

Evaluation of a Calcium - Based Soil Conditioner in Irrigated Cotton

J.C. Silvertooth and E.R. Norton

Abstract

A two site evaluation of a calcium (Ca^{2+})-based soil conditioner was conducted during the 1999 cotton season. The two locations included one at the Maricopa Agricultural Center (MAC) in Maricopa, AZ and the other was on a grower-cooperator field in Tacna, AZ. Both studies involved the use of CN-9, a Ca – nitrate solution with 9% nitrogen and 11% Ca. At MAC the CN-9 solution was sprayed over the seedbed post planting but prior to the first water-up irrigation. At the Tacna site CN-9 was applied in a sidedress application at planting. Routine plant measurements were taken throughout the duration of both studies and lint yield estimates were made at each location at the end of the season. No significant differences due to the application of CN-9 were detected in any data collected.

Introduction

Soils that are high in soluble salts, and particularly those high in Na salts are very common to arid and semi-arid regions of the desert southwest. The high concentrations of soluble salts in the soil can lead to problems associated with decreased water penetration, low seedling vigor, poor stand establishment, and also unbalanced nutrient relationships. With increasing amounts of ‘prime’ farmland being taken out of production and subjected to urban development, an increasing number of acres of ‘marginal’ land consisting of Na- or salt-affected soils is being brought into production. This results in the need for more research and investigation into how these ‘marginal’ lands can be managed for profitably and sustainability.

The classical definition of a saline soils would be one with an electrical conductivity of a saturated paste extract (EC_e) greater than 4 ds m^{-1} . Saline soils with high levels of soluble salts can lead to a decrease in plant available water. Problems associated with saline soils include osmotic inhibition, wherein the osmotic potential of the soil solution is lowered to a point that the uptake of water by the plant becomes compromised possibly leading to water stress in the crop. High salt concentrations can also negatively affect seed germination for similar reasons. Saline soils are generally easier to reclaim through an adequate leaching program.

Soils that are affected with high concentrations of sodium (Na^+) salts present a different set of problems which are not so easily rectified. A sodic soil (by definition) is one that has an EC_e value of less than 4 ds m^{-1} and an exchangeable Na percentage (ESP) of greater than 15%. Soils high in Na salts commonly have decreased rates of water penetration and infiltration problems due to the dispersion of clay particles within the soil (Yousaf et.al. 1987; Amezketa and Aragues, 1995). Two primary cations that contribute to soil flocculation are Ca and magnesium (Mg^{2+}) while high concentrations of Na lead to soil particle dispersion. Sodium causes dispersion of a soil because of its large hydrated radius, as compared to Ca, Mg and potassium (K). The large hydrated radius of Na forces the clay particles apart creating a dispersed soil condition. Dispersed clay particles can be transported into pore spaces that were previously available for water penetration and infiltration. Once the soil pores are filled with the dispersed clay particles, soil surface drying can result in a crusting problem that can inhibit seedling emergence and growth. Sodic conditions cannot be corrected with additional irrigation (leaching) applications alone, in fact, the problem may be exacerbated by applying additional water, particularly if it has a high Na concentration. Leaching a sodic soil can remove the divalent cations Ca^{+2} and Mg^{+2} from the soil leaving a high proportion of Na. In order for a sodic soil to be reclaimed, the Na must be first displaced from the soil colloid. There are several techniques that can

be employed to accomplish this task. One approach involves the use of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Gypsum tends to increase the levels of Ca in the soil that can then exchange with the Na creating Na sulfate (Na_2SO_4), which is mobile and can be leached from the soil. The addition of Ca lowers the sodium adsorption ratio (SAR) and contributes to the exchange and removal of Na.

Another common treatment of sodic soils is the addition of elemental sulfur (S). Elemental S, when oxidized by soil microbes and combined with water, reacts to form sulfuric acid (H_2SO_4), which reacts with naturally occurring Ca carbonate (CaCO_3), releasing “free” Ca^{2+} . This Ca^{2+} in the soil solution can then exchange for Na^+ in the form of Na_2SO_4 , which can be leached from the soil. Sulfuric acid (H_2SO_4) can also be added to the irrigation water directly. Sulfuric acid applications to irrigation water also counteracts the corrosive effects of bicarbonate (HCO_3^-). When adding elemental S or H_2SO_4 , not only can Na be converted to a leachable form but the pH of the soil is also lowered via the release of hydrogen (H^+) into the soil.

Along with the conventional methods of treating sodic and saline conditions, there has been an increasing emergence of numerous synthetic water-soluble polymers (WSP's). The WSP's include polyacrylamide (PAM), polyvinyl alcohol (PVA), polymaleic anhydride (PMA), and polysaccharides. Research studies have shown that these synthetic polymers have reduced soil surface crusting (Helalia and Letey, 1989; Wood and Oster, 1985; Terry and Nelson, 1986), improved water holding capacity (Nimah et al., 1983; Shanmuganathan and Oades, 1982; Woodhouse and Johnson, 1991), improved aggregation and reduced clay dispersion (Aly and Letey, 1988), enhanced nutrient uptake by crops (Fuller et al., 1953) and enhanced ability for reclamation of saline and sodic soils (Wallace et al. 1986a). However, they do not impart an exchange for Na on the soil adsorption complex.

Over the recent years there have been several commercially available Ca bearing products have become available for a potential treatment of sodic soil conditions. These products include CAN-17 (17-0-0-24Ca), N-CaI[™] (18-0-0-6Ca), and CN-9 (9-0-0-11Ca) just to name a few. These products contain a plant available form of N and Ca that are in a water-soluble form. These products can be applied through the irrigation water, sprayed directly to the soil surface, or injected into the soil. The materials are designed to serve as a Ca source and displace Na on the soil colloids, thus allowing the Na to be leached from the soil. However, these types of products have been inconclusive in terms of lowering ESP in sodic soil environments where high levels of total and exchangeable Ca are already present (Griffin et al., 1998 and Griffin et. al., 1999). However, there may be some advantage to the use of water-up applications of these products in promoting early seedling vigor due to movement of Na^+ away from the seedling by Ca^{2+} (Griffin et al., 1997; and Griffin et al., 1998).

The objectives for this set of experiments were to further evaluate the effects of CN-9 applied prior to planting on soil conditions, subsequent crop growth and development, and ultimately final yield.

Materials and Methods

A study was conducted in 2000 at the University of Arizona Maricopa Agricultural Center (MAC). General agronomic information regarding the MAC study is presented in Table 1. The experimental design employed at MAC was a randomized complete block design consisting of three treatments (Table 2) and ten replications. Each plot was 30 feet in length and four, 40 inch rows in width. Treatments were applied as a liquid (CN-9) spray over the top of the bed just prior to the initial water-up irrigation. All other agronomic practices were carried out in an optimal fashion through the duration of the study. Plants were monitored during the season and routine plant measurements were collected which included plant height, total mainstem nodes, position of first fruiting branch, number of aborted or missing sites on positions one and two, nodes above white flower, flowers per unit area, and canopy closure. Lint yield estimates were calculated by harvesting the center two rows of each four-row plot. Lint yield data was then subjected to analysis of variance as outlined by the Steel and Torrie (1980) to determine if any significant differences were found due to CN-9 applications.

Results and Conclusions

Results from the MAC location showed no significant differences ($P \leq 0.05$) due to the application of CN-9 to the seedbed prior to the initial water-up irrigation. Plant measurement results indicate very little differences among the three treatments with respect to either the height to node ratio which is an indication of crop vigor, and fruit retention which is an indication of the boll load on the plant (Figure 1). This result was also confirmed with the resultant lint yield estimates for each treatment (Table 3). Lint yields ranged from just over 1000 lbs. lint per acre to around 1075 lbs lint per acre with no distinct trends among the treatments. The analysis of variance resulted in an observed significance level (OSL) of 0.5678 which is not significant. The coefficient of variation (CV), a general measure of experimental variability, was only 14%, which for a small plot study is relatively good.

References

- Amezketta, E., and R. Aragues. 1995. Hydraulic conductivity, dispersion, and osmotic explosion I arid-zone soils leached with electrolyte solutions. *Soil Sci.* 159:287-293.
- Aly, S.M., and J. Letey. 1988. Polymer and water quality effects on the flocculation of montmorillonite. *Soil Sci. Soc. Am. J.* 52:1453-1458.
- Flocker, W.J., and W.H. Fuller. 1956. Availability of Calcium in Calcareous Soils. *Soil Sci. Soc. Am. J.* 387-391.
- Fuller, W.H., N.V. Gomness, and L.V. Sherwood. 1953. The influence of soil aggregate stabilizers on stand, composition, and yield of crops on calcareous soils of southern Arizona. *University of Arizona Tech. Bull.* 129.
- Griffin, J.R., J.C. Silvertooth, and E.R. Norton. 1997. Evaluation of calcium soil conditioners in an irrigated cotton production system. . *Cotton, Univ. of Arizona Rep.* P-108. P. 408-421.
- Griffin, J.R., J.C. Silvertooth, and E.R. Norton. 1998. Evaluation of calcium soil conditioners in an irrigated cotton production system, 1997. *Cotton, Univ. of Arizona Rep.* P-112. P. 517-539.
- Griffin, J.R., and J.C. Silvertooth. 1999. Evaluation of A Foliar Applied Seed Bed Calcium Soil Conditioner in an Irrigated Cotton Production System, 1998. *Cotton, Univ. of Arizona Rep.* P-116. P. 275-289.
- Helalia, A.M., and J. Letey. 1989. Effects of different polymers on seedling emergence, aggregate stability, and crust hardness. *Soil Science.* 148:199-203.
- Nimah, M.N., J. Ryan, and M.A. Chaudhry. 1983. Effect of synthetic conditioners on soil water retention, hydraulic conductivity, porosity, and aggregation. *Soil Sci. Soc. Am. J.* 43:742-745.
- SAS Institute. 1988. SAS/STAT:Procedures. Release 6.03 ed. SAS Inst., Cary, NC.
- Shanmuganathan, R.T., and J.M. Oades. 1982. Effect of dispersible clay on the physical properties of the B horizon of a red-brown earth. *Aust. J. Soil Res.* 20:315-324.
- Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York.
- Terry, R. E., and S.S. Nelson. 1986. Effects of polyacrylamide and irrigation method on soil physical properties. *Soil Science.* 141:317-320.
- Wallace, A., and G.A. Wallace. 1986a. Effects of soil conditioners on emergence and growth of tomato, cotton, and lettuce seedlings. *Soil Science* 141:313-316.
- Wood, J.D., and J.D. Oster. 1985. The effect of cellulose xanthate and polyvinyl alcohol on infiltration, erosion, and crusting at different sodium levels. *Soil Sci.* 139:243-249.

Woodhouse, J., and M.S. Johnson. 1991. Effect of superabsorbent polymers on survival and growth of crop seedlings. *Agric. Water Manag.* 20:63-70.

Yousaf, M., O.M. Ali., and J.D. Rhoades. 1987. Clay dispersion and hydraulic conductivity of some salt-affected arid land soils. *Soil Sci. Soc. Am. J.* 51:905-907.

Table 1. General agronomic information for CN-9 study conducted at Maricopa Agricultural Center, 2000.

Variety	DP 33B
Planting Date	4 April
Treatment Application Date	13 April
Termination Date	5 August
Harvest Date	4 October

Table 2. Outline of treatments for the CN-9 study conducted at the Maricopa Agricultural Center, 2000.

Treatments	CN-9 Applied gal/acre	N Rate lbs. /acre	Ca Rate lbs. /acre
1	0	0	0
2	12	13.2	15
3	15	16.5	24

Table 3. Yield results for the CN-9 study conducted at the Maricopa Agricultural Center, 2000.

Treatments	Yield (lbs lint/acre)	Micronaire
3	1422 a*	53
1	1421 a	52
2	1319 a	51
LSD¶	NS	
OSL†	0.5567	
C.V. (%)‡	18.98	

*Means followed by the same letter are not significantly different according to a Fisher's LSD means comparison test

¶ Least Significant Difference

† Observed Significance Level

‡ Coefficient of Variation

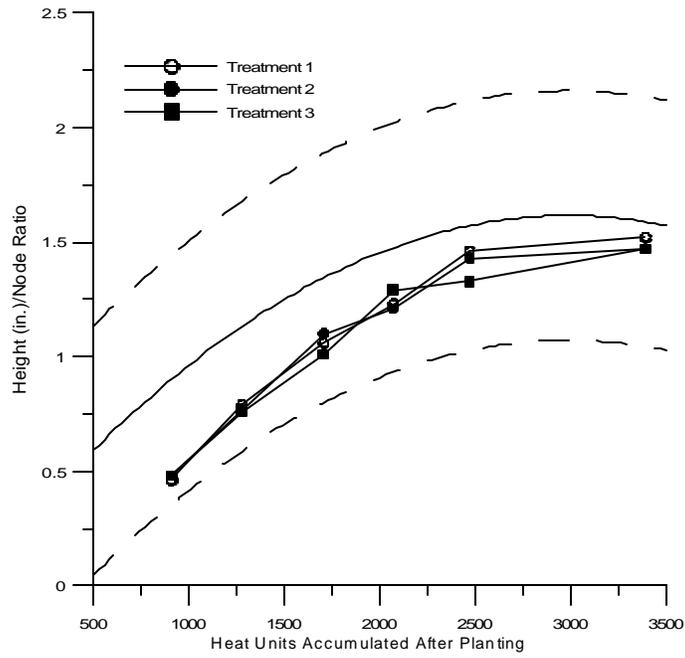
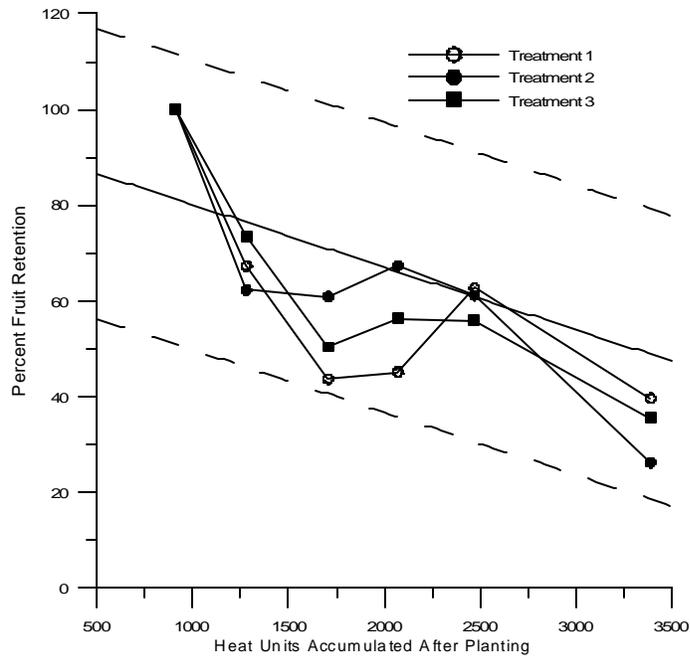


Figure 1. Percent fruit retention and height to node ratio results for the CN-9 study, Maricopa, AZ, 2000.