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The Effect of Fertilizers on the Germination of Seeds as Influenced by Temperature and Moisture.

" A Thesis "

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Introduction

The effect of fertilizers and the variable weather conditions of temperature and moisture have presented many problems of a scientific nature to the agronomist. Not only has this been true for sometime with the scientific agronomist, but of late years these problems have found their place in the working knowledge of the practical farmer from a crop standpoint. Many times the farmer fails to get a stand of certain crops due to bad germination of the seed. This is attributed to bad seed, disease seed, old seed, to wet land and many other similar reasons. Not until recent years has the farmer attributed the inability to get a good stand of different crops on the land to the effect of fertilizers.

Some of the more wide awake farmers of today have noticed repeatedly that with certain seeds when sown with certain fertilizers a poor germination has always resulted.

It has become common practice of many farmers in planting crops in which the seed is sown with the drill to mix the fertilizer with the seed and sow it out the same spout together, thus putting the fertilizer in contact with the seed. Many of the farmers are reporting bad germination from this practice and are asking for information about the effect of certain fertilizers on germination of certain seeds.

To be able to give practical information on such problems as these, is the aim for this experiment work.

HISTORY OF PREVIOUS WORK

Considerable work has been done in germinating seeds with fertilizers and in reviewing the work on the subject, " The Germination of Seeds as Effected by Commercial Fertilizers," it is the purpose of the writer to be plain and yet be as brief and concise as possible in the article. The History of the work as found here was taken from the article written by Hicks (U. S. Dept. Agr. Div. Bot. Bul. 24, 1900).

The earliest important contribution to this work was presented by Tautphoeus 1876 (1) Solutions employed were those found to a greater or less extent in commercial fertilizers. Solution of o. 5% to 5% strength were applied to seeds. Seeds used were: wheat, rye, rape, maize, beans and peas. A check of each was made with distilled water. Chemicals used; Potassium chloride, sodium chloride, calcium nitrate, sodium nitrate, potassium sulphate, and hydric di-potassic phosphate.

The results of this work were;

1. All checks germinated best.
2. Rape showed scarcely no injury from chemicals in solution up to strength of 2 per cent.
3. In all other seeds vitality was seriously injured in salt sloution of greater strength than 0.5 per cent.

Similar work was done the same year (1876) by Henri Vǽlmorin (2). The chief salts he used were: potassium nitrate, sodium nitrate, calcium phosphate. His conclusions were as follows:

1. Beet seed germinated very slowly or not at all in soils containing large proportions of mineral fertilizer (i.e. sodium nitrate).

* Small figures denote reference found in Bibliography.

2. Wheat as well as beet germination was retarded to a marked degree when calcium nitrate, calcium phosphate and especially sodium nitrate were used in amounts equaling 5 per cent of the weight of earth. Wheat failed to germinate at all in a 10 per cent sodium nitrate soil. These percentages are rather high to actual practice.

Hindrof (3) claims that magnesium chloride and calcium chloride used in proper amounts have favorable effects on germination and growth of wheat and rye, barley, oats, peas, red clover, and rape and that they never injure unless used in greater amounts than occur in agricultural practice.

Nessler (4) in 1877 noticed that hemp seed sown in fields fertilized with sodium chloride (cooking salt) at the rate of 250 kilos per hectre, germination was very uneven and it made poor development.

In 1885 W. Jarius (5) conducted several experiments, but the methods he used were very impractical and conclusions he reached were of little value from a practical standpoint.

The most valuable work done so far in connection with germination was published in 1896 by Claudel and Chrochetelle. (6) They employed chemically pure (distilled) sand. They maintained as near as possible the same degree of moisture. Soluble materials were used, potassium sulphate, amonium sulphate, sodium nitrate, and potassium chloride. Slag and superphosphates were mixed with the superficial layer of sand, direct contact with seed being avoided

Results;

1. Potash fertilizers in form of sulphate and chloride of potassium in general retard germination, the retardation being greater for the chloride than sulphate, the difference was especially

noticeable for the Leguminosae and flax.

2. Amonium sulphate had a disasterous effect upon the sprouting of seeds in unequal degrees, colza, flax, wheat and mustard being very sensative to its influence, sainfoin and wheat less so than other seeds.

3. Sodium nitrate acted in a similar manner to amonium sulphate, but less energetically. One part per thousand had no appreciable effect upon wheat, barley, sugar beet, colza and beans, but seriously injured buckwheat and greatly clover. In 5 parts per thousand no seeds sprouted except barley which was 100 per cent.

Phosphoric acid in very feeble amounts, 2 parts per thousand or less, aided germination, stronger solutions retarded germination. The authors conclude that in acid soils the use of superphosphates does not retard germination, if the free acid is quickly combined with bases of the soil.

Summing up the whole experiment, the authors conclude three things;

1. In the amounts employed, and leaving the seeds constantly in contact with materials used, sulphate of amonia, sulphate of soda, chloride of potassium, sulphate of potassium, and superphosphate exercised an injurious action on the germination of seed in general.

2. Not all the species sown were influenced to the same extent, for example, wheat resisted best among the species tested, whereas lentils, lucerne and flax were very sensative to fertilizers used.

3. Alkaline substances with a basis of lime or potash favored in a marked degree the germination of certain seeds, especially the Leguminosae. The slag used produced better effects than the lime alone.

Station
Prof. Buffin of Wyoming Experiment made extensive study of alkali soils on germination of seeds and found that even small per cents of alkali in soils retard germination, altho as a rule about as high a per cent of seeds germinated in a soil containing 1 per cent alkali as in an alkali free soil if seeds were left long enough.

Hicks (7) in his experiment used the following seeds; winter wheat, lettuce, radish, and crimson clover, Fertilizers used were, nitrate of soda, muriate of potash, bone black made soluble with treatment of sulphuric acid, lime from powdered oyster shells. In addition a complete fertilizer was used made from the above chemicals.

He concludes from his work;

1. That muriate of potash and sodium nitrate used as fertilizers in strengths of 1 per cent or more, are very detrimental to the germination of seeds, whether applied directly or mixed with soils.

2. That fertilizers composed of phosphoric acid or lime are much less injurious to germination than sodium nitrate or muriate of potash, and if not used to excess may be harmless.

3. That commercial fertilizers should not be brought in direct contact with germinating seeds.

4. That the effect of treating seeds with chemicals before planting is no index to the action of those chemicals when applied as manures to the soils.

5. That the chief injury to germination from chemical fertilizers is inflicted upon the young sprouts after they leave the seed coat and before they emerge from the soil, while the seeds are injured only slightly or not at all.

6. It is highly probable that potash, phosphoric acid, nitrogen or lime used as a fertilizer actually favor germination.

J. W. Shive (N. J. Agr. Exp. Sta. Rpt. 1916 455-457) worked on "Effects of Salt Concentration on the Germination of Seeds."

His experiments were conducted to determine to what extent the concentration of pure and mixed solutions resist water absorption by seeds placed in contact with them, and whether such resistance to water absorption has a direct bearing on germination.

Salts used were nitrate, carbonate, phosphate, (mono-baisic) and chloride of potassium, magnesium sulphate, and calcium nitrate. Beans and corn were used.

Conclusions;

1. Experiment showed that the average percentage of germination for the highest and lowest salt concentration here used was practically equal and was only slightly lower than the average percentage of germination for the control cultures.

2. That the amount of water absorbed per gram of air-dry seed in the cultures with highest concentration is much less than in the cultures with lowest concentration or than that in the control cultures. Here the retarding influences of salt concentration on water absorption is clearly brought out.

3. While seed germination was not prevented by the higher salt concentration, it was considerably retarded. Retarded germination seems to be directly related to the amount of water absorbed by the seeds, which in turn is dependent upon the concentration of the soil solution. While seed germination was not actually prevented by the highest concentration employed, injury to the root tips occured after germination had taken place even in concentrations as low as 2.0 atmospheres of osmotic pressure.

Ewart, A. J., U. S. Dept. Agri. 1912, "The Influence of Superphosphates on the Germination of Wheat."

It has been stated that, if wheat lies in dry soil for a long time in contact with superphosphates of lime, its germination may be seriously effected. It appears however that the injurious action only becomes pronounced when there is a little moisture to begin with and the soil subsequently dries. When germination takes place rapidly, a stimulating rather than an injurious action appears to be exercised. Fertilizers were put in contact with grain and below the grain. Planting fertilizer some little distance below the wheat did not seem to retard growth in any way.

Two experiments were conducted under the supervision of Mr. Ewart; First experiment was tried by storing dry wheat with an equal amount of dry superphosphate for three to six weeks and noting the germination at the end of that time.

Result - when grain and superphosphate are dry, little or no injurious effect is exercised in a moderate length of time.

In second experiment different depths were used in planting fertilizer with grain.

Plot A- grain and gertilizer were planted together at 1"

Plot B- grain planted 1", phosphate 2"

Plot C- grain planted 1", phosphate 4"

Results- So far as small scale experiments can be relied on, planting superphosphate from 1-3" below the grain seems to slightly increase the yield in both head and straw and since the results in each series are consistant with the average of the whole plots, it seems probable that field tests would give similar results.

Since it is impossible to state how long the grain may have to lie in the soil, planting the superphosphate under the grain instead of in contact with it, does not seem to injuriously affect the yield.

Haskell, S. B. Jour. Amer. Soc. of Agron. No. 4, pp 141-152. "The Effects of Fertilizer of the Germination of Seeds."

He writes that the best information on this subject is from the work of Hicks (7) who states that superphosphates in contact with seeds is much less injurious than the standard carriers of nitrogen and potash, and that use in large quantities may retard germination without final injury to the seed itself.

This conclusion was confirmed by Ewart. (8) He found that germination of wheat was not affected by seed remaining in contact with superphosphates, in a dry soil, for a relatively long period of time. From these results it would then follow, that the method of application of soluble phosphates may depend in part on the extent of which these materials are mixed with carriers of other plant food.

Rusche, (9) a German, upheld these results in working with a great many seeds.

Shive (10) in making his explanation for the different effects of superphosphates and other fertilizer materials on germination states, while germination was not prevented by the higher salt concentration, it was greatly retarded. Retarded germination seems to be directly related to the amount of water absorbed by the seeds which in turn is dependent on the concentration of the soil solution.

General summary of this experiment is that with deep drilling of fertilizer, farmers can use larger quantities of fertilizer with profit than has been possible to use with ordinary drill.

Rusche, (9) a German, about the same time 1912, did similar work with wheat, oats, peas, beans, lapines, white clover, rape, barley, rye, beets, alfalfa, red clover, alsike clover and serradella He used fertilizer at a heavy rate but thoroughly mixed with soil.

Results- Found oats crop resistant to influence of all chemicals used. With all other crops germination was retarded by use of nitrate of soda and muriate of potash. The effect varying from serious loss of time and possible actual injury in case of red and white clover, alfalfa and serradella to a mere passing delay in case of rape, wheat, barley, peas and beets. Showed that superphosphates gave much less retarding effect on germination than did other chemicals used, only barley being an exception to general rule. His work also supports Hicks (7) that superphosphate is much less injurious to germination than either nitrate of soda and muriate of potash.

Two facts were established;

1. That a reasonable quantity of superphosphates alone may be applied near the seed or in contact with seed without material injury to or delay in germination.

2. That when superphosphates are mixed with carriers of potash and nitrogen, much greater care must be taken in the application than would otherwise be the case.

Work is being done at the Wis. Exp. Sta. under leadership of Dr. E. Troug in relation to work done by Shive. This data is not complete and very little has been published. However, they indicate that injury to germination is influenced by first, rate of fertilizer application, second, by the method of application, third, by soil type, fourth, by the moisture content of the soil.

High rate of application was used on very moist soils without damage. The same amount applied on a soil with low moisture content did serious damage.

A summary of this article would be-

That even when superphosphate comes in contact with the seed, it is much safer than is mixed fertilizer carrying nitrogen and potash in addition to phosphoric acid.

That the retarding effect of fertilizers on germination varies with (1) the crop, (2) the soil, (3) the moisture content of soil.

THE EXPERIMENT

The purpose; To determine the influence, if any, of temperature and moisture on the germination of seeds when placed in contact with fertilizers and when not placed in contact.

Plan of Experiment; This experiment was conducted in the greenhouse. Hagerstown silt loam soil was used. The seeds planted were allowed to reach the seedling stage, when they were discarded. A record was kept of the number of seeds planted and the percentage of germination was determined by counting the number of plants that appeared above the ground and comparing this number with the number of seeds planted. Great care was taken to see that all seeds of a particular kind were planted to a uniform depth.

The seeds used were; corn, wheat, soy beans, and barley. The fertilizers used were 16% acid phosphate, nitrate of soda, amonium sulphate, muriate of potash and ground burnt lime.

Procedure; Hagerstown silt loam soil was obtained from experiment farm, it being screened before hauled to the greenhouse where it was allowed to dry out some. The water holding capacity of the soil was determined, it being 50.4%.

Water tight galvanized boxes 8 x 4x 2½" with lids were used for the experiment. After the soil had become sufficiently dry, it was again put through a very fine screen, the soil being in a very fine condition. Screened soil was mixed thoroughly and a sample taken from which a moisture test was run. Six hundred grams of soil were weighed to each box and covered until after moisture test was made. In the center of each box a half inch glass tube 2 inches long was inserted, through which water was added to soil.

The following seeds were planted, sixteen seeds to each box; Silver King corn, Virginia soybeans, V. P. I. 131 wheat, and Tennessee Winter barley.

Fertilizers were applied to the amounts of, nitrate of soda 100 lbs. per acre, muriate of potash 100 lbs per acre, sulphate of ammonia 100 lbs per acre, 16% acid phosphate 400 lbs per acre, and ground burnt lime 500 lbs per acre.

All seeds planted were hand picked and great care was exercised in selecting all firm and plump seed.

Effects of Moisture; All four seeds were planted in the soil at the following percentages of saturation, 40, 50, 60, 70, 80. At all five percentages of saturation the seeds were sown in contact with the fertilizers, after the fertilizers had been applied and mixed with the soil, and in soil where no fertilizer had been applied. After fertilizer and seed were put into soil, the boxes were placed on gram scales and water added to give the required saturation. The boxes were weighed at intervals and the loss of moisture, if any, supplied to maintain the desired percentage of saturation through the germinating period. In all there were 55 boxes to each seed in the moisture test. Tests were run in duplicate. Table 1. shows results for 40% saturation of corn and soybeans.

Throughout the whole experiment, from a study of the tables, it will be noticed that in a number of places the check boxes (those) without fertilizer) did not germinate with as high per cent germination as did those to which fertilizer was applied. The explanation why this was, the writer will endeavor to make here, and this will apply for such results in the entire experiment.

Though great care was exercised in selecting all plump and what seemed to be good seed, there were a number of seeds infected with disease bacteria. After all plants coming up were above the

the ground, a search was made for the seeds that did not germinate or come up. In a large number of cases, it was found that the seed germinated, but it being infected with bacteria the young seedling rotted before it could get out of the ground. This was more prevalent with corn and soybeans, the corn showing ear rot and the soybeans, though not showing infection from the outside of seed coat, had disease infection on the seed leaves and this rotted the seedling before appearing above the ground.

There were some seeds to rot with the wheat and barley, Wheat germinated the lowest of all four seeds used. The reason for this seemed to be a large number of hard shelled seed in the wheat used, many of the seeds swelled slightly but neither germinated nor rotted within the time it took all of the other seedlings to appear above the ground.

There will also be noticed in the tables in many instances that germination was better with fertilizer in contact with the seed than mixed with soil before seed was planted, where in the second trial it would be reversed. This the writer thinks was not due so much to the effect of the fertilizer, but was again caused by the disease bacteria prevalent with the seed.

In a study of table No. 1, it is found, with corn, that in no case did seedlings appear above the ground until the fourth day after planting. The checks germinated at 96.8 per cent. In only two other trials was germination lower than the checks and these were with nitrate of soda mixed with soil before planting and with lime mixed with soil the germination for both being 93.7 per cent, just one seed less than the check failing to germinate.

From this no serious effect is shown by the application of the fertilizers used, but with soil this low in moisture (40% saturation) a retarding effect is seen, with all fertilizers here used.

Table I.

Results with 40% saturation.

Corn (germination on days after planting)		FIRST TEST 3	4	5	6	7	Total	SECOND TEST 3	4	5	6	7	8	Total	Percent germination
Nitrate of soda	contact			3	10	3	16		4	6	5			15	96.8
	mixed			4	8	4	16		2	4	8			14	93.7
Muriate of potash	contact			6	8	2	16		1	11	2	2		16	100
	mixed		1	5	5	5	16		1	7	4	4		16	100
Sulphate of ammonia	contact		1	11	4		16		2	7	7			16	100
	mixed		1	8	7		16		2	10	1	2	1	16	100
Acid phosphate	contact		3	7	6		16		1	6	7	2		16	100
	mixed		1	9	4	2	16		8	7	1			16	100
Lime	contact			6	10		16		2	11	2			15	96.8
	mixed			14	1		15		3	9	2	1		15	93.7
	check		1	9	6		16		5	9		1		15	96.8
Soybeans															
Nitrate of soda	contact		10	5	1		16		2	9	3	1	1	16	100
	mixed		11	4	1		16			13	2			15	96.8
Muriate of potash	contact		14	2			16			2	5	6	2	15	96.8
	mixed		13	3			16			2	3	2	8	15	96.8
Sulphate of ammonia	contact		4	9	1		14			3	4	3	6	16	93.7
	mixed		12	3	1		16			7	6	1	2	16	100
Acid phosphate	contact		7	7	2		16			5	5	3	2	15	96.8
	mixed		10	5	1		16			14	2			16	100
Lime	contact		5	9	1		15			10	3	2	1	16	96.8
	mixed		4	9	2		15		3	3	8	1	1	16	96.8
	check		5	8		1	14		4	7	2	1		14	87.5

Comparing this with the check, nitrate of soda and muriate of potash give strongest retarding effect. Lime where in contact with seed retards germination fairly strong.

With soybeans as with corn, no seedlings appeared above the ground before the fourth day after planting. The checks germinated with a per cent of 87.5 and in every trial with fertilizer, the percent of germination of soybeans was better than the checks, with only one fertilizer the seeds gave better germination than where fertilizer was mixed with soil, this being with nitrate of soda, contact 100%, mixed 96.8 per cent. Muriate of potash and lime gave same percent germination for both, fertilizer in contact with seed and mixed soil, this being 96.8%; sulphate of amonia and acid phosphate gave 100 percent germination for fertilizer mixed with soil against 93.7% and 96. 8% respectively for contacts. No ill effect can be seen on the germination of soybeans from the fertilizer used, but all fertilizers check germination to a certain extent. Taking both tests and comparing to checks, nitrate of soda in contact, muriate of potash contact and mixed, sulphate of amonia contact and acid phosphate, where in contact show strongest retarding effects. All fertilizers where mixed with soil except nitrate of soda gave slight retarding.

Wheat showed no seedlings above the ground until the fifth day, in both tests. Germination as a whole is low though checks germination best, muriate of potash in contact with seed gave a higher germination than where mixed with soil, 84.3 percent for contact, 68.7 percent for mixed and phosphate did the same thing 84.3 percent contact and 81.2 for mixed. With lime, sulphate of amonia and nitrate of soda, the fertilizer mixed gave higher percent germination than in contact with seed. The most ill effect is with sulphate of amonia.

in contact with seed the percent of germination being 59.3. Nitrate of soda also gave a slight effect on germination in contact with seed. The low percent of muriate of potash where mixed seems to be due to bad seed since contact is 84.3 percent.

All fertilizers show a stronger retarding effect at 40% saturation on wheat than with either corn or soybeans, lime in contact with seeds seems to be one of the strongest retarders of all. Taking both tests together and comparing to checks, sulphate of amonia is a strong retarder, nitrate of soda and muriate of potash are next in retarding effect on wheat at a low moisture. This is according to the findings of Ewart (8) and Hicks (7).

In the first test with barley very few seedlings appeared above the ground until the sixth day after planting. In the second test seedlings appeared on the fourth day and the majority were up on the fifth day after planting. The checks gave 93.7 percent germination. Three trials germinated less than the checks, these were muriate of potash both for contact with seed 87.5 percent and mixed with soil 90.6 percent, and sulphate of amonia, where it was mixed with soil, the percent of germination being 90.6 percent, however this same fertilizer in contact with seed germinated 100 percent. From this it seems that muriate of potash has a slight effect on the germination of barley in a comparatively dry soil. With all other trials the percent of germination was better than the checks, nitrate of soda both contact and mixed and acid phosphate both contact and mixed germinated the same, 96.8 percent. Lime in contact with seed germinated 100 per cent against 96.8 percent where mixed with soil.

The only ill effects on germination of barley seems to be with muriate of potash and it is only slight at this low moisture

Table II.

Results of Wheat and Barley at 40% saturation.

Wheat

(Germination on days after planting)		FIRST TEST												SECOND TEST										Percent
		3	4	5	6	7	8	9	10	11	12	Total		3	4	5	6	7	8	9	10	Total		Germ.
Nitrate of soda	contact			1	7	3		2				13				1	6	2		1	2	12		78.1
	mixed				1	9	2				1	13				5	4	1		4		14		84.3
Muriate of potash	contact			1	2	3	7	1				14				6	4	1		1	1	13		84.3
	mixed					5	4	2				11				7	3	1				11		68.7
Sulphate of ammonia	contact			3		2	2	1	1	2	1	12				5	1				1	7		59.3
	mixed				2	6	4					12				9	2	1		1	1	14		81.2
Acid phosphate	contact				3	10			1			14				8	4	1				13		84.3
	mixed			1	3	5	1			1		11				12	1	2				15		81.2
Lime	contact					7	2	1	2	1		13				3	3	7				13		81.2
	mixed			3		3	3	4				13				6	2	6				14		84.3
	check			1	6	5	1					13					14					14		87.5

Barley

Nitrate of soda	contact				6	8	2					16			11	4						15		96.8
	mixed			1	5	7	3					16		1	12	2						15		96.8
Muriate of potash	contact				3	10			1			14			8	4	1	1				14		87.5
	mixed				1	13		1				15		2	9	1	2					14		90.6
Sulphate of ammonia	contact				5	9	1		1			16		2	14							16		100
	mixed					5	6	2	1	1		15		1	11	2						14		90.6
Acid phosphate	contact			1	10	4						15		3	13							16		96.8
	mixed				6	9	1					16		2	13							15		96.8
Lime	contact				5	7	2		2			16			14	2						16		100
	mixed				7	6	2					15		2	12	2						16		96.8
	check			3	12	1						16		1	13							14		93.7

content in soil, all fertilizers somewhat check germination, when soil is as dry as with 40% saturation. Muriate of potash and sulphate of ammonia are strongest retarders on barley. Nitrate of soda and lime shows a slight effect on retarding germination and acid phosphate when compared to checks gives practically no retarding effect.

The soil at 40% saturation is too dry for good crop growth, but germination will take place, but not as quickly as when soil contains a higher percent of moisture.

Germination at 40% saturation was slower with wheat and barley than with corn and soybeans.

Lime with all four seeds used shows as strong a retarding effect on germination as any of the fertilizers. Nitrate of soda on corn shows a stronger retarding effect than other fertilizers, with soybeans, sulphate of ammonia shows a strong retarding effect, with wheat sulphate of ammonia in contact with seed gave ill effects. No fertilizers show bad effects on germination of barley, but muriate of potash and sulphate of ammonia appear to retard germination of barley most in this trial.

Muriate of potash and sulphate of ammonia show stronger effect on germination. This is according to work of Hicks(7) who showed that superphosphates were much less injurious to germination of seeds than all the standard carriers of nitrogen and potash.

Table III gives the results with soil at 50 percent saturation for corn and soybeans.

Results here are very similar to those in Table I where soil contained 40 percent saturation. With higher moisture content corn in first test showed seedlings above ground a day sooner, they appearing on third day after planting. Check plats in this trial germinated 100 percent, the same is true for muriate of potash mixed with soil, and with lime both contact with seed and mixed with soil. Here again,

nitrate of soda in contact with seed gave better germination, 92.7 percent, than when mixed with soil, 87.5 percent. This is the only fertilizer applied to corn at 50 percent saturation that gave a higher percentage of germination when applied direct to seed, than when mixed first with soil. No serious effect is shown by any fertilizer on germination of corn, but a slight effect seems to be with nitrate of soda and sulphate of ammonia when applied in contact with seed. This is according to findings of Hicks (7) and Shive (10).

Retardation is not as pronounced here with corn as it was in soil with lower water content. In comparing to checks, lime still shows a slight retarding effect, and same for muriate of potash and sulphate of ammonia, and the stronger retarding is where applications were made in direct contact to seed. This is according to the work of Rusche (9).

Soybeans.

With soil at 50 percent saturation, soybeans did not give any better percent germination than at 40 percent saturation. Checks germinated 96.8 percent. Sulphate of ammonia gave the lowest percent but gave a better germination where it was in contact with seed, 90.6 percent against 87.5 percent where mixed with soil.

Lime gave 100 percent for contact and 96.8 percent for mixed. All other fertilizers gave equal or better percent germination where it was mixed with soil.

Nitrate of soda gave 100 percent both contact and mixed, Muriate of potash 93.7 percent contact and 100 percent mixed. Acid phosphate 93.7 percent for contact and 96.8 percent for mixed.

The strongest effect of fertilizer is with sulphate of ammonia when compared to checks, there appears to be a slight effect where muriate of potash and acid phosphate are in direct contact with seed.

Table III.

Results with 50% saturation.

Corn (Germ. days after planting)		FIRST TEST 3	4	5	6	7	8	9	10	11	12	Total	SECOND TEST 3	4	5	6	7	8	9	10	11	12	Total	Percent Germ.
Nitrate of soda	contact	6	4	6								16			7	6	1						14	93.7
	mixed	1	2	10	1							14			8	5	1						14	87.5
Muriate of potash	contact	2	3	11								16			4	8	1	2					15	96.8
	mixed		2	14								16			5	9		2					16	100
Sulphate of ammonia	contact	2	2	9	1							14			6	7	1	1	1				16	93.7
	mixed	1	4	10	1							16			7	6	1	1					15	96.8
Acid phosphate	contact	3	6	7								16			2	10	3						15	96.8
	mixed		7	9								16		1	12	3							16	100
Lime	contact		3	7	6							16			9	7							16	100
	mixed		4	8	4							16		2	12	2							16	100
	check		11	5								16		3	11	2							16	100
Soybeans																								
Nitrate of soda	contact		15	1								16			3	7	3	3					16	100
	mixed		15	1								16			5	6	1	4					16	100
Muriate of potash	contact		13		2							15			2	6	3	4					15	93.7
	mixed		16									16			6	3	4	3					16	100
Sulphate of ammonia	contact		14	1								15				3	6	5					14	90.6
	mixed		14		1							15				3	2	8					13	87.5
Acid phosphate	contact		8	5	1	1						15			5	8	2						15	93.7
	mixed		9	2	3	1						15			7	7	2						16	96.8
Lime	contact		7	8	1							16			11	3	2						16	100
	mixed		5	10								15		4	8	2	2						16	96.8
	check		4	11	1							16		4	4	3	4						15	96.8

In the first test acid phosphate and lime retard germination most, but in the second test sulphate of amonia checks germination most with nitrate of soda and muriate of potash next in retarding effect. This may be due to temperature. With all saturations of moisture the second test was run in mid-winter months and the first test in the fall months. The temperature in the second test may be responsible for a more retardation of germination than the effect of the fertilizers.

Sulphate of amonia, muriate of potash and nitrate of soda are strongest retarders on germination of soybeans at 50% saturation, acid phosphate shows slight retarding effect and lime gives very little, if any, at 50% saturation.

Table IV gives results of germination of wheat and barley at 50% saturation.

Wheat gave the poorest germination of all four seeds used and not as high as 40% saturation.

Checks gave germination of 78.1 per cent, Sulphate of amonia here again as in Table II, gave the most serious effect on wheat germination and is the only fertilizer that gave a lower percent germination for both, contact with seed (56.2 percent) and when mixed with soil (68.7 percent) than did checks. Muriate of potash and lime again both showed better germination with wheat where it is in contact with seed, than where mixed with soil.

Seedlings, in either test did not show above the ground until the fifth day after planting and checks did not show seedlings until the sixth day and all that came up appeared in second test on this day.

Muriate of potash, sulphate of amonia, acid phosphate, and lime all showed a marked retarding effect on germination where in contact with seed, the strongest being muriate of potash and lime.

Table IV.

Results of Wheat and Barley at 50% saturation.

Wheat

(Germ. days after planting)		FIRST TEST 3	4	5	6	7	8	9	10	11	12	Total	SECOND TEST 3	4	5	6	7	8	9	10	Total	Percent Germ.
Nitrate of soda	contact			2	5	5		1				13			1	6	2	1	2		12	78.1
	mixed			1	2	6	2					11			5	4	1		4		14	78.1
Muriate of potash	contact						4	5		3		12			6	4	1		1	1	13	78.1
	mixed			2	3	6	1					12			7	3	1				11	71.8
Sulphate of ammonia	contact			3		4	3			1		11			5	1				1	7	56.2
	mixed			2	2	1	2	1				8			9	2	1		1	1	14	68.7
Acid phosphate	contact				7	6		2				15			8	4	1				13	87.5
	mixed			3	3	3						9			12	1	2				15	75.0
Lime	contact					4	2	5	1			12				3	3	7			13	78.1
	mixed			2	2	4	2	2				12				6	2	6			14	81.2
	check				2	3	1	3	1	1		11				14					14	78.1

Barley

Nitrate of soda	contact			1	14							15			12	1	1				14	90.6
	mixed			2	9	3	1					15			15						15	93.7
Muriate of potash	contact				8	5	1					14			11	5					16	93.7
	mixed				9	4	1	1				15			12	2					14	90.6
Sulphate of ammonia	contact				5	6	2				1	14		3	10	1	1				15	90.6
	mixed					5	9			1		15		4	9	2	1				16	96.8
Acid phosphate	contact			1	11	1	2					15		5	10						15	93.7
	mixed			1	2	11	2					16		6	8	1					15	96.8
Lime	contact				8	6	2					16		1	12	2					15	96.8
	mixed		1	1	4	6	1					13		2	14						16	90.6
	check			1	13	2						16		1	14						15	96.8

This is according to Ewart. (9) In the second test nitrate of soda gave retarding effect. There is not much difference in the germination of barley at 50% saturation than it was at 40% saturation Checks germinated slightly better in this trial 96.8% and with none of the fertilizers in this trial was germination any better than checks. Muriate of potash and lime as in Table II gave better germination where in contact with seed than where mixed with soil, contact for muriate of potash 93.7%, mixed 90.6%, contact for lime 96.7%, mixed 90.6%. With other fertilizers used, germination was best where mixed with soils. No marked serious effect is seen on the germination of barley at 50% saturation.

Seedlings appeared in first test earlier at 50% saturation than at 40%. Sulphate of amonia appears to check germination most with lime in contact, and muriate of potash both contact and mixed about equal and next to sulphate of amonia in retarding effect on germination of barley. Acid phosphate gives a slight effect.

At 50% saturation the soil is in good working condition and in good state for plant growth yet there is not sufficient moisture to make land stick together, but remain in a loose condition.

Tables No. V and VI show results of germination at 60 per cent saturation. I find with corn that germination at 60 percent saturation was faster than at either 50 percent or 40 percent saturation, practically all trials showing a number of seedlings up on the third day after planting, in first test and around half trials showed seedlings up on the fourth day in second test. Checks germinated 96.8 percent, nitrate of soda in the other two tables discussed showed better germination where in contact with seed, but in this trial it was better where mixed with soil, being 93.7 percent for contact with seed and 96.8 percent where mixed with soil.

In comparing with checks, nitrate of soda in contact with seed, may have a slight effect on germination.

Muriate of potash gave in this trial lowest percent of germination of all, for contact with seed 90.6 percent, and for mixed with soil 93.7 percent. This looks as if muriate of potash gave a detrimental effect, but it is very slight. However comparing this to the percent of germination of tables Nos. I and III which are lower saturation of moisture there was no detrimental effect. At 40 percent saturation there was 100 percent germination for both contact and mixed and at 50 percent saturation 96.8 percent for contact and 100 percent for mixed. I would say then that the low percent germination in trial with 60 percent saturation was more probably due to disease infected seed rather than a detrimental effect of the fertilizer.

Sulphate of ammonia for first time in the three saturations tried, gave a better percent germination where in contact with seed over mixed with soil. The difference is only one seed and therefore not enough to speak about, the percentage for germination being 96.8 percent for contact with seed and 93.7 percent where mixed with soil. This indicates a detrimental effect, but it could hardly be expected to get a more serious effect where fertilizer was mixed with soil than where in direct contact with seed. Results at 50 percent saturation were higher for fertilizer mixed with soil and at 40 percent saturation, 100 percent for both. No serious effect could be well attributed here.

Acid phosphate gave a germination of 96.8 percent, same as for checks.

Lime was 93.7 percent germination for contact and 100 per cent for mixed with soil. This would also indicate some ill effect due to the fertilizer, but comparing with checks which was 96.8

percent the effect is slight. Comparing with results of 50 percent saturation which was 100 percent germination for both mixed and contact, a serious effect could hardly be attributed to the lime.

Therefore, at 60 percent saturation there is no serious effect or retarding effect on germination of corn with the applications of fertilizer used.

At 60 percent saturation soybeans same as corn showed seedlings above the ground earlier than in previous trials at lower moisture content. Checks germinated 100 percent. Lime both contact and mixed also germinated 100 percent. Nitrate of soda germinated 93.7 percent for contact, mixed 100 percent. Nitrate of soda here seems to give some effect on germination but in comparing to results at 50 percent saturation which is 100 percent germination for both contact and mixed, there would be no detrimental effect.

At 50 percent saturation muriate of potash in contact showed a slight effect, sulphate of ammonia the strongest and acid phosphate in contact a slight effect on germination of soybeans. This same effect is again shown at 60 percent saturation. Muriate of potash showing strongest with 90.6 percent for contact and 93.7percent for mixed. Sulphate of ammonia in contact was as strong in effect as muriate of potash, it being 90.6 percent for contact and 96.8 percent for mixed. The effect of acid phosphate is very slight,if any, germination being 96.8 percent for both contact and mixed.

In first test again as with 50 percent saturation, acid phosphate and lime show a slight retarding effect, but in second test same as with Table III muriate of potash and sulphate of ammonia give strongest retarding effect. Taking both tests and comparing to checks sulphate of ammonia, gives strongest retarding effects, at 60 percent saturation especially in contact with seed. Muriate of potash is about as strong as sulphate of ammonia, acid

Table V.

Results with 60% saturation.

Corn

(Germination each day)		FIRST TEST 3	4	5	6	7	8	9	10	Total	SECOND TEST 3	4	5	6	7	8	9	10	Total	Percent Germ.
Nitrate of soda	contact	9	6	1						16		1	10	3					14	93.7
	mixed	3	7	5	1					16		3	12						15	96.8
Muriate of potash	contact	3	3	8						14			12	3					15	90.6
	mixed	3	2	9	1					15			11	3	1				15	93.7
Sulphate of ammonia	contact	5	8	3						16			8	6	1				15	96.8
	mixed	6	5	4						15		4	11						15	93.7
Acid phosphate	contact	11	4	1						16		1	10	3	1				15	96.8
	mixed	1	7	7						15			13	3					16	96.8
Lime	contact	1	6	8						15			11	3	1				15	93.7
	mixed		7	8	1					16		2	13	1					16	100
	check		6	9	1					16			9	6					15	96.8

Soybeans

Nitrate of soda	contact	5	8	1						14			7	7	2				16	93.7
	mixed		11	5						16		2	1	5	8				16	100
Muriate of potash	contact	6	8			1				15			1	5	3	5			14	90.6
	mixed	7	4	4	1					16			1	6	4	3			14	93.7
Sulphate of ammonia	contact	10	4							14				7	5	3			15	90.6
	mixed	6	7	2	1					16			8		1	6			15	96.8
Acid phosphate	contact		14	1						15			8	5	3				16	96.8
	mixed		5	9	1	1				16			10	6					16	100
Lime	contact		5	6	3	2				16			11	3	2				16	100
	mixed		7	8	1					16		3	12	1					16	100
	check		13	2						16		12	2	2					16	100

phosphate and lime both show some retarding effect.

Wheat as in both previous trials germinated poor. Checks germination was 75 percent, nitrate of soda was the same as checks in percent germination. When comparing to checks, muriate of potash and sulphate of amonia in this trial as in previous trials show some detrimental effect on germination. The percent of germination for both fertilizers where in contact with seed and mixed with soil was the same 71.8 percent.

Acid phosphate gave 65.6 percent germination where in contact with seed and 78.1 percent where mixed with soil. This appeared to give a bad effect where in contact with seed. In comparing this with results of 40 and 50 percent saturations, the percent of germination is much higher than this and in both these trials germination is better where acid phosphate was in contact with seed than when mixed with soil. The low percent of germination in this trial then would not seem to be due to effect of fertilizer, but to the seed itself.

Lime in both previous trials gave a higher percent germination where in contact with seed than where mixed with soil. In this trial it was reverse. In comparison with checks no ill effects are shown. More seedlings appeared sooner at 60 percent saturation than at 40 and 50 percent saturation. Lime in contact still shows a retarding effect. Muriate of potash and sulphate of amonia still show some retarding effect, but when compared to checks it is very slight.

The germination of barley at 60 percent saturation is about the same as in the two previous trials. Checks germinated 90.6 per cent. In only two instances in germination less than checks that is with muriate of potash in contact with seed and lime mixed with soil. Nitrate of soda both in contact and mixed averaged 93.7 percent.

Table VI

Results with 60% saturation

Wheat

(Germination each day)		FIRST TEST 3	4	5	6	7	8	9	10	11	12	Total	SECOND TEST 3	4	5	6	7	8	9	10	Total	Percent Germ.
Nitrate of soda	contact				6	4					1	10		2	10	2					14	75.0
	mixed			3	5	4					1	13		2	8	1					11	75.0
Muriate of potash	contact			4	2	2	2					10			12	1					13	71.8
	mixed				3	5	1	1				10		2	10	1					13	71.8
Sulphate of ammonia	contact			5		3	3					11		1	11						12	71.8
	mixed				7	2		1	1			11			7	4	1				12	71.8
Acid phosphate	contact			2	3	4	2					11		1	8	1					10	65.6
	mixed			7	3	3						13		1	10	1					12	78.1
Lime	contact			2	2	1	1		3	1		10		1	4	5	2	2			14	75.0
	mixed			3	4	2	1	1		1		12		2	10	1					13	78.1
	check				5	3	1		1	1		11		9	1	2	1				13	75.0
Barley																						
Nitrate of soda	contact				1	10	3					14		6	10						16	93.7
	mixed				1	14						15		9	6						15	93.7
Muriate of potash	contact					7	6					13		1	14						15	87.5
	mixed					13	3					16		6	10						16	100
Sulphate of ammonia	contact					5	9	2				16		2	13						15	96.8
	mixed						13	2				15		5	11						16	96.8
Acid phosphate	contact			2	5	8	1					16		7	9						16	100
	mixed				1	11	3					15		4	11						15	93.7
Lime	contact			1		4	7	2		2		16		8	8						16	100
	mixed				4	9	1	1				15		5	8						13	87.5
	check				5	8	1					14			15						15	90.6

Muriate of potash mixed with soil was 100 percent against as stated 87.5 percent for contact with seed. This is the strongest effect shown by any fertilizer on germination of barley at 60 percent saturation.

Sulphate of amonia gave same percentage for both contact and mixed being 96.8 percent.

Lime and acid phosphate both gave 100 percent for contact against 93.7 percent and 87.5 percent respectively for mixed. Lime in both previous trials 40 percent and 50 percent saturation, gave better germination for contact than mixed: with higher percent germination in former trials and with 90.6 percent in this trial for checks, it could hardly be said that lime at 87.5 percent in this trial gave any serious effect on germination, considering also lime in contact with seed gave 100 percent germination.

In the first test with barley at 60 percent saturation a somewhat retarding effect is noticed with muriate of potash and sulphate of amonia in contact and mixed, this being the strongest retarder, and with lime where in contact, but in the second test a retarding effect is not noticeable.

Sixty percent saturation is the optimum moisture content of this type of soil. The soil here contains sufficient water for a good plant growth and is not in a state too wet to cultivate advantageously.

Table VII gives results at 70 percent for corn and soybeans. At this percent of saturation, the land is plenty wet in fact too heavy to cultivate. When squeezed in the hand it would stick together easily, which is a condition too wet for cultivation.

Corn at this moisture content of the soil germinated very good, in no trial it being lower than 90.6 percent. Checks germinated at 93.7 percent.

Table VII.

Results with 70% saturation.

Corn (Germination each day)		FIRST TEST 3	4	5	6	7	8	9	10	Total	SECOND TEST 3	4	5	6	7	8	9	10	Total	Percent Germ.
Nitrate of soda	contact	8	7							15		9	6		1				16	96.8
	mixed	5	7	3						15		2	12	1					15	93.7
Muriate of potash	contact	5	5	2	2					14		4	10	1	1				16	93.7
	mixed	6	3	6						15		2	12	2					16	96.8
Sulphate of ammonia	contact	6	7	2						15		2	6	3	3	1			15	93.7
	mixed	1	3	12						16		2	13						15	96.8
Acid phosphate	contact	8	3	4						15			6	7	3				16	96.8
	mixed	6	6	3						15			10	6					16	96.8
Lime	contact	2	3	9	2					16			11	3	2				16	100
	mixed	1	5	8						14		3	12						15	90.6
	check		5	8	1					14		3	12	1					16	93.7
Soybeans																				
Nitrate of soda	contact	4	10	2	1					16			11	3	2				16	100
	mixed	5	10	1						16			12	4					16	100
Muriate of potash	contact		13	2						15			8	6		1			15	93.7
	mixed	2	10	3						15			6	6	2	2			16	96.8
Sulphate of ammonia	contact	5	7	1		2				15			6	3	3	4			16	96.8
	mixed	4	6		3	2				15			6	1		8			15	93.7
Acid phosphate	contact		8	8						16			13	3					16	100
	mixed		4	10		1				15			10	4	2				16	96.8
Lime	contact		9	4	1	1				15		7	6	3					16	96.8
	mixed		13	3						16		3	9	2	2				16	100
	check	6	7	2						15		9	6	1					16	96.8

Nitrate of soda for the third time in the four tables discussed gave a slightly higher percent germination where in contact with seed than where mixed with soil, it being 96.8 percent for contact and 93.7 percent for mixed, muriate of potash gave 93.7 percent germination for contact and 96.8 percent where mixed with the soil. The same percentage of germination applied to sulphate of amonia for contact and mixed. Acid phosphate gave the same percent germination for both contact amd mixed, 96.8 percent.

Lime gave 100 percent germination where in contact with seed and 90.6 percent where mixed with soil. This is the lowest percent of germination in this trial. When comparing this result with that of the two previous saturations, 60 percent and 50 percent in which germination was 100 percent where mixed with soil, the low percent of germination in this trial can hardly be attributed to the effect of the lime but rather to bad seed.

Taking germination of checks in comparison with percent of germination of all fertilizers in trial at 60 percent saturation, no ill effect of fertilizers is shown and no retarding worthy of mention, except a slight effect with muriate of potash, sulphate of amonia and acid phosphate where in contact with seed. This is according to the work done by Dr. Truog. (11)

Germination of soybeans at 70 percent was about the same as at 60 *percent. Checks germination was 96.8 percent, nitrate of soda* gave 100 percent both for contact and mixed. Muriate of potash showed percent germination where in contact with seed of 93.7 percent and 96.8 percent for mixed, while sulphate of amonia gave a higher germination where in contact with seed, it being 96.8 percent and for mixed it is 93.7. at lower moisture content these two fertilizers both showed an effect on germination of soybeans but

at 70 percent saturation when compared to checks any effect shown is very slight, according to the works of Dr. Truog (11). At 70 percent saturation neither acid phosphate nor lime gave any ill effect.

Muriate of potash and sulphate of ammonia tho not giving any marked effect on germination did retard germination more than any other fertilizers at this saturation. In the second test with comparison to checks acid phosphate shows some retarding both in contact and mixed and lime in contact in both tests gives slight retarding effect.

Table VIII gives results of wheat and barley.

In all trials so far studied, wheat at 70 percent saturation gives a lower percent germination. The higher moisture content in the soil appears to affect the germination of wheat more so than corn, soybeans or barley, which will be discussed next. This is according to the work of Dr. Truog. (11) "Injury to germination is influenced by rate of application, moisture content of soil, etc." Wheat checks at 70 percent saturation germinated at 75 percent. Nitrate of soda showed percent germination of 68.7 percent where in contact with seed and 65.6 percent where mixed. Muriate of potash 71.8 percent for contact and 68.4 percent where mixed. Sulphate of of ammonia 68.7 percent for contact and 84.3 percent for mixed. This being the highest percentage in this trial and above checks. From this nitrate of soda, muriate of potash both contact and mixed and sulphate of ammonia where in contact has a detrimental effect on germination at a high moisture content in soil. Acid phosphate where in contact with seed was 68.7 percent germination which also showed some effect, but where mixed with soil the effect was light, if any.

Lime, both contact and mixed, germinated better than checks but according to checks no fertilizer gave a retarding of germination at 70 percent saturation. The high moisture in the soil held

Table VIII

Results with 70% saturation

Wheat

(Germination each day)		FIRST TEST										SECOND TEST										PERCENT
		3	4	5	6	7	8	9	10	Total		3	4	5	6	7	8	9	10	Total		Germination
Nitrate of soda	contact			2	4	4				10			7	5						12		68.7
	mixed			4	5		1		1	11			7	3						10		65.6
Muriate of potash	contact			2	7	2				11			1	11						12		71.8
	mixed			3	1	6				10			6	3	1					10		62.4
Sulphate of	contact				5	5			1	11			6	4	1					11		68.7
ammonia	mixed			1	6	6	1			14			5	7		1				13		84.3
Acid phosphate	contact			3	6	3	1			14			2	6						8		68.7
	mixed			5	2	1			1	9			10	4						14		71.8
Lime	contact			2	3	4	1	2	1	13			5	7		1				13		81.2
	mixed			3	4	4	1	1		13			9	3						12		78.1
	check			3	4	2		1	4	14			7	3						10		75.0
Barley																						
Nitrate Of sOda	contact				3	12	1			16			2	13						15		96.8
	mixed				3	11				14			5	10	1					16		93.7
Muriate of	contact					13	3			16			3	9	1					13		90.6
potash	mixed				3	9	2			14			2	13						15		90.6
Sulphate of	contact					8	7	1		16			2	11	3					16		100
ammonia	mixed					1	12	2		15			1	11						12		84.3
Acid phosphate	contact				1	13	2			16				12	2					14		93.7
	mixed				1	7	5		1	14				14	2					16		93.7
Lime	contact			4	4	5	2		1	16				10	4	1				15		96.8
	mixed					9	4			13				13	2	1				16		90.6
	check				1	14				15			13	2						15		93.7

germination back in this trial.

Barley the same as corn and soybeans, shows just as good germination at 70 percent as at 60 percent. Checks gave 93.7 percent germination. Nitrate of soda shows no ill effects on germination, but for first time it gave a slightly better percent of germination where in contact with seed than where mixed with soil, it being 96.8 percent for contact and 93.7 percent for mixed.

Muriate of potash here again shows some effect on germination of barley, but when compared with checks it is slight. The percent germination is 90.6 percent for both contact and mixed. Sulphate of amonia gave 100 percent for contact with seed and 84.3 percent where mixed with soil. This is the lowest germination in the trial, but when compared to results of previous tables the low percentage germination in this trial seems to be due to seed and not fertilizer effects.

Acid phosphate gave 93.7 percent for both contact and mixed and lime as has been in all previous tables gave higher germination for contact with seed than when mixed with soil. Taking both tests in comparison to checks, sulphate of amonia retarded most the germination of barley at 70 percent saturation, acid phosphate and lime giving a slight retarding effect.

Table No. IX gives results of germination at 80 percent saturation for corn and soybeans. The soil at this 80 percent saturation is very wet. It is just the same as mud and to have tilted the boxes any, the water would have drained out of the soil.

Corn germination was very high in this wet soil. Checks germinated 100 percent and so did lime both contact and mixed. No trials were below 90.6 percent germination.

Table IX

Results with 80% saturation

Corn

(germination each day)		FIRST TEST 3	4	5	6	7	8	9	10	Total	SECOND TEST 3	4	5	6	7	8	9	10	Total	Percent Germination
Nitrate of soda	contact	9	6	1						16		5	10	1					16	100
	mixed	7	5	2	1					15		6	9						15	93.7
Muriate of potash	contact	7	4	4						15		5	7	2	1				15	93.7
	mixed	2	7	7						16		12	2	1					15	96.8
Sulphate of ammonia	contact	6	6	1						13		12	3	1					16	90.6
	mixed	1	6	6	1					14		4	10	1	1				16	93.7
Acid phosphate	contact	4	4	4	1	2				15		5	10	1					16	96.8
	mixed	2	5	6						13		2	11	3					16	90.6
Lime	contact	1	4	10	1					16		5	10	1					16	100
	mixed		8	7	1					16		4	11	1					16	100
	check		6	9	1					16		1	8	6	1				16	100

Soybeans

Nitrate of soda	contact	14	1							15		5	8		1	1			15	93.7
	mixed	4	4	3	3					14		7	4	3	1				15	90.6
Muriate of potash	contact	12								12		2	6	2	1	2			13	78.1
	mixed	11	2	1						14			6	3	1				10	75.0
Sulphate of ammonia	contact	11	1	3	1					16			1		3	2			6	68.7
	mixed	13	1	2						16			2	1	2	2			7	71.8
Acid phosphate	contact	3	13							16			3	3	1	4			11	84.3
	mixed	6	5	3						14				3	4	3			10	75.0
Lime	contact	5	5	1	1					12			1	1	4	2			8	62.4
	mixed	12	3							15				4	2				6	65.6
	check	2	7	3	2					14		1	10	1		2			14	87.5

Nitrate of soda for the fourth time in the five different saturations gave higher germination where in contact with seed than when mixed with soil, it being 100 percent for contact and 93.7 percent for mixed. Muriate of potash showed 93.7 percent germination for contact and 96.8 percent for mixed. There maybe a slight effect on germination here by the potash fertilizer.

Sulphate of amonia gave lowest percent germination of any of the fertilizers at 80 percent saturation, it being 90.6 percent in contact with seed and 93.7 percent where mixed with soil. Greatest effect is here shown by this fertilizer.

Acid phosphate gave 96.8 percent germination where in contact with seed and only 90.6 percent when mixed with soil, at all other saturations the percentage for germination with corn where acid phosphate was mixed with soil is higher than this and the low percent germination in this trial would be more attributed to bad seed and to wet soil and not fertilizer effect.

Germination at 80 percent moisture was really faster than at low saturation, that is more seedlings appeared on the third and fourth days after planting and no retarding of germination is strikingly evident.

Soybeans were considerably affected in germination by higher moisture content of the soil. Lower percents of germination were obtained in this trial than with any other trial. Checks germinated at 87.5 percent. The writer does not attribute any more effect of the fertilizers lowering the percents of germination in this trial than were shown in any other tables or trials, but rather to the high water content of the soil which caused the soybeans to rot instead of germinating.

Nitrate of soda gave higher germination for contact than mixed, but both were better than checks.

All other fertilizers used gave a lower percent of germination than checks and the lowest being with lime 62.4 percent for contact and 65.6 percent for mixed. Lime in all other saturations gave no detrimental effect on germination of soybeans. With a comparison to the checks it would appear that muriate of potash, sulphate of amonia, acid phosphate and lime all gave detrimental effect on germination of soybeans at 80 percent saturation, but I rather think it was more due to high moisture content of soil, according to the work of Dr. Truog.(11)

Wheat all through the experiment maintained its low percentage of germination. Though checks gave the same percent of germination 75 percent in the last three saturation experiments, the percent of germination for fertilizers used with wheat seems to lower as moisture is increased.

Nitrate of soda gave 53.1 percent germination in contact with seed and 75 percent where mixed with soil. Muriate of potash, 65.6 percent contact and 62.4 percent for mixed. Sulphate of amonia 59.3 percent for contact and 81.2 percent when mixed with soil, acid phosphate 65.6 percent for both contact and mixed. Lime showed 68.7 percent for contact and 78.1 percent for mixed. Lime all through the experiments shows a retarding effect on germination of wheat. Nitrate of soda and sulphate of amonia in contact with seed give the most detrimental effect on wheat germination in comparison with checks. Muriate of potash and acid phosphate both give some effect but not so strong as the first two fertilizers mentioned.

Barley like corn can withstand considerable moisture and germinate to a fairly high average. Checks gave 100 percent germination. Nitrate of soda for the second time gave a better germination where in contact with seed than where mixed with soil, 93.7 percent for contact and 90.6 percent for mixed. Nitrate of soda has given such

Table X

Results with 80% saturation

Wheat

(Germination each day)		FIRST TEST 3	4	5	6	7	8	9	10	Total	SECOND TEST 3	4	5	6	7	8	Total	Percent Germination
Nitrate of soda	contact			1	6	1				8	3	6					9	53.1
	mixed				6	1	1	4		12	4	7	1				12	75.0
Muriate of potash	contact			1	4	4			1	10	4	6	1				11	65.6
	mixed				5	6				11	3	6					9	62.4
Sulphate of ammonia	contact			1	2	6				9	2	7	1		m		10	59.3
	mixed				9	2			1	12	2	10	1		1		14	81.2
Acid phosphate	contact			4	3	2				9	5	6	1				12	65.6
	mixed			3	4	3		1		11	5	2	1	2			10	65.6
Lime	contact			1	2	3	2		1	9	3	6	4				13	68.7
	mixed			3		7	1	1		12	4	9					13	78.1
	check			3	2	7				12	4	7	1				12	75.0

Barley

Nitrate of soda	contact			2	12			1		15	2	13					15	93.7
	mixed			3	10					13	1	15					16	90.6
Muriate of potash	contact			3	11	1				15		15					15	93.7
	mixed			3	9	1				13	1	13					14	84.3
Sulphate of ammonia	contact				6	6	1	1		14	2	12	1				15	90.6
	mixed				2	11	2	1		16		13	3				16	100
Acid phosphate	contact			5	6	5				16	2	13					15	96.8
	mixed			2	13	1				16		14			1		15	96.8
Lime	contact				6	5	2	1		14	1	11	1				13	84.3
	mixed			2	12	2				16		14					14	93.7
	check			1	13	2				16		16					16	100

results with only the two highest saturations.

Muriate of potash same as nitrate of soda gave better germination for contact, it being 93.7 percent and 84.3 percent for mixed. Sulphate of amonia gave 90.6 percent for contact and 100 percent for mixed. Acid phosphate 96.8 percent for both contact and mixed. Lime for the first time with barley gave a lower germination where in contact than where mixed, giving 84.3 percent for contact and 93.7 percent for mixed. From the standpoint of checks all fertilizers used with the exception of sulphate of amonia mixed with soil, and acid phosphate show some slight effect on germination of barley at a high moisture content in soil. This is according to Rusche (9) who states "That different crops show difference of susceptibility to germination injury from fertilizer salts" and to Dr. Truog (11) on the moisture content of soil.

From standpoint of checks sulphate of amonia both contact and mixed and lime in contact with seed show some slight retarding effect.

THE EFFECT OF TEMPERATURE.

Seeds were planted in soil as before, but this time all were planted to soil at 60 percent saturation. One series of boxes were kept in general greenhouse, another in a cold greenhouse. A record of temperature was made three times each day, 8 A. M., Noon, between twelve and one and between 5 and 6 P. M., all tests were run in duplicate. TablesXI and XII give result with wheat.

Discussion of Table No. XI.

When this experiment was run, the weather was very changeable. Some days were very cold and others moderately warm and for this reason the temperature over night and through the day could not be held at a constant temperature but varied some. All temperatures are recorded degrees centigrade.

In both, first and second trials seedlings appeared above the ground on the third day after planting in practically every case and in all cases except lime in the second trial the majority of all seedlings that were coming up were above the ground on the fifth day.

In no case of any of the five fertilizers used was the percent germination of both trials above the percent of the checks boxes, which was 78.1 percent, and in only one instant was the percent germination equal to the check boxes that being where acid phosphate was in direct contact with seed.

From column on percentage of germination, it is found that with nitrate of soda, acid phosphate and lime the percent of germination is higher where fertilizer was in direct contact with seed than where fertilizer was mixed with soil. With sulphate of ammonia the percent germination was the same for both where fertilizer was in contact with seed and when mixed with soil, it being 62.5 percent. With muriate of potash, fertilizer mixed with soil gave the best germination.

Since in only one case where fertilizers were applied, the percent of germination was equal to the checks, they must have had some effect on the germination of the seeds. Sulphate of ammonia seemed to have the most serious effect, the percent germination being 62.5 percent, muriate of potash and lime were about equal in effecting germination with acid phosphate next.

In slowness of germination, lime gave the greatest retarding effect with acid phosphate next.

Discussion of Table No. XII.

This table gives results of wheat being germinated in cold room. The same weather conditions prevailed here as with results of table XI. Here the temperatures were more nearly to field conditions where seed is sown in late fall. Several days were fairly cold,

cold winds and at night heavy frosts prevailed, the middle of the day getting fairly warm. The temperature of the cold room varied much more to such conditions than did warm room.

As would be expected, germination was delayed several days longer than in warm room, the first seedlings appearing on the sixth day after planting and running to the twelfth day after planting before germination was complete.

The percent of germination in cold room was 78.1 percent for the check boxes, the same as in warm room. Here again it was found that nitrate of soda gave a higher percent germination where fertilizer was in contact with the seed than when mixed with soil. Also, acid phosphate which is a duplicate of results in warm room. In cold room sulphate of amonia changed and highest percent of germination is with fertilizer mixed in soil. Lime did the same thing, giving better results where it was mixed with soil than where it was put in contact with the seed.

In the case of three applications germination was of a higher percentage than checks, nitrate of soda contact,, percentage was 81.2 percent, mixed with soil equal to checks 78.1 percent, others were acid phosphate contact 87.5 percent, and lime mixed with soil 81.2 per cent.

From the standpoint of serious effect on germination, muriate of potash and sulphate of amonia again show greatest effect,

Lime again shows the retarding effect on wheat germination, it taking as long as twelve days for germination to be completed and with lime as with other fertilizers practically all seedlings appeared above the ground on the 9th to 10th day after planting.

In summarizing results of these two tables on temperature effects on germination, it can be said that;

First; germination is slower under the cooler temperature

Table XI

Results on Wheat, Effect of Temperature on Germination conducted in Warm Room.

(Germination on days after planting)		FIRST TEST 3	4	5	6	6	8	Total	SECOND TEST 3	4	5	6	7	8	Total	% Germ.	TEMPERATURE OF ROOM "C" Date	A.M.	Noon	P.M.
Nitrate of soda	contact	2	8	3				13	2	7	2				11	75	2/9	19.5°C	18.5°C	17.5° C
	mixed	3	4	1	1			9	2	8	4				14	71.8	2/10	18.5	24.0	17.5
Muriate of potash	contact	2	7		1			10	0	8	2				10	62.5	2/11	18.5	22.0	16.0
	mixed	4	5	1				10	4	9	1				14	75.	2/12	10.5	16.0	15.5
Sulphate of amonia	contact	3	7	2				12	2	4	1	0	1		8	62.5	2/13	19.0	21.5	14.0
	mixed	4	5	1	2			12	1	5	2				8	62.5	2/14	10.5	16.0	15.5
Acid phosphate	contact	1	6	3	0	2		12	4	7	2				13	78.1	2/15	13.5	20.0	17.5
	mixed	0	7	2	1			10	4	5	0	1			10	62.5	2/16	16.0	29.0	12.0
Lime	cojtact	1	6	1	0	3		11	0	3	1	1	4	3	12	71.8	2/16			
	Mixed	1	3	3	1	0	1	9	3	4	1	1	2	1	12	65.6				
Check		1	10	2	1			14	4	6	0	0	1		11	78.1				

TABLE XII

Results on wheat effect of temperature on germination conducted in cold room.

(Germination on days after planting)		FIRST TEST 6	7	8	9	10	11	Total	SECOND TEST 6	7	8	9	10	11	12	Total	% Germ.	TEMPERATURE OF ROOM "C" Date	A.M.	Noon	P.M.
Nitrate of soda	contact	0	3	5	3	2		13	2	5	4	1	0	1		13	81.2	2/9	10°c	14.5°c	11.5°c
	Mixed	1	5	3	1	1		11	1	5	7	0	0	1		14	78.1	2/10	10.0	16.0	13.5
Muriate of potash	contact	0	3	5	3			11	2	7	1	2	0	1		13	75.0	2/11	10.0	14.0	6.5
	mixed	1	5	5				11	0	6	1	1	2			10	65.5	2/12	0.0	15.5	15.0
Sulphate of ammonia	contact	0	4	4	2			10	0	6	5	1				12	68.7	2/13	11.5	25.0	12.0
	mixed	2	4	7	0	0	1	14	3	4	0	2	1			10	75.0	2/14	0.0	10.0	5.0
Acid phosphate	contact	2	6	3	1	1		13	1	6	7	0	1			15	87.5	2/15	9.5	14.0	9.5
	mixed	1	6	4				11	1	4	4	1	1			11	68.7	2/16	3.0	23.5	11.0
Lime	contact	3	4	0	2	1	1	11	0	2	5	1	1	2		11	68.7	2/17	8.0	15.0	10.0
	mixed	5	6	3				14	0	3	6	0	0	2		12	81.2	2/18	4.5	25.0	10.0
Check		6	5	2	1			14	5	4	1	0	1			11	78.1	2/19	1.0	23.0	13.0
																		2/20	2.0	29.0	13.0

as would be expected. Checks in both experiments germinated 78.1 percent, but in every other trial with all fertilizers used both in contact with seed and mixed with the soil, the percent of germination was higher with the cool temperature, which goes to prove that wheat being a plant adapted to cooler climates will give best results in germination under temperature more like conditions in the fall of the year than with much warmer temperature.

Second; under influence of both a warm room or medium temperature and a cool room or fairly low temperature, sulphate of amonia and muriate of potash gave most serious effect on germination.

Third; Lime in both trials on temperature showed the strongest retarding effect on germination. Acid phosphate also showed some retarding effect but not as great as lime.

The Effects of Temperature on the Germination of Barley.

This experiment was run at the same time as the wheat and the same weather conditions prevailed and the same temperatures were recorded, all temperatures being in degrees, centigrade(oc).

Table No. XIII gives results of experiment conducted in a warm room. Seedlings appeared in all boxes on the third day after planting and a majority were above the ground on the fifth day. In only a few trials did seedlings appear as late as the seventh day after planting.

Checks gave a percent germination of 93.7 percent. In all other trials with different fertilizers used, both in contact with seed and mixed with soil the percent of germination was equal to and higher than the check.

In the case of nitrate of soda, percent of germination was the same with contact to seed and mixed with soil, it being 96.8 per cent. The same is true with sulphate of amonia, germination being

100 percent. Acid phosphate mixed with soil gave 100 percent germination against 93.7 percent for contact with seed. Muriate of potash and lime both gave higher percent of germination when in contact with seed than when mixed with soil, it being the same for both fertilizers 96.8 percent for contact and 93.7 percent for mixed.

With barley none of the applications of fertilizers as compared with check gave any serious effect on germination. There seems to be very little retarding effect on the germination of barley by the different fertilizers used except with lime which shows a slight retarding effect.

Table XIV gives results of the temperature on the germination of barley when conducted at a low temperature.

Discussion; As in the experiment with wheat, germination with barley was delayed several days longer, first seedlings appearing on the sixth day after planting and last appearing on the 11th day. A striking thing in this experiment was that the checks were the slowest to germinate.

Check boxes in the cold room gave the lowest percent germination with one exception, that being acid phosphate in contact with seed which was 75. percent to 87.5 percent for check, In all other trials with the different fertilizers, the percent germination was equal to and above the check.

Nitrate of soda again gave the same percent germination for both contact with seed and mixed with soil, it being 93.7 percent. With other four fertilizers higher percentages of germination were with fertilizers mixed with soil. As a whole here again comparing the percentage of germination of applications of fertilizers with that of the check, there seems to be no serious effects on germination of barley except in one instant, that of acid phosphate in contact

Table XIII

Results on Barley-- Effects of Temperature on Germination, conducted in warm room.

(Germination on days after planting		FIRST TEST 3	4	5	6	7	8	Total	SECOND TEST 3	4	5	6	7	8	Total	% Germ.	TEMPERATURE OF ROOM DEGREEC Date	A.M.	Noon	P.M.
Nitrate of soda	contact	6	10					16	7	7	1				15	96.8	2/9	19.5°c	18.5°	17.5°c
	mixed	8	7	1				16	13	2					15	96.8	2/10	18.5	24.0	17.5
Muriate of potash	conatct	7	7	1	0	1		16	1	12	2				15	96.8	2/11	18.5	22.0	16.0
	mixed	6	10					16	4	9	1				14	93.7	2/12	10.5	21.0	19.0
Sulphate of amonia	conatact	3	12	1				16	3	12	1				16	100	2/13	19.0	21.5	14.0
	mixed	5	9	0	0	2		16	11	5					16	100	2/14	10.5	16.0	15.5
Acid phosphate	contact	5	9					14	7	9					16	93.7	2/15	13.5	20.0	17.5
	mixed	4	10	1	0	1		16	5	10	0	0	1		16	100	2/16	16.0	29.0	12.0
Lime	contact	3	11	1				15	3	10	1	0	2		16	96.8	2/17			
	mixed	4	6	3	0	1		14	8	8					16	93.7				
Check		5	8	1				14	3	13					16	93.7				

Table XIV

Results on Barley-- Effects of Temperature on Germination, conducted in cool room.

(Germination on days after planting		FIRST TEST 6	7	8	9	10	11	12	Total	SECOND TEST 6	7	8	9	10	11	12	Total	% Germ.	TEMPERATURE OF ROOM DEGREEC" Date	A.M.	Noon	P.M.
Nitrate of soda	contact	1	7	7					15	6	7&1		1				15	93.7	2/9	10.0°c	14.0°c	11.5°c
	mixed	0	2	8	2	3			15	0	3	10	2				15	93.7	2/10	10.0	16.0	13.5
Muriate of potash	contact	0	6	9					15	5	5	2	1				13	87.5	2/11	10.0	14.0	6.5
	mixed	10	6						16	7	5	3	1				16	100	2/12	0.0	16.5	15.0
Sulphate of amonia	contact	0	3	9	2	2			16	0	4	9	0	1			14	93.7	2/13	4.5	20.0	12.0
	mixed	4	12						16	4	9	2					15	96.8	2/14	0.0	10.0	5.0
Acid phosphate	contact	5	7	0	1				13	2	7	0	2				11	75	2/15	9.5	14.0	9.5
	mixed	3	11	1	L				16	7	7	1					15	96.8	2/16	3.0	23.5	11.0
Lime	contact	1	2	11	2				16	0	4	5	3				12	87.5	2/17	8.0	15.0	10.0
	mixed	2	4	10					16	1	4	5	2				13	90.6	2/18	4.5	25.0	10.5
Checks		0	0	5	3	2	3		13	0	2	8	3	1	1		15	87.5	2/19	1.0	23.0	13.0
																			2/20	2.0	29.0	13.0

with seed, the percent of germination being 75 percent.

When considering the fertilizers with the check in this experiment, there seems to be no retarding effect but a stimulating effect of the fertilizers on germination. However, in comparing the fertilizers with each other, sulphate of amonia and nitrate of soda and lime seem to show a slight retarding effect in order named.

Summary of effects of temperature on germination of barley.

First; taking experiment as a whole and comparing the percentages of germination where fertilizers were applied with percentage of germination of checks, it was found in every trial with but one exception the fertilizer applications gave higher germination than the checks. This seems conclusive that the application of fertilizer used have no detrimental effect on germination of barley under ordinary conditions of soil and temperature.

Second; germination at a low temperature was not as good as germination at a medium temperature. This, with barley as with wheat is suggestive of the nature and type of the barley plant. Barley is sown about two weeks earlier than wheat when soil and air are warmer than when wheat is sown and the experiment shows better germination as a whole at the higher temperature.

With barley the kinds and amounts of fertilizers used do not seem to have any serious effect on germination. Lime, nitrate of soda, and sulphate of amonia may give some retarding effect on germination of barley, but it is slight.

The results of the effect of temperature on the germination of corn are found in tables Nos. XV and XVI.

This experiment was conducted the last part of March. From the standpoint of weather conditions, this was a very changeable period.

Table XV

Results on corn-- Effects of Temperature on Germination, conducted in warm room.

(Germination on days after planting		FIRST TEST 4	5	6	7	8	Total	SECOND TEST 4	5	6	7	8	9	Total	% Germ.	TEMPERATURE OF ROOM "C" Date	A.M.	Noon	P.M.
Nitrate of soda	contact		3	11	2		16	1	6	6	3			16	100	3/25	18.0°c	24.0°c	10.0°c
	mixed		7	6	3		16	2	5	7	2			16	100	3/26	&14.0	36.0	18.0
Muriate of potash	contact	4	6	5	1		16	1	8	7				16	100	3/27	15.5	28.0	18.0
	mixed	3	8	4			15	2	9	5				16	96.8	3/28	16.0	35.0	18.0
Sulphate of ammonia	contact	2	9	3	1		15	1	10	5				16	96.8	3/29	11.0	26.0	14.0
	mixed	3	10	1	1		15	4	9	3				16	96.8	3/30	11.5	35.0	16.0
Acid phosphate	contact	1	12	2	1		16	3	5	7				15	96.8	3/31	18.0	24.0	16.0
	mixed	1	10	4	1		16	2	10	4				16	100				
Lime	contact		7	6	2		15		7	4	2			13	87.5				
	mixed		12	2	1		15	4	9	3				16	96.8				
Check		1	10	4	1		16	1	9(	4	1			15	96.8				

Table XVI

Results on corn-- Effects of Temperature on Germination, conducted in cool room.

(Germination on days after planting		6	7	8	9	10	Total	6	7	8	9	10	Total	% Germ.	TEMPERATURE OF ROOM "C" Date	A.M.	Noon	P.M.
Nitrate of soda	contact	4	3	8			15	2	8	4	2		16	96.8	3/25	18.0°c	24.0°c	19.0°c
	mixed	5	6	3	1		15	9	1	4(	1		15	93.7	3/26	14.0	32.0	18.0
Muriate of potash	contact	6	7	2			15	9	1	2	2		14	90.6	3/27	11.0	16.0	10.0
	mixed	5	7	2	1		15	7	7	2	m		16	96.8	3/28	10.0	20.0	10.0
Sulphate of ammonia	contact	7	2	4	2		15	3	8	1	3	1	16	96.8	3/29	7.0	26.0	8.0
	mixed	4	5	3	2	1	15	3	7	3	2	1	16	96.8	3/30	3.0	(28.0	10.0
Acid phosphate	contact	2	9	4	1		16	2	9	3	2		16	100	3/31	10.0	(24.0	12.0
	mixed	1	10	4	1		16	5	5	2	3		15	96.8	4/1	10.0	18.0	12.0
Lime	contact	3	9	3	1		16	5	8	2	1		16	100	4/2	8.0	25.0	14.0
	mixed	2	8	6			16	8	2	3	2		15	96.8				
Check		1	10	3	2		16	5	2	6	2		15	96.8				

Due to the weather conditions which were cold and blustry one day and warmer probably the next day, temperature varied. Morning and evening temperatures would be low and at noon much higher. For this reason a constant temperature of the greenhouse room could not be maintained. All temperatures were recorded between 7 and 8 A. M., 12 and 1 noon, and between 5:30 and 6 P.M. and in degrees centigrade.

In warm room corn germinated well, seedlings appeared in both tests on the fourth day after planting and all germination was completed on the 7th day. Lime and nitrate of soda gave the only retarding effects and this was only slight.

Checks germinated 96.8 percent. Lime in contact with seed gave 87.5 percent germination, and this in the only trial where it appears below checks. All other trials are equal and above checks in germination. From previous experiments lime has given no serious effects on germination and in this particular case, do not think the low germination is due to lime but to seed. With no other fertilizer is any effect shown on germination by application used.

Corn as a whole did not germinate with quite as high an average at the colder temperature as at a warmer temperature, but germination was good. Seedlings appeared above the ground two days later in cool room than in warm room and it took five days for all seedlings to show above the ground at cooler temperature, where at warmer temperatures they were all up in four days.

Temperatures as a whole were several degrees lower in cool room throughout days of experiment, but in the middle of the day rooms would warm up considerably. All temperatures are recorded degrees centigrade.

Germination was same for checks in cool room as in warm room, 96.8 percent.

Acid phosphate, lime and nitrate of soda gave a slight

better germination percent in contact with seed than when mixed with soil, but in results in warm room, these fertilizers gave better germination where mixed with soil. It is a matter of only one seed in each case and cannot be considered to any extent in change of results. Muriate of potash gave lowest results 90.6 percent.

None of the fertilizers gave any serious effect on germination of corn at a low temperature, but sulphate of amonia does show a slight retarding effect at a cooler temperature.

Tables XVII and XVIII give results on the effect of temperature on germination of soybeans.

Temperatures for soybeans in both cool and warm room are the same as for corn in both cool room and warm room, both experiments being run at the same time.

In this experiment with soybeans as has been noted in previous trials, many of the young seedlings germinated but rotted before getting out of the ground. This is true in this experiment where conducted in a warm room and the percents of germination are fair. Checks germianted 93.7 percent. Nitrate of soda is same as checks for both contact and mixed. Muriate of potash shows most effect on germination, where in contact with seed germination was 84.3 percent and where mixed with soil 90.6 percent. Sulphate of amonia germinated 87.5 percent for contact with seed and 93.7 percent where mixed with soil. No effects to amount to anything is shown on the germination of soybeans by this fertilizer other than it retards germination of soybeans strongest. Phosphate gave 84.3 percent germination where in contact with seed. In previous experiments it showed no ill effect on soybaans and I feel safe to say this low germination is due to bad seed. Mixed germinated 93.7 percent same as checks. No effect is shown by lime on germination and with all fertilizers used germination was better where fertilizer was mixed with soil

Table XVII

Results on soybeans-- Effects of Temperature on Germination, conducted in warm room.

(Germination on each day after planting		FIRST TEST 4	5	6	7	8	Total	SECOND TEST 4	5	6	7	8	Total	% Germ.	TEMPERATURE OF ROOM "C" Date	A.M	Noon	P.M.
Nitrate of soda	contact	10	4	1			15	14		1			15	93.7	3/25	18.0°c	24.0°c	19.0°c
	mixed	9	3	1	2		15	11	3	1			15	93.7	3/26	14.0	36.0	18.0
Muriate of potash	contact	11		2			13	9	3	2			14	84.3	3/27	15.5	28.0	18.0
	mixed	8	4	3			15	3	5	5	1		14	90.6	3/28	16.0	35.0	16.0
Sulphate of ammonia	contact	4	4	4	2		14	4	4	4		2	14	87.5	3/29	11.0	26.0	14.0
	mixed	4	1	8	2		15	5	4	3	1	2	15	93.7	3/30	11.5	35.0	16.0
Acid phosphte	contact	8	6				14	5	4	3	1		13	84.3	3/31	18.0	24.0	16.0
	mixed	8	5		1		14	9	5	1	1		16	93.7				
Lime	contact	7	4	3	1		15	7	7		1		15	93.7				
	mixed	9	5	2			16	10	3	2			15	98.6				
Check		10	4				14	4	7	5			16	93.7				

Table XVIII

Results of soybeans-- Effect of Temperature on Germination, conducted in cool room.

(Germination each day after planting		6 FIRST TEST 7	8	9	10	Total	SECOND TEST 6	7	8	9	10	Total	% Germ.	TEMPERATURE OF ROOM DEGREES"C" Date	A.M.	Noon	P.M.
Nitrate of soda	contact	8	4	4		16	13	1	2			16	100	3/25	18.0°c	24.0°c	19.0°c
	mixed	10	3	1		14	14		2			16	93.7	3/26	14.0	32.9	18.0
Muriate of potash	contact	8	5	3		16	10	1	1	3		15	96.8	3/27	11.0	16.0	10.0
	mixed	8	6	2		16	10	2	1	3		16	100	3/28	10.0	20.0	10.0
Sulphate of ammonia	contact	10	1	2	3	16	8		2	5	1	16	100	3/29	7.0	26.0	8.0
	mixed	12	3		1	16	10	3	1	1	1	16	100	3/30	3.0	28.0	10.0
Acid phosphate	contact	13	2		1	16	7	2	6		1	16	100	3/31	10.0	24.0	12.0
	mixed	13	1	1	1	16	12	2	1	1		16	100	4/1	10.0	18.0	12.0
Lime	contact	12	1	3		16	11	2	3			16	100	4/2	8.0	25.0	14.0
	mixed	14	1	1		16	15	1				16	100	4/			
Check		12	1	1	1	15	12	4				16	96.8				

than where in contact with seed.

At a cooler temperature the germination of soybeans was delayed two days longer. Seedlings did not appear above the ground before the 6th day after planting, where in a warm room a good number of seedlings were up on the 4th day after planting.

Germination of soybeans at a cooler temperature was better than at a warmer or higher temperature. This is a strange phenomena when it is generally concluded that soybeans must have a warm soil and similar conditions for good germination. The only explanation feasible from the writers point of view in this:- In the warm room many seedlings rotted before appearing above the ground due to diseased seed. In the cool room this disease bacteria was held more in check, thus enabling the seedlings to come out of the ground. Why this explanation may be true is that a good number of the seedlings showed on the seed-leaves disease spots and the bacteria had not as yet become active or the stage of rot started. Checks germinated 96.8 percent, muriate of potash in contact with seed germinated same as checks and nitrate of soda mixed with soil germinated 93.7 percent and is the only trial in this table that germination is less than checks and it is only by one seed. All other trials germinated 100 percent.

No serious effects are shown by fertilizers on germination of soybeans at a low temperature, but sulphate of ammonia showed strongest retarding of germination, with muriate of potash next and acid phosphate a slight retarding of germination at a low temperature.

Conclusion; As a general rule germination is better with all seeds used where fertilizer is mixed with soil and not in contact with seed under temperature experiments.

2. Cooler temperature delayed germination two or three days two days with corn and soybeans and three days with wheat and barley.

3. Warmer temperature gave slightly better germination with

corn and barley, cooler temperature was best for wheat and for this particular soybeans (the Virginia variety), the cooler temperature had no effect on germination other than delaying it a few days.

SUMMARY;

1. The optimum moisture content for the type of soil used in this experiment is 60 percent saturation. Sixty percent saturation as a whole gave best results on germination of all seeds used, 40 percent being too dry and 70 percent to 80 percent saturation too wet.

2. Germination at 40 percent saturation was slower than at higher saturation.

3. Eighty percent saturation had no effect on germination of corn but considerably reduced the percentage on germination of soybeans and wheat and slightly barley. Wheat appeared to be affected at 70 percent saturation.

4. As a general rule, germination with fertilizers was better where mixed with soil than where in direct contact with seed.

5. All fertilizers used gave a retarding effect on germination of all seed used, (corn, soybeans, wheat and barley) at a low moisture content in soil, retarding effect decreased as moisture increased.

6. Nitrate of soda has a strong retarding effect on germination of corn, wheat, and barley in a dry soil, but corn was the only seed in the four worked with that nitrate of soda gave any detrimental effect on germination and this was slight. In fact four out of five saturations, nitrate of soda gave higher germination in contact with seed than mixed first with soil.

7. Muriate of potash is a strong retarder on germination with soybeans, wheat and barley more so than with corn and effects germination slightly with soybeans up to 60 percent saturation and effects germination of wheat and barley through all saturations slightly, usually where in contact with seed.

8. Sulphate of amonia retards germination with all seeds at 40 percent and is very strong in this respect at 50 percent saturation with wheat and barley and gives a retarding effect on barley up to 60 percent saturation.

Sulphate of amonia gives a slight effect on germination throughout the experiment on soybeans and wheat, the strongest where in contact with seed and with wheat.

9. Acid phosphate retards germination at 40 percent saturation with all four seeds, but soybeans is the only one where germination is affected and this is only slight where in contact with seed up to 60 percent saturation.

10. Lime caused no effects on germination other than retarding of germination. It is one of the strongest retarders of the five applications used, retarding wheat germination most, showing this effect on wheat throughout the experiment. It was next strongest on barley up to 60 percent saturation, and least on corn and soybeans, this effect only being through 50 percent saturation on these two seeds. The retarding effect was stronger where in contact with seed than where mixed with soil.

11. The rate of applications used in this experiment which are common to home practice, gave no strong detrimental effect on germination on the seeds used.

12. High moisture content of the soil shows a marked effect on germination of wheat and soybeans and a slight effect on barley. Corn germinated well at a high moisture content of soil.

13. Cooler temperatures delays germination two to three days.

14. Warmer temperature gave slightly better germination with corn and barley, the cooler temperature was best for wheat and for this particular soybeans, (the Virginia variety), the cooler temperature having no effect on germination other than delaying it

a few days.

15. The retarding effect of fertilizers on germination varies with the crop, the soil type, and moisture conditions.

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