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Emergence of Corn as Affected by Source and Rate of Solution Fertilizers Applied with the Seed[1]

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ABSTRACT

Three experiments were established at different times in 1984 to evaluate salt effects on corn (*Zea mays* L.) emergence as affected by rate (0, 5, 10, 15 and 20 lb/ac), and source (7-21-7, 7-21-7 with ammonium thiosulfate, 10-34-0 and 9-18-9) of solution fertilizers placed with corn seed at planting. Emergence counts were taken at periodic times following planting. In two of these experiments, small amounts of salt (5 lb/ac, $N+K_2O$) reduced corn seedling emergence nearly 10% whether or not precipitation occurred soon after planting. Salt rates in excess of 10 lb/ac delayed seedling germination until precipitation occurred, resulting in small corn plants emerging in established corn stands. Fertilizer sources did not significantly affect seedling germination. The salt index method ($N+K_2O$ in lb/ac) of determining the detrimental effect of placing fertilizers with corn seed seemed to evaluate well both the effect of different fertilizer sources and rates of application on corn seedling emergence.

Additional index words: **(*Zea mays* L.), Salt injury, Salt index.**

CURRENT recommendations of placing fertilizers with corn (*Zea mays* L.) seed have generated considerable concern with respect to seedling emergence (1, 2, 6, 7, 8, 9, 10, 11, 14). Advantages of applications of fertilizer solutions with the seed are varied. Most yield responses to starter fertilizers have been found in the northern states where crops are planted early and where soils are wet and cold (7, 9). Increased effectiveness of some micronutrients has been found when starter fertilizers were band applied (7). Sulfur containing fertilizers such as ammonium thiosulfate, when banded in a concentrated zone, temporarily acidify the band area in high pH soils which may result in increased availability of phosphorus, boron, copper, iron, manganese and zinc (4, 5). Even a 15 lb/ac salt rate ($N+K_2O$) had no effect on reduction of corn stands when ample moisture was present in the seed zone (9). No effect on emergence was found when applying 13 lb of salt/ac as a liquid fertilizer that employed potassium hydroxide as the potassium source (6). While delayed emerged plants were found when fertilizers were placed with the seed, no delay in silking and yields were found for these treatments (11).

Other data have indicated that either reductions in stands, delayed emergence, and/or yield losses will occur when placing solution fertilizers with corn seed (2, 9, 1). Placement of various solutions with the seed at salt rates less than 20 lb/ac have also shown reductions in emergence for other crops (8, 14). Moisture content of the seed zone influences the way in which solution fertilizers placed very close to the seed at planting will affect germination. Crops grown on sandy soils are generally more susceptible to salt damage when fertilizers are applied with the seed than are fine textured soils because of the rapid drying that can occur (7, 9, 10, 11). Diammonium phosphate and urea have been found to have a toxic effect on seedlings when placed with the seed due to the subsequent release of ammonia (7, 13). This toxic affect is less pronounced in clay soils with higher cation exchange capacities as the NH_4^+ would be absorbed by the soil exchange complex (14). Substantial dilution of liquid sources applied with the seed was required before no delay and or reduction in germination took place when compared to solid sources at the same rate (3). In the same study a reduction in the respiration rate of corn seeds was found when solid or liquid fertilizer sources were applied with the seed. With an increase in salt concentration, the plant's ability to absorb water diminishes until it cannot extract water, even in wet soils (13). The pH of fertilizer materials applied with the seed demonstrated no effect on corn emergence (9).

It has been proposed that salt index rates of 5 to 7 lb applied with the seed of corn are safe for sandy and nonsandy soils, respectively, when the salt index is determined by adding the rate of nitrogen to rate of potassium as K_2O (10, 13). Current applications of the salt index do not consider added salting agents other than N and K_2O. In light of the different salt rates at which delayed emergence of reductions in stands have been found, and because current recommendations are made that exceed these "safe" rates, the objectives of this study were to determine the effect of different fertilizer sources and rates of application with the seed on emergence of corn in a fine-textured soil.

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MATERIALS AND METHODS

Three experiments were established in 1984 at the Mead Field Laboratory at Mead, Nebraska on a Sharpsburg silty clay loam (Typic Argiudoll). Pioneer 3377 corn was planted at a depth of two inches using an adapted Buffalo till ridge planter on June 8, 27 and July 24 (Experiments 1, 2 and 3), to obtain different environmental conditions for corn emergence. Three rates (5, 10 and 20 lb/ac) of salt (N + K_2O in lb/ac) were used in experiment 1, while experiments 2 and 3 employed four rates (5, 10, 15 and 20 lb/ac) of salt applied with the seed. Four fertilizer sources were used in all experiments, 7-21-7, 7-21-7 with ammonium thiosulfate (7-21-7 T), 10-34-0 and 9-18-9 (N-P_2O_5-K_2O). The 7-21-7 and 10-34-0 were ammonium polyphosphate (APP). The 7-21-7 was formulated from 10-34-0 by adding potassium chloride. The 7-21-7 T consisted of one, two, three and four gallons of ammonium thiosulfate (ATS)/ac, adjusted accordingly with 7-21-7 to formulate the 5, 10, 15 and 20 lb salt rates. All sources were applied with a planter driven "John Blue" squeeze pump. The 9-18-9 fertilizer was formulated from ammonia, orthophosphoruc acid, urea and potassium hydroxide. Due to the different analyses of the sources used, salt rates were constant for each source but the nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) rates varied. A completely randomized block (Experiments 2, 3) or completely randomized (Experiment 1) statistical design with a factorial treatment arrangement was used with three (Experiments 2, 3) and two (Experiment 1) replications.

A planting rate of 28,260 seeds/ac was employed in 30-inch rows. Sixteen plants per 10 linear ft represented 100% emergence. Plot length was 30 ft. The center 10 ft from each plot was marked for seedling emergence counts. Seedling counts began when the first plants were visible and continued until there were no further changes.

Each experiment was disked prior to planting. Immediately following planting, each experiment received a broadcast treatment of 1.25 pints of Roundup per acre. Soil moisture was determined at the two inch depth at planting. Table 1 shows soil moisture at planting and soil test data for each experiment. Standard analysis of variance with single degree of freedom contrasts and regression were used to evaluate treatments (12). In the third experiment, data from the 20 lb salt rate using 10-34-0 was not obtained due to mechanical error.

RESULTS AND DISCUSSION

Numbers of emerged plants by source, rate and experiment are found in Figure 1. Precipitation received following planting for each experiment is illustrated at the bottom of Figure 1. The environments present at planting and emergence were markedly different for each experiment. These three environments provided variable soil moisture and seed bed conditions with which the farmer could be confronted. Dates selected for discussion represented points at which no further change in emerged plants was found prior to and following any rainfall that may have occurred during the experiments.

Table 1. Planting time, soil characteristics of the experimental area and conductivity of the fertilizer sources.

	Exp #1	Exp #2	Exp #3
Planting date	June 8	June 27	July 24
Soil moisture % at planting			
Surface 2 inches	21	7	5
Soil pH†	6.3	6.3	6.5
Bray & Kurtz P1, ppm†	15	15	17
K, ppm†	301	322	289

Source	Conductivity, mmhos
9-18-9	582
10-34-0	670
7-21-7	705
7-21-7T	828

†Surface 0-6 inch sample

Seedbed conditions for the first planting on June 8 were generally poor. Excessive spring precipitation resulted in a rough, cloddy seedbed. However, plants emerged quickly and uniformly although emergence was only 80% where no fertilizer was applied. There was relatively little change in the number of emerged plants from the time counts were started (10 days after planting) to the time counts were terminated, 17 days after planting (Figure 1). Soil moisture at the planting depth equalled or exceeded 20% during most of the period. Presumably because of the high soil moisture, there was no significant effect of the different fertilizer sources on seedling emergence regardless of applied salt rate. However, as the rate of salt increased, seedling emergence decreased in a linear manner (Table 2). For each pound of applied salt, seedling emergence decreased 1.75 percent (Figure 2).

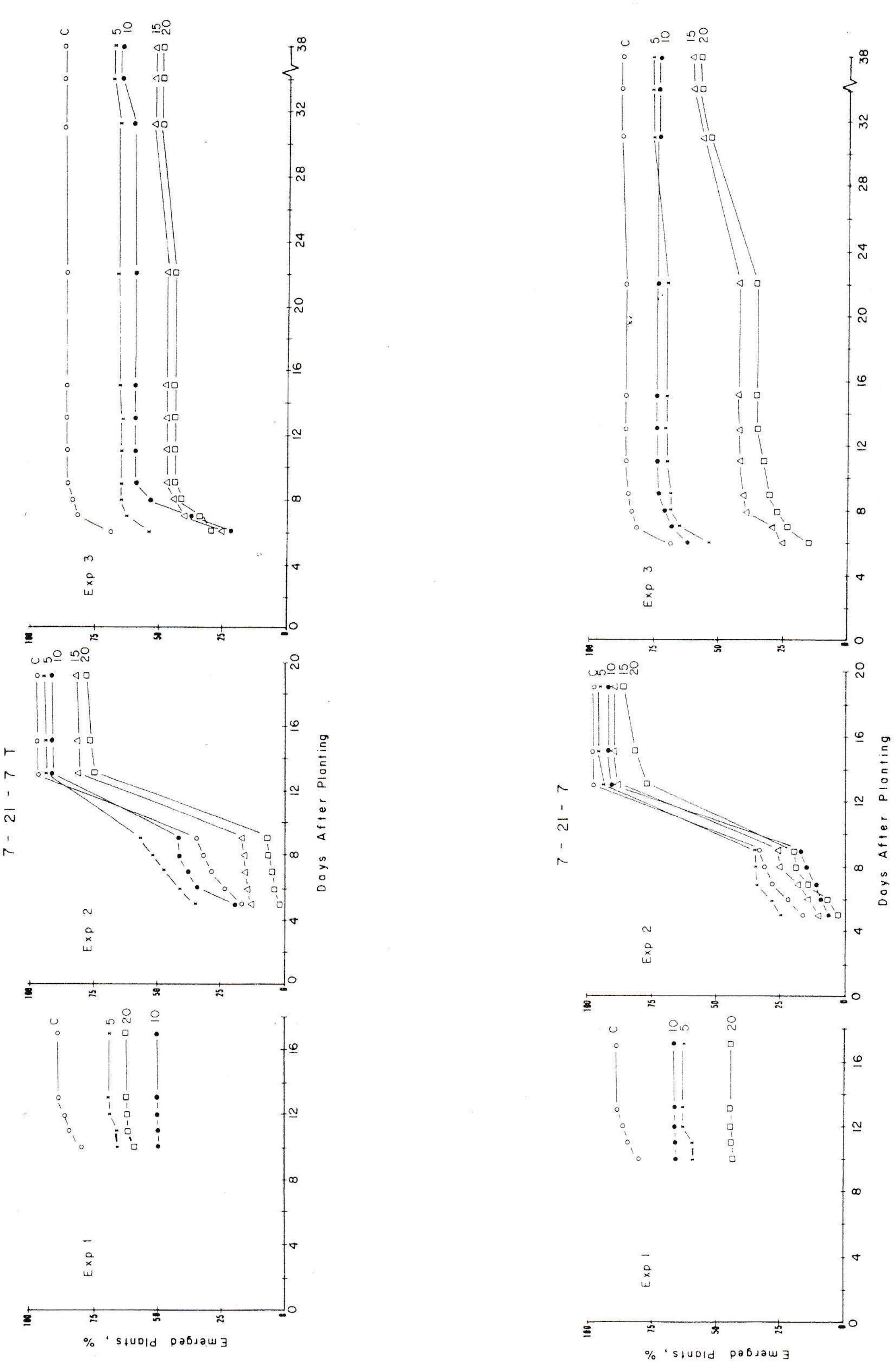

Figure 1. Emerged corn plants as affected by source, rate and time for experiments 1, 2 and 3.

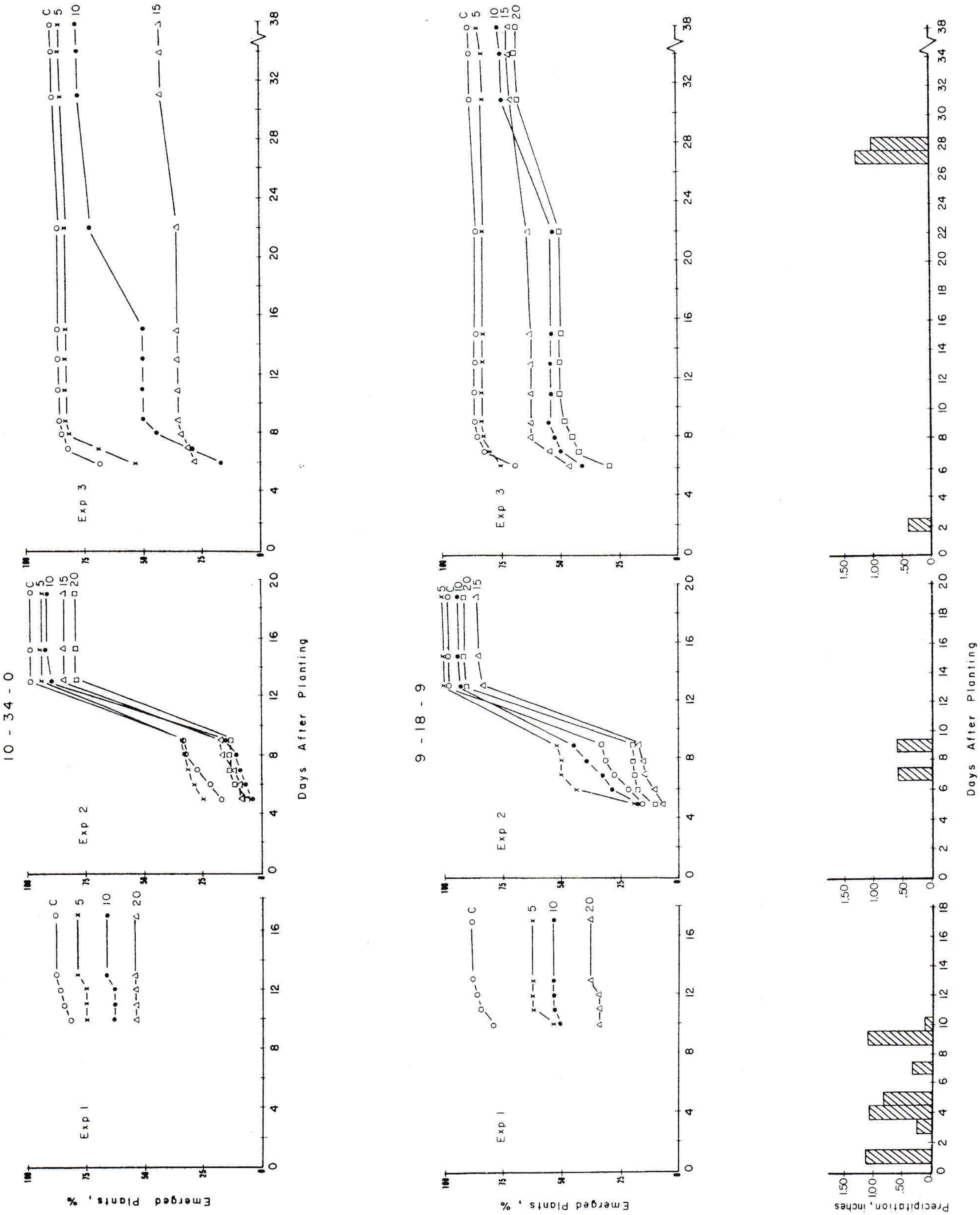

Figure 1. Continued.

Table 2. Analysis of variance of emerged plants for experiments 1, 2 and 3.

Source of variation	df	PR F	
Experiment #1 — 17 days after planting, June 25:			
Rate	2	*	
Source	3	NS	
Rate*source	6	NS	
Error	12		
Total	23		
Contrasts			
Rate linear	1	*	
Rate quadratic	1	NS	
C.V.		20	
Experiment #2 — 9 and 19 days after planting, July 4 and July 16:			
		July 4	July 16
Rep	2	*	NS
Rate	3	**	*
Source	3	NS	NS
Rate*source	9	NS	NS
Error	30		
Total	47		
C.V.		70	12
Contrasts			
Rate linear	1	**	**
Rate quadratic	1	NS	NS
Experiment #3 — 13 and 38 days after planting, Aug 6 and Aug 31:			
		Aug 6	Aug 31
Rep	2	NS	NS
Rate	3	**	**
Source	3	NS	@
Rate*source	9	NS	NS
Error	30		
Total	47		
C.V.		34	23
Contrasts			
Rate linear	1	**	**
Rate quadratic	1	NS	NS
9-18-9 vs rest	1	NS	@

**, *, @ — significant at 0.01, 0.05 and 0.10 probability levels, respectively, NS — nonsignificant

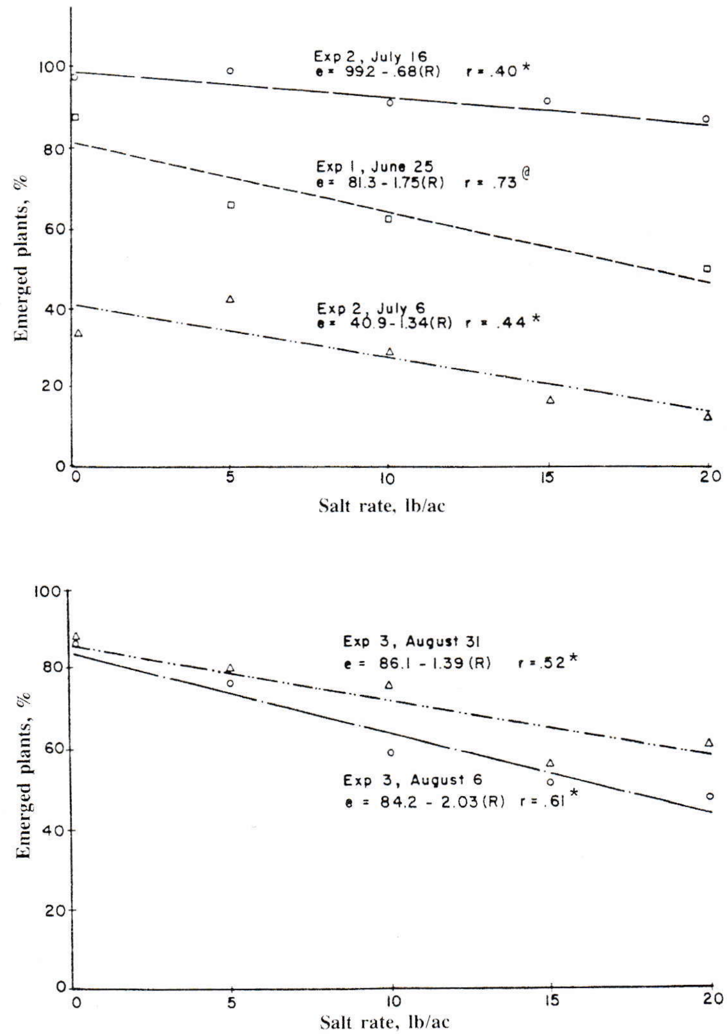

Figure 2. Percent emerged plants (average over sources) vs rate of applied salt, experiments 1, 2 and 3. * - r significant at 0.01 probability level with 58 df error. @ - r significant at 0.01 probability level with 30 df error. R = rate of applied salt.

Soil conditions for planting were improved for the second experiment (planted June 27) compared to the first experiment. No rainfall was received for seven days following planting. Consistent with the first experiment, there was no significant difference in seedling emergence among fertilizer sources nine days after planting (Table 2). However, variation was high since seedlings were still emerging. Plant emergence was significantly reduced depending on the amount of salt applied. Regression analysis indicated that plant emergence nine days after planting decreased from 41% where no fertilizer was applied to only 14% where 20 lb of salt/ac was applied (Figure 2).

Precipitation (1.09 inches) received from July 4 thru July 6 greatly changed plant emergence in the following 10 day period. Emergence increased to nearly 100% where no fertilizer was applied (Figure 2). Nineteen days after planting, seedling emergence increased to over 75% for all sources and salt rates. Fertilizer sources did not affect seedling germination (Table 2).

Precipitation did not greatly influence the relative effect that increasing salt rates had on seedling emergence since slopes relating emergence to salt rate for both nine days and 19 days after planting are surprisingly similar. One would expect precipitation to move the salt from the seed and greatly reduce or eliminate the salt effect (Figure 2). Some seeds apparently lacked moisture for germination until precipitation occurred. Salt and seed contact did not affect germination and seedling emergence as long as the seeds not yet germinated remained dry.

The third experiment was planted on July 24 in order to simulate planting conditions in dry soils. While soil temperatures were higher than spring conditions, possibly increasing salt damage, seedling emergence was more rapid, reducing salt contact time. It remained dry except for 0.35 inches of precipitation recorded two days after planting. Maximum seedling emergence was obtained at about 13 days after planting. Even without adequate precipitation to move fertilizer salts from the seed, there was no significant difference in seedling emergence among fertilizer sources (Table 2).

Once no further changes in emergence had been obtained for all treatments, an artificial watering of 1.25 inches 27 days after planting of the third experiment was applied to the entire study. The following day 0.95 inches of precipitation was recorded. Counts taken 10 days after watering showed a significant main effect of fertilizer source which was not present at any time prior to watering in experiments 1, 2 or 3. Over rates, there were significantly more newly emerged plants for 9-18-9 compared to the three other fertilizer materials. This was possibly due to the formulation of 9-18-9 which resulted in lower conductivity compared to other fertilizers of equal salt content (Table 1). The delayed seedling emergence, approximately a month after planting, was significant only for the 9-18-9, but there was a trend for this to occur with all fertilizer sources especially at the higher salt rate applications (Figure 3). Seedlings that emerge this late essentially become weeds competing for moisture and nutrients with almost no chance of reproductive development. Although the main effect of sources was not significant, it is important to note that one could apply 2.2, 3.2 and 3.4 times as much P_2O_5 using 10-34-0 at the same salt rate versus the other sources (7-21-7, 7-21-7 T, 9-18-9, respectively). It is therefore conceivable that in certain areas sufficient P fertilization could take place when applied with the seed using 10-34-0 while having no significant reduction in stands. While this study did not evaluate different planters and

Figure 3. Delayed emerged plants at high rates of salt applied with the seed.

planting depths, treatment by planting method interactions could exist due to different seed bed compaction as influenced by tillage and planter design that affect seed-fertilizer contact. In addition, one would expect to increase the probability of seed-fertilizer contact with increasing rates due to the surging flow associated with squeeze pumps. It is possible that a portion of what was measured in terms of reducing emergence with increasing rates was actually due to a greater probability of having seed-fertilizer contact.

CONCLUSIONS

In general, the effect of fertilizer salts on corn seedling emergence has been thought to be largely related to soil moisture at planting and/or whether or not adequate water is received to leach salt from the seed area thus preventing injury. The three experiments in this study had widely varying soil moisture conditions. Soil moisture at planting in the first experiment was 20% in the seed area compared to seven and five percent for the following two planting dates (Table 1). During the second experiment adequate precipitation was received after nine days to move fertilizer salts from the seed area, while inadequate precipitation was received to move fertilizer salts from the seed area in the third experiment. While the severity of the salt effect is greatest in experiment 3, and the least in experiment 2, as expected, it is surprising that the effects of salt were not greater than encountered in experiment 3 and less than found in experiment 1. The effects of the amount of salt applied on corn seedling emergence were relatively uniform considering the differences in environment in the three experiments. Even small amounts of salt (5 lb/ac) reduced final seedling emergence 9, 3 and 7 percent in experiments 1, 2 and 3, respectively. It is apparent that soil moisture at planting and especially subsequent precipitation after planting affects total germination much more than it affects germination due to applied salt (81, 99, 84 percent seedling emergence for checks, experiments 1, 2 and 3, respectively). Recommendations of 5 to 7 lb of salt (N + K_2O)/ac appear to present a relatively low risk of substantial germination injury and loss of corn stands, but rates exceeding 7 lb of salt probably will produce an unacceptable loss of corn stands unless precipitation occurs soon after planting. Seedlings may emerge, due to a late precipitation, but the contribution of such plants to grain yield will vary greatly depending on when they germinate in relation to the rest of the stand. Late germination could result in competitor plants that could reduce yields.

Fertilizer sources can potentially affect corn germination and seedling emergence differently. In this study, however, different fertilizer sources had little or no significant effect on seedling emergence. Even the inclusion of ammonium thiosulfate in 7-21-7 did not reduce seedling emergence when compared to other sources. The 9-18-9 fertilizer source, which is claimed to have less potential for inhibiting seedling emergence, was no more effective than other fertilizer sources in these studies. The summation of lb N + K_2O/ac for seed placed fertilizer was found to be an adequate index of salt tolerance regardless of fertilizer source.

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