THE EFFECT OF APPLYING PLANT NUTRIENTS TO VARIOUS SEEDS BEFORE PLANTING ON RATE OF SEEDLING DEVELOPMENT AND CROP YIELD

By

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INTRODUCTION

The purpose of this study was to determine the growth responses of various crops to seed treatment with fertilizers prior to planting. The experiment was divided into four phases: adsorption studies, a germination study, greenhouse experiments, and field studies. The adsorption study consisted of determining how much liquid fertilizer would adhere to the various seeds. Emergence experiments with oats, and early growth measurements of corn, cotton, wheat, and oats were conducted in the greenhouse. Root growth measurements were made on corn and cotton. Studies in the field consisted of an emergence test with corn and a yield study with oats.

Seed treatment with liquid fertilizer has been practiced as early as 1628 when Frances Bacon, (Buttress and Dennis)[1] conducted certain seed soaking experiments. He soaked wheat seed for 12 hours with cow-dung, horse dung, urine of man, soot, wood ashes, bay salt, and claret wine, with water as a check treatment. Best growth was obtained from urine, dung, soot, ashes, salt, water, and wine, respectively. Jethro Tull and his followers, (Buttress and Dennis)[1] practiced steeping wheat seed in salt brine to get rid of smut. Arsenic was used as a disease inhibitor. It was placed in salt brine, and wheat seed were soaked in the solution. Afterward the seed were rolled in lime to dry them and to make the seed favorable to the hands for sowing.

Bryant, (Buttress and Dennis)[1] at the conclusion of his small treatise, recommended the farmer to lay aside his old, irrational practice and pay particular attention to proper culture of the soil, to keep it clean from weeds; and to supply it with proper manure. "These", he remarked, "are the best remedies for diseases in corn; these will

contribute most to health and vigor, and make his fields, as well as himself, laugh and sing."

REVIEW OF LITERATURE

Roberts[7] was the only investigator who obtained significant increases in yield of barley and wheat by treating the seed with liquid fertilizer. Her experiment was unique in that she soaked the seed in the fertilizer solutions, whereas most of the later investigators merely wet the surface of the seed. She soaked barley seed for 12 hours in 17 per cent K_2HPO_4 and planted in potassium deficient soil. The yield was increased from 41.8 bushels (untreated) to 46.4 bushels per acre (treated). Barley seed soaked in a similar manner and planted in phosphorus deficient soil increased the yield from 7.4 bushels (untreated) to 11.0 bushels per acre (treated). This was significant at the 1 per cent level. It was found that the compound in which to supply a certain element and the concentration was of great importance and must be varied according to the species of grain. Of importance was the fact that drying soaked seed at above 22 degrees centigrade reduced germination markedly. Roberts[7] found that the efficiency of phosphorus was 60 times as great when wheat seed were soaked in K_2HPO_4 solution as compared to basic slag added to the soil.

Volk, et al[8] found that liquid fertilizer seed treatment at the rate of 1 pint of 5-10-5 per bushel on oats, wheat, corn, soybeans, and alfalfa gave no significant response. Complete dry fertilizers in the same experiment showed significant increases both in seedling growth and yield over the liquid fertilizer on all crops except soybeans. The dry fertilizer was banded or drilled in the row.

Smith[6] conducted tests on germination and yields of small grains using a 5-10-5 liquid fertilizer compared with dry fertilizers. The

germination tests were as follows:

The effect of liquid fertilizer on the germination of wheat, oats, and barley (Smith)

Treatment	Germination % wheat	oats	barley
No treatment	97	97	83
5-10-5 @ 1 gal./8 bu.	97	94	79
5-10-5 @ 1 gal./1 bu.	85	58	23

The recommended treatment (1 gallon per 8 bushels) did not reduce germination significantly, whereas the 1 gallon per bushel treatment reduced germination of all grains. It was noted that germination was reduced less on wheat and oats than on barley. There was no significant difference in the yields of small grains treated with fertilizer solutions over untreated seed under greenhouse or field conditions. Dry fertilizer alone at 2.5 grams of 10-30-10 per 2,000 grams of soil increased yields of wheat 3.1 bushels per acre; oats 9.73 bushels per acre; and barley 15.98 bushels per acre under greenhouse conditions. About the same differences existed in the field.

McVickar[3] quotes work from Ohio and four other stations where liquid fertilizers have been used with small grains. In every case, there was no significant increase in yield over the check plots. Dry fertilizers increased the yields significantly in most cases. Many more references could be quoted, but due to the fact that the data in each case are similar to that already presented, it was not deemed necessary to include them. The North Dakota Agricultural Experiment Station[5], and the University of Saskatchewan, Saskatoon, Saskatche-

wan[4], have completed extensive studies on the subject. Also the work done at the University of Manitoba, Fort Garry, Manitoba[2] might be mentioned. This work was done principally to follow up the work of Roberts[7]. No significant differences were noted with liquid fertilizers on oats.

EXPERIMENTAL METHODS

Adsorption Studies

The first problem was to find how much liquid fertilizer would adhere to the seed coat of each type of seed. One-hundred grams of seed were weighed in a sifter which was then dipped into the solution just long enough to wet the surface of the seed. This was done to insure a minimum of seed soaking. The sifter was then bounced 100 times and re-weighed. The difference was converted to bushels of seed needed per gallon of liquid. Data for cotton, barley, rye, oats, wheat, corn, and soybeans was obtained in this manner.

Germination Study

A preliminary germination study was conducted to determine the effect of the concentration of glue on oats and the effect of Arasan on fungal growth. The "horn and hoof" glue (14% nitrogen) was heated in distilled water, cooled, and the different concentrations poured over the seed. After mixing well, the seed were spread out on paper for air drying. Arasan was used at the recommended rate of 2 ounces per bushel. The medium used for germination was blow sand obtained near the Cimarron river. This sand was used in all greenhouse experiments with the exception of the Kirkland silt loam used in the growth study with five-gallon pots.

The seed were germinated at 21 degrees centigrade in a flat with a glass cover for 6 days and counted.

Greenhouse Experiments

An emergence test was conducted with Neosho oats using fourteen types and three concentrations of salts. In most cases the low concentration was in the liquid form. Twice and four times the solution concentration was added to the seed as a dry salt with glue. Salts such as K_2SO_4, superphosphate, and others which had a low solubility were pulverized and passed through a 100 mesh screen in order to give more surface area of salt per seed.

A 10 ml. graduated pipet was used to deliver 1.31 ml. of the liquid fertilizers to each 10 gms. of seed, which is the equivalent of 1 gallon to 2 bushels of oats. One ml. of 1 to 10 glue solution was added to each 10 gms. of seed where dry salts were used. The seed were then air dried and 50 seed planted in 6-inch pots in duplicate. The planting date was February 24, 1951, and emergence counts were taken March 8, 1951.

Early growth studies were conducted with corn, cotton, oats, and spring wheat with blow sand as the media. There were 8 fertilizer treatments and 13 seed of each crop were planted in duplicate 6-inch pots. Corn and cotton were also studied in 5-gallon pots using surface soil from a Kirkland silt loam.

Each plant in each pot was measured twice daily with a centimeter rule. In this manner the daily growth per pot was accumulated for 12 days. The small pots were planted April 17th and the large pots April 24, 1951. Soil and room temperatures were kept daily. Room temperatures

were much too warm for wheat and oats due to the fact that the greenhouse was being used at the time for sorghum breeding work.

Root growth of corn and cotton was measured for 24 hours (the roots were usually out of sight by then) with a centimeter rule. Seven wooden boxes with glass placed on one side were used. Black paper was placed over the glass to keep algal growth at minimum and the roots in darkness as much as possible. Hourly root measurements started at 11:00 AM, April 23 until 7:00 PM; resumed at 6:00 AM on the 24th, and the roots were out of sight by noon of that day. Two liquid fertilizers and 4 dry fertilizers with glue were used. The seed were planted on April 20, 1951. Limited top growth measurements were also made.

Field Studies

Emergence tests were conducted on corn which had been previously treated with various liquid and dry fertilizers. Glue containing Arasan was applied to the seed and the dry fertilizer was added and mixed so that each kernel of corn had an opportunity to be coated with some fertilizer. One bushel of seed corn was treated with the liquid fertilizers at the rate of 1 gallon to 7 bushels. The corn was planted April 14, 1951, and emergence counts made on May 3.

A yield study with Neosho oats using various liquid fertilizers and dry salts with glue and Arasan was made. In addition, 16-20-0 at 100 pounds per acre was used alone and in combination with the liquid fertilizers. A 4-12-4 fertilizer was also included. Three hundred grams of oats were used for each treatment and the equivalent of 1 gallon of

liquid fertilizer to 2 and 4 bushels of oats was used. The dry salts were pulverized to pass through a 100 mesh screen and added after the glue was applied to the seed. An attempt was made to keep the phosphorus constant with the nitrogen and potassium varying.

Four series of oat plots, randomized within each block, were planted March 1, 1951, on plot numbers 1329, 30, and 31 of series 1300 at the Perkins farm. The land was in oats in 1949. The rows were laid out in an east-west direction with 3 rows in each small plot. Series I was on the north part of plot 1329; series II was on plot 1330; and series III was on plot 1331. Series IV was laid out with 9 small plots on the south end of plot 1331, and 8 small plots each on the south ends of plots 1330 and 1329 and were numbered from north to south. The randomized treatment numbers in each block are shown in Table 1.

Table 1. Showing randomization of the oat fertility plots.

Series I	Series II	Series III	Series IV
12	20	10	6
1	7	15	22
23	15	7	1
3	4	13	25
25	13	5	2
16	2	21*	9
13	12	11	14
19	23	4	3
20	9	12	20
5	21	6	10
21	18	25	18
9	16	18	21
17	1	1	5
10	8	23	17
6	14	20	11
14	19	2	7
11	11	8	4
2	25	14	12
24	3	3	24
8	5	19	8
22	17	24	15
7	6	16	23
4	22	9	16
15	10	22	13
18	24	17	19

* A mistake was made and 16-20-0 at 100 pounds per acre was applied instead of 4-12-4, which was applied to the other 3 series.

RESULTS AND DISCUSSION

Adsorption Studies

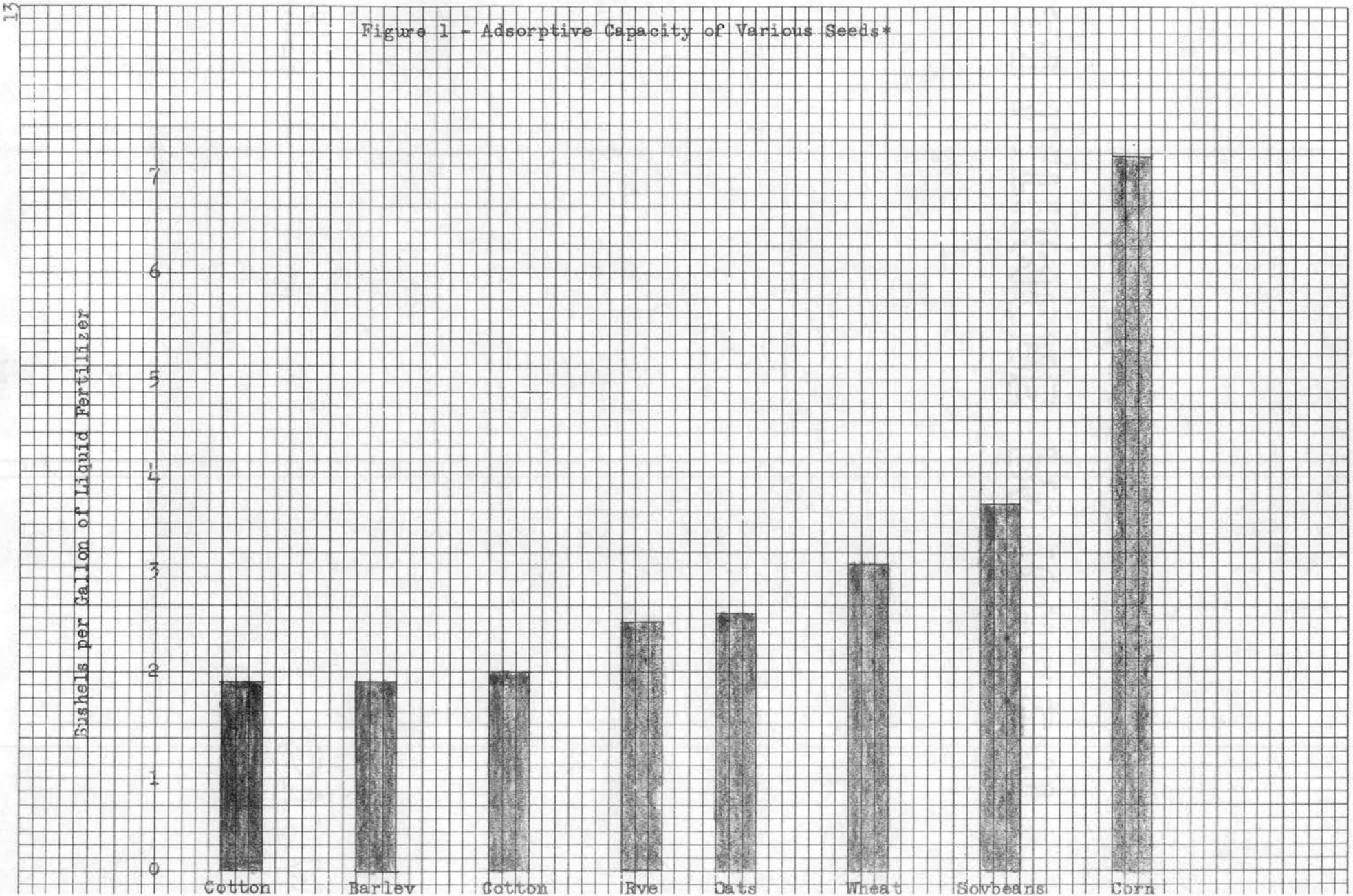
Although certain liquid fertilizer companies recommend 1 gallon of the fluid to 8 bushels of most seed, it was believed that the concentration would necessarily need to be greater in order to give any response at all. Therefore, a study was made to show how much fertilizer would adhere to the surface of various seeds. Figure 1 shows graphically that considerably more liquid fertilizer can be retained by the seed than has been recommended.

It will be noted that delinted cotton, barley, and cotton with lint adsorbed the greatest amount of liquid, with corn retaining the smallest amount. Of interest is the fact that delinted cotton held more liquid than cotton with lint. This possibly could have been due to the waxy nature of the lint. From the data obtained in Figure 1, the amount of fertilizer in pounds per acre was calculated and is presented in Table 2. This assumes that there are 4.1 pounds of fertilizer material in 1 gallon of liquid.

Table 2. The amount of 3-18-9 fertilizer in pounds per acre as applied to various seeds in liquid form.

Seed	Bushels of seed per gallon of solution retained	Amount of fertilizer in pounds per bushel	Seeding rate	Amount of fertilizer in pounds/acre
Delinted cotton	1.9	2.15	½ bu.	1.07
Cotton	2.0	2.05	1 bu.	2.05
Barley	1.9	2.15	2 bu.	4.30
Oats	2.6	1.58	2 bu.	3.16
Rye	2.5	1.64	1½ bu.	2.48
Wheat	3.1	1.32	1 bu.	1.32
Soybeans	3.7	1.11	20 lbs.	0.37
Corn	7.2	0.58	7 lbs.	0.07

Figure 1 - Adsorptive Capacity of Various Seeds*



It is easily seen from the data in Table 2 why little or no response can be ordinarily expected especially on deficient soils, otherwise unfertilized. Even our most deficient soils would release more nutrients than could be applied to the seed by the recommended methods. After finding how much liquid fertilizer would adhere to the various seeds, it was deemed necessary to conduct a test to note the effect of higher concentrations on emergence.

A preliminary germination study on the effects of various concentrations of glue with and without Arasan was conducted and the data are presented in Table 3.

Table 3. The effect of the concentrations of glue with and without Arasan on germination of Neosho oats.

Treatment per 10 gm. of oats						% germination			Approx. %
Glue					Arasan	1	2	avg.	fungal growth
1 ml	(1 gm.	20 ml	H_2O)		.04 gm.	94.0	91.0	92.5	1.0
2 ml	"	"	"	"	.04 gm.	81.0	81.0	81.0	0.0
1 ml	"	"	"	"	----	77.0	82.0	79.5	40.0
2 ml	"	"	"	"	----	79.0	86.0	81.5	40.0
1 ml	(1 gm.	10 ml	H_2O)		.04 gm.	89.0	84.0	86.5	0.0
2 ml	"	"	"	"	.04 gm.	84.0	81.0	82.5	0.0
1 ml	"	"	"	"	----	82.0	84.0	83.0	40.0
2 ml	"	"	"	"	----	83.0	85.0	84.0	40.0
Check					.04 gm.	79.0	82.0	80.5	0.0
Check					----	82.0	79.0	80.5	40.0

The results show that glue in the amounts used did not inhibit germination of the oats and that Arasan did depress fungal growth. In fact, almost complete elimination of mycelia was noted on the treated seed with about 40% mycelia on untreated seed. The high percentage germination with treatment number 1 probably occurred because there was a depression in the flat where these seed were placed allowing for higher moisture content. Also the glass cover gave better contact in this particular corner than in the rest of the flat. This would naturally hold evaporation to a minimum at that point.

Greenhouse Experiments

The effect of the concentration of fertilizer salts on emergence of Neosho oats is shown in Table 4. The dilution effect of the soil is very much in evidence here, because many of the high concentrations did not affect the emergence of oats. Smith (6) found that germination of oats was markedly reduced with 1 gallon 5-10-5 liquid fertilizer per bushel. It would seem in this case that an emergence test would have more value than a germination test. Of course, soaking seed could have an entirely different effect on emergence than coating the surface of the seed with fertilizer salts.

The liquid solution of $MgSO_4$ reduced emergence markedly, whereas the higher concentrations used as a seed coating did not harm, but rather seemed to increase emergence slightly. The high concentrations of NH_4NO_3, Treble super phosphate, KCl, $MgCl_2$, and NH_4NO_3 plus KCl tended to reduce emergence. These data would support the findings of

Roberts[7], who found that the compound in which a certain element was supplied and the concentration was of great importance.

Table 5 shows the rates of liquid and dry fertilizers applied to one bushel of oats before planting. With the exception of treatment number 7, the rates shown in Table 5 were calculated, as it was necessary to treat only one pint of seed for each treatment. Two pellets of 16-20-0 per seed was found to be equivalent to .49 gms. per 3,890 gms. of sand. Pellets about 2 mm. in size were used. These treatments were used for all early growth studies in the greenhouse with the exception of treatment 7, which was not included in the root growth experiment.

The data presented in (appendix) Tables 6 through 9 show the rates of growth and growth increments of the tops of wheat, oats, cotton, and corn as influenced by fertilizer seed treatment. Tables 10 and 11 give similar data for cotton and corn grown in a Kirkland silt loam. There was a significant increase in the growth of wheat and oats with treatment number 7, and also treatment number 2 gave a significant decrease on both wheat and oats. The data on wheat show significance at the 5 per cent level with the data on oats being highly significant. There was no significant difference in the growth of corn and cotton.

Tables 10 and 11 (appendix) show the rate of growth and growth increments of cotton and corn grown in a Kirkland silt loam. There was no significant difference between treatments.

Table 4. Emergence of Neosho oats after seed treatment.

Fertilizer	Gms. salt per 10 gms. seed: gms. per 1.31 ml.*	gms. dry with glue	Calculated rate	Emergence %: 1	2	avg.	Variance from check***
NH_4NO_3	0.78		1 gal./2 bu.	88	94	91	+ 5
		1.56	**1 gal./1 bu.	90	80	85	- 1
		3.12	1 gal./½ bu.	80	86	83	- 3
$NaNO_3$	0.38		1 gal./2 bu.	88	94	91	+ 5
		0.76	1 gal./1 bu.	92	96	94	+ 8
		1.52	1 gal./½ bu.	88	94	91	+ 5
Urea	0.57		1 gal./2 bu.	86	94	90	+ 4
		1.14	1 gal./1 bu.	88	86	87	+ 1
		2.28	1 gal./½ bu.	86	86	86	0
NaH_2PO_4	0.57		1 gal./2 bu.	96	90	93	+ 7
		1.14	1 gal./1 bu.	94	98	96	+ 10
		2.28	1 gal./½ bu.	98	98	98	+ 12
$CaH_4(PO_4)_2$		1.31	1 gal./1 bu.	80	98	89	+ 3
		2.62	1 gal./½ bu.	88	88	88	+ 2
Treble super-phosphate		1.31	1 gal./1 bu.	90	96	93	+ 7
		2.62	1 gal./½ bu.	72	80	76	- 10
KCl	0.07		1 gal./2 bu.	80	90	85	- 1
		0.14	1 gal./1 bu.	84	86	85	- 1
		0.28	1 gal./½ bu.	86	74	80	- 6
K_2SO_4	0.09		1 gal./2 bu.	98	96	97	+ 11
		0.18	1 gal./1 bu.	84	88	86	0
		0.36	1 gal./½ bu.	90	92	91	+ 5
$MgCl_2$	0.33		1 gal./2 bu.	90	94	92	+ 6
		0.66	1 gal./1 bu.	96	86	91	+ 5
		1.32	1 gal./½ bu.	76	72	74	- 12
$MgSO_4$	0.20		1 gal./2 bu.	76	70	73	- 13
		0.40	1 gal./1 bu.	88	92	90	+ 4
		0.80	1 gal./½ bu.	88	96	92	+ 6
$(NH_4)_2HPO_4$	0.31		1 gal./2 bu.	98	86	92	+ 6
		0.62	1 gal./1 bu.	90	94	92	+ 6
		1.24	1 gal./½ bu.	82	88	85	- 1
$NH_4H_2PO_4$	0.27		1 gal./2 bu.	96	86	91	+ 5
		0.54	1 gal./1 bu.	94	96	95	+ 9
		1.08	1 gal./½ bu.	90	96	93	+ 7
NH_4NO_3 (1) / NaH_2PO_4 (2)	0.39 / 0.29		1 gal./2 bu.	88	90	89	+ 3
		(1)0.78 (2)0.58	1 gal./1 bu.	96	94	95	+ 9
		(1)1.56 (2)1.16	1 gal./½ bu.	84	92	88	+ 2
NH_4NO_3 (1) / KCl (2)	0.39 / 0.12		1 gal./2 bu.	90	92	85	- 1
		(1)0.78 (2)0.24	1 gal./1 bu.	90	88	89	+ 3
		(1)1.56 (2)0.48	1 gal./½ bu.	72	78	75	- 11
Check				80	80	80	
Check and glue				92	84	88	
Check and glue and arasan				86	86	86	
Check and arasan				86	94	90	

* This was calculated from the amount of salts used per 100 ml. of solution.

** Dry fertilizers are expressed as gallons per bushel for convenience in comparing with liquid fertilizers.

*** Mean of four checks. (86 per cent)

Table 5. Seed treatments for corn, cotton, wheat, and oats.

Treatment numbers	Treatment	Form	Crop: Amount fertilizer per bushel of seed — corn	cotton	wheat	oats
1	12-12-12	Dry with glue	4.00 lbs.	4.00 lbs.	4.00 lbs.	4.00 lbs.
2	12-12-0	Dry with glue	3.17 lbs.	3.17 lbs.	3.17 lbs.	3.17 lbs.
3	12-0-0	Dry with glue	2.09 lbs.	2.09 lbs.	2.09 lbs.	2.09 lbs.
4	0-12-0	Dry with glue	1.07 lbs.	1.07 lbs.	1.07 lbs.	1.07 lbs.
5	6-9-7	Liquid	0.139 gal.	0.526 gal.	0.322 gal.	0.384 gal.
6	3-18-9	Liquid	0.139 gal.	0.526 gal.	0.322 gal.	0.384 gal.
*7	16-20-0	Pellets	2 pellets per seed		2 pellets per seed	
8	No treatment					

* Treatment 7 was not used in the root growth studies. With this exception, the treatments were the same in all growth measurement studies.

Growth curves are illustrated in Figures 2 through 7 (tabular data found in Tables 6 through 11). The time at which growth measurements commenced was taken as the base line for all curves. It was interesting to note that there was definite lag in growth of wheat between the second and fifth day, and between the fifth and eighth day on oats. The lag was more variable on cotton and corn, but there was some evidence of a slight growth lag of these crops in both the sand and the Kirkland silt loam. The growth curves showed almost a straight line effect on cotton and corn in the silt loam as compared to the much more curved effect with the same plants in sand. This, of course, was to be expected.

Root and top growth measurements on corn are presented in (appendix) Table 12 and are illustrated in Figure 8. Any conclusion as to what effect the fertilizer seed treatments had on the root growth of corn would be very difficult to arrive at, due to the fact that only a limited number of roots could be measured. In some cases, only one root per treatment was measured, because the roots were out of sight. The data presented in Table 12 would indicate that the growth of corn was influenced by the fertilizer treatments with treatment number 1 having grown 2 cm. more than treatment number 7 in 24 hours. A similar study on cotton was made, but was not included because the roots from almost half of the plants were out of sight a few hours after measurements started.

Field Studies

Two liquid fertilizers and six dry fertilizers with glue were applied to corn as seed treatments. Figure 9 (appendix) shows the field layout. The corn was planted on a sandy loam soil with a John Deere corn planter. Two rows about one-fourth mile long per treatment were used and there were two replications of each treatment.

Table 13 (appendix) shows the emergence data and the type and amount of fertilizer material used for the various seed treatments. Glue containing Arasan was applied to the seed and then the dry fertilizer and mixed so that each kernel of corn had an opportunity to be coated with some of the fertilizer. The 33-0-0 and 3-18-9 fertilizers were not ground before applying and some of the larger crystals did not adhere to the seed. The 16-20-0 fertilizer was finely ground and it adhered to the seed better than coarser granules of the other nitrogen containing materials and potassium salts. Comparison of the unpulverized fertilizers with the other treatments is not valid because of the difference in physical condition.

The data in Table 13 clearly show that 6-9-7 at 1 gallon to 7 bushels of corn did not depress emergence to any extent. The 3-18-9 liquid fertilizer did not depress emergence as much as most of the treatments. The 16-20-0 and the 12-0-0 treatments depressed emergence considerably. The remainder of the treatments lowered the per cent of emergence only slightly. The important fact was that the liquid fertilizers used in this study were not inhibitive to the emergence of corn. Also it might be mentioned that the corn did not show any visual

difference in early growth, nor were there any visual differences during the entire growth period of the corn.

A yield study was conducted in the field on Neosho oats. The type and amounts of fertilizers used in this study may be seen in (appendix) Table 14. Since previous studies had shown that most liquid fertilizers and dry salts with glue did not appreciably effect the emergence of Neosho oats, this study was conducted to note the effect of various fertilizer seed treatments on early growth and yield. The 16-20-0 was placed in the row alone and in combination with the liquid fertilizers. Figures 10 through 14 (appendix) show visible evidence of the effect of some of the fertilizers on early growth. The 3-18-9 liquid fertilizer plus 16-20-0 in the row shows about the same or possibly a little better growth than the 16-20-0 alone. It was also noted that the 3-18-9 fertilizer had a favorable effect on growth as compared with the check. Treble superphosphate plus $NaNO_3$ when compared with the check shows quite an adverse effect on growth which was found to be reflected in the yield.

The data presented in Table 15 (appendix) show that all treatments using 16-20-0 with the exception of treatment 15 gave highly significant increases over the no treatment plots. Of interest to note is the fact that the 3-18-9 fertilizer gave a much better increase in yield than the 6-9-7 fertilizer. The highest yield (60.6 bushels) was obtained through the use of 3-18-9 plus 16-20-0, which gave a 4.38 bushel increase over the 16-20-0 alone. Although a significant increase was not obtained with the 3-18-9 fertilizer, it should be pointed out that the yield was increased 6 bushels over the oats which were not treated.

Treatments 14, 17, and 18 show a noticeably adverse effect on the yield with treatment 17 being the most striking. This effect may also be seen in Figure 13 (appendix) as compared with the check (Figure 14). This data would indicate that the pre-planting treatment of oats with dry fertilizer and glue would not be desirable. The data also show that the lighter rates of liquid fertilizer were as good and often better than the heavier rate.

SUMMARY AND CONCLUSIONS

Adsorption studies were conducted on delinted cotton, cotton with lint, barley, oats, rye, wheat, soybeans, and corn. It was found that the delinted cotton, barley and cotton with lint had the highest adsorptive capacity, with corn having the lowest. With the exception of corn, it was noted that considerably more solution could be retained by the seed studied than had been previously recommended. When the amount of actual fertilizer material added was computed on a per acre basis, it was found that only minute amounts could be applied.

It was found that the concentration of glue had no effect on the germination of Neosho oats.

Emergence studies conducted on Neosho oats indicated that the limit of tolerence of oats is very high. Emergence was lowered 10 to 13 per cent in four cases, and in some cases it would seem that s stimulative effect was present. The data are not conclusive, but would indicate that a more detailed study is needed.

Greenhouse experiments on the daily growth of wheat, oats, cotton, and corn, with an additional root growth study on corn, is presented. A significant increase in the total 12 day growth of wheat and oats was found with the use of 2 pellets per seed of 16-20-0. Liquid fertilizers had no appreciable effect on the growth of any crop (roots or tops) in the greenhouse.

An emergence study with corn in the field was conducted, which indicated that emergence was not affected by liquid fertilizer seed

treatment. The 16-20-0 and 12-0-0 fertilizers with glue were found to have an adverse effect on emergence.

The yield study in the field with Neosho oats showed a significant increase with the use of 16-20-0 in the row alone and in combination with other fertilizers. The 3-18-9 fertilizer gave a six bushel increase over the check, but this was not found to be significant. With this exception, liquid fertilizers applied to seed as a pre-planting treatment had almost no influence on the yield of oats. Three of the dry fertilizers added to the seed with glue depressed the yield appreciably.

From the data presented here and at other stations throughout the United States and Canada, it would seem that the use of liquid fertilizers as a pre-planting seed treatment are, in most cases, of no particular benefit to the early growth and subsequently the yield of field crops.

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A P P E N D I X

Table 6. Rate of growth and growth increments of wheat treated with liquid and dry fertilizers.

Days after planting	Growth per day (cm) treatment numbers*								Mean soil temp. (oc)	Total growth increments (cm) treatment numbers							
	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
6									33	5.9	5.6	5.4	5.4	6.0	6.4	4.3	5.7
7	1.4	1.4	1.5	1.4	1.3	1.4	2.1	1.3	23	7.3	7.0	6.9	6.8	7.3	7.8	6.4	7.0
8	0.9	0.6	0.9	0.8	0.6	0.8	1.4	0.8	28	8.2	7.6	7.8	7.6	7.9	8.6	7.8	7.8
9	0.0	0.0	0.2	0.0	0.3	0.0	0.2	0.0	27	8.2	7.6	8.0	7.6	8.2	8.6	8.0	7.8
10	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.1	30	8.2	7.6	8.2	7.6	8.2	8.6	8.3	7.9
11	0.4	0.2	0.5	0.4	0.2	0.8	0.2	0.5	25	8.6	7.8	8.7	8.0	8.4	9.4	8.5	8.4
12	1.2	1.0	1.0	0.5	0.8	1.6	0.9	1.3	21	9.8	8.8	9.7	8.5	9.2	11.0	9.4	9.7
13	0.9	0.6	0.7	0.6	0.2	0.9	1.2	0.9	26	10.7	9.4	10.4	9.1	9.4	11.9	10.6	10.6
14	0.5	0.2	0.4	0.5	1.0	0.5	0.6	0.4	29	11.2	9.6	10.8	9.6	10.4	12.4	11.2	11.0
15	0.2	0.2	0.3	0.3	0.4	0.1	0.4	0.3	29	11.4	9.8	11.1	9.9	10.8	12.5	11.6	11.3
16	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	26	11.4	9.9	11.2	10.0	10.9	12.6	11.8	11.4
17	0.2	0.0	0.1	0.1	0.1	0.0	0.2	0.0	24	11.6	9.9	11.3	10.1	11.0	12.6	12.0	11.4
18	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.3	25	11.7	10.0	11.4	10.2	11.1	12.7	12.4	11.7
Total growth (cm) 12 days	5.8	4.4	6.0	4.8	5.1	6.3	8.1	6.0									

* $L.S.D._{.01} = 2.14$

$L.S.D._{.05} = 1.44$

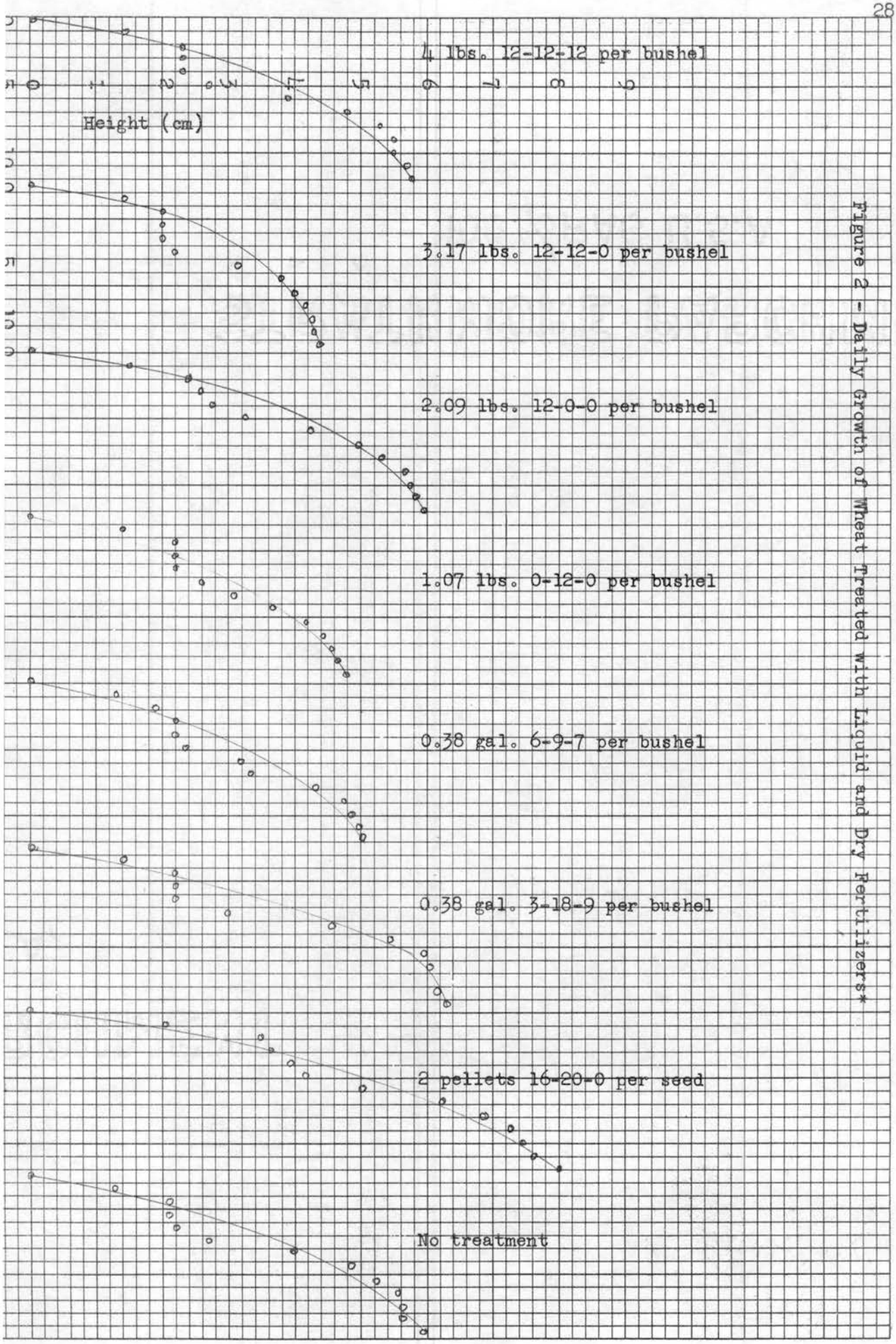

Figure 2 - Daily Growth of Wheat Treated with Liquid and Dry Fertilizers*

Table 7. Rate of growth and growth increments of oats treated with liquid and dry fertilizers.

Days after planting	Growth per day (cm) treatment numbers								Mean soil temp. (oc)	Total growth increments (cm) treatment numbers							
	1	2	3	4	5	6	7	8*		1	2	3	4	5	6	7	8
6									33	4.7	3.4	4.6	4.4	4.5	4.6	2.4	4.8
7	0.2	0.2	1.0	1.1	1.1	1.2	1.2	1.2	23	4.9	3.6	5.6	5.6	5.6	5.8	3.7	6.0
8	0.8	0.0	1.1	1.1	1.0	0.9	1.2	1.2	28	5.7	3.6	6.7	6.7	6.6	6.7	4.8	7.2
9	0.5	0.2	0.7	0.7	0.5	1.0	1.0	0.9	27	6.2	3.8	7.4	7.4	7.1	7.7	5.8	8.1
10	0.6	0.0	0.5	0.4	0.6	0.4	0.8	0.4	30	6.8	3.8	7.9	7.8	7.7	8.1	6.6	8.5
11	0.4	0.0	0.5	0.6	0.3	0.3	1.2	0.4	26	7.2	3.8	8.4	8.4	8.0	8.4	7.8	8.9
12	0.6	0.0	0.0	0.0	0.3	0.0	0.4	0.1	21	7.8	3.8	8.4	8.4	8.3	8.4	8.2	9.0
13	0.4	0.0	0.2	0.1	0.0	0.4	0.2	0.0	26	8.2	3.8	8.6	8.5	8.3	8.8	8.4	9.0
14	0.4	0.0	0.0	0.0	0.1	0.5	0.7	0.5	29	8.6	3.8	8.6	8.5	8.4	9.3	9.1	9.5
15	0.3	0.0	0.6	0.1	0.0	0.9	0.9	0.5	29	8.9	3.8	9.2	8.6	8.4	10.2	10.0	10.0
16	0.3	0.0	0.5	0.3	0.2	0.9	1.4	0.4	26	9.2	died	9.7	8.9	8.6	11.1	11.4	10.4
17	0.4	0.0	0.7	0.2	0.1	0.7	0.9	0.6	24	9.6	----	10.4	9.1	8.7	11.8	12.3	11.0
18	0.4	0.0	0.3	0.2	0.3	0.4	1.1	0.4	25	10.0	----	10.7	9.3	9.0	12.2	13.4	11.4
Total growth (cm) 12 days	5.3	0.4	6.1	4.8	4.5	7.6	11.0	6.6									

* $L.S.D._{.01} = 4.30$

$L.S.D._{.05} = 2.90$

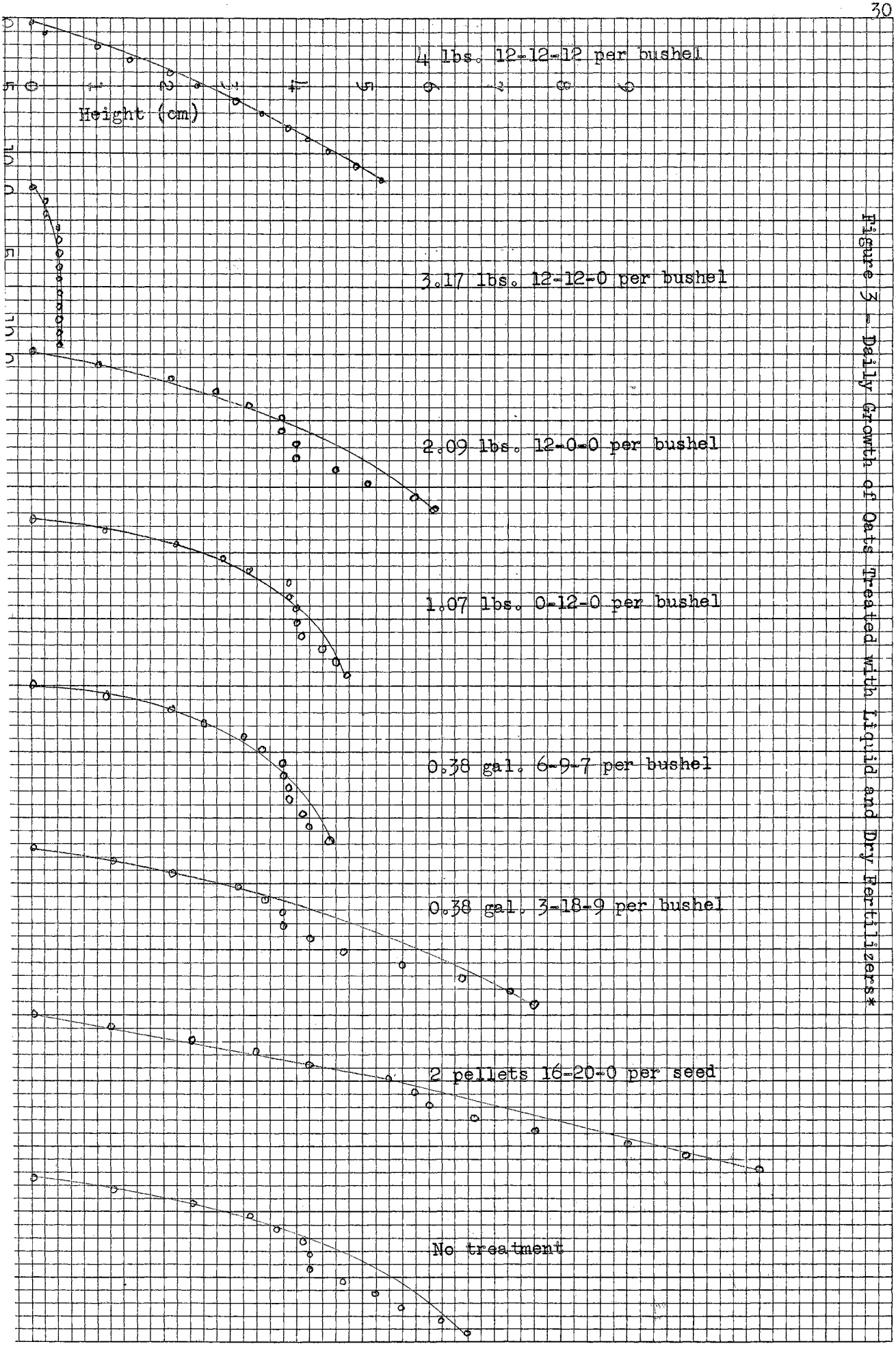

Figure 3 - Daily Growth of Oats Treated with Liquid and Dry Fertilizers*

Table 8. Rate of growth and growth increments of cotton treated with liquid and dry fertilizers. (Sand Media)

Days after planting	Growth per day (cm) treatment numbers								Mean soil temp.	Total growth increments (cm) treatment numbers							
	1	2	3	4	5	6	7	8**	(oc)	1	2	3	4	5	6*	7*	8
6									33	2.6	2.4	2.8	2.5	2.4	1.8	1.6	1.8
7	0.9	1.2	0.8	0.9	0.6	1.1	1.0	1.0	23	3.5	3.6	3.6	3.4	3.0	2.9	2.6	2.8
8	0.6	0.6	0.4	0.6	0.8	0.6	0.7	0.8	28	4.1	4.2	4.0	4.0	3.8	3.5	3.3	3.6
9	0.5	0.2	0.4	0.5	0.4	0.1	0.1	0.4	27	4.6	4.4	4.4	4.5	4.2	3.6	3.4	4.0
10	0.4	0.4	0.2	0.3	0.4	0.3	0.4	0.2	30	5.0	4.8	4.6	4.8	4.6	3.9	3.8	4.2
11	0.6	0.7	0.6	0.4	0.6	0.5	0.4	0.5	25	5.6	5.5	5.2	5.2	5.2	4.4	4.2	4.7
12	0.6	0.7	0.6	0.6	0.6	0.7	0.6	0.8	21	6.2	6.2	5.8	5.8	5.8	5.1	4.8	5.5
13	0.6	0.6	0.4	0.6	0.6	0.4	0.7	0.5	26	6.8	6.8	6.2	6.4	6.4	5.5	5.5	6.0
14	0.2	0.2	0.3	0.2	0.2	0.4	0.3	0.4	29	7.0	7.0	6.5	6.6	6.6	5.9	5.8	6.4
15	0.3	0.4	0.3	0.2	0.3	0.2	0.3	0.2	29	7.3	7.4	6.8	6.8	6.9	6.1	6.1	6.6
16	0.3	0.2	0.0	0.2	0.3	0.3	0.4	0.0	26	7.6	7.6	6.8	7.0	7.2	6.3	6.5	6.6
17	0.4	0.4	0.3	0.2	0.2	0.2	0.6	0.4	24	8.0	8.0	7.1	7.2	7.4	6.9	7.1	7.0
18	0.2	0.3	0.3	0.4	0.5	0.5	0.2	0.2	25	8.2	8.3	7.4	7.6	7.9	7.1	7.3	7.2
Total growth (cm) 12 days	5.6	5.9	4.6	5.1	5.5	5.3	5.7	5.4									

* One pot only.

** No significant difference between treatments.

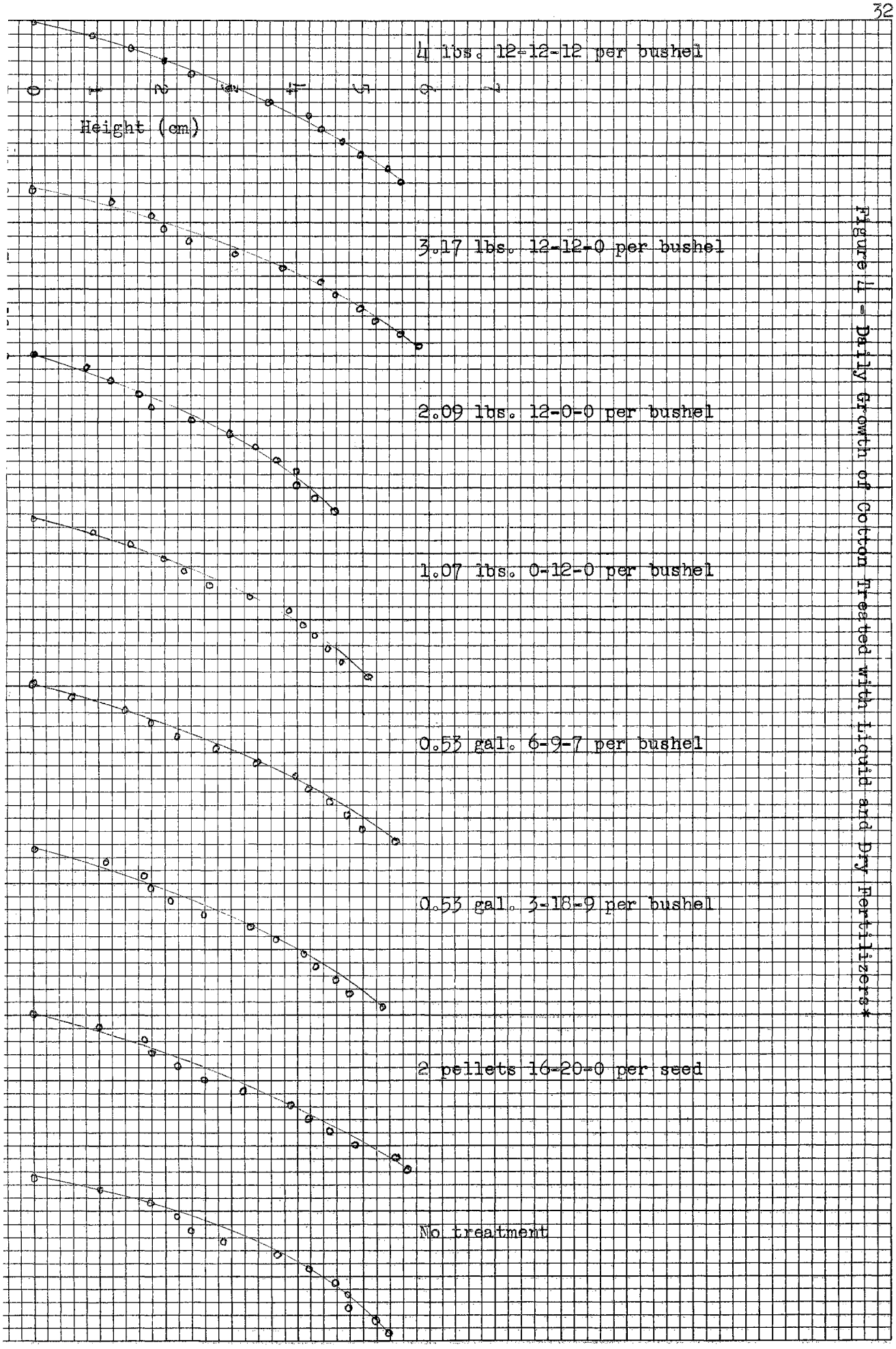

Figure 4 - Daily Growth of Cotton Treated with Liquid and Dry Fertilizers*

Table 9. Rate of growth and growth increments of corn treated with liquid and dry fertilizers. (sand media)

Days after planting	Growth per day (cm) treatment numbers							Mean soil temp.	Total growth increments (cm) treatment numbers							
	1	2	3	4	5	6	7*	8**(oc)	1	2	3	4	5	6	7*	8
6								33	6.1	5.5	4.6	5.0	6.2	4.6		6.8
7	2.3	2.5	1.8	2.2	2.4	2.6	3.5	23	8.4	8.0	6.4	7.2	8.6	7.2		10.3
8	3.0	2.2	2.2	2.6	2.3	2.4	2.6	28	11.4	10.2	8.6	9.8	10.9	9.6		12.9
9	1.6	1.2	1.6	1.7	1.6	1.6	1.5	27	13.0	11.4	10.2	11.5	12.5	11.2		14.4
10	1.6	1.0	1.2	1.4	1.0	1.5	1.4	30	14.6	12.4	11.4	12.9	13.5	12.7		15.8
11	2.3	2.6	2.0	3.0	2.5	2.0	2.7	25	16.9	15.0	13.4	15.9	16.0	14.7		18.5
12	2.8	2.2	2.6	4.1	3.5	2.9	2.7	21	19.7	17.2	16.0	20.0	19.5	17.6		21.2
13	0.7	1.6	1.6	2.4	2.1	1.5	1.6	26	20.4	18.8	17.6	22.4	21.6	19.1		22.8
14	2.2	2.1	1.9	1.1	1.4	1.7	1.1	29	22.6	20.9	19.5	23.5	23.0	20.8		23.9
15	1.0	1.3	1.8	1.6	1.6	2.0	1.4	29	23.6	22.2	21.3	25.1	24.6	22.8		25.3
16	0.6	1.2	1.1	1.4	1.2	0.7	1.2	26	24.2	23.4	22.4	26.5	25.8	23.5		26.5
17	0.8	1.0	0.6	2.8	0.7	0.7	1.7	24	25.0	24.4	23.0	29.3	26.5	24.2		28.2
18	2.1	1.1	0.7	1.9	1.0	0.9	1.1	25	27.1	25.5	23.7	31.2	27.5	25.1		29.3
Total growth (cm) 12 days	21.0	20.0	19.1	26.2	21.3	20.5	22.5									

* Both pots of treatment 7 were ruined by birds.

** No significant difference between treatments.

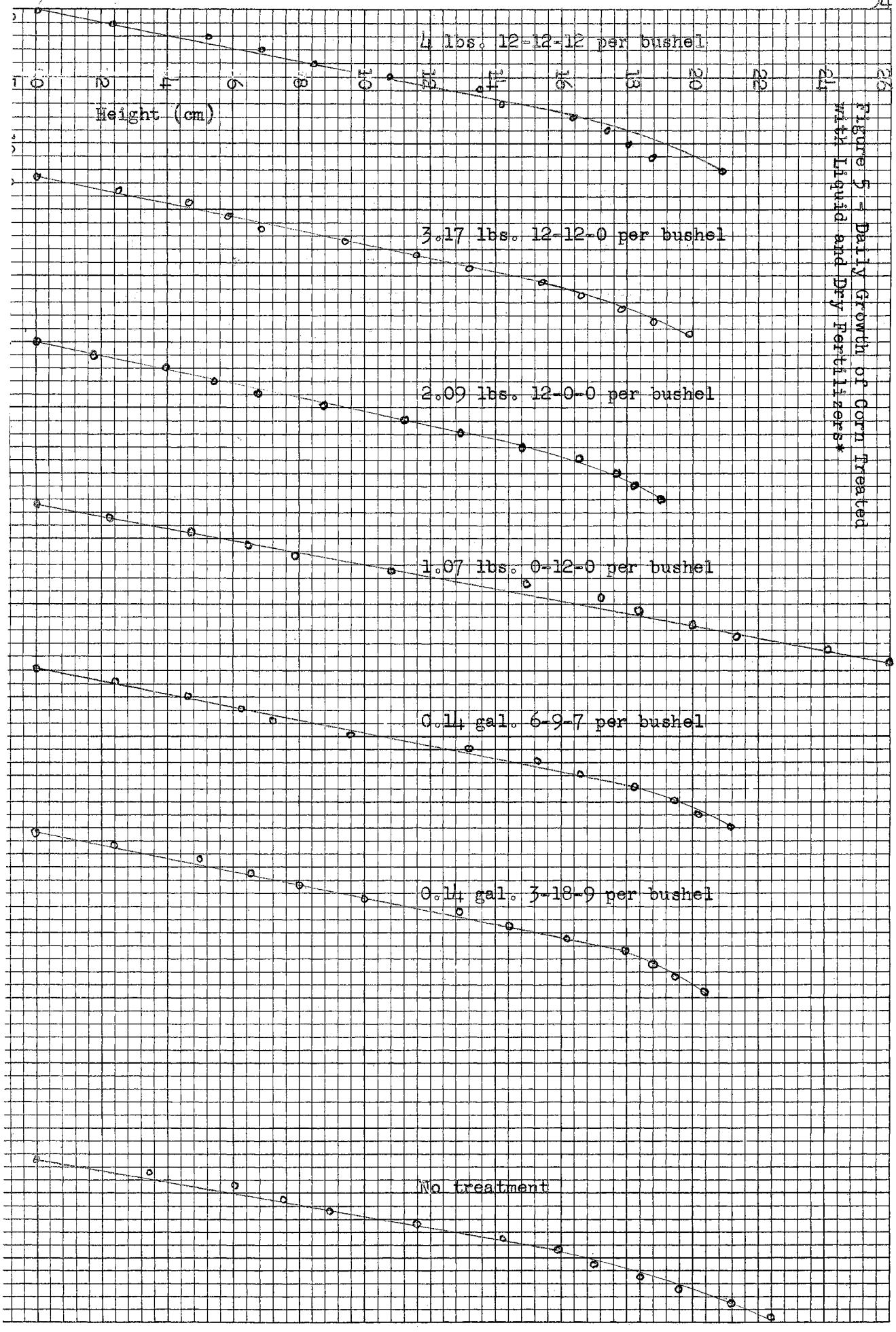

Figure 5 - Daily Growth of Corn Treated with Liquid and Dry Fertilizers*

Table 10. Rate of growth and growth increments of cotton treated with liquid and dry fertilizers. (Kirkland silt loam)

Days after planting	Growth per day (cm) treatment numbers								Mean soil temp.	Total growth increments (cm) treatment numbers							
	1	2	3	4	5	6	7	8*	(oc)	1	2	3	4	5	6	7	8
4									25	1.6	0.8	1.3	0.7	1.3	0.9	1.3	0.5
5	0.5	1.2	1.5	1.9	1.4	1.5	2.0	0.6	21	2.1	2.0	2.8	2.6	2.7	2.4	3.3	1.1
6	0.9	0.7	0.8	0.9	0.7	0.8	0.5	0.9	26	3.0	2.7	3.6	3.5	3.4	3.2	3.8	2.0
7	0.5	0.7	0.4	0.5	0.5	0.3	0.5	0.7	29	3.5	3.4	4.0	4.0	3.9	3.5	4.3	2.7
8	0.4	0.5	0.4	0.3	0.5	0.7	0.6	0.3	29	3.9	3.9	4.4	4.3	4.4	4.2	4.9	3.0
9	0.9	0.6	0.5	0.7	0.8	1.0	1.0	0.8	26	4.8	4.5	4.9	5.0	5.2	5.2	5.9	3.8
10	0.9	0.9	0.9	0.6	1.1	0.9	1.1	1.0	24	5.7	5.4	5.8	5.6	6.3	6.1	7.0	4.8
11	0.7	0.6	0.9	0.6	0.5	0.7	0.9	0.5	25	6.4	6.0	6.7	6.2	6.8	6.8	7.9	5.3
12	0.6	0.3	0.6	0.5	0.5	0.5	0.7	0.6	30	7.0	6.3	7.3	6.7	7.3	7.3	8.6	5.9
13	0.1	0.3	0.2	0.2	0.1	0.4	0.3	0.2	31	7.1	6.6	7.5	6.9	7.4	7.7	8.9	6.1
16	0.8	1.2	1.4	1.4	1.3	1.3	1.3	1.5	26	7.9	7.8	8.9	8.3	8.7	9.0	10.2	7.6
Total growth (cm)	6.3	7.0	7.6	7.6	7.4	8.1	8.9	7.1									

* Only one replication on the check.

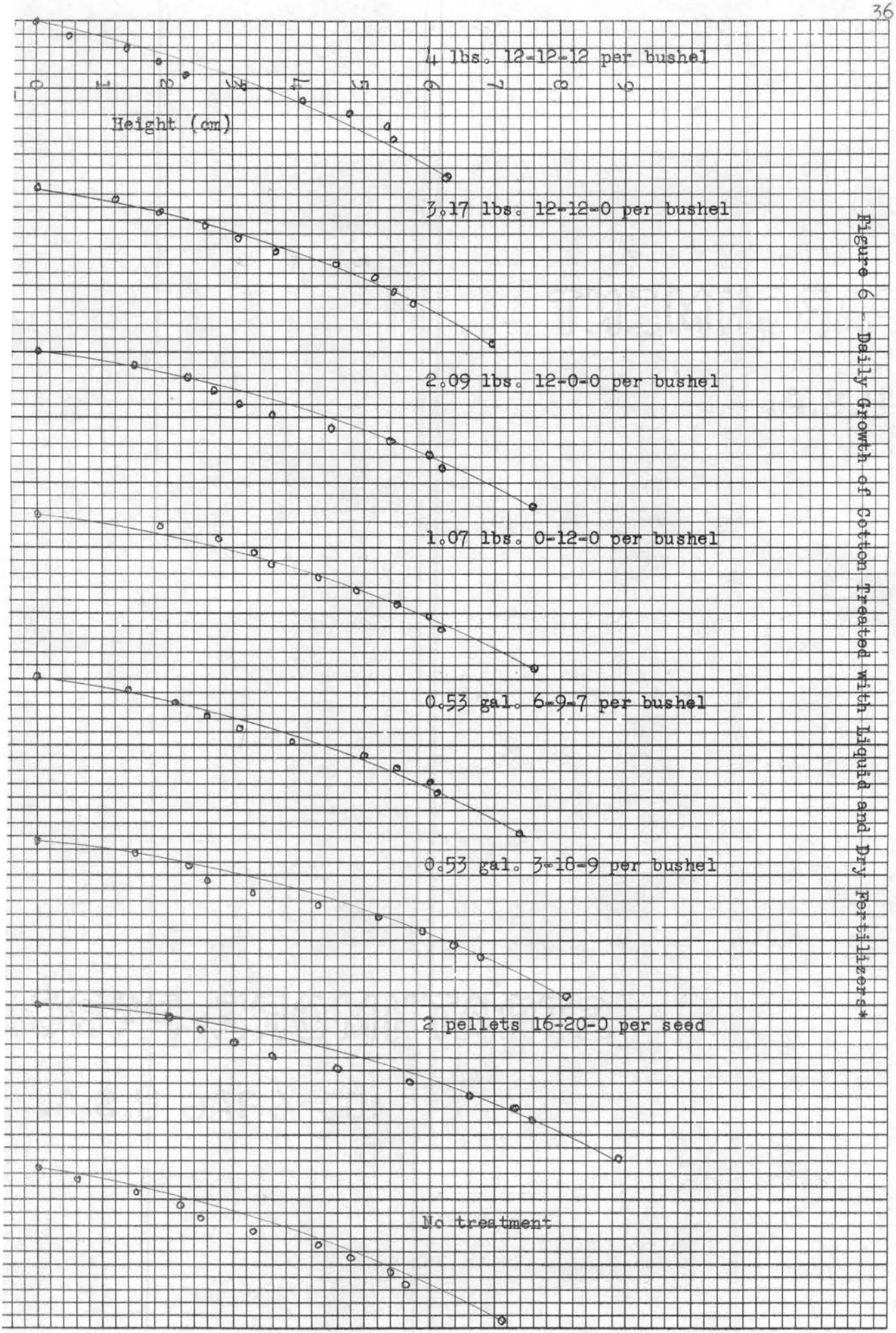

Figure 6 - Daily Growth of Cotton Treated with Liquid and Dry Fertilizers*

Table 11. Rate of growth and growth increments of corn treated with liquid and dry fertilizers.

Days after planting	Growth per day (cm) treatment numbers								Mean soil temp.	Total growth increments (cm) treatment numbers							
	1	2	3	4	5	6	7	8	(oc)	1	2	3	4	5	6	7	8
4										2.9	3.0	3.8	3.6	3.9	3.2	3.8	2.4
5	2.5	2.6	2.6	2.8	2.9	2.7	2.9	2.9	21	5.4	5.6	6.4	6.4	6.8	5.9	6.7	5.3
6	1.9	1.7	2.0	2.3	2.2	1.9	2.1	1.8	26	7.3	7.3	8.4	8.7	9.0	7.8	8.8	7.1
7	1.6	2.4	3.0	2.6	2.9	2.9	3.3	3.1	29	8.9	9.7	11.4	11.3	11.9	10.7	12.1	10.2
8	2.4	1.9	2.9	3.8	3.7	3.1	3.0	3.4	29	11.3	11.6	14.3	15.1	15.6	13.8	15.1	13.6
9	2.4	3.6	1.9	3.0	3.2	3.1	2.8	3.8	26	13.7	15.2	16.2	18.1	18.8	16.9	17.9	17.4
10	2.7	2.0	3.6	3.4	3.3	2.0	2.6	2.3	24	16.4	17.2	19.8	21.5	22.1	18.9	20.5	19.7
11	3.3	3.0	3.2	3.2	3.1	3.0	2.7	3.3	25	19.7	20.2	23.0	24.7	25.2	21.9	23.2	23.0
12	1.6	3.6	1.5	2.1	1.7	2.4	2.0	2.8	30	21.3	23.8	24.5	26.8	26.9	24.3	25.2	25.8
13	2.3	1.8	1.9	1.6	1.8	2.1	1.7	1.9	31	23.6	25.6	26.4	28.4	28.7	26.4	26.9	27.7
16	3.4	4.7	4.2	3.8	3.9	4.0	3.5	4.5	26	27.0	30.3	30.6	32.2	32.6	30.4	30.4	32.2
Total growth (cm) 12 days	24.1	27.3	26.8	28.6	28.7	27.2	26.6	29.8									

* Only one replication on the check.

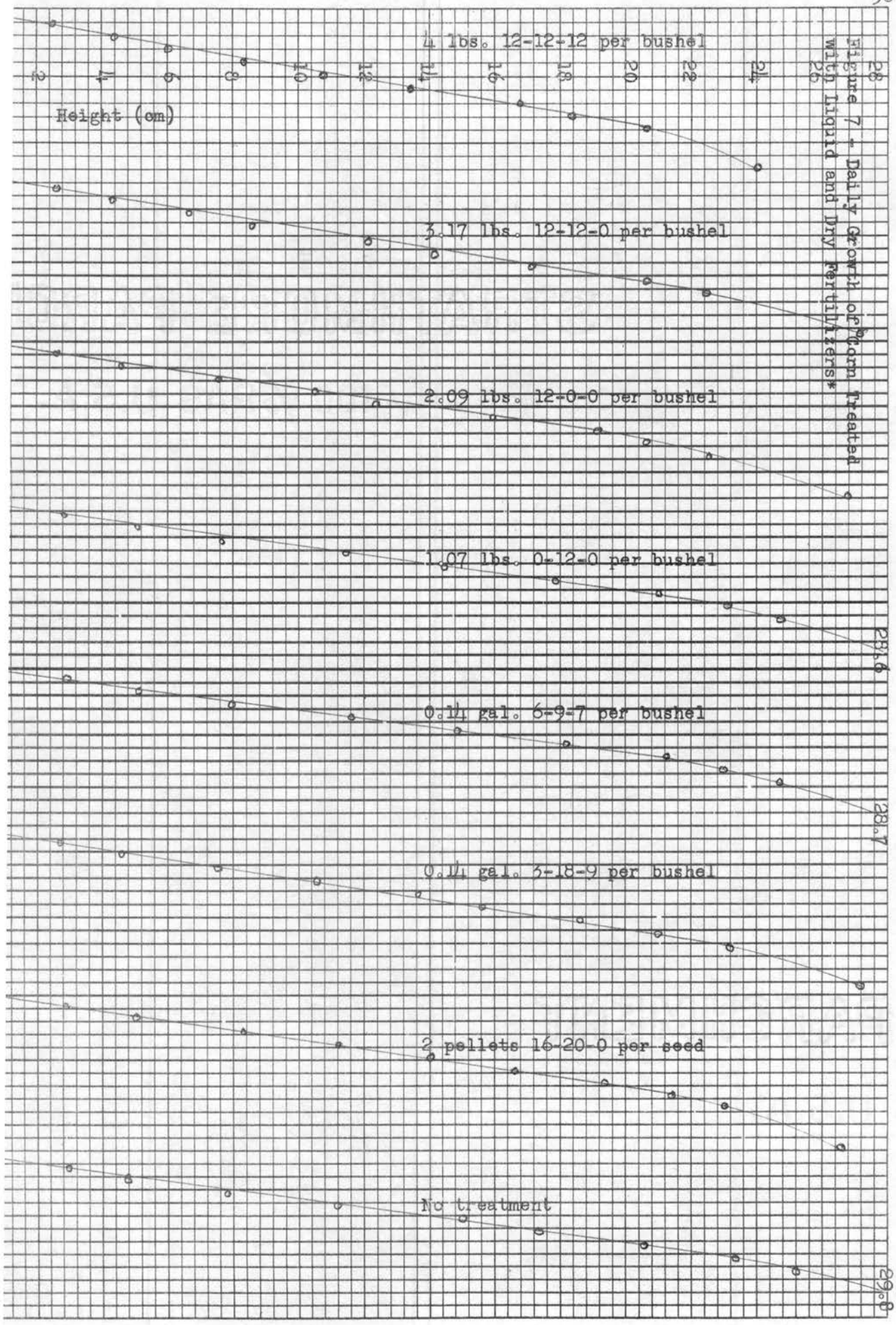

Figure 7 - Daily Growth of Corn Treated with Liquid and Dry Fertilizers*

Table 12. Growth increments of the roots and tops of corn* treated with liquid and dry fertilizers.

Measurement interval (hours)	Treatment numbers 1	2	3	4	5	6	7	Measurement interval (hours)	Treatment numbers 1	2	3	4	5	6	7
	Growth increments (cm) Roots								Growth increments (cm) Tops						
	≠	≠				≠			≠			≠			
1	0.5	0.6	0.4	0.6	0.6	0.6	0.6	3	0.4	0.7	0.6	0.9	0.4	0.4	0.3
1	0.4	0.4	0.4	0.3	0.3	0.2	0.3	3	0.6	0.6	0.4	0.4	0.4	0.5	0.5
1	0.3	0.2	0.3	0.2	0.2	0.2	0.2	11	1.6	1.8	1.6	1.5	1.7	2.2	1.8
1	0.7	0.7	0.5	0.6	0.6	0.6	0.4	3	0.3	0.3	0.3	0.4	0.4	0.2	0.4
1	0.3	0.3	0.5	0.3	0.3	0.2	0.2	4	0.7	0.7	0.6	0.6	0.7	0.9	0.6
1	0.4	0.4	0.3	0.4	0.4	0.3	0.3	3	0.4	0.3	0.5	0.7	0.3	0.4	0.4
1	0.4	0.4	0.3	0.3	0.4	0.3	0.2	3	0.0	0.0	0.2	0.0	0.2	0.4	0.4
1	0.3	0.3	0.2	0.3	0.2	0.3	0.2	12	0.7	1.4	0.8	0.7	1.3	1.5	1.1
11	4.2	4.3	3.6	4.1	4.2	3.8	3.5	3	0.4	0.5	0.4	0.6	0.2	0.4	0.4
1	0.3	0.3	0.3	0.4	0.4	0.3	0.2	3	0.6	0.5	0.5	0.4	0.6	0.3	0.6
1	0.4	0.8	0.2	0.4	0.3	0.4	0.2								
1	0.4	---	0.2	0.2	0.3	0.3	0.2								
1	0.2	---	0.2	---	0.3	0.2	0.2								
1	0.3	---	0.4	---	0.3	0.4	0.4								
Total growth	9.1	8.7	7.8	8.1	8.8	8.1	7.1		5.7	6.8	5.9	6.2	6.2	7.2	6.5

* Average of 2 plants.
≠ One plant only.

Figure 8 - Influence of Liquid and Dry Fertilizers on Growth of Roots and Tops of Corn

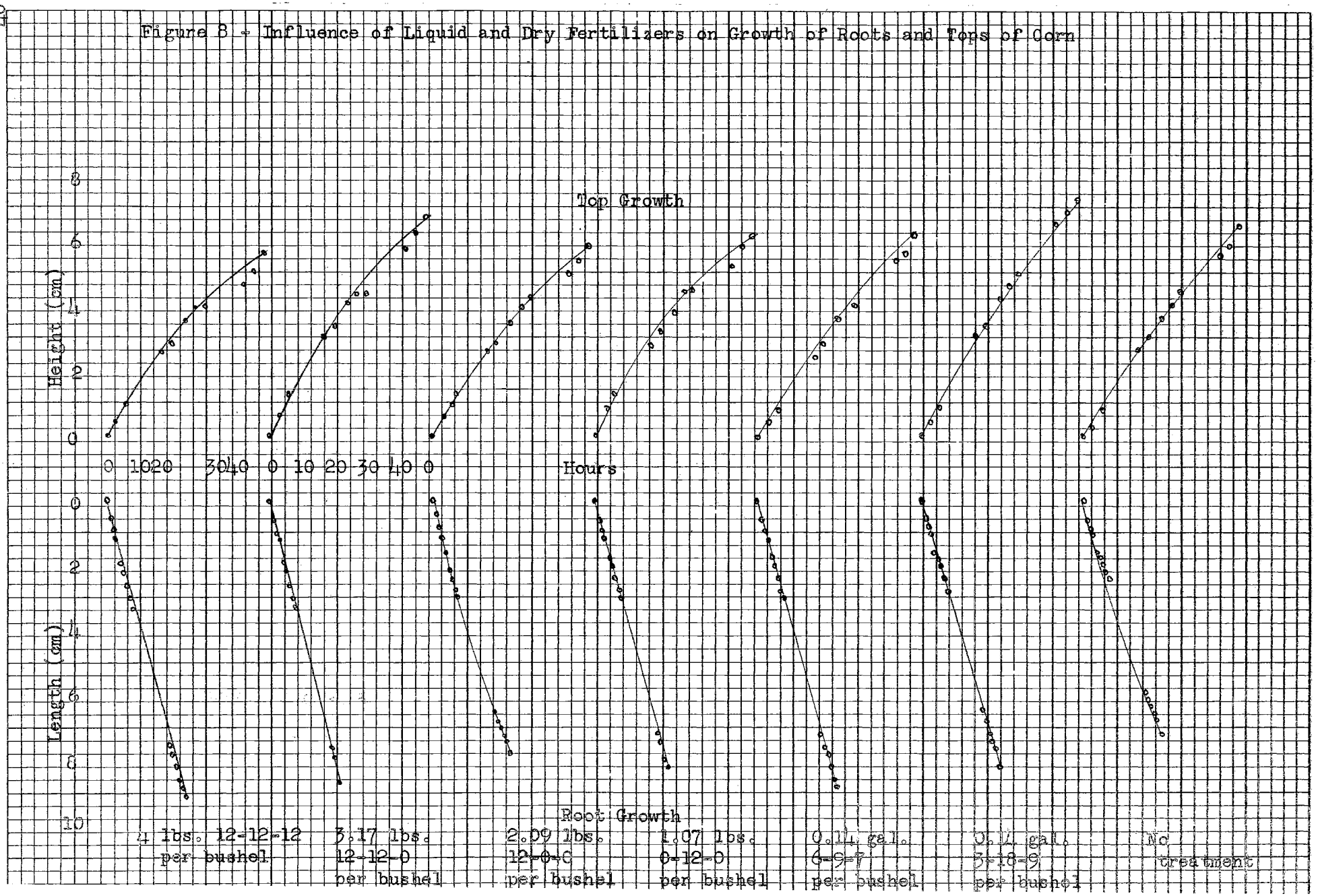

Table 13. The effect of pre-planting fertilizer seed treatment on the emergence of corn.

Treatment no.	Fertilizer grade or material	Amount fertilizer per gallon of corn (gms. or ml.)	Glue used (ml.)	Relative emergence (% of check) 1	2	avg.
1	No treatment					100
2	16-20-0	85.05 gms.	60	48.5	61.7	55.1
3	6-9-7	70.00 ml.	---	87.4	92.8	90.4
4	3-18-9	70.00 ml.	---	76.0	81.4	79.0
5	12-52-17	113.4 gms.	60	76.6	80.8	79.0
6	12-12-12*	112.3 gms.	70	68.9	83.2	76.0
7	0-12-0	30.3 gms.	60	97.6	86.8	92.2
8	12-12-0*	89.6 gms.	70	79.6	68.9	74.2
9	12-0-0*	59.3 gms.	60	67.7	69.5	68.9

* The nitrogen in treatments 5 to 8 contained 34.7 gms. of $NaNO_3$ and 24.6 gms. of NH_4NO_3. The phosphorus was supplied as 30.3 gms. of mono calcium phosphate and the potash was supplied as 22.7 gms. KCL.

Figure 9. Sketch of fertilizer seed treatment on corn
Clarence Shafer farm
April 4, 1951

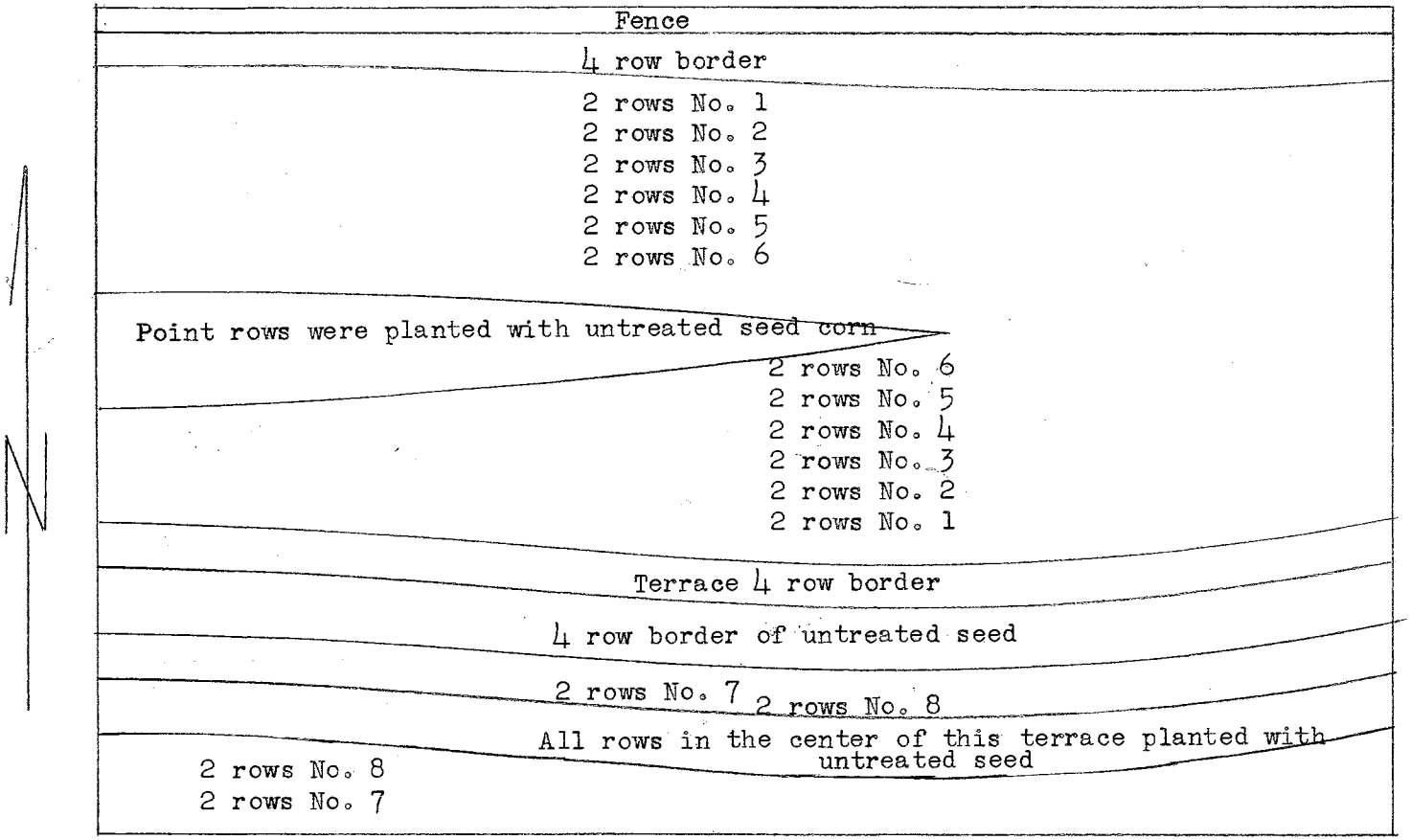

Table 14. Seed treatment of Neosho oats with various amounts of liquid and dry fertilizers.

No.	Material	$N-P_2O_5-K_2O$ %	Actual rate per 300 gm. seed	Calculated rate	Amount glue used	Fertilizer row treatment
1	"Natures"	3-18-9	18.8 ml.	1 gal. - 4 bu.	------	------
2	"Natures"	3-18-9	37.5 ml.	1 gal. - 2 bu.	------	------
3	"Natures"	3-18-9	37.5 ml.	1 gal. - 2 bu.	------	16-20-0 @ 100#/A
4	"Liqua vita"	6-9-7	18.8 ml.	1 gal. - 4 bu.	------	------
5	"Liqua vita"	6-9-7	37.5 ml.	1 gal. - 2 bu.	------	------
6	"Liqua vita"	6-9-7	37.5 ml.	1 gal. - 2 bu.	------	16-20-0 @ 100#/A
7	$(NH_4)_2$ HPO_4	4-5 8-11.57-0	18.8 ml.	1 gal. - 4 bu.	------	------
8	$(NH_4)_2$ HPO_4	4-5 8-11.57-0	37.5 ml.	1 gal. - 2 bu.	------	------
9	$(NH_4)_2$ HPO_4	4-5 8-11.57-0	37.5 ml.	1 gal. - 2 bu.	------	16-20-0 @ 100#/A
10	$(NH_4)_2$ HPO_4 plus NH_4 NO_3	8.68-10.95-0	18.8 ml.	1 gal. - 4 bu.	------	------
11	$(NH_4)_2$ HPO_4 plus NH_4 NO_3	8.68-10.95-0	37.5 ml.	1 gal. - 2 bu.	------	------
12	$(NH_4)_2$ HPO_4 plus NH_4 NO_3	8.68-10.95-0	37.5 ml.	1 gal. - 2 bu.	------	16-20-0 @ 100#/A
13	K_2HPO_4 + $NaNO_3$	3.25-8.54-11.27	18.8 ml.	1 gal. - 4 bu.	------	------
14	K_2HPO_4 + $NaNO_3$	3.25-8.54-11.27	37.5 ml.	1 gal. - 2 bu.	------	------
15	K_2HPO_4 + $NaNO_3$	3.25-8.54-11.27	37.5 ml.	1 gal. - 2 bu.	------	16-20-0 @ 100#/A
16	$CaH_4(PO_4)_2$ H_2O	0-45-0	9.8 gm.	1 lb. - 1 bu.	$2\frac{1}{2}$ pts. bu.	
17	$CaH_4(PO_4)_2$ H_2O $NaNO_3$	11.4-13.5-0	9.8 gm. 22.75 gm.	1 lb. - 1 bu. $2\frac{1}{2}$ lbs. - 1 bu.	$2\frac{1}{2}$ pts. bu.	
18	$CaH_4(PO_4)_2$ H_2O KNO_3	10-12-34	9.8 gm. 27.1 gm.	1 lb. - 1 bu. 3 lbs. - 1 bu.	$2\frac{1}{2}$ pts. bu.	------
19	Arasan	------	1.2 gms.	2 oz. - 1 bu.	$2\frac{1}{2}$ pts. bu.	------
20	Arasan	------	1.2 gms.	2 oz. - 1 bu.		------
21	------	------	------	------		4-12-4 @ 200#/A
22	------	------	------	------		16-20-0 @ 100#/A
23	------	------	------	------		0-20-0 @ 200#/A
24	Check	------	------	------		------
25	Check	------	------	------		------

Table - seed treatment of oats at Perkins farm, February 28, 1951.
Dry salts pulverized and added to seed with glue.

Table 15. Seed treatment fertilization experiment with Neosho oats. Perkins farm, 1951.

Treatment no.	Yield of grain (bu./A) Series I	Series II	Series III	Series IV	Average*
1	46.29	45.15	48.78	56.56	49.20
2	40.69	51.81	52.42	52.54	49.34
3	57.02	63.93	64.54	57.03	60.63
4	38.49	57.39	27.27	44.06	41.80
5	42.35	51.15	43.21	44.42	45.28
6	47.89	54.90	57.27	61.21	55.32
7	39.35	56.96	51.03	45.75	48.27
8	36.22	55.57	41.21	45.63	44.64
9	48.02	55.99	61.21	60.60	56.46
10	29.48	45.75	49.69	44.24	42.29
11	40.62	37.21	42.92	50.42	42.79
12	48.69	60.60	59.93	52.49	55.43
13	46.22	41.63	50.90	50.60	47.34
14	39.09	39.81	40.60	40.12	39.41
15	53.03	56.06	54.24	50.66	53.50
16	47.69	29.69	44.84	43.09	41.33
17	26.61	29.39	43.81	43.45	35.82
18	40.55	40.12	37.57	41.21	39.86
19	46.02	51.51	46.30	40.60	46.11
20	36.35	61.21	43.33	45.81	46.68
21	46.69	55.33	59.39	46.54	51.99
22	48.02	52.12	56.36	68.11	56.15
23	47.02	47.69	43.94	43.51	45.54
24	31.68	46.78	44.54	45.62	42.16
25	47.69	32.91	51.93	40.72	43.31

*$L.S.D._{.01}$ = 11.6

$L.S.D._{.05}$ = 8.7

Figure 10. Showing the effect of 16-20-0 on the growth of Neosho oats. Rate - 100 pounds per acre in the row.

Figure 11. Showing the effect of a 3-18-9 liquid fertilizer on the growth of Neosho oats.

Figure 12. Showing the effect of a 3-18-9 liquid fertilizer plus 16-20-0* on the growth of Neosho oats.
*16-20-0 at 100 pounds per acre in the row.

Figure 13. Showing the adverse effect of Treble Superphosphate plus $NaNO_3$* added to the seed with glue on the stand and growth of Neosho oats.

*See table 14, treatment 17.

Figure 14. Showing a "no treatment plot for comparison with figures 10 through 13.

VITA

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Master of Science

Thesis: THE EFFECT OF APPLYING PLANT NUTRIENTS TO VARIOUS SEEDS BEFORE PLANTING ON RATE OF SEEDLING DEVELOPMENT AND CROP YIELD

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