MOISTURE FROM CYLINDERS OF SOIL

Rate loss moisture per day in grams

No. Plat	Ist.Hr.	2nd. Hr.	2 - 24 Hrs.	1st. Day	1 - 3 Day	3-6 3/4 Days	6 3/4 - 9 3/4 da	9 3/4 to 13	13 to 17
I	II	III	IV	V	VI	VII	VIII	IX	X
1	222	10	67	299	53	28.5	22.6	18.5	19
4	288	6	69	363	53.5	47.2	24.3	19.4	19.5
7	283	16	58	357	45.5	48.3	37	23.7	22.0
10	179	12	75	266	54	51.7	38.6	26.8	23
16	222	20	70	312	58	45.1	25	24	21.7
19	209	11	67	287	54.5	44.5	26	24	23.2
22	230	15	59	304	56.5	32.8	24	23.1	20
25	185	11	81	277	56.5	49.6	25.6	23.7	19.5
2	247	10	80	337	55.5	31.7	22.6	19.1	19.7
3	224	10	77	311	55	32	21.6	17.9	17.7
5	234	11	78	323	56.5	41.3	22.6	21.5	18.2
9	188	7	75	270	53.5	52.5	43.3	30.2	23.2
22a	207	10	72	289	63.5	41.6	23.6	24.9	23.7
23	270	21	61	352	49.5	48	33	22.5	28.0

TABLE G CONTINUED SHOWING RATE OF LOSS OF MOISTURE FROM CYLINDERS OF SOIL

No. Plat	17 -22 Days	22 - 27 Days	27 - 34 days	34-41 Days	41-48 Days	48 -57 Days	57-67 Days	Gms	%
	Rate loss moisture per day in grams							Moisture retained	
I	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
1	19.6	19.8	17.4	15	8.1	9.2	6.2	252	6.25
4	21.2	18.	14.6	12.1	7.7	8.6	5.4	231	5.69
7	20.6	16.2	15.1	11	6.4	8.6	4.9	225	5.62
10	21	17.2	14.7	9.3	6.1	7.6	4.7	140	3.12
16	20.4	21.4	18.4	11.7	8.4	9.1	5.9	245	6.18
19	22.8	20.2	17.3	12.7	8.1	9.1	5.8	221	5.60
22	21.6	19.6	17.7	13.6	7.9	8.6	4.9	157	3.70
25	19.6	18.4	16.1	10.7	7.0	8.8	5.4	202	4.89
2	19.6	18.6	16.8	13.3	8.0	9.1	5.6	272	6.62
3	17.6	16.6	18.1	14	9.0	10	6.2	248	5.77
5	21	17	15.1	11.3	7.6	8.8	5.8	246	6.07
9	22.8	19.6	14.7	9.6	6.9	7.2	4.7	141	3.21
22a	21.4	19.2	16.8	12.3	9.4			125	2.96
26	18.6	18.4	15.4	13.3	8.3	8.7	5.6	229	5.72

TABLE "H" MISCELLANEOUS DATA ON TEST WITH CYLINDERS OF SOIL

No. Plat	Wt. dry Soil	Water in Saturated soil		Water in soil as taken from field	Water lost in 34 days	Water in soil at end of 34 days		
	Gms.	Gms.	% dry soil	%	Gms.	Gms.	% total water	% dry soil
I	II	III	IV	V	VI	VII	VIII	IX
1	4061	1596	39.30	27.46	1035	561	35.15	13.81
4	4058	1660	40.91	23.89	1159	501	30.18	12.35
7	4000	1668	41.70	22.11	1195	473	28.36	11.82
10	4489	1520	33.86	15.20	1157	363	23.88	8.09
16	3962	1702	42.96	28.07	1175	527	30.96	13.30
19	3945	1659	42.05	27.22	1148	511	30.80	12.95
22	4240	1530	36.08	23.75	1097	433	28.30	10.21
25	4133	1570	37.99	23.04	1111	459	29.24	11.11
2	4110	1644	40.00	26.87	1085	559	34.00	13.60
3	4296	1594	37.14	25.29	1033	561	35.19	13.06
5	4056	1613	39.77	24.96	1098	575	31.93	12.70
9	4389	1578	35.95	16.36	1210	368	23.32	8.39
22	4225	1527	36.14	23.18	1140	387	25.34	9.16
23	4005	1682	42.00	24.13	1168	514	30.56	12.83

The loss from these cylinders was aided by gravity which assistance was continued throughout the experiment, th though in a diminishing degree as the experiment progressed. When the first few weighings were made it was noted that the cheese cloth extending beyond the under edge of the cylinders was moist under the samples from plats 2,3,7 & 10, and that this condition continued largest in the case of the latter. This assistance to evaporation rendered by the cloth would serve to increase the variation between the finer and courser soils.

After the loss from sensible percolation had ceased, the further loss rapidly declined till what seemed to be a fairly uniform level was usually reached. This fairly uniform level gradually became less pronounced as the soil became coarser till in plat 10 it was somewhat indefinite.

Table "G" shows the loss of water for the first hour to be very variable, plats 10, 25,and 9 being the lowest. By referring to Table "C", Column VII, it will be noted that where the pore space was determined by taking the sum of of the water retained from saturation and the water in the samples as taken from the field (Formula 1), these plate give the lowest determination (of pore space) of any other plats except the two samples from plat 22. Too much importance should not be attached to the variation in these latter samples since the various data show that they often vary from what would be expected.

The correllation between the relatively small

loss the first hour and the low per cent pore space indicates that too much water was lost before the saturated samples were placed on the scale pan. This supports the conclusion stated above that this direct method of determining pore space is not dependable.

TABLE "I" ; COMPARING MOISTURE CONTENT IN CYLINDERS WHEN THE FAIRLY UNIFORM LEVEL WAS REACHED WITH MOISTURE IN THE ENDS OF PLATS IN THE FIELD JULY 9TH, 1907.

No. Plat	Moisture when level reached	Moisture of end plats	Calculated from checks
	%	%	%
1	25.0	24.5	
4	23.2	22.1	
7	21.3	19.9	
10	16.7	17.4	
16	24.0	24.0	
19	23.8	21.7	
22	19.9	21.3	
25	20.3	20.6	
2	24.5	24.4	24.4
3	23.0		23.8
5	23.5		22.6
9	17.7		18.2
22a	22.6		
23	23.8	22.9	

The amount of moisture which is shown in the table was determined at the end of 6 3/4 days for plat 22a, 9 3/4 days for plats 1, 4, 2, 3, 5, and 23, and at the end of 13 days for plats 7, 10, 16, 19, 22, 25, and 9. By inspection of the table it will appear that the selection of the points for which the calculations were made was slightly arbitrary. It would seem probable that the level was reached in some cases between the dates at which the data was taken. But the closeness of agreement between the per cent of moisture as calculated from this data with the moisture in the field July 9th. when the moisture was supposedly about the optimum indicates, that this is a fairly dependable method at least in this soil, notwithstanding its variations, for the determination of the optimum moisture content. After the loss continued on the "fairly uniform level" for some time the rate of loss began to decrease slowly at first, then rapidly. The moisture in the soil just before the most marked fall occurred is calculated and shown in Table "J".

TABLE "J": AMOUNT OF MOISTURE IN THE SOIL WHEN THE FIRST RAPID FALL OCCURRED AFTER PASSING THE FAIRLY UNIFORM LEVEL, AND THE MOISTURE CONTENT IN THE CORRESPONDING FIELD SOIL GROWING CORN

No. Plat	Moisture		
	When fall occurred	In Soil in growing corn Aug. 26	calculated from checks
	%	%	%
1	11.2	14.5	
4	10.2	10.2	
7	9.9	10.6	
10	8.9	10.5	
16	13.30	13.7	
19	13.0	13.9	
22	8.0	11.4	
25	11.1	10.7	
2	11.3		13.1
3	10.8		11.6
5	10.7		10.1
9	8.4		9.2
22a	9.2		
23	10.5		

The moisture is calculated at the end of 41 days (Table G, XIV) for plats 1, 4, 7, 22, 2, 3, 5, & 23; at the end of 34 days (XIII) for plats 10, 16, 19, 25, 9,

and 22a. These points as in the case of those for optimum moisture content were all selected before the calculations were made. On the whole the results are usually below those found in the corn at a time when most of the plats were suffering for lack of moisture. Plat 10, however, was perhaps not suffering as much as the others, if indeed it was suffering at all, since capillarity appears to have been stronger in the soils of the coarser plats. The differences between the two columns are greatest in plats 1 and 22. The method appears to be fairly dependable for the determination of the relative drought limit in these soils, but the results were not as conclusive as those for the optimum moisture. However, the greater variation in the results for the "drought limit" may have been due as much to variations from the drought limit in the corn as in the results from the cylinders of soil.

The differences in the rate of capillarity together with other factors would make it impossible to secure results in the field which were more than approximations.

While these two results are below the drought limit for corn they are above that for some other plants. It should be remembered that this drought limit is considerably below the point where plants can make a vigorous growth. Perhaps if capillary water is excluded, the water available

for the vigorous growth of corn would be that from slightly above optimum to the end of the "fairly uniform level".

The results gotten at the end of 34 days for all the plats (Table "H" IX) show a surprising consistency, with the exception of plat 22, which is somewhat low. From this it would appear that by calculating the moisture retained at the same time for all the plats about, or just previous to the most abrupt fall in most of the plats the results will not only give the relative so called drought limit for corn, but will be approximately the amount which will be available for corn. Plat 22, however, is the exception; yet this is not marked. Whether these results can be obtained with different soil types, or whether a variation in the conditions of the evaporation test would affect results can only be determined by further experiment.

The results gotten at the e nd of 67 days (Table H, XI) show differences in the same direction as at the end of 34 days, but the differences are percentagely greater. The samples from plat 22 (22 & 22a) ran about the same as that from plat 10. It will be remembered that the samples from plat 22 were taken from the poorest part of the whole series under experiment. Sample 22a was taken from the north end of the plat which was representative of the poor spot and 22 from the centre of the plat (as in the case with the other samples experimented with) which was in the edge of this spot.

The yields show this plat not to be the lowest in production, but this is due to the south end being considerably better than the north end.

In conducting tests by this method, where data is secured at short intervals, uniform conditions should be maintained, especially as regards temperature. This is especially important as the drought limit is approached for the fluability of the water film is increased as the temperature rises thus assisting drainage. The increase in Column XVI over XV (Table "G") is probably due to this cause.

But where it is desired to get only approximate results, as may be desired when selecting land for plat experiments, it would seem unnecessary to take such painstaking care. The optimum moisture could be gotten from the soil taken from the field at the proper time, and taking samples in cylinders for drainage and evaporation according to the method above described. Make weighings of two or more samples till the last fall begins to occur, then weigh all the cylinders and calculate results. It would perhaps be unnecessary to saturate the soil in the cylinders.

The determination of the moisture capacity of the soil detached from the field would seem to be of value as a reconnoisance method for the selection of land

for field plats. This would perhaps usually give a fair indication of the uniformity of the land. But in the opinion of the writer a record of the growth of the same crop by plats for the year preseeding the commencement of the experiment would be far more dependable. It should be remembered that the moisture capacity is only one of the factors which affect the amount of water which the plants receive. Capillarity is a most important factor and varies markedly in different soils. On the other hand the productive capacity determined by growing a previous crop is subject to error from experimental variation, difference in seasons and change in productive capacity, even relatively, from season to season. Under some conditions this latter variation may be very marked. Where it is not possible to secure the yields a previous season, the determination of the moisture capacity would seem to be of some value.