Subtropical Plant Science, 62:38-43.2010

Effect of Starter Fertilizer Rate and Composition on Stand Establishment of Corn

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ABSTRACT

The possibility of a response to starter fertilizer would increase if the applied nutrients stimulated corn (*Zea mays* L) root growth and were associated with a relatively low fertilizer salt index. In this study to reduce the salt index, processed organic materials obtained from mined humus deposits were blended with ammonium orthophosphate fertilizers at concentrations ranging from 1.0, 1.7 and 2.4% of the total fertilizer mix. Orthophosphate concentrations (N-P_2O_5-K_2O) with the corresponding organic additives were as follows: 3-9-0 + 1.0% organic material, 5-15-0 + 1.7 % organic material and 7-21-0 + 2.4% organic material. All blended materials were compared against conventionally used ammonium polyphate (11-37-0, APP) treatment rates consisted of an untreated check (0-0-0), liquid treatment blends 3-9-0, 5-15-0 and 7-21-0 each applied at 28, 56 and 81 L/ha and containing 1.0, 1.7 and 2.4% organic material in the fertilizer mixes. All treatments were studied at two soil moisture regimes, adequate [60% of field capacity (F.C.) and low (30% of F.C.)]. Air temperature in the greenhouse was maintained at approximate levels present in adjacent fields during the first week in March, the normal planting date in the field. At 5 days after planting (DAP) and 28L/ha, the conventional starter (APP) significantly suppressed plant emergence while the 5-15-0 and 3-9-0 blends did not delay stand establishment. At 11 DAP and adequate soil moisture, all blended starter materials produced 100% emergence while the APP standard treatment resulted in a 75% stand establishment (n.s.). As soil moisture decreased, significant stand reduction occurred for all starters except 3-9-0 + 1.0% organic material. Plant shoot growth was not significantly influenced by rate and source of starter fertilizer when soil moisture was adequate but response was more variable when moisture became limiting. Root growth was greater for the 3-9-0 + 1.0% organic material than the other blended starters at adequate soil moisture. Although stand establishment was affected somewhat by starter fertilizer source and rate, these results did not translate into a positive effect on plant growth.

Additional Key Words: low-salt fertilizer, root growth, shoot dry matter, shoot growth, organic material, soil moisture

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Research results on benefits of starter fertilizer applied in the seed furrow or as a surface band above the seed furrow using standard chemical materials have been inconsistent in showing significant increases in seedling growth and yields of agronomic crops (Cahill et al., 2008; Funderburg and Burris, 1992; Guthrie, 1991; Howard et al., 1992). Other research has shown reduced stand establishment with starter materials applied in the seed furrow (Hutchinson et al., 1992). The common starter fertilizer material used in most studies has been liquid ammonium polyphosphates (APP) such as 11-37-0 or 10-34-0. Additions of certain organic materials to standard fertilizer materials during their manufacture, for the purpose of ameliorating the toxicity of fertilizer salts to germinating seed and providing positive influence on the micro-environment of the soil surrounding the seedling roots, have been suggested. This study was conducted to determine if starter fertilizer composition, application rates and seedbed soil moisture can affect rate of corn seedling emergence, shoot and root growth.

MATERIALS AND METHODS

DeKalb hybrid corn (DK-689) was grown in the greenhouse on an Orelia sandy clay loam (fine, montmorillonitic, hyperthermic Typic Ochraqualf) with soil pH 8.2; soil organic matter – 1.9%; NO_3 – 28 mg/kg (water extractable); HCO_3 – extractable P, 12 mg/kg; and exchangeable K, 340 mg/kg. The study was conducted in plastic trays which enabled row lengths of 46 cm and 19 kg of soil per tray. Seeds were planted in rows and stand counts were initiated five days after planting (DAP) and counts continued daily until 28 DAP. Plant height measurements were made at 20 DAP. To simulate field operations, all starter fertilizer applications were as solutions directly

in the seed furrow. The 12 treatments were comprised of a control (0-0-0), 7-21-0; 5-15-0 and 3-9-0 liquid blends containing correspondingly proportioned amounts of 2.4, 1.7 and 1.0% organic acid (derived from mined mineral), respectively. Each formulation was applied at 28, 56, and 84 L/ha. All treatments were arranged in a complete randomized block design with three replications. Source of P in the blends was ammonium orthophosphates. These materials were formulated by industry personnel and marketed as starter fertilizers. A conventional starter fertilizer, ammonium polyphosphate (APP, 11-37-0), was included at 28 and 56 L/ha but not 84L/ha. Soil moisture levels were maintained at 30% and 60% of field capacity (F.C., 1/3 atm tension F.C.) and are referred to as low and adequate soil moisture, respectively, throughout the experiment. Trays were individually weighed and distilled water was added to obtain predetermined weights. Air temperatures in the greenhouse were maintained at the approximate temperature levels present in adjacent fields during the first week in March. Plants were harvested at 35 DAP and roots were separated from shoots, dried in a forced draft oven and weighed. Statistical analyses including analyses of variance and separation of least squares means by least significant differences ($LSD_{0.05}$) were performed using the General Linear Models (GLM) procedure in the SAS Version 8.2 (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

At 5 DAP and adequate soil moisture at planting, the conventional starter (APP) at low rate produced a significantly lower seedling population (stand) than the three amended starter fertilizers. At the medium rate (56 L ha^{-1}), the 7-21-0 + 2.4 organic acid and the 5 -15-0 + 1.7 organic acid starters produced 44% stand relative to the non-starter control which equaled the APP starter (Fig. 1). Significantly higher relative stands were measured with the 3-9-0 + 1% organic acid at the 84 L ha^{-1} rates in comparison with conventional APP. Even at the high rate, this blended organic acid material produced 86% stand relative to the control. At low soil moisture (30% F.C.) and 5 DAP, all the starter fertilizers showed negligible seedling emergence and therefore stand data is not presented.

At 11 DAP, all amended starters produced essentially the same results showing close to 100% emergence at the higher soil moisture (Fig. 2a). However, the conventional APP formulation resulted in 76 and 58% emergence rates, respectively, for 28 and 56 ha^{-1} rates, when compared to the control. Under reduced soil moisture (30% F.C.), a significantly higher stand was recorded at 11 DAP for the 28 L ha^{-1} rates of all three blended starters when compared to the conventional APP formulation (Fig. 2b).

At 56 L/ha, APP caused severe injury to plant stand while the 5-15-0 + 1.7% organic acid starter produced a non significant (27%) higher relative seedling emergence. An impressive 90% stand relative to the control was obtained with the 3-9-0 + 1.0% organic acid starter. Even at the highest rate (84 L ha^{-1}), the blended starters with the lower analysis produced significantly better stands than the low rates of conventional APP starter. In general, lowering soil moisture at planting aggravated the adverse effects of starters on seedling emergence.

At 28 DAP and under adequate soil moisture, all three blended starters at the low, medium, and high rates of application produced 100% seedling emergence (Fig. 3a). However, differences in seedling emergence varied highly and still persisted at 28 DAP when soil moisture was reduced to 30% F.C. (Fig. 3b). The APP starter at 28 and 56 L/ha rates decreased relative emergences from 76 and 58% of control at adequate soil moisture to 27 and 30%, respectively, at the lower soil moisture. Blended starter fertilizers that caused the least damage to germinating seedlings under reduced moisture were 3-9-0 + 1.0% organic acid and 5-15-0 + 1.7% organic acid.

These data indicate conclusively that use of conventional APP applied directly in the seed furrow cannot exceed 28 L ha^{-1} if it comes in contact with the seed. Even when soil moisture is adequate this rate can cause a 25% reduction in seedling emergence. The APP starter should not be used at soil moisture levels of 30% of field capacity or less. Howard et al. (1992) also reported stand reductions when APP was placed in the seed furrow. On the other hand, orthophosphate blends with organic acid extracts (5-15-0 + 1.7%, 3-9-0 + 1% organic acid) allowed application rates as high as 84 L ha^{-1} placed in the seed furrow while maintaining 80 – 90% seedling emergence.

Plant Height. In general, at adequate soil water, all treatments produced taller plants at 20 DAP than at low soil water (Figures 4a-4b). Ammonium polyphosphate (APP, 11-37-0) produced plants with greater heights at 56 L/ha than at 28 L/ha only when adequate soil moisture was present, while at low soil moisture the higher rate had essentially no effect on plant height. No significant change in plant heights was observed among the blended sources of starter fertilizers for most rates when moisture was maintained at an adequate level. However, at the 84 L ha^{-1} starter rate of 7-21-0 + 2.4% organic acid, a significant reduction in plant height was measured as compared to the medium rate. At the lower soil water

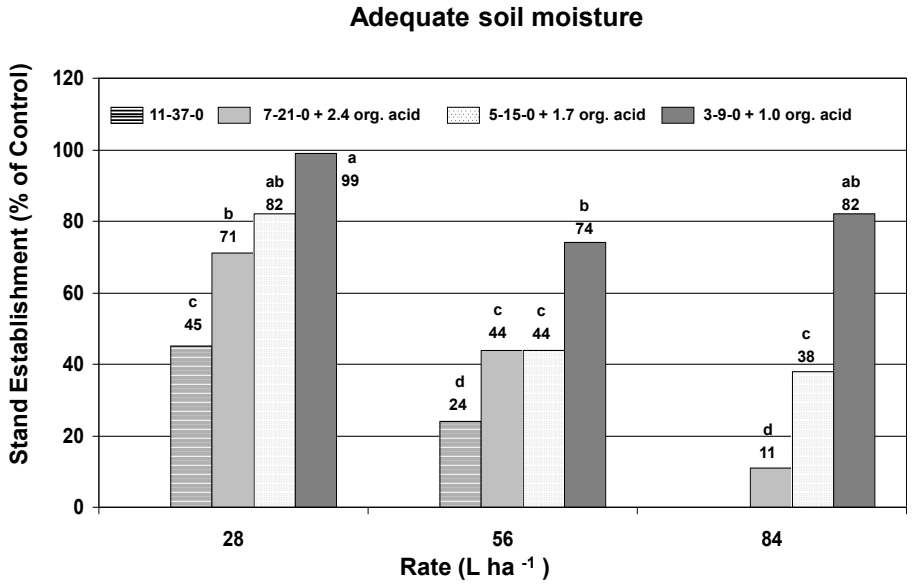

Fig. 1. Relative stand establishment at 5 days after planting as affected by source and rate of starter fertilizers at adequate soil moisture. No plant emergence measured at low soil moisture. Mean %'s with the same letter are not significantly different (P>0.05). $LSD_{0.05}$ = 24.

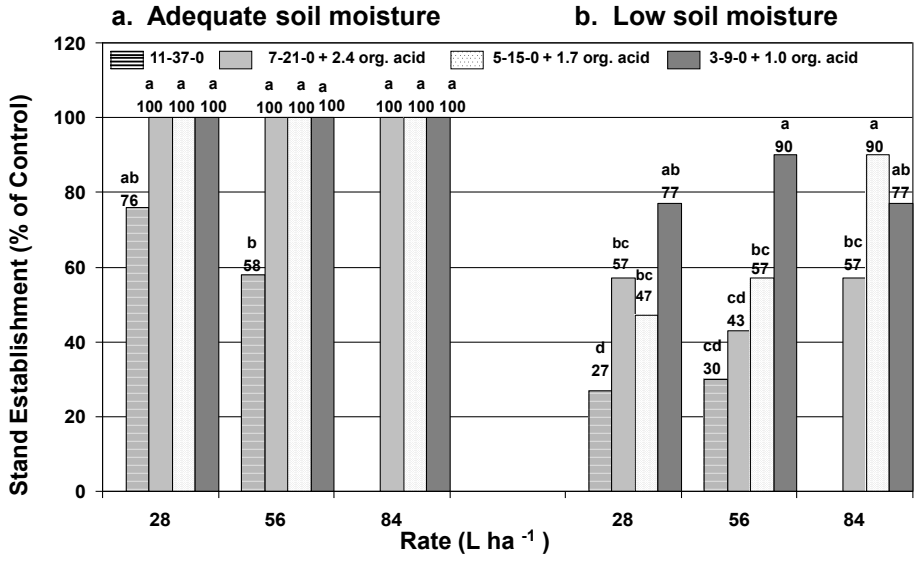

Fig 2. Relative stand establishment at 11 days after planting as affected by source and rate of starter fertilizers at a) adequate soil moisture and b) low soil moisture. Mean %'s with the same letter within soil moisture regime are not significantly different (P>0.05). $LSD_{0.05}$ = 29 and 26 for adequate and low moisture, respectively.

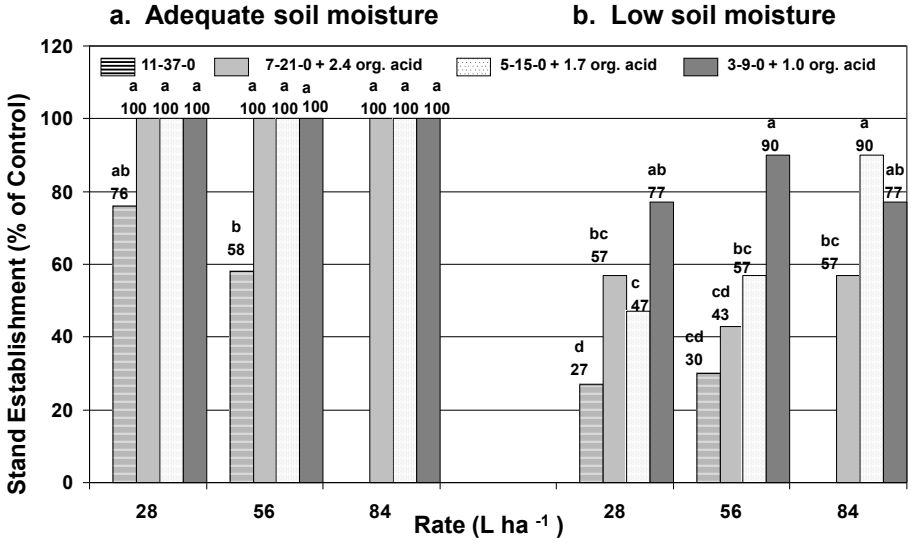

Fig. 3. Effect of composition, rates of starter fertilizers, and soil moisture at planting on relative stand establishment at 28 days after planting. Mean %'s with the same letter are not significantly different (P>0.05). $LSD_{0.05}$ = 29 and 23 for adequate and low moisture, respectively.

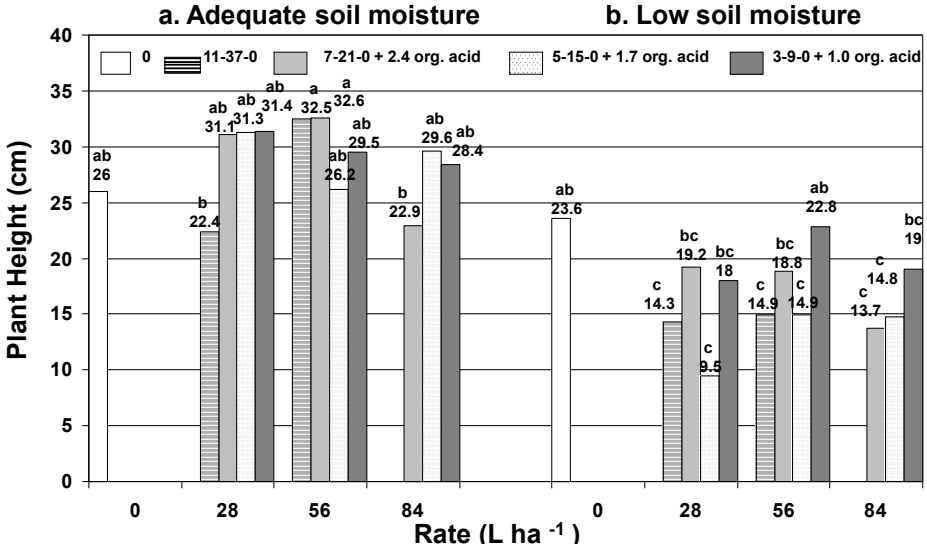

Fig. 4. Effect of composition, rates of starter fertilizers, and soil moisture at planting on plant heights at 20 DAP. Means with the same letter within soil moisture regime are not significantly different (P>0.05) $LSD_{0.05}$ = 9.2 and 5.9 for adequate and low moisture, respectively.

level, most treatments produced plants with visible symptoms of moisture stress, reduced plant heights, and erratic responses to treatments (Fig. 4b). Data showed that 56 L ha^{-1} of blended starter 3-9-0 + 1.0% organic acid increased plant height over the APP starter. Medium rates of APP 7-21-0 + 2.4% organic acid and 5-15-0 + 1.7% organic acid produced substantially shorter plants as compared to the non-starter control.

Plant Growth. Dry matter yields of plant tops and roots are presented in Figs. 5 and 6 for both levels of soil water. Data for the higher soil moisture level (Fig. 5a) show a sharp increase in shoot weights with 56 L/ ha of the conventional APP starter in comparison with 0 L/ha. While treatment differences varied, none of the three blended starters produced significantly greater shoot growth than the APP. As rates were increased to 84 L/ha, none of the blended starters showed a substantial effect on shoot weights. This agrees with the plant height data reported earlier. Although the blended starters appeared visually to produce improved seedling vigor over the standard APP starter fertilizer, comparisons with the control (no starter) showed little or no significant advantage in shoot growth from starter materials regardless of source. As expected, overall growth comparisons from starter materials under lower soil water level showed substantially lower shoot growth and less treatment response as compared to the higher soil water regime (Fig. 5b).

Dry matter yield of roots followed top growth with only a few exceptions. Data indicates that blended starters produced positive root and shoot growth responses over the conventional starter only at the lowest application rate and at adequate soil moisture levels. Basically, the zero starter treatment produced statistically nonsignificant effects on the growth of corn plants. Root growth was not enhanced by any of the starter fertilizer sources when compared to the starter control at both soil regimes. However, at the higher soil moisture level (28 L/ha of 5-15-0 + 1.7% organic acid and 3-9-0 + 1% organic acid) significantly increased root growth over the same rate of conventional APP. At the highest rate of blended starters (84 L ha^{-1}), materials with lower N-P analyses (5-15-0; 3-9-0) trended toward increased root and shoot weights. It appears that using starter fertilizers regardless of source increased the deleterious effect of moisture stress on both root and shoot growth of corn (Figs. 5; 6b).

CONCLUSIONS

All starter fertilizers had some delaying effect on corn seedling emergence with the exception of the blended 3-9-0 + 1.0% organic acid. The delay and actual reduction in seedling emergence due to starter

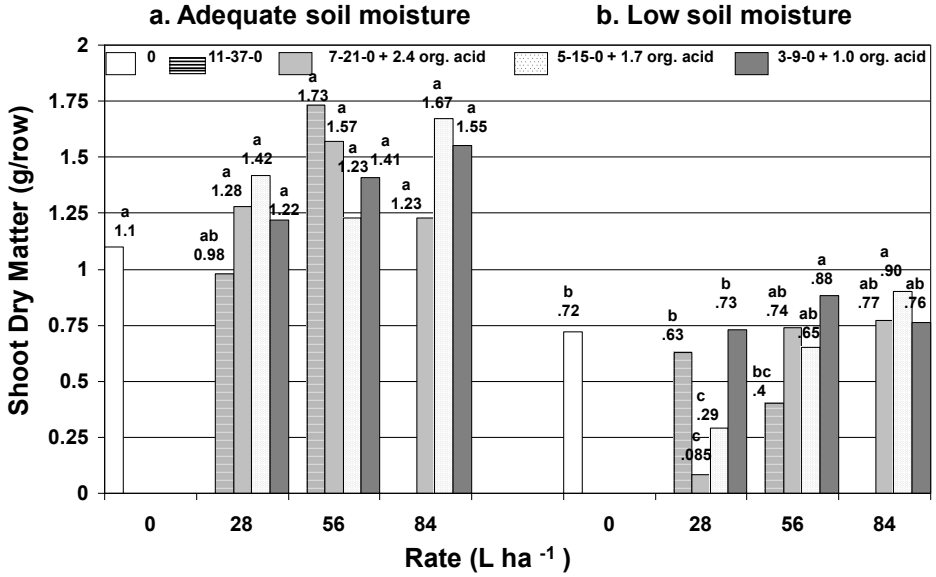

Fig. 5. Effect of composition, rates of starter fertilizers, and soil moisture on top growth of corn. Means with the same letter within soil moisture regime are not significantly different (P>0.05). $LSD_{0.05}$ = 0.64 and 0.41 for adequate and low moisture, respectively.

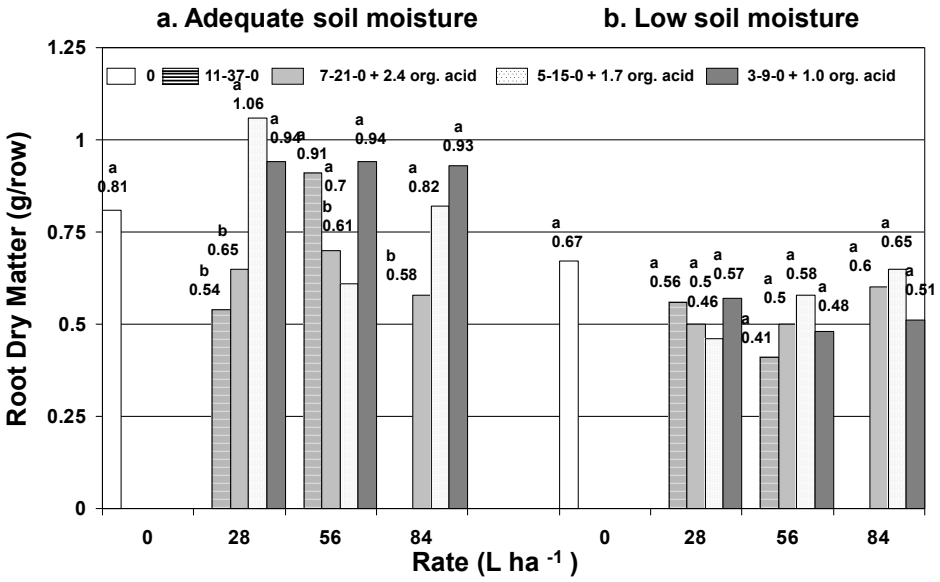

Fig. 6. Effect of composition and rate of starter fertilizers on corn seedling root growth. Means with the same letter within soil moisture regime are not significantly different (P>0.05). $LSD_{0.05}$ = 0.34 and 0.23 for adequate and low moisture, respectively.

fertilizers was definitely associated with lower soil moisture at planting. Conventional APP application even at a low rate caused drastic reduction in stand especially at low soil moisture. This study indicated that the inclusion of organic, humus type materials with orthophosphate fertilizer carrier ameliorated some of the deleterious effects and encouraged root growth as compared to the standard APP treatment but essentially had no effect on final plant growth after 35 days.

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