THE EFFECT OF FERTILIZER PLACEMENT ON STAND ESTABLISHMENT OF FORAGE GRASSES AND LEGUMES

By

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INTRODUCTION

The use of high analysis, readily soluble fertilizers is increasing yearly. The high cost of these fertilizers, coupled with the cost of certified seed makes the problem of fertilizer placement, and safe rates of application more important than ever before.

The proper placement of fertilizer in relation to the seed now appears to be fully as important as the rate of application, and the proper analysis. The main problem confronting the farmer of today is how to get the maximum returns from the fertilizer applied. This can only be accomplished by placing the fertilizer close enough to the seed so it can be efficiently utilized by the growing plant, without causing injury to germination by an excessive concentration of soluble salts.

Workers in pasture investigations at this station have encountered difficulty in getting stands of pasture grasses and legumes established under the present systems. They have reported stands of only about ten per cent in some cases. The reason for this low per cent of stand establishment is not definitely known, but the low level of soil fertility, competition, and climate are some of the factors being considered. If a method of fertilizer placement can be found that will increase the per cent of stand on these crops it will be of considerable value to the farmer and other workes in the field of agriculture.

Much work has been done in the past on the effects of fertilizer placement on the germination, growth and yields of field crops. Most of the investigators in previous studies are generally agreed upon the

superiority of the fertilizers banded to the side of the seed over the broadcast and other placement methods. The investigators explain this superiority on the basis that an available supply of fertilizer is present when, and where the plant needs it most. In the case of the broadcast and other placement methods, the fertilizer is not available to the plant at the critical time, or in some cases might cause injury to seed germination.

The primary objective of the experiment reported in this paper was to determine the most satisfactory method of fertilizer placement in establishing stands of grasses and legumes under field conditions by comparing the effects of the different placement methods on germination and seedling development. The crops used in this experiment are well adapted to certain areas of Oklahoma. The two cool season grasses, brome grass (Bromus inermis Leyss), and tall fescue (Festuca arundinacea Schreb), are very popular in the pasture programs in the state, while the two legumes, alfalfa (medicago sativa L.) and Ladino clover (Trifolium repens L.) are used frequently in improved pasture mixtures.

Five fertilizer placement methods were used in this study, these being: (1) broadcast on the soil surface after the seeding operation, (2) broadcast on the surface and worked into the soil before seeding, (3) one inch below the seed in bands, (4) one inch below and one inch to the side of the seed in bands, (5) mixed with the seed at planting. Only one rate of application was used in this study, so any differences reported will be due to method of placement alone, and not to variations in rate, as was the case in most of the previous work reviewed by the author.

It is hoped that the work reported in this paper may be of some help to future workers in fertilizer placement investigations, and also to workers in other phases of agriculture.

REVIEW OF LITERATURE

In some early fertilizer placement experiments using corn as the indicator crop Coe (3, 4,) found the banding of fertilizers resulted in faster germination with less damage than did any other placement method tested.

The fertilizers used in these experiments were nitrate of soda, commercial 2-12-2, mixed 0-12-2 and 16 per cent acid phosphate.

The acid phosphate, when mixed with the seed, did not cause any noticeable injury to germination when used at rates up to 300 pounds per acre. The 2-12-2 caused pronounced injury to germination at the rate of 200 pounds per acre, as did the 0-12-2 fertilizer. The nitrate of soda caused decreased germination when applied above and below the seed at the rate of 200 pounds per acre, whereas little damage resulted from side placings at rates up to 450 pounds per acre. Coe stated this injury to germination was probably due to the higher degree of solubility of the potassium and ammonium salts in these fertilizers. He also stated the best method of applying any fertilizer appeared to be one inch to the side of the seed in bands.

Barnes (2) reported stands of soybeans were reduced in every case where fertilizers other than superphosphate were applied in direct contact with the seed. The fertilizers in this experiment were applied at the rate of 200 pounds per acre either in direct contact with the seed or separate. Barnes' study showed less damage occurred to germination when the seed and fertilizers were applied to the soil in two separate operations.

Collins and associates (5) reported the germination and early growth of cotton were more rapid and the yields higher when the fertilizer was placed in a narrow band on both sides of the row regardless of the rate of application. They also reported delayed and reduced germination when the fertilizer was banded below the seed or mixed with the soil in the root zone.

In an experiment at Rothamsted Cooke (6) reported results similar to those obtained by Coe in earlier trials. However, he found some injury to germination where a ten per cent P_2O_5 fertilizer was applied at the rate of 200 pounds per acre in contact with the seed or directly below the seed. Cooke also found a more vigorous early growth where the fertilizers were banded one inch from the seed as compared to bands three inches from the seed.

A marked decrease in the germination of wheat, crimson clover, radish and lettuce seed was reported by Hicks (9) when sodium nitrate and muriate of potash fertilizers were applied at a high rate (one per cent of the soil weight) in direct contact with the seed. Hicks stated that the nitrogen fertilizers caused more damage to germination than did the lime and phosphate fertilizers due, probably, to the higher solubility of the ammonium salts in the nitrogen fertilizers. The main damage to the seedlings by the various fertilizers was found by Hicks to occur primarily at the time the young sprout emerged from the seed coat and before they emerged from the soil.

In a study of the effects of phosphate and nitrogen fertilizers on germination, Hutcheson and Wolfe (11), stated that the soil type, crop used and method of fertilizer placement were some of the factors

which should be taken into consideration. Results from this study showed that fertilizer applied in direct contact with the seed was much more injurious to germination than the same amount and kind of fertilizer broadcast on the soil surface and then worked into the soil. Two different soils were used in this study and the greatest damage to germination occurred on a Norfolk sandy loam soil with less damage on a Hagerstown soil.

It was reported by Sherwin (24) that the soil class did not influence the degree of germination damage. In a study on two different soil classes which compared the effects of mixing the fertilizer with the seed versus banding of the fertilizer, it was found that the injury to germination was directly proportional to the amount of fertilizer used. The injury was more severe with the more soluble mineral fertilizers. In the case of the more soluble fertilizers, the injury apparently was due to the decreased osmotic absorption of water from the soil solution, rather than to the effects of the fertilizer on the viability of the seed. Sherwin stated that germination was greatly inhibited when the fertilizer was mixed with the seed before planting, and that the banding of fertilizer to the side of the seed appeared to be the most satisfactory method from a germination standpoint.

Parker and Oliver (16) in a controlled moisture placement experiment reported essentially the same results as Sherwin, however, no reference to soil class was made.

The banding of fertilizer 1½ inches to the side of the seed was found by Lewis (13) to be the most satisfactory method of placement. He also stated that the mixing of seed and fertilizer was satisfactory

only when the soil was deficient in one or more nutrients. When the soil was not deficient in nitrogen, phosphorus, or potassium and the seed was mixed with the fertilizer, some injury to germination occurred.

Contrary to the results obtained by several investigators, (3, 4, 5, 13, 15, 16, 23, 24, 27), Troug and associates (26) concluded that the best placement of fertilizer for row crops was in a band $\frac{1}{2}$ inch above the seed in the hill or drill row. These investigators list three factors which determined the extent of fertilizer injury to germination these being; the osmotic pressure of the seed, osmotic pressure of the sprout and the amount of protective covering on the sprout.

Allen (1) reported the mixing of superphosphate with the soil in the root zone at rates of 60 pounds to 240 pounds per acre produced higher yields than did the banding of the superphosphate to the side of the seed. This is contrary to the findings of most of the other investigators who contend that the banding of fertilizers to the side of the seed is the best method of placement. Allen also concluded that the broadcasting of the fertilizers on the surface of the soil was unsatisfactory for stand establishment.

Hobbs (10) in an emergence study using sorghum, concluded that superphosphate at the rate of 30 pounds per acre caused a delay in germination of about seven days when in direct contact with the seed. Hobbs also stated that the sorghum seed was germinating better, eighteen days after planting, than the seed on the unfertilized plots. It was also found that ammonium nitrate and muriate of potash fertilizers caused a reduction and retardation of germination where applied in direct contact with the seed, whereas the superphosphate only caused a delay in emergence.

In an emergence study with soybeans Probst (17) stated that the seedlings emerged from the soil more rapidly when the fertilizer was banded or absent, than where the fertilizer was in direct contact with the seed. Probst also found that the phosphorus caused less delay in emergence than did the potash fertilizers and when both fertilizers were combined the emergence of the seedlings was delayed and the number of seed germinating were reduced.

In a greenhouse emergence study with beans, Sayre and Clark (23) reported all of the fertilizers applied inhibited root growth in the fertilizer placement zone for a period of at least 14 days. A definite advantage was reported in side banding of superphosphate over broadcasting on the surface and mixing it with the seed. These studies showed that the superphosphate, in direct contact with the seed, would inhibit germination for a period of only two days.

Wagner and Hulbert (27) in an extensive placement study at Beltsville, Maryland, reported some striking differences in the effects of several methods of fertilizer placement. Using tall fescue and Ladino clover with varying rates and methods of placement of a 3-12-6 fertilizer it was found that the seedlings in rows where the fertilizer was banded got off to a much faster early growth than did the seedlings where other methods of placement were used. The stands of Ladino clover were found to be seriously suppressed when the fertilizer was applied at the rate of 750 pounds per acre, in contact with the seed.

These studies also showed that the highest growth rate occurred when the plots were seeded at the high rate of eight pounds of fescue and two pounds of Ladino per acre with 750 pounds of the 2-12-6 fertilizer applied in bands beside the seed. According to these investigators,

the most effective method of stand establishment appeared to be the drilling of the seed at a depth of $\frac{1}{4}$ inch and the banding of the fertilizer at a depth of 1 inch below the seed, with the soil being firmed in the row after the seeding operation. Cooke and Dodd (7) in a study to determine the effects of fertilizer placement on crop yields, reported the banding of 250 pounds of superphosphate to the side of the seed rows produced slightly higher yields than twice this amount of fertilizer broadcast on the soil surface. These trials were conducted on soils low in phosphorus which might explain the striking difference in yields from the two placement methods.

In a later experiment by Cooke and Widdowson (8) similar results were reported as in the trial above, however, it was found that crop yields were not increased by splitting the fertilizer application by placing half of the fertilizer with the seed and banding the remainder to the side of the seed.

At Purdue, Robertson (22) using radio-active phosphorus, stated the early utilization of phosphorus was greatest when the phosphorus fertilizers were placed to the side of the seed rows in bands. The placement of the nitrogen and potassium fertilizers also affected the phosphorus uptake of the plants. When these two fertilizers were mixed with the phosphorus and applied in side bands the phosphorus uptake was greater than when they were applied separately in bands. According to Robertson, the uptake of banded phosphorus fertilizers decreases rapidly as the season progresses, and the rate of application has only a slight effect on the rate of this decrease.

Results similar to Robertson were obtained by Mitchell (15), in studying nutrient uptake. He reported highest yields resulted from banding the fertilizer three inches below and to the side of the seed.

A placement experiment in Scotland conducted by Reith (19) produced results similar to other investigators, in that the banded superphosphate produced faster early growth and higher yields than did the broadcast fertilizer.

In a study comparing the effects of banding the fertilizer to the side of the seed row and placement on the plow sole Rich and Odeland (21) stated there was not enough difference in yields to justify the added expense and labor of plow sole placements, except under extremely drouthy conditions.

No reduction in germination was found by Miller and Mitchell (14) when a 16 per cent acid phosphate fertilizer was mixed with bean seed at rates up to 350 pounds per acre. Contrary to the above results, a retardation of growth was reported when 200 pounds of the same fertilizer was placed in contact with the seed. The effects of a 3-12-4 fertilizer on germination and growth was also studied and it was found that this fertilizer did not inhibit germination to any appreciable extent regardless of the rate, but extensive damage to the plant occurred when 200 pounds per acre was used in contact with the seed. According to these investigators the increased toxicity of the 3-12-4 fertilizer as compared to the acid phosphate was due to the higher degree of solubility of the ammonium and potassium salts present in the mixed fertilizer.

In an experiment at Purdue (18) it was found that there were no appreciable effects on the yields of soybeans regardless of the fertilizer placement used. Superphosphate was applied in direct contact with the seed at rates up to 200 pounds per acre and no adverse effects on germination were noted. There was some evidence of growth retardation with all of the fertilizers used in direct contact with the seed except with the superphosphate. The authors stated that the soil had a good supply of moisture all during these trials which might account for the lack of injury to germination.

Hutcheson and Wolfe (12) reported results similar to those from Purdue, but in this trial, a 16 per cent acid phosphate was applied in direct contact with soybeans at rates up to 400 pounds per acre with no injury to germination occurring. These tests were made under greenhouse conditions and a good supply of moisture was made available to the plants which might explain the lack of injury to the germinating seeds.

Reynolds and Smith (20) also reported no damage to germination, using hairy vetch as the indicator crop and applying the fertilizer in direct contact with the seed. These investigators used a low rate of application in this study, (40 pounds of nitrogen and 40 pounds of phosphorus per acre) which might help explain why the seedlings were not damaged.

MATERIALS AND METHODS

A study was conducted on the Oklahoma A. and M. Agricultural experiment station farm at Perkins, Oklahoma, during the spring and summer of 1954, to determine the effects of fertilizer placement on the growth response of two grasses and two legumes. Two previous field plantings made in November, 1953 and March, 1954, were unsuccessful due to extremely dry weather conditions prevailing during these months.

The crops and varieties used in this study were Oklahoma common alfalfa, certified Blue Tag Ladino clover, Southland brome and Kentucky 31 fescue. The seed used for planting was from the same source as was used by the station in the 1953 yield tests and was considered the best available at the time.

The fertilizers used were an 0-20-0 for the legumes and a 10-20-0 for the grasses. Each fertilizer was applied at the rate of 200 pounds per acre in all of the treatments.

There were six fertilizer treatments used in this study including the check plots. The treatments were as follows: (1) one inch below and one inch to the side of the seed in bands, (2) one inch below the seed in bands, (3) broadcast on the surface after the seeding operation, (4) broadcast on the surface before seeding and worked into the soil, (5) mixed with the seed.

Germination tests were run in a Manglesdorf germinator to determine the per cent of seed germination of the four crops used, and an attempt was made to correlate these germination percentages with those occurring in the field.

The plots were seeded at a heavier rate than is usually recommended for this area, in order to insure a good stand. The seeding rates on a per acre basis were, alfalfa 10 pounds, Ladino clover 2 pounds, brome grass 10 pounds, and Kentucky 31 fescue, 6.5 pounds.

The soil in these plots is a Norge sandy loam and is fairly high in natural fertility. Soil samples were taken and analyzed for organic matter, phosphorus and potassium. The content of these were as follows: Organic matter approximately two per cent, phosphorus medium to high, and potassium medium to high. The reaction of the soil was moderately acid.

The seedbed was prepared the same day the plantings were made by working the ground with a rotary hoe several times. The area had been in sorghum the previous year, and was relatively free of weeds and litter, which simplified the task of seedbed preparation.

The field was laid out in a randomized block design with the plots of each crop lying side by side, making complete randomization only within each crop and not within the entire field. The plots were $\frac{1}{436}$ of an acre in size and each contained 5 rows, 20 feet long, with 1 foot spacings between the rows and 3 foot spacings between the plots. Four replications of each treatment were used, making a total of 24 plots per crop or a grand total of 96 plots for the four crops. Seed counts were taken, using an Ames power seed-counter, to determine the

number of seed planted per row. The average of these plantings for the four crops were, alfalfa 1000, Ladino 722, brome 661, and fescue 454.

All of the seed and all of the fertilizer, except that in the broadcast treatments, was applied with a modified Allis Chalmers belt fertilizer machine. The machine was modified so that five rows could be planted or fertilized at one time. This simplified the planting and fertilizing operations and also reduced the number of times necessary to run the machine over the plots, thereby keeping the soil compaction to a minimum. The seed and fertilizer for each row had been weighed and put into separate packages prior to the date of planting, and the machine had been previously calibrated to spread the seed and fertilizers evenly within the 20 foot rows. The broadcast fertilizers were applied by hand and an effort was made to distribute the fertilizer as uniformly as possible over the plots.

The plantings were made on May 5, 1954, under good moisture conditions, and the germination counts were begun as soon as the seedlings started to appear in the rows. These counts were taken approximately every five days and were continued until the germination, for all practical purposes, had ceased. Two stand counts per row were taken, by placing a one foot rule along the edge of the row at random, and counting the number of plants within this one foot distance. Height measurements were also taken, along with the stand counts, to see what effect, if any, the various treatments had on rate of growth of the four crops.

There were ten germination counts taken for each of the four crops from May 26, 1954 until July 1, 1954. These ten counts were divided into three groups, by taking the mean of the first three counts, the second three counts and the last four counts. It was thought that this would give a better indication of the effects of the fertilizer treatments on germination. The germination counts and the growth measurements were analyzed statistically to see if there were any indications of a significant difference between the methods of placement.

RESULTS AND DISCUSSION

The soil and moisture conditons were very good at the time of planting and the seeds germinated rapidly.

Two days after the plantings were made, a two inch rainfall occurred. This heavy rainfall might have had considerable effect on germination by a dilution of the fertilizer concentration. There was also some soil compaction and crusting, resulting from the rain, which might have affected the germination and early growth of the plants.

The results obtained from the measurements of seedling height showed no significant difference in the growth rate of the plants, regardless of the fertilizer treatment.

ALFALFA

The greatest number of alfalfa seedlings were obtained from the side placement of fertilizer (treatment 2, table 1). This difference was great enough to reach significance as shown by analysis of variance (table 2). The plots with the lowest seedling count were those planted to the mixture of seed and fertilizer (treatment 5).

There was significant difference between treatments 2, and treatments 1, 5, and 6 at the 5% level. Results from the analysis of variance of the seedling counts indicated that the plots receiving treatment 2 had a significantly greater number of plants than the plots receiving treatments 1, 5, and 6. There was significant difference between treatment 2 and 5 at the 1% level.

Table 1. The average seedling count of alfalfa as affected by six fertilizer treatments.

Count** No.	Treatment* 1	2	3	4	5	6	Total	$\bar{X}$
1	27.03	29.63	29.29	28.59	25.09	26.69	169.32	28.22
2	28.68	31.57	28.96	26.83	26.44	27.64	170.12	28.35
3	28.98	30.99	30.78	30.68	29.34	28.67	179.44	29.90
Total	84.69	92.19	89.03	86.10	80.87	86.00	518.88	
$\bar{X}$	28.23	30.73	29.67	28.70	26.95	28.33		28.83

* Fertilizer treatments were as follows:

(1) Below the seed in bands

(2) One inch to the side and below the seed

(3) None

(4) Broadcast on the surface after seeding

(5) Mixed with the seed

(6) Broadcast on the surface and worked into the soil

** The counts shown in the table above were derived by dividing the ten stand counts, taken from May 26 to July 1, into three groups; count 1 is the mean of the first three counts, count 2 is the mean of the second three counts and count 3 is the mean of the last four stand counts.

Table 2. Analysis of variance for alfalfa seedling counts.

CF= 14.957.5808

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	17	49.7502	---	---
Treatments	5	24.7192	4.9438	3.4142*
Counts	2	10.5509	5.2754	3.6432
Error	10	4.4801	1.4480	

$$L.S.D. = t\sqrt{\frac{2ve}{k}}$$

.05=2.228 x .982=2.19

.01=3.169 x .982=3.11

$$C.V. = \frac{1.203}{28.83} \times 100 = 4.17\%$$

* Indicates that the F Value exceeds the value required for significance at the 5% level.

The seedling counts of the check plots was almost as high as the plots receiving the side bands of fertilizer. The check plots showed a significant increase in number of seedlings over the plots receiving the mixed seed and fertilizer treatments. This difference was significant at the 5% level. There appeared to be no significant difference between the date of counts as they affected the stand of alfalfa.

LADINO CLOVER

The germination of Ladino clover seed as indicated by seedling counts was slightly higher on the plots where the fertilizer was broadcast on the surface and worked into the soil (treatment 6). The effect of the fertilizer treatments on production of Ladino clover seedlings is shown in table 3.

The mixing of the seed and fertilizer (treatment 5) resulted in the lowest seedling count, however, none of the treatments showed significance over the others in an analysis of variance (table 4).

The difference between counts was highly significant on the Ladino clover plots. The highest stand counts occurred during the first three counts with a sharp decrease following immediately afterward.

The favorable soil and moisture conditions prevailing during the early part of the experiment and the hot dry weather in the latter part would partially account for this sharp decrease in stand count.

BROME GRASS

The average seedling count of the brome grass is shown in table 5. There was little variation in the number of seedlings in the different plots. Analysis of variance (table 6) indicated there was no significant difference between the fertilizer treatments.

Table 3. The average seedling count of Ladino clover as affected by six fertilizer treatments

	Treatments (2)							
Counts (1)	1	2	3	4	5	6	Total	$\bar{X}$
1	2.27	1.75	2.37	2.46	2.26	2.90	14.01	2.33
2	1.46	1.60	1.14	1.25	0.98	1.32	7.75	1.29
3	1.35	1.55	1.05	0.98	0.85	1.35	7.13	1.19
Total	5.08	4.90	4.56	4.69	4.09	5.57	28.89	
$\bar{X}$	1.69	1.63	1.52	1.56	1.36	1.85		1.61

(1) Counts are on the same basis as those shown in footnotes Table 1.

(2) Treatments were the same as shown in footnotes of Table 1.

Table 4. Analysis of variance for Ladino clover seedling counts.

C. F. = 46.3684

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	17	6.1225		
Treatments	5	0.4180	0.0836	0.954
Counts	2	4.8282	2.4141	27.558**
Error	10	0.8763	0.00876	

C. V = $\frac{0.296}{1.61} \times 100 = 18.38\%$

** Indicates that the F value exceeds the value required for significance at the 1% level.

The difference between counts was highly significant as it was in the case of the Ladino clover. This difference in rate of germination was probably due to climatic factors rather than to differences in the fertilizer treatments. The brome plots with the highest seedling counts were those receiving no fertilizer. The plots with the lowest number of seedlings were those receiving the mixed seed and fertilizer treatment. Neither of these treatments approached significance over the other treatments as shown by table 6.

TALL FESCUE

The average number of tall fescue seedlings is shown in table 7. These tresults are similar to those obtained on the brome grass with a few minor exceptions. The plots receiving the side bands of fertilizer had the highest seedling count (table 7). The lowest number of seedlings occurred on the plots receiving the mixed seed and fertilizer. The difference in these treatments did not approach significance in analysis of variance (table 8).

The analysis of variance of the three groups of seedling counts showed a significant difference between the time of counts. The highest rate of germination as determined by seedling counts occurred during the last four counts in this case, instead of occurring earlier in the experiment as was the case with the other three crops. This high rate of germination late in the experiment might be the result of several factors such as climate, osmotic pressure of the soil and seed, seedling vigor and competition, as well as the effects of the fertilizers and soil fertility.

Table 5. The average seedling count of brome grass as affected by six fertilizer treatments.

	Treatments [2]							
Counts[1]	1	2	3	4	5	6	Total	$\bar{X}$
1	5.57	6.29	5.71	5.26	4.30	5.44	32.57	5.43
2	4.91	3.74	4.44	3.76	4.30	3.89	25.04	4.50
3	4.68	3.69	5.13	4.19	3.86	4.14	25.69	4.28
Total	15.16	13.72	15.28	13.21	12.46	13.47	83.30	
$\bar{X}$	5.05	4.57	5.09	4.40	4.15	4.49		4.74

[1] Counts were made as explained in footnotes of Table 1.

[2] Treatments are the same as shown in footnotes of Table 1.

Table 6. Analysis of variance for brome grass seedling counts.

C. F = 385.4939

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	17	10.4501	0.4171	
Treatments	5	2.0857	2.9016	1.6282
Counts	2	5.8032	0.2561	11.330**
Error	10	2.5612		

C. V = $\frac{0.506}{4.74}$ x 100 = 10.67%

** Indicates that the F value exceeds the value required for significance at the 1% level.

Table 7. The average seedling count of tall fescue as affected by six fertilizer treatments.

	Treatments [2]							
Counts[1]	1	2	3	4	5	6	Total	$\bar{X}$
1	24.08	27.01	24.59	25.21	21.39	25.47	147.75	24.63
2	29.65	30.40	28.36	30.17	29.80	30.17	178.55	29.76
3	30.37	29.79	30.41	28.79	31.13	29.93	180.42	30.07
Total	84.10	87.20	83.36	84.17	82.32	85.57	506.72	84.46
$\bar{X}$	28.03	29.06	27.78	28.05	27.44	28.52		28.15

[1] Counts were made as explained in footnotes of Table 1.

[2] Treatments are the same as shown in footnotes of Table 1.

Table 8. Analysis of variance for tall fescue seedling counts.

C. F = 14,264. 7310

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	17	135.4856		
Treatments	5	4.9143	0.9829	0.5348
Counts	2	112.1926	56.0963	30.5219**
Error	10	18.3787	1.8379	

C. V. = $\frac{1.353}{28.15} \times 100 = 4.81\%$

** Indicates that the F value exceeds the value required for significance at the 1% level.

SUMMARY AND CONCLUSIONS

The results of this study are summarized as follows:

(1) The fertilizer placements had a significant effect on germination as determined by seedling counts, only in the case of the alfalfa.

(2) The mixing of the seed and fertilizer resulted in lower germination on all four crops, however, this difference was not significant statistically.

(3) The difference in time of counts was highly significant on the Ladino, brome grass, and tall fescue. The difference was attributed to climatic factors, physiological factors, and competition as well as to the effects of the fertilizers.

(4) The natural fertility of the soil in these plots possibly prevented greater differences between the various fertilizer treatments.

(5) The heavy rainfall received two days after the plantings were made and the extremely dry weather during June, undoubtedly ffected the germination and the rate or growth.

(6) We might safely conclude that in this area moisture is more important than fertility in obtaining stands.

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