THE EFFECT OF FERTILIZER SALTS ON GERMINATION OF SORGHUMS

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INTRODUCTION

Soil fertility is the key to agricultural production under the present conditions. The search for more productive crop plants, and the improvement of crop plants, in the final analysis, will not make a successful contribution to agricultural production if soil fertility is allowed to decline.

Many soils in Oklahoma are not high in fertility. If production is to be maintained on these soils at a level high enough to assure the farmer a reasonable income, then commercial fertilizers must be used. Due to climatic limitations, however, the Oklahoma farmer does not have a wide variety of crops from which to select. The production of grain feed and forage crops is primarily limited to the sorghums because of summer drought hazard. To obtain high yields on the low fertility soils of Oklahoma, fertilizers should be used. However, fertilizers on sorghums have often given a deleterious effect on the early seedling growth. This impasse has resulted in the general warning that 'fertilizer burn' must be avoided by not applying fertilizer on sorghums.

It is the objective of this investigation to more clearly elucidate some of the facts and casual relationships involved in the germination of sorghum seed placed in direct contact with several fertilizer salts. It is hoped that the findings of this investigation will be a step toward increasing the yield of grain and forage sorghums by allowing the farmer to increase his soil fertility without impunity.

REVIEW OF LITERATURE

A number of investigators (2,3,4,5,6,8,9,10) have studied the effects of fertilizers upon the germination of seed. In these investigations, fertilizers applied in direct contact with seed were generally more injurious than when applied to the side of the seed, under the seed, or broadcast on the surface of the soil after seeding.

The effect of 'Ammo-phos' (13-48-0) upon the germination of soybean, wheat, and corn seed was studied by Coe (2). He obtained pronounced injury to germination and some retardation in emergence of soybeans and wheat when 'Ammo-phos' was applied at rates as low as 25 pounds per acre in direct contact with the seed. The 25 pounds per acre rate when applied either one-half or one inch away from and on the same level as the seed, produced little or no injury or retardation of germination. Corn showed normal germination when 'Ammo-phos' was applied in direct contact with the seed at the rate of 25 pounds per acre, but germination was retarded when 50 pounds was used. In a later experiment Coe (3) found that muriate of potash and nitrate of soda applied in direct contact with seed, in quantities as low as 25 pounds per acre, retarded the germination of corn. In greenhouse studies, Coe (2) found that various chemical and pure organic fertilizers applied in direct contact with corn seed both retarded and reduced germination even when applied in relatively small quantities. He found that some of the fertilizers were more

injurious than others; for example, nitrate of soda proved more injurious to germination than either 'Ammo-phos' or ammonium sulfate when each was applied on an equal weight and equivalent nitrogen basis. Ammonium nitrate was less toxic, pound for pound, than nitrate of soda, but was more toxic than 'Ammo-phos', while muriate of potash was more toxic than potassium sulfate. Germination injury varied with both the kind and amount of fertilizer applied; however, germination injury usually increased progressively with the amount of fertilizer applied. He found that the moisture content of the soil was a more important factor than soil type in germination of corn, wheat, and cotton seed. Coe concluded that the greater the moisture content of a given soil, the more fertilizer required to impair germination.

Hicks (4) found that muriate of potash and sodium nitrate applied at very high rates (1% of soil weight) were very detrimental to the germination of wheat, radish, lettuce and crimson clover, while fertilizers composed of phosphoric acid or lime, applied at the same rates, were much less injurious to germination. The chief injury, according to Hicks, from chemical fertilizers was inflicted upon the young seedlings, after they emerged from the seed-coat and before they emerged from the soil. The seeds were injured slightly or not at all, but injury to the seedlings was very severe. Albrecht (1) obtained a higher percent germination of tomato seed in soil that that had been treated with calcium chloride than in untreated soil. From these results he suggested the possible significance of calcium in the soil for better seed germination.

Hobbs (5) studied the effects of fertilizer on emergence or Redlan sorghum seed. He reported that ammonium nitrate, superphosphate, muriate of potash, ammonium nitrate plus superphosphate, ammonium nitrate plus muriate of potash, superphosphate plus muriate of potash, ammonium nitrate plus superphosphate plus muriate of potash all retarded germination at seven days. Hobbs applied nitrogen (N), phosphate (P_2O_5) and potassium (K_2O) at the rate of 30 pounds per acre in rows spaced 20 inches apart. The fertilizer was placed in the bottom of the furrows and the sorghum seed placed on top of the fertilizer. He found that, eighteen days after planting, seed that had been treated with superphosphate germinated as well or better than those that had not been in contact with fertilizer. The other fertilizer materials, however, had a permanent damaging effect on emergence of sorghum seedlings. This work revealed not only a retardation but a reduction of germination as well when ammonium nitrate and muriate of potash fertilizers were applied in contact with seed, whereas superphosphate only retarded emergence of sorghum seedlings.

Millar and Mitchell (7) found that the germination of white beans was not reduced by 16% acid phosphate when applied in direct contact with seed, at rates up to 350 pounds per acre. However, chemically pure mono-calcium phosphate was less detrimental to germination than commercial treble superphosphate. A complete fertilizer with a 3-12-4 composition was more toxic than 16% acid phosphate when applied in direct contact with and above the seed. Probst (8) reported that soybeans emerged more rapidly in the

absence of fertilizer or in the presence of fertilizer applied in bands than when the fertilizer was applied in contact with the seed. He found that phosphate fertilizer delayed emergence and reduced final emergence less than potash. In combination these fertilizers gave cumulative deleterious effects on emergence and rapidity of emergence when applied in contact with seed. Sayre and Clark (9) obtained reduced germination of wax beans with nitrogen, phosphate, and potash fertilizers applied in direct contact with the seed at time of planting. Fertilizers were applied at the rate of 24 pounds of nitrogen (N) or 96 pounds of P_2O_5 or 24 pounds of K_2O per acre. Nitrate of soda, ammonium sulfate, granular calcium cyanamid and calcium nitrate were all very injurious to seed germination. They pointed out that emergence was inhibited in proportion to the rate of application and kind of fertilizer used when applied in direct contact with the seed.

The effect of fertilizers on germination of corn and cotton seeds was studied by Sherwin (10) on four different soils. He reported that the class of soil had no relation to the effect of the fertilizers. Also, germination was generally inhibited by the presence of fertilizer and the inhibition was greater when the fertilizer was in direct contact with seed than when mixed with the soil.

MATERIALS AND METHODS

A greenhouse experiment was initiated to determine the effect of fertilizers on the emergence and germination in contact with sorghum seed under controlled conditions.

Sorghum varieties selected were representative of those commonly grown in Oklahoma. Varieties were selected on the basis of type (grain or forage), height of the plant, size, and color of the seed. A preliminary germination check of the varieties used was made in 'The Mangelsdorf Germinator'. The varieties used and a brief description of each is given in Table 1.

Table 1. Varieties of sorghum used in the experiment.

Variety	Type of Sorghum	Height of Plant	Size of Seed	Color of Seed
Sumac F.C.I. No. 1712	forage	tall	small	dark reddish-brown
Atlas C.I. 899	forage	tall	medium	pure white
African Millet	forage	tall	medium	tan
Sugar Drip	forage	tall	medium-small	reddish-brown
Darset	grain	combine	medium	reddish-brown
Wheatland G.C. 38288	grain	combine	large	yellow
Redlan	grain	combine	large	red
Hegari C.I. No. 750	grain & forage	standard	medium	crypto-brown
Dwarf kafir 44-14	grain	combine	medium	pure white

The fertilizer treatments used are given in Table 2.

Table 2. Fertilizer treatments used in the experiment.

Treatment No.	Treatment
1	Check, no fertilizer
2	Ammonium nitrate
3	Calcium phosphate (monobasic)
4	Calcium nitrate
5	Sodium Nitrate
6	Potassium chloride
7	Mixed fertilizer (5-10-5)

Chemically pure reagents were used in all treatments. The mixed fertilizer (5-10-5) was made by mixing ammonium nitrate, mono-calcium phosphate, potassium chloride, and sufficient reagent grade (powder) calcium carbonate to dilute to the required formula. Fertilizer treatments were applied at 25, 50 and 100 pounds per acre, assuming that the rows were 42 inches apart, and a layer of fertilizer 2 inches wide was placed in contact with the seed. The 25 pound per acre treatments were planted April 30, 1954, the 50 pound treatments May 17 and the 100 pound treatments June 3. Each rate and each fertilizer treatment was replicated 4 times in a split plot randomized block design. One row of each variety was planted per 14 by 20 inch flat, with 10 seeds planted per row. The location of varieties in the flats and the location of each treatment on the greenhouse bench was decided by random selection.

The flats were prepared by placing in each approximately 2 inches of white, sterile sand. The sand was soaked with distilled water immediately before planting. The seed were planted in rows 2 inches apart and spaced at 1.4 inch intervals in the row. The fertilizer was applied with a small sieve in direct contact with the

seed in a 2 inch band the length of the row. After the fertilizer was applied, approximately one-fourth inch of sand and a three-fourths inch layer of vermiculite were placed over the seed then lightly sprinkled with distilled water (distilled water was used throughout the experiment). From time to time the flats were watered lightly to keep them moist, but at no time was sufficient moisture added to cause appreciable movement of fertilizer materials.

Seedling counts were made in the 50 and 100 pound rate treatments on the 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th and 14th days after planting. Seedling counts in the 25 pound rate treatment were made on the 7th, 9th, 11th, 13th and 14th days after planting. In all cases only live seedlings were counted.

Photographs were made of the seedlings in the 50 and 100 pound rate treatments 11 days after planting. Root growth examination and photographs were made of the 50 pound rate treatment on the 14th day after planting. A comparison of root development between the check and the mixed fertilizer treatments at the 100 pound rate was made 14 days after planting and a photograph of each variety was taken.

All data collected were subjected to analysis of variance on a 4 replicate split plot randomized block design.

RESULTS AND DISCUSSION

The numbers of emerged seedlings counted 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 days after planting with no fertilizer treatment are given in Table 8. The number of emerged seedlings for each variety in the check and fertilizer treatments at the 25 pound rate was less than the number in the check and fertilizer treatments at the 50 pound rate. This anomalous behavior can possibly be attributed to cold and rainy weather during this period of the experiment. The germination of Sumac 1712, Atlas, African Millet, and Darset was lower in the check plots in the greenhouse than the germination obtained in the germinator, while Sugar Drip, Wheatland, Redlan, Hegari, and Dwarf kafir 44-14 germinated as well or better in the check plots in the greenhouse as in the germinator. Seedling growth at 11 days after planting for the check plots of the 50 and 100 pound rate treatments is shown in Figures 1 and 2. The root growth at 14 days after planting for the check plot of the 50 pound rate treatments is shown in Figure 5.

The germination percentage obtained for each variety in 'The Mangelsdorf Germinator' is given in Table 7.

Effect of a Mixed Fertilizer (5-10-5) on Sorghum Seed Germination

The emergence of all the varieties was not retarded or reduced by the mixed fertilizer (5-10-5) at the 25 and 50 pound rates and Hegari was the only variety injured by the mixed fertilizer at the 100 pound rate (See Table 9). The number of seedlings of Atlas and African Millet was greater in the mixed fertilizer treatments at both

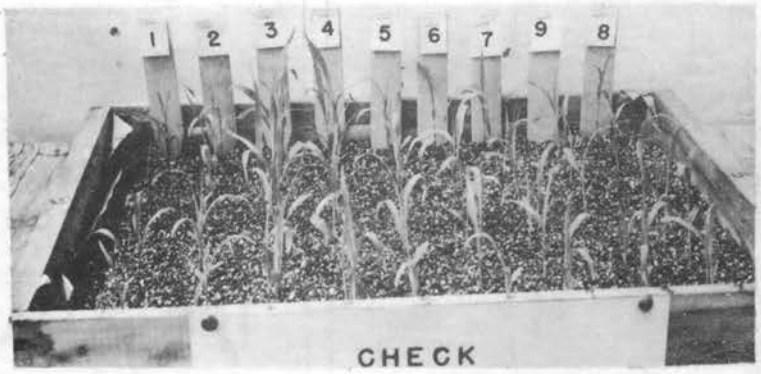

Figure 1. The growth of sorghums eleven days after planting in the check plots of the 50 pound per acre rate. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sumac F.C.I. No. 1712	6	African Millet
2	Hegari C.I. No. 750	7	Atlas C.I. 899
3	Wheatland G.C. 38288	8	Darset
4	Redlan	9	Dwarf kafir 44-14
5	Sugar Drip		

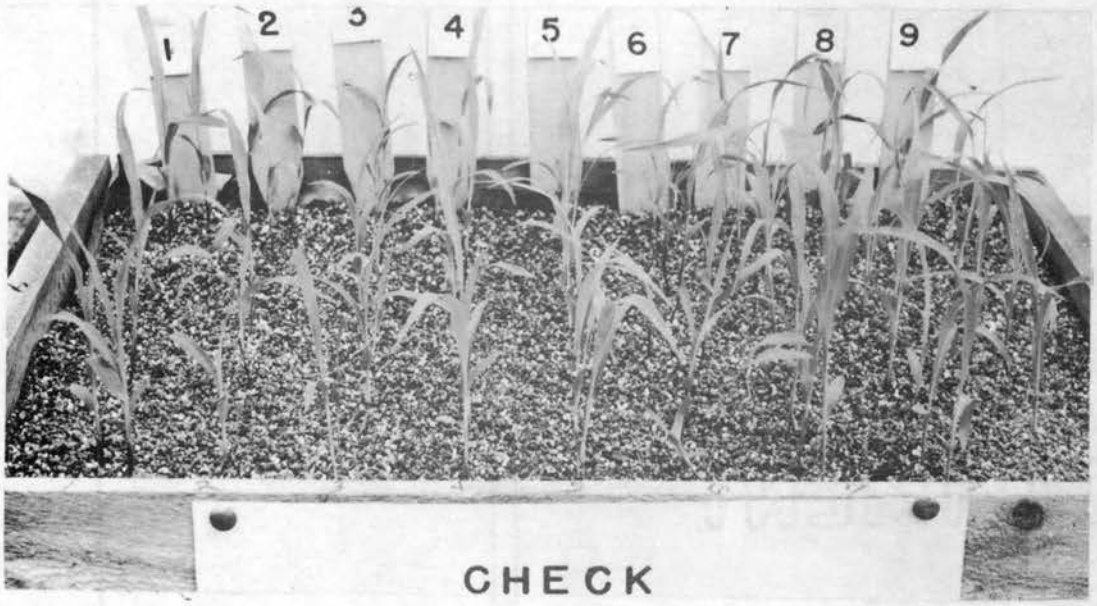

Figure 2. The growth of sorghums eleven days after planting in the check plots of the 100 pound per acre rate. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Wheatland G.C. 38288	6	Sumac F.C.I. No. 1712
2	Darset	7	Sugar Drip
3	Dwarf kafir 44-14	8	Hegari C.I. No. 750
4	African Millet	9	Redlan
5	Atlas C.I. 899		

Figure 3. The growth of sorghums eleven days after planting with a mixed fertilizer (5-10-5) at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Darset	6	African Millet
2	Wheatland G.C. 38288	7	Sugar Drip
3	Redlan	8	Hegari C.I. No. 750
4	Atlas C.I. 899	9	Dwarf kafir 44-14
5	Sumac F.C.I. No. 1712		

Figure 4. The growth of sorghums eleven days after planting with a mixed fertilizer (5-10-5) at 100 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Darset	6	African Millet
2	Atlas C.I. 899	7	Sugar Drip
3	Redlan	8	Wheatland G.C. 38288
4	Dwarf kafir 44-14	9	Sumac F.C.I. No. 1712
5	Hegari C.I. No. 750		

the 50 and 100 pound rates than in the check plots. Seedling growth 11 days after planting with the mixed fertilizer at the 50 and 100 pound rates was much greater than in any of the other treatments (See Figures 3 and 4). As compared to the other fertilizer treatments the plants were larger and were more vigorous in the mixed fertilizer treatment at both the 50 and 100 pound rates. Root growth 14 days after planting with the mixed fertilizer at the 50 pound rate is shown in Figure 16. The root system was examined and was found to be more extensively developed than the other treatments, and the roots were larger and showed very little or no pigmentation.

Effect of Mono-calcium Phosphate on Sorghum Seed Germination

Sumac 1712 was severely retarded and reduced by mono-calcium phosphate at all rates of application. The 25 and 50 pound rates produced little or no injury to the germination of Atlas, African Millet, Sugar Drip, Darset, Wheatland, Redlan, Hegari, and Dwarf kafir 44-14 (See Table 10.) The 100 pound rate retarded germination of all varieties when compared with check on the 5th and 6th days after planting. Seedling emergence of Sumac 1712, African Millet, Hegari, and Dwarf kafir 44-14 was reduced at the 100 pound rate. However, 11 days after planting, the germination of Atlas, Sugar Drip, Darset, Wheatland, and Redlan at the 100 pound rate was as good or better than the 50 pound rate. The seedling growth of plants treated with mono-calcium phosphate at the 50 and 100 pound rates was less than in the no fertilizer treatments 11 days after planting (See Figures 13 and 14). The margins of the leaves in all

varieties were whitish and the tips of the leaves were shriveled. The roots of the plants treated with mono-calcium phosphate at the 50 pound rate were small and showed pigmentation when examined 14 days after planting (See Figure 21).

Effect of Calcium Nitrate on Sorghum Seed Germination

The germination of all the varieties was retarded and reduced by calcium nitrate at the 50 and 100 pound rates (See Table 11). The amount of retardation 5 and 6 days after planting was greater at the 100 pound rate than at the 50 pound rate. The germination of Atlas, Darset, Wheatland, Redlan, and Dwarf kafir 44-14 was appreciably reduced by calcium nitrate treatment at the 100 pound rate. The germination of Sumac 1712, African Millet, Sugar Drip, and Hegari was reduced only slightly or not at all by calcium nitrate at the 100 pound rate. The calcium nitrate treatments were not as injurious to seedling emergence, seedling growth or root growth as ammonium nitrate, sodium nitrate, or potassium chloride treatments. The seedling growth 11 days after planting with calcium nitrate at the 50 and 100 pound rates is shown in Figures 5 and 6. Root growth of plants treated with calcium nitrate at the 50 pound rate 14 days after planting is shown in Figure 17.

Effect of Sodium Nitrate on Sorghum Seed Germination

The emergence of seedlings was retarded 5 and 6 days after planting with sodium nitrate at the 25, 50 and 100 pound rates (See Table 12). Seedlings were permanently injured by sodium nitrate at the 50 and 100 pound rates and the amount of injury

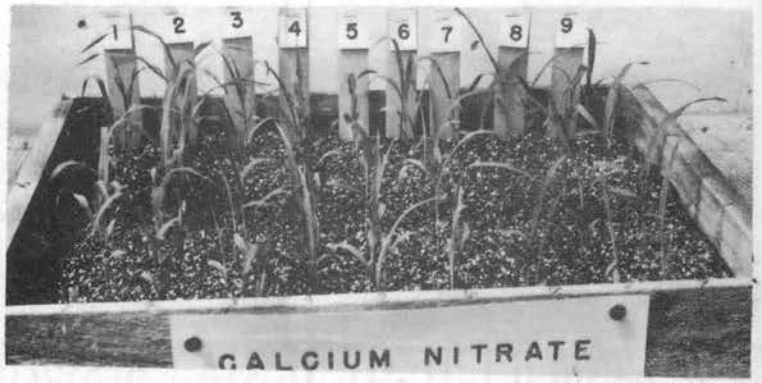

Figure 5. The growth of sorghums eleven days after planting with calcium nitrate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sugar Drip	6	Hegari C.I. No. 750
2	Wheatland G.C. 38288	7	Dwarf kafir 44-14
3	African Millet	8	Atlas C.I. 899
4	Sumac F.C.I. 1712	9	Redlan
5	Darset		

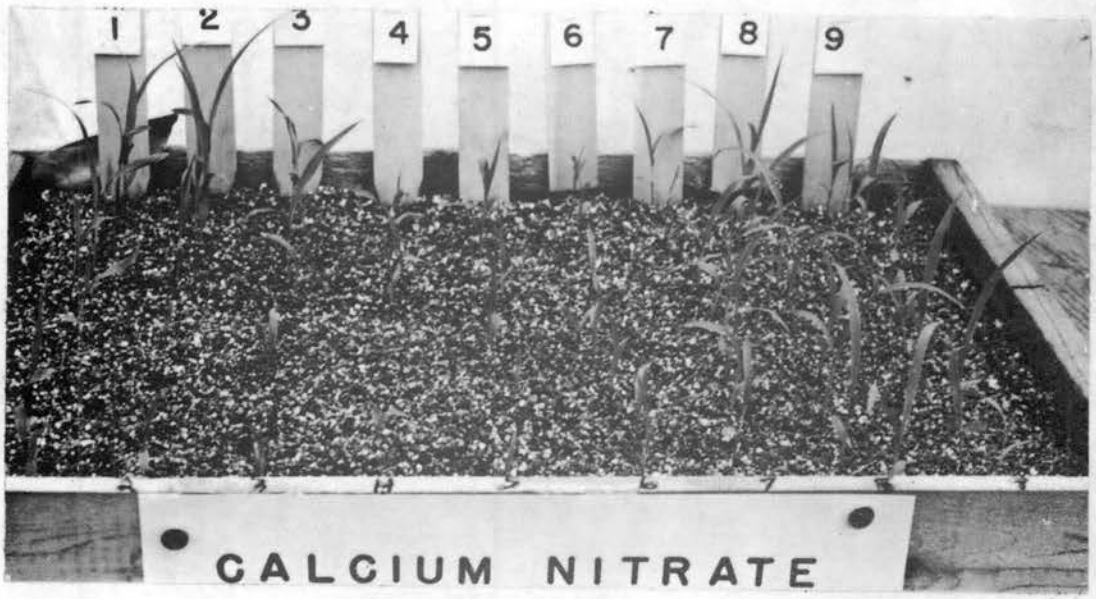

Figure 6. The growth of sorghums eleven days after planting with calcium nitrate at 100 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Wheatland G.C. 38288	6	Sumac F.C.I. No. 1712
2	Redlan	7	African Millet
3	Atlas C.I. 899	8	Hegari C.I. No. 750
4	Darset	9	Sugar Drip
5	Dwarf kafir 44-14		

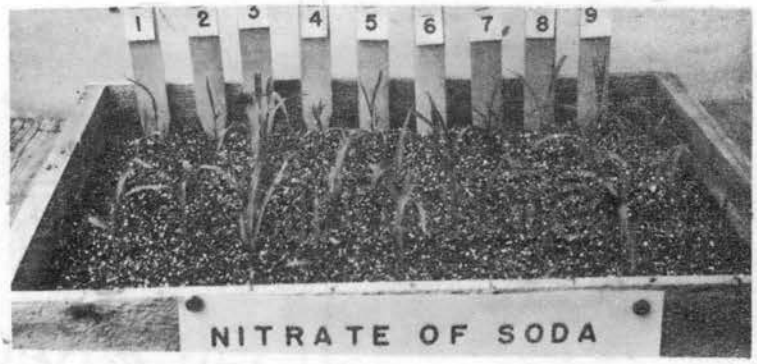

Figure 7. The growth of sorghums eleven days after planting with sodium nitrate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	African Millet	6	Redlan
2	Atlas C.I. 899	7	Sumac F.C.I. No. 1712
3	Wheatland G.C. 38288	8	Hegari C.I. No. 750
4	Darset	9	Dwarf kafir 44-14
5	Sugar Drip		

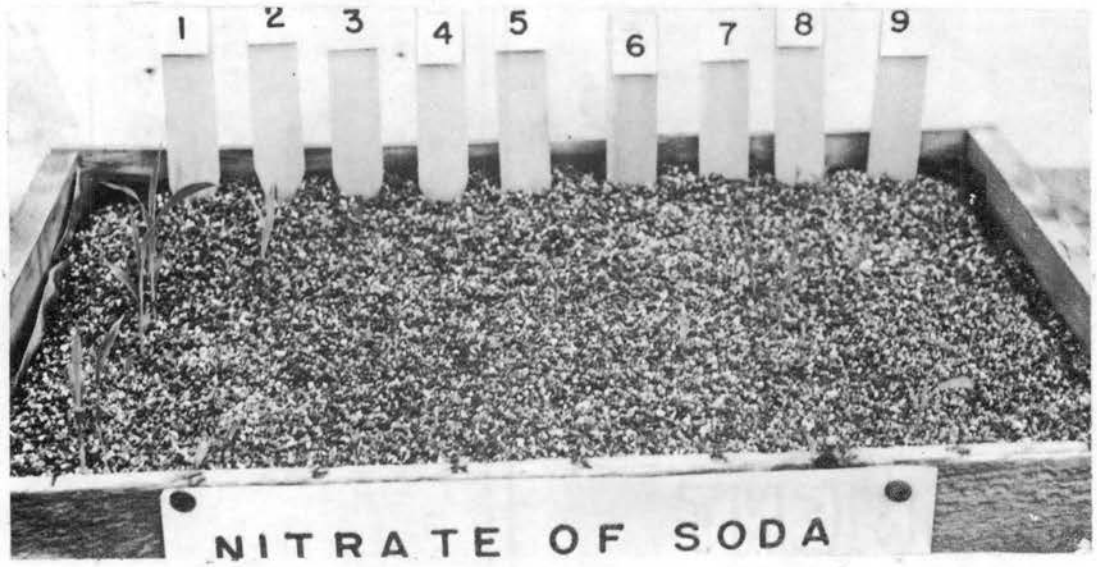

Figure 8. The growth of sorghums eleven days after planting with sodium nitrate at 100 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Redlan	6	Atlas C.I. 899
2	Sumac F.C.I. 1712	7	Hegari C.I. No. 750
3	Dwarf kafir 44-14	8	Sugar Drip
4	African Millet	9	Darset
5	Wheatland G.C. 38288		

increased as the rate of application increased. However, Hegari was injured only slightly at the 50 pound rate. The germination of African Millet, Darset, and Wheatland was more severely reduced at the 100 pound rate than Sumac 1712, Atlas, Sugar Drip, Redlan, Hegari, and Dwarf kafir 44-14 at this rate. Seedling growth 11 days after planting with sodium nitrate at the 50 and 100 pound rates is shown in Figures 7 and 8, and root growth 14 days after planting with sodium nitrate at 50 pounds per acre is shown in Figure 18. Seedling emergence, seedling growth, and root growth in the sodium nitrate treatments were less than in the calcium nitrate, but more than in the ammonium nitrate or potassium chloride treatments.

Effect of Ammonium Nitrate on Sorghum Seed Germination

The germination of Sumac 1712, Darset, and Hegari was not reduced by ammonium nitrate at the 25 pound rate, whereas, the germination of Atlas, African Millet, Sugar Drip, Wheatland, Redlan, and Dwarf kafir 44-14 were reduced slightly at the 25 pound rate (See Table 13). The germination of all varieties was retarded when compared to checks on the 5th and 6th day after planting with ammonium nitrate at the 50 and 100 pound rates, while seedling injury was permanent in all varieties with this salt at these rates. Germination injury increased as the rate of application was increased. The seedlings in the 50 and 100 pound rates began to die 9 days after planting.

The emergence of seedlings was very severely inhibited at the 100 pound rate. The emergence of Hegari was reduced more severely than any of the other varieties.

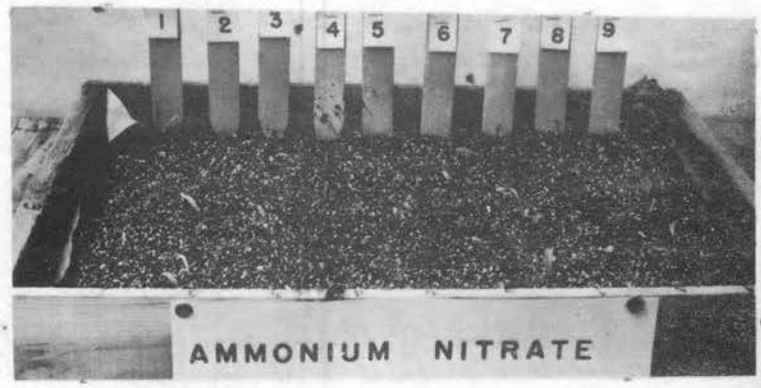

Figure 9. The growth of sorghums eleven days after planting with amonium nitrate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sumac F.C.I. 1712	6	African Millet
2	Hegari C.I. No. 750	7	Redlan
3	Dwarf kafir 44-14	8	Atlas C.I. 899
4	Darset	9	Sugar Drip
5	Wheatland G.C. 38288		

Figure 10. The growth of sorghums eleven days after planting with amonium nitrate at 100 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Darset	6	Sugar Drip
2	Redlan	7	Wheatland G.C. 38288
3	Sumac F.C.I. No. 1712	8	Dwarf kafir 44-14
4	Hegari C.I. No. 750	9	African Millet
5	Atlas C.I. 899		

Ammonium nitrate was more injurious to the germination of seed, seedling growth, and root growth than any of the fertilizer treatments, when applied at the 50 and 100 pound rates. Seedling growth 11 days after planting with ammonium nitrate at the 50 and 100 pound rates is shown in Figures 9 and 10. The seedlings in this treatment were stunted and the leaves were brown and shriveled. Root growth 14 days after planting with ammonium nitrate at the 50 pound rate is shown in Figure 19. Note that the roots were small and heavily pigmented (Pigmentation suggests necrotic dead tissue according to microscopic examination).

Effect of Potassium Chloride on Sorghum Seed Germination

The emergence of all varieties, with the exception of Hegari planted with potassium chloride in quantities as low as 25 pounds per acre was retarded and reduced (See Table 14). The amount of seedling injury increased progressively as the rate per acre increased. All varieties were very severely retarded and reduced at the 100 pound rate. The seedlings began to die 10 days after planting with potassium chloride at the 50 and 100 pound rates. The growth of the seedlings 11 days after planting at the 50 and 100 pound rates is shown in Figures 11 and 12. The seedlings in the 100 pound rate treatment were stunted and the leaves were brown and shriveled. The roots were small, very heavily pigmented and lacked the development of those found in the check or mixed fertilizer treatments (See Figure 20). The potassium chloride treatment at the 100 pound rate was more detrimental than all the other treatments except ammonium nitrate.

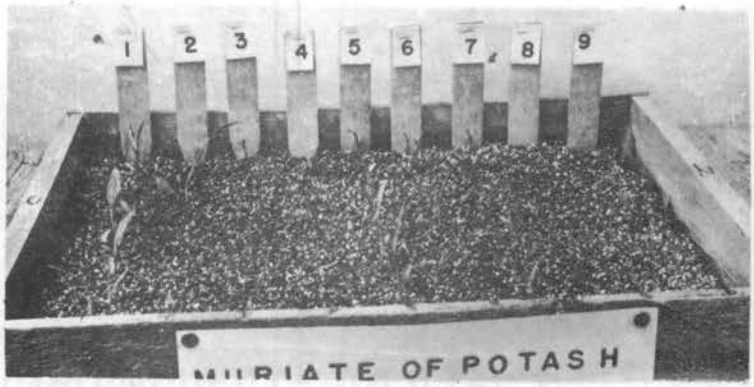

Figure 11. The growth of sorghums eleven days after planting with potassium chloride at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sugar Drip	6	Redlan
2	Wheatland G.C. 38288	7	African Millet
3	Sumac F.C.I. 1712	8	Dwarf kafir 44-14
4	Atlas C.I. 899	9	Darset
5	Hegari C.I. No. 750		

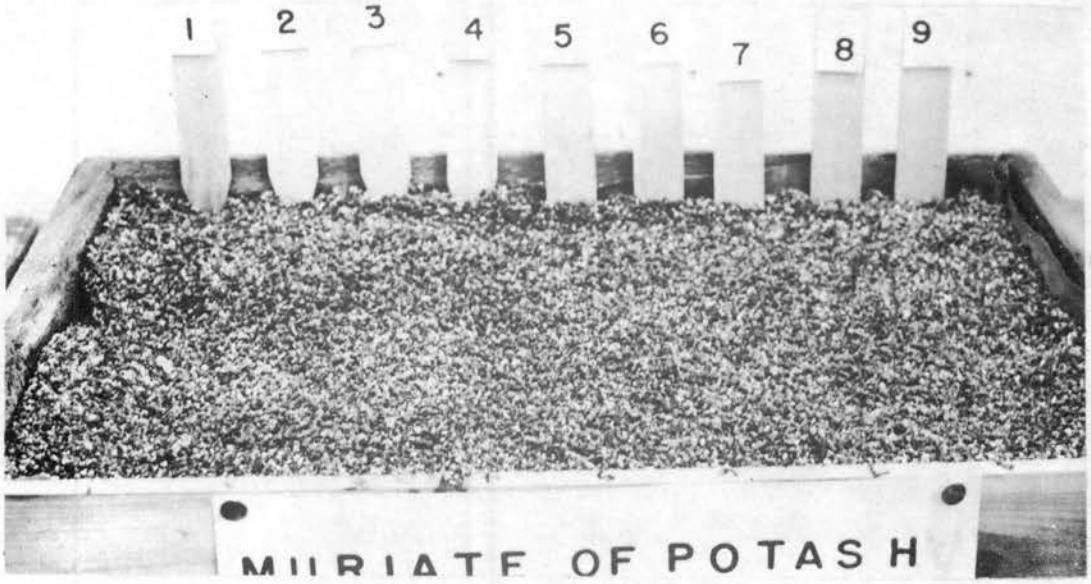

Figure 12. The growth of sorghums eleven days after planting with potassium chloride at 100 pounds per acre. (Variety identity numbers given below.)

Row No.	Variety	Row No.	Variety
1	Dwarf kafir 44-14	6	Darset
2	Atlas C.I. 899	7	Hegari C.I. No. 750
3	African Millet	8	Sumac F.C.I. 1712
4	Wheatland G.C. 38288	9	Redlan
5	Sugar Drip		

Figure 13. The growth of sorghums eleven days after planting with monobasic calcium phosphate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	African Millet	6	Wheatland G.C. 38288
2	Dwarf kafir 44-14	7	Hegari C.I. No. 750
3	Sugar Drip	8	Redlan
4	Sumac F.C.I. 1712	9	Atlas C.I. 899
5	Darset		

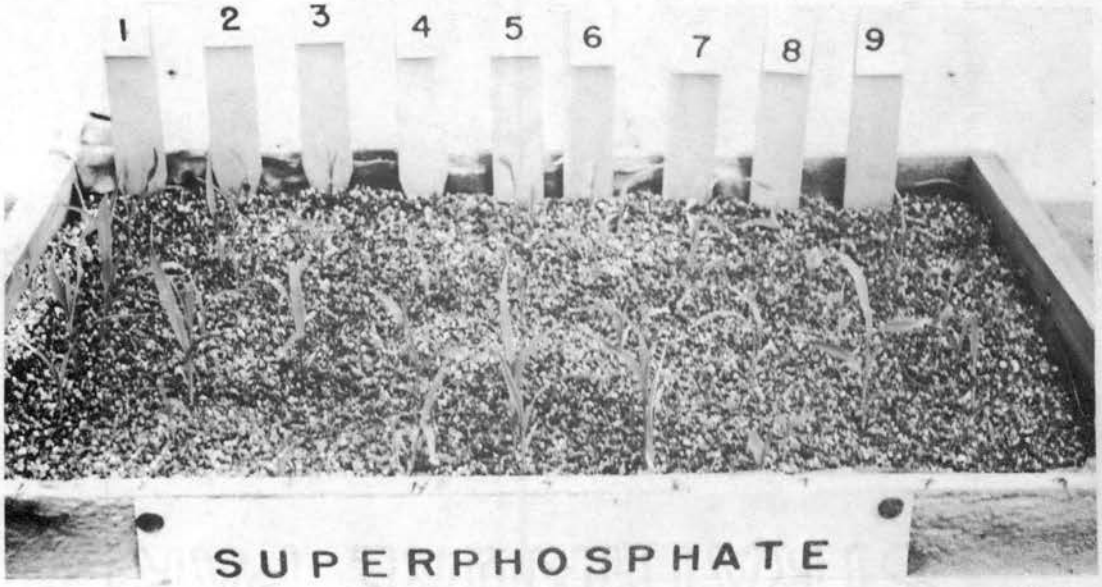

Figure 14. The growth of sorghums eleven days after planting with monobasic calcium phosphate at 100 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Redlan	6	Sugar Drip
2	Hegari C.I. 750	7	African Millet
3	Sumac F.C.I. 1712	8	Darset
4	Atlas C.I. 899	9	Dwarf kafir 44-14
5	Wheatland G.C. 38288		

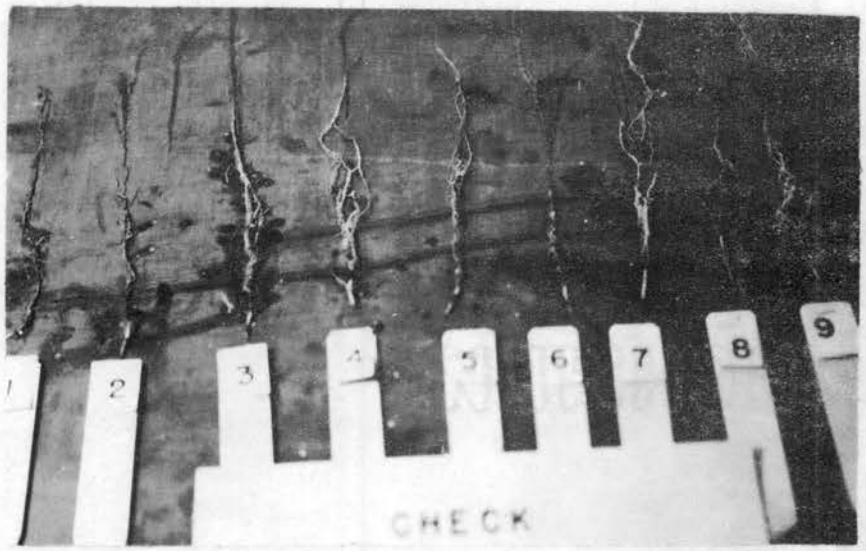

Figure 15. Root growth of sorghums fourteen days after planting in the check plots of the 50 pound per acre rate. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sumac F.C.I. No. 1712	6	African Millet
2	Hegari C.I. No. 750	7	Atlas C.I. 899
3	Wheatland G.C. 38288	8	Darset
4	Redlan	9	Dwarf kafir 44-14
5	Sugar Drip		

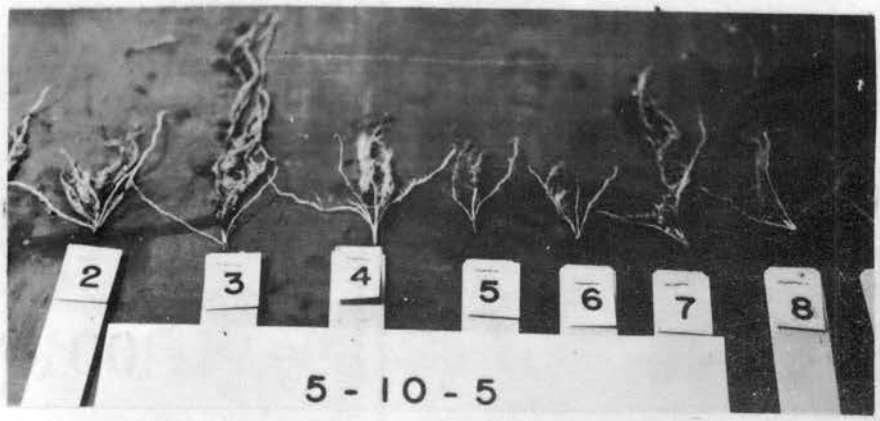

Figure 16. Root growth of sorghums fourteen days after planting with a mixed fertilizer (5-10-5) at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Darset	6	African Millet
2	Wheatland G.C. 38288	7	Sugar Drip
3	Redlan	8	Hegari C.I. No. 750
4	Atlas C.I. 899	9	Dwarf kafir 44-14
5	Sumac F.C.I. No. 1712		

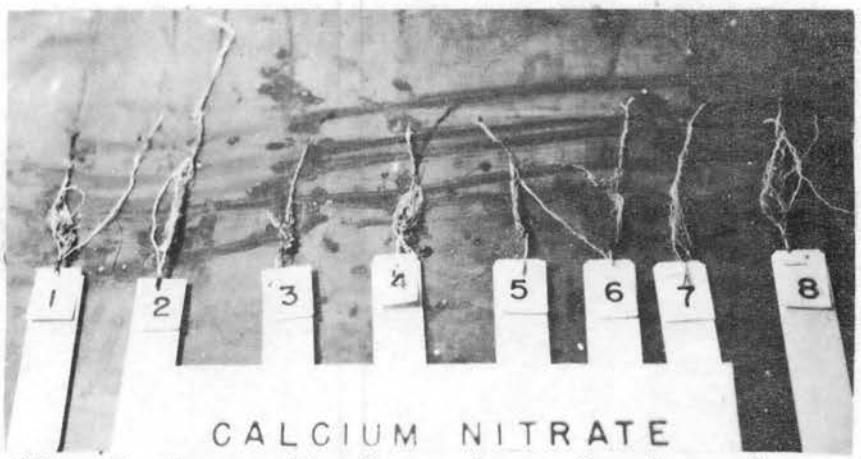

Figure 17. Root growth of sorghums fourteen days after planting with calcium nitrate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sugar Drip	6	Hegari C.I. No. 750
2	Wheatland G.C. 38288	7	Dwarf kafir 44-14
3	African Millet	8	Atlas C.I. 899
4	Sumac F.C.I. 1712	9	Redlan
5	Darset		

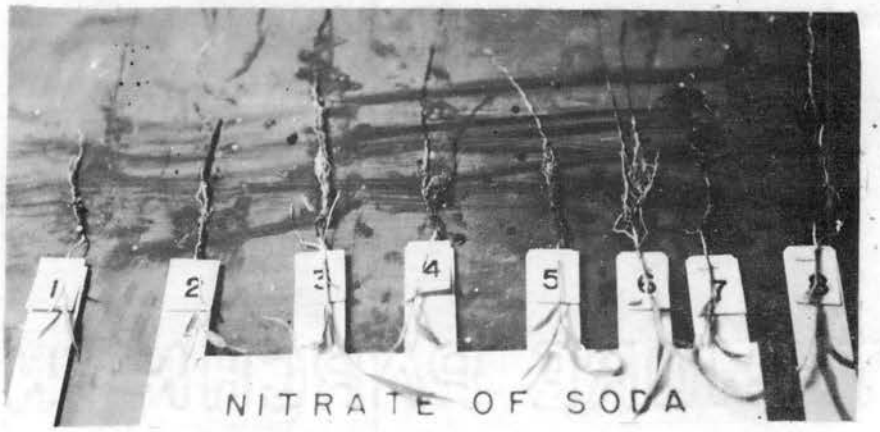

Figure 18. Root growth of sorghums fourteen days after planting treated with sodium nitrate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	African Millet	6	Redlan
2	Atlas C.I. 899	7	Sumac F.C.I. No. 1712
3	Wheatland G.C. 38288	8	Hegari C.I. No. 750
4	Darset	9	Dwarf kafir 44-14
5	Sugar Drip		

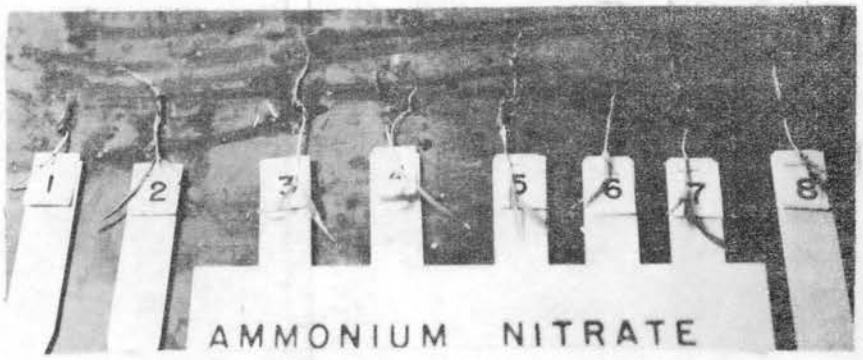

Figure 19. Root growth of sorghums fourteen days after planting with ammonium nitrate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sumac F.C.I. 1712	6	African Millet
2	Hegari C.I. No. 750	7	Redlan
3	Dwarf kafir 44-14	8	Atlas C.I. 809
4	Darset	9	Sugar Drip
5	Wheatland G.C. 38288		

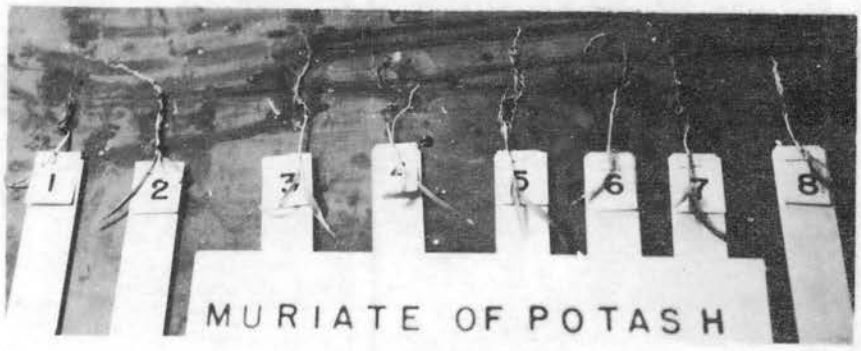

Figure 20. Root growth of sorghums fourteen days after planting with potassium chloride at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	Sugar Drip	6	Redlan
2	Wheatland G.C. 38288	7	African Millet
3	Sumac F.C.I. 1712	8	Dwarf kafir 44-14
4	Atlas C.I. 809	9	Darset
5	Hegari C.I. No. 750		

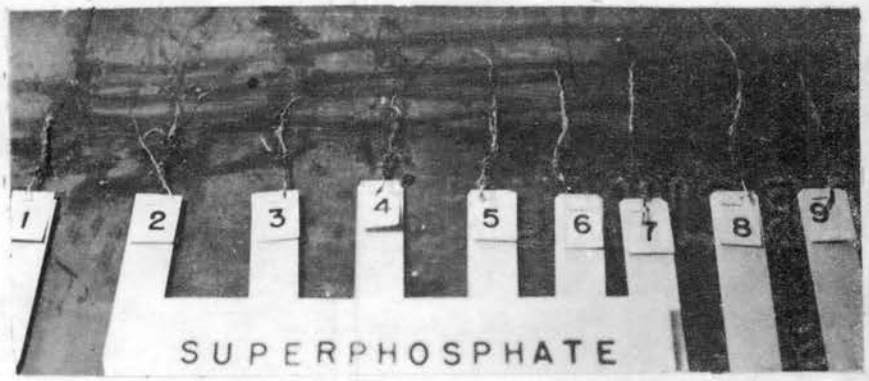

Figure 21. Root growth of sorghums fourteen days after planting with monobasic calcium phosphate at 50 pounds per acre. (Variety identity number given below.)

Row No.	Variety	Row No.	Variety
1	African Millet	6	Wheatland G.C. 38288
2	Dwarf kafir 44-14	7	Hegari C.I. No. 750
3	Sugar Drip	8	Redlan
4	Sumac F.C.I. 1712	9	Atlas C.I. 899
5	Darset		

Analysis of Variance Tables

The statistical significance of the results obtained 14 days after planting is indicated in the accompanying analysis of variance tables.

Table 3. Analysis of variance for seedling emergence when the fertilizer treatments were placed in direct contact with the seed at the 25 pound rate. Seedling counts were made 14 days after planting.

Source	df	SS	MS	F	5%F	1%F
Total	251	41.68	----	----	----	----
Replication	3	0.85	0.28	----	----	----
Fertilizer	6	3.35	0.56	1.22	2.66	4.01
Error A	18	8.23	0.46	----	----	----
Variety	8	5.03	0.63	5.45**	2.00	2.62
Variety x Fertilizer	48	4.83	0.10	0.87	1.44	1.66
Error B	168	19.39	0.12	----	----	----

**Significant at the 1% level.

Table 4. Analysis of variance for seedling emergence when the fertilizer treatments were placed in direct contact with the seed at the 50 pound rate. Seedling counts were made 14 days after planting.

Source	df	SS	MS	F	5%F	1%F
Total	251	114.42	----	----	----	----
Replication	3	1.55	0.52	----	----	----
Fertilizer	6	57.59	9.60	17.56**	2.66	4.01
Error A	18	9.84	0.55	----	----	----
Variety	8	7.82	0.98	6.82**	2.00	2.62
Variety x Fertilizers	48	13.55	0.28	1.97**	1.44	1.66
Error B	168	24.07	0.14	----	----	----

**Significant at the 1% level.

Table 5. Analysis of variance for seedling emergence when the fertilizer treatments were placed in direct contact with the seed at the 100 pound rate. Seedling counts were made 14 days after planting.

Source	df	SS	MS	F	5%F	1%F
Total	251	213.48	----	----	----	----
Replication	3	2.16	0.72	----	----	----
Fertilizer	6	161.22	26.87	40.96**	2.66	4.01
Error A	18	11.80	0.66	----	----	----
Variety	8	6.21	0.78	6.96**	2.00	2.62
Variety x Fertilizer	48	13.32	0.28	2.49**	1.44	1.66
Error B	168	18.74	0.11	----	----	----

**Significant at the 1% level.

Table 6. Combined analysis of variance for seedling emergence when the fertilizer treatments were placed in direct contact with the seed at all three rates of application. Seedling counts were made 14 days after planting.

Source	df	SS	MS	F	5%F	1%F
Total	755	385.77	----	----	----	----
Rate	2	16.19	8.09	14.63**	3.1	5.01
Replication in rate	9	4.57	0.51	----	----	----
Fertilizer in rate	18	222.16	12.34	----	----	----
Fertilizer	6	149.12	24.85	44.92**	2.27	3.15
Fertilizer x rate	12	73.04	6.09	11.00**	1.93	2.53
Error A	54	29.88	0.55	----	----	----
Variety in rate	24	19.06	0.79	----	----	----
Variety	8	10.78	1.35	10.92**	1.96	2.55
Variety x rate	16	8.28	0.52	4.20**	1.67	2.04
Variety x Fertilizer in rate	144	31.71	0.22	----	----	----
Variety x Fertilizer	48	13.98	0.29	23.60**	1.38	1.58
Variety x Fertilizer x Rate	96	17.73	0.18	14.97**	1.28	1.42
Error B	504	62.19	0.12	----	----	----

**Significant at the 1% level.

Fertilizer applied at 25 pounds per acre was not significant. Variety x fertilizer interaction was not significant at the 25 pounds per acre rate. Fertilizer, variety, and, variety x fertilizer reactions at the 50 and 100 pounds per acre rates were significant at the 1% level. Rate, fertilizer, fertilizer x rate, variety, variety x fertilizer, and variety x fertilizer x rate interactions were significant at the 1% level in the combined analysis of variance for all rates of application.

SUMMARY AND CONCLUSIONS

The results of this experiment may be summarized as follows:

(1) Germination injury varied with the kind and rate of fertilizer application.

(2) The mixed fertilizer (5-10-5) produced little or no retardation or reduction of sorghum seed germination at 25, 50, and 100 pound rates. The number of emerged seedlings for some varieties was more in the mixed fertilizer treatment than in the check plot.

(3) Mono-calcium phosphate, calcium nitrate, sodium nitrate, ammonium nitrate and potassium chloride retarded the germination of sorghums when applied in quantities as low as 25 pounds per acre. Seedling injury increased as the rate of application increased.

(4) Ammonium nitrate and potassium chloride were very detrimental to seedling emergence at the 50 and 100 pound rate. Seedlings in these treatments began to die 9 and 10 days after planting.

(5) Sodium nitrate was less toxic to germination than ammonium nitrate, but more toxic than calcium nitrate.

(6) Until further experiments are made in an attempt to determine the relative ability of the sorghum varieties to withstand the various fertilizer treatments, no conclusion will be made on this point. However, the varieties were not affected by all fertilizer treatments in the same manner.

(7) A statistical analysis showed that fertilizers applied at 25

pounds per acre did not significantly affect germination. Variety by fertilizer reaction was also not significant at the 25 pounds per acre rate. Fertilizer, variety, variety x fertilizer reactions were significant at the 1% level in the 50 and 100 pounds per acre rates. In the combined analysis of variance for all rates of application, rate, fertilizer, fertilizer x rate, variety, variety x rate, variety x fertilizer, variety x fertilizer x rate were significant at the 1% level.

LITERATURE CITED

1. Albrecht, Wm. A. Calcium as a factor in seed germination. Jour. Amer. Soc. Agron. 33:153-155. 1941.

2. Coe, D. G. "Ammo-phos" Its effect upon seed germination and plant growth. N. J. Agr. Exp. Sta. Bul. 375:1-102. 1923.

3. _____. Effects of various methods of applying fertilizers on crops and on certain soil conditions. Soil Science 21:7-21. 1926.

4. Hicks, Gilbert H. The germination of seeds as affected by certain chemical fertilizers. U. S. Department of Agriculture, Division of Botany Bulletin No. 24. 1900.

5. Hobbs, J. A. The effect of fertilizer contact on emergence of sorghum seedlings. unpublished data. Annual Report Soil Management Section. Okla. Agr. Expt. Sta. Stillwater, Okla. pp. 47-54. 1952.

6. Hutcheson, T. B. and Wolfe, T. K. The effect of fertilizers on the germination of seeds. Va. Agr. Exp. Sta. Ann. Rpt. 1918-19:33-37. 1919.

7. Millar, C. E. and Mitchell, J. F. Effect of rate and method of application of fertilizer on the germination of white beans. Jour. Amer. Soc. Agron. 19:270-279. 1921.

8. Probst, A. H. Influence of fertilizer, fertilizer placement, soil moisture content, and soil type on the emergence of soybeans. Jour. Amer. Soc. Agron. 36:111-120. 1944.

9. Sayre, Charles B., and Clark, Arthur W. Rates of solution and movement of different fertilizers in the soil and the effects of the fertilizers on the germination and root development of beans. N. Y. State Agr. Exp. Sta. Tech. Bul. 231:1-67. 1935.

10. Sherwin, M. E. The effect of fertilizers on germination and seedling growth. Jour. Amer. Soc. Agron. 15:66-73. 1923.

11. Snedecor, George W. Statistical Methods. Ames, Iowa: The State College Press. Ed. 4. 1946.

APPENDIX

Table 7. Germination percentages of the varieties obtained in 'The Mangelsdorf Germinator'.

Variety	% Germination
Sumac F.C.I. 1712	88
Atlas C.I. 899	96
African Millet	95
Sugar Drip	90
Darset	84
Wheatland G.C. 38288	90
Redlan	84
Hegari C.I. No. 750	93
Dwarf kafir 44-14	87

Table 8. The germination counts obtained on the varieties in the check plots in the greenhouse.

Variety	Date planted	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	*			20		21		22		22	22
	**	34	33	33	33	33	33	33	33	33	33
	***	31	32	32	32	32	32	32	32	32	32
Atlas C.I. 899	*			20		25		32		32	32
	**	37	37	37	37	37	37	37	36	36	36
	***	37	37	38	38	38	38	38	38	38	38
African Millet	*			11		18		27		28	28
	**	35	35	36	37	37	37	37	37	37	36
	***	32	34	35	35	35	35	34	34	34	34
Sugar Drip	*			20		22		24		25	25
	**	33	35	35	36	36	36	36	36	36	36
	***	34	34	35	37	38	38	38	38	38	38
Darset	*			12		15		19		21	22
	**	30	30	30	31	30	30	30	30	30	28
	***	32	33	33	33	33	33	33	33	33	33
Wheatland G.C. 38288	*			12		15		19		22	24
	**	38	38	38	39	39	39	38	38	38	38
	***	32	32	32	32	32	32	32	32	32	32
Redlan	*			22		29		30		31	32
	**	35	35	35	35	35	35	35	35	35	34
	***	34	34	34	34	34	34	34	34	34	34
Hegari C.I. No. 750	*			19		26		26		26	26
	**	40	40	40	40	40	40	40	39	39	39
	***	36	36	37	37	37	37	37	37	37	37
Dwarf kafir 44-14	*			23		26		30		30	30
	**	31	31	34	34	34	34	34	33	33	33
	***	39	39	39	39	39	39	39	39	39	39

* Planted April 30, 1954.
** Planted May 17, 1954.
*** Planted June 3, 1954.

Table 9. Effect of a mixed fertilizer (5-10-5) upon germination and emergence of sorghum varieties when applied in direct contact with the seed.

Variety	lbs. per acre	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	25			14		20		21		22	22
	50	31	30	30	30	30	30	30	30	30	30
	100	33	34	34	34	34	34	34	34	34	34
Atlas C.I. 899	25			23		30		33		34	34
	50	39	40	40	40	40	40	40	40	40	40
	100	35	36	36	36	36	36	36	36	36	36
African Millet	25			15		23		28		28	28
	50	38	39	39	39	39	39	39	39	39	39
	100	35	38	38	38	38	37	37	37	37	37
Sugar Drip	25			22		28		32		32	32
	50	37	37	37	37	37	37	37	37	37	37
	100	34	35	35	35	35	35	35	35	35	35
Darset	25			17		22		24		25	25
	50	36	36	36	36	36	36	36	36	36	36
	100	32	32	32	32	32	32	32	32	32	32
Wheatland G.C. 38288	25			25		30		32		32	32
	50	38	38	38	38	38	38	38	38	38	37
	100	38	38	38	38	38	38	37	37	37	37
Redlan	25			25		26		29		29	29
	50	32	33	33	33	33	33	33	33	32	32
	100	36	36	36	36	35	35	35	35	35	35
Hegari C.I. No. 750	25			25		30		32		34	34
	50	38	38	39	39	39	38	38	38	38	38
	100	32	34	33	33	33	33	32	32	32	32
Dwarf kafir 44-14	25			30		34		34		35	35
	50	38	38	39	39	37	37	37	37	37	37
	100	35	37	37	37	37	37	37	37	37	37

Table 10. Effect of mono-calcium phosphate upon germination and emergence of sorghum varieties when applied in direct contact with the seed.

Variety	lbs. per acre	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	25			8		10		15		17	19
	50	28	30	30	30	30	29	28	27	26	22
	100	0	9	15	23	25	24	25	24	24	24
Atlas C.I. 899	25			14		21		26		27	27
	50	36	37	37	37	37	36	35	34	34	32
	100	7	24	32	34	35	35	35	35	35	35
African Millet	25			21		26		33		33	33
	50	38	40	40	40	39	38	38	37	35	32
	100	8	15	24	30	31	32	32	31	31	31
Sugar Drip	25			12		14		23		23	24
	50	34	36	36	37	37	36	36	36	36	36
	100	6	16	28	33	37	37	38	38	38	38
Darset	25			13		16		20		23	24
	50	34	35	35	35	35	35	34	32	32	29
	100	15	23	29	34	36	34	34	34	34	34
Wheatland G.C. 38288	25			16		18		22		26	26
	50	36	37	37	37	37	37	36	34	33	32
	100	12	22	33	35	36	36	37	36	36	36
Redlan	25			14		18		21		23	26
	50	30	31	30	30	30	30	30	29	29	26
	100	13	23	31	33	33	35	35	35	35	35
Hegari C.I. No. 750	25			11		17		18		19	19
	50	35	38	38	38	38	38	37	37	37	36
	100	6	18	28	30	32	32	32	31	30	30
Dwarf kafir 44-14	25			26		29		30		31	31
	50	36	37	38	38	39	38	37	36	36	32
	100	16	23	28	28	29	28	28	28	28	28

Table 11. Effect of calcium nitrate upon germination and emergence of sorghum varieties when applied in direct contact with the seed.

Variety	lbs. per acre	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	25			9		11		14		17	18
	50	30	32	33	33	33	32	31	31	31	30
	100	19	25	29	29	30	30	30	31	31	31
Atlas C.I. 899	25			22		27		28		28	28
	50	31	32	32	33	32	32	32	32	32	32
	100	12	18	22	26	29	29	29	29	28	28
African Millet	25			15		19		25		27	28
	50	32	34	35	37	38	38	37	37	37	37
	100	14	20	30	33	35	35	33	33	33	33
Sugar Drip	25			19		21		27		27	27
	50	28	32	32	34	36	36	36	36	36	35
	100	14	18	25	30	32	34	35	35	35	35
Darset	25			15		21		23		26	27
	50	25	28	28	28	28	28	27	27	27	27
	100	21	24	27	27	28	28	28	28	28	28
Wheatland G.C. 38288	25			9		18		24		25	25
	50	26	28	28	28	28	27	27	27	27	25
	100	17	27	32	34	35	35	35	35	34	34
Redlan	25			22		25		28		28	28
	50	29	30	30	30	30	30	30	30	30	30
	100	15	24	28	29	30	30	30	30	30	30
Hegari C.I. No. 750	25			22		25		30		30	30
	50	36	36	36	36	36	36	36	36	36	36
	100	30	33	37	37	37	37	37	37	37	37
Dwarf kafir 44-14	25			27		27		28		28	29
	50	27	29	30	30	29	29	28	28	28	27
	100	16	22	27	30	31	31	31	31	31	31

Table 12. Effect of sodium nitrate upon germination and emergence of sorghum varieties when applied in direct contact with the seed.

Variety	lbs. per acre	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	25			11		15		17		19	20
	50	16	21	26	30	31	31	32	32	32	32
	100	3	11	17	18	20	19	19	18	17	17
Atlas C.I. 899	25			18		22		22		23	23
	50	19	24	25	26	29	29	29	29	29	28
	100	4	10	13	15	19	18	16	17	14	13
African Millet	25			15		21		22		25	26
	50	18	24	27	32	33	33	32	33	31	30
	100	1	4	8	7	10	9	9	9	8	7
Sugar Drip	25			15		19		19		19	20
	50	14	20	21	22	25	27	29	32	32	32
	100	2	5	5	6	16	19	22	22	23	23
Darset	25			11		16		17		20	21
	50	22	26	26	27	27	27	26	25	25	24
	100	2	4	7	10	8	5	6	5	3	3
Wheatland G.C. 38288	25			18		22		23		23	24
	50	14	23	26	29	30	30	29	29	29	28
	100	2	5	6	6	5	4	6	5	4	4
Redlan	25			12		19		19		19	19
	50	15	18	21	25	26	25	25	25	25	25
	100	8	15	20	21	19	20	20	19	19	19
Hegari C.I. No. 750	25			20		22		22		22	22
	50	29	35	38	38	38	38	38	38	38	38
	100	2	19	21	22	22	21	21	20	19	18
Dwarf kafir 44-14	25			26		30		30		30	31
	50	21	27	30	31	31	31	31	30	30	30
	100	7	13	15	17	17	17	17	17	16	15

Table 13. Effect of ammonium nitrate upon the germination and emergence of sorghum varieties when applied in direct contact with the seed.

Variety	lbs. per acre	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	25			17		21		23		23	23
	50	23	25	26	27	26	23	19	17	11	6
	100	8	12	14	17	16	14	12	8	2	2
Atlas C.I. 899	25			22		24		24		24	24
	50	28	32	34	34	34	34	30	18	14	8
	100	8	15	17	17	17	13	12	6	3	2
African Millet	25			12		16		20		20	20
	50	25	28	31	34	35	34	34	29	24	18
	100	9	19	20	20	18	18	16	13	10	4
Sugar Drip	25			19		21		22		23	24
	50	26	28	30	32	33	29	29	25	23	21
	100	13	18	24	26	27	25	23	21	15	14
Darset	25			20		23		25		26	26
	50	24	26	27	26	27	25	23	17	13	7
	100	8	15	16	15	12	8	6	5	2	0
Wheatland G.C. 38288	25			19		20		20		23	23
	50	18	24	27	29	30	29	26	22	16	12
	100	9	15	16	16	15	14	11	8	5	4
Redlan	25			19		24		27		27	27
	50	29	32	33	35	38	37	35	29	23	16
	100	8	13	17	17	17	14	12	10	6	3
Hegari C.I. No. 750	25			27		31		34		34	34
	50	32	34	33	30	30	26	21	19	14	11
	100	5	8	8	8	7	6	5	4	2	2
Dwarf kafir 44-14	25			21		25		26		26	26
	50	30	31	31	31	29	26	21	15	8	3
	100	20	25	27	27	24	18	13	6	2	0

Table 14. Effect of potassium chloride upon germination and emergence of sorghum varieties when applied in direct contact with the seed.

Variety	lbs. per acre	Seedlings Days after planting 5	6	7	8	9	10	11	12	13	14
Sumac F.C.I. No. 1712	25			11		12		14		14	14
	50	15	27	29	31	30	28	28	28	28	27
	100	3	4	8	8	11	11	10	10	9	9
Atlas C.I. 899	25			15		19		25		24	24
	50	17	21	25	25	24	21	17	16	14	10
	100	4	7	13	17	16	14	10	9	6	6
African Millet	25			11		14		21		22	22
	50	20	29	24	28	26	24	23	24	22	21
	100	2	5	11	12	14	12	12	11	6	5
Sugar Drip	25			14		19		22		22	22
	50	8	18	21	25	30	32	32	31	32	31
	100	0	3	5	8	10	12	8	12	11	9
Darset	25			13		14		19		19	21
	50	17	17	19	20	20	13	9	7	7	6
	100	2	7	7	8	8	7	7	6	4	4
Wheatland G.C. 38288	25			8		11		15		19	19
	50	5	9	13	14	14	11	10	9	8	7
	100	3	5	5	6	6	5	3	2	1	1
Redlan	25			15		21		23		23	24
	50	10	20	24	25	23	19	19	18	18	18
	100	8	14	18	21	20	20	18	17	14	14
Hegari C.I. No. 750	25			22		29		30		31	31
	50	20	32	31	31	31	29	29	27	27	27
	100	6	13	17	17	15	14	13	12	11	11
Dwarf kafir 44-14	25			24		25		28		28	28
	50	26	27	28	28	27	25	22	20	19	16
	100	1	5	9	11	13	10	8	8	5	4

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