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NOTE

# YIELD AND NITROGEN UPTAKE OF SOYBEANS AND SAFFLOWER PLANTS GROWN ON ALKALINE SOIL AS AFFECTED BY IRON CHELATE, CCC AND NITROGEN[1]

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**Abstract** – An experiment was conducted to investigate the effects of two nitrogen fertilizers, iron chelate (138 Fe) and 2-chloroethyl trimethylammonium chloride (CCC) on the chlorosis and nitrogen content of a local cultivar of soybean (*Glycine max* L.) and safflower (*Carthamus tinctorium* L.), cultivar Gila, seedlings. Nitrogen as calcium nitrate or ammonium sulfate was applied at rates of 0, 0.6 and 1.2 g/pot.

Soybeans showed chlorosis only with calcium nitrate which was associated with reduced dry matter production. Chlorosis was prevented by application of 135 Fe chelate but not with CCC. The only measured affect of CCC application was an increase in nitrogen content of soybean leaves.

Calcium nitrate increased the dry matter production and nitrogen content of safflower seedlings, while ammonium sulfate increased the dry matter production. Application of CCC to safflower did not affect plant height.

## INTRODUCTION

Lime-induced Fe chlorosis has been recognized in a wide range of horticultural and field crops in the region of Isfahan. The effect of N fertilization, Fe chelate and CCC in treating Fe chlorosis in periwinkle (*Vinca minor* L.) plants grown on the alkaline soil of Isfahan, was reported by Farrahi-Aschtiani [6].

Uptake and translocation of iron has been shown to have a genetic basis in soybeans [14] and iron content of soybean seed has an effect on the early growth characteristics of this plant [1, 2, 3]. The effect of iron on nitrogen metabolism of plants has been reported by others [8, 9, 13].

This research was designed to study the effect of an iron chelate (138 Fe), CCC and nitrogen fertilization by calcium nitrate and ammonium sulfate, on iron deficiency of soybean and safflower seedlings grown in a calcareous soil which had previously exhibited iron chlorosis in soybean seedlings. The nitrogen content and yield of dry matter of all treatments combination are compared.

## MATERIALS AND METHODS

Two experiments were conducted in clay pots with a calcareous soil (pH 8.0) near Isfahan in which lime-induced chlorosis had been previously observed. The soil was mixed

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with sand at a soil 9:1 sand ratio (for experiment No. 1) and soil 6:1 sand ratio (for experiment No. 2) to improve the physical properties. Because the pots were not of uniform size, in the experiment using calcium nitrate each pot was filled with 5 kg soil–sand mixture and in the experiment involving ammonium sulfate 6 kg/pot was used.

Each pot received 1 g of P as superphosphate (46% $P_2O_5$) and 0.5 g of K as potassium sulfate (50% $K_2O$). Nitrogen was applied at two levels of 0.6 and 1.2 g per pot as either calcium nitrate or ammonium sulfate. The calcium nitrate was applied as solution to the soil surface 25 days after seedling emergence, while the ammonium sulfate was mixed with the soil.

Soybeans (*Glycine max* L. a local cv.) and safflower (*Carthamus tinctorius* L. cv. Gila) were grown in the pots which were placed outdoors at a temperature range of 18–33°C.

Fifteen seeds were planted in each pot and after 23 days, the seedlings were thinned to 3 plants/pot. When the seedlings were 25-days old, either 250 mg Fe chelate (138 Fe) or 400 mg CCC as cycocel were applied in solution to the soil surface. Each treatment had four replications, and the seedlings were harvested after 47 days.

The second experiment with safflower was conducted in a greenhouse with a day mean temperature of 23°C and a night mean temperature of 17°C. Each pot received 3.5 kg soil–sand mixture and 0.5 g of P as superphosphate.

Fifteen seeds of safflower were sown in each pot and thinned to six plants/pot after 20 days. Some pots then received 1 g of N (either calcium nitrate or ammonium sulfate) applied as a soil drench when the seedlings were 20 days old (27 days after sowing), and at the same time CCC solution was applied, either to the soil (200 mg CCC/pot) or as a leaf spray (1000 ppm CCC solution); again each treatment was replicated four times. Plant height was measured from the soil surface and the seedlings were harvested after 54

Table 1. Dry weight and N uptake of soybean seedlings, as affected by 138 Fe chelate, CCC and rate and source of nitrogen

| | Source of N | | | |
|---|---|---|---|---|
| | Calcium nitrate | | Ammonium sulfate | |
| Treatment | Dry wt of shoots (g/plant) | N uptake (mg/plant) | Dry wt of shoots (g/plant) | N uptake (mg/plant) |
| Control | 1.4* | 38 | 1.4* | 39 |
| Fe chelate | 1.6 | 45 | 1.6 | 50 |
| CCC | 1.3* | 42 | 1.3* | 49 |
| 0.6 gN | 1.0* | 45 | 1.6 | 44 |
| 0.6 gN+Fe chelate | 1.8 | 55 | 1.7 | 54 |
| 0.6 gN+CCC | 0.9† | 37 | 1.5 | 55 |
| 0.6 gN+Fe chelate+CCC | 1.7 | 58 | 1.5 | 57 |
| 1.2 gN | 1.0† | 39 | 1.7 | 61 |
| 1.2 gN+Fe chelate | 1.6 | 59 | 2.0 | 71 |
| 1.2 gN+CCC | 0.9† | 36 | 1.3 | 55 |
| 1.2 gN+Fe chelate+CCC | 1.6 | 55 | 1.8 | 69 |
| LSD, 0.05 | 0.2 | 4.7 | 0.2 | 5.5 |

* Mild chlorosis

† Severe chlorosis

days. The shoots were dried to constant weight at 70°C and then ground in a stainless Wiley mill.

The total nitrogen in the plant tissue was determined by a micro-Kjeldahl method using the Technicon Autoanalyzer [12].

## RESULTS AND DISCUSSION

Application of calcium nitrate increased leaf chlorosis in soybean seedlings while ammonium sulfate prevented it. Safflower seedlings showed no chlorosis.

Calcium nitrate alone or with CCC decreased dry matter yield of seedlings, but this character increased when calcium nitrate was used with either 138 Fe chelate or 138 Fe chelate plus CCC (Table 1). The lowest dry weight occurred with calcium nitrate plus CCC.

Addition of iron alone or in combination with N, significantly increased N uptake by soybean. The increase of N uptake by Fe application may be related to higher yields resulting from correction of Fe deficiency. The decrease in dry weight by calcium nitrate and CCC indicated that CCC could not prevent iron chlorosis in soybean seedlings. Reduction in dry weight with calcium nitrate alone or calcium nitrate with CCC is due to Fe chlorosis at the early seedling stage, probably as a result of an increase in pH of the plant tissue; which would affect the physiological function of Fe in the plant [4, 11]. The application of ammonium sulfate (1.2 g N/pot) alone or with 138 Fe chelate, increased soybean dry weight significantly, whereas the effect of ammonium sulfate plus CCC was not significant. Application of Fe chelate, CCC and ammonium sulfate alone or as a combination of ammonium sulfate with Fe chelate of CCC increased N uptake in soybean plants.

Since the availability of Fe increases as the soil pH decreases, the observed reduction in chlorosis may be due to the decrease in pH caused by the ammonium sulfate as an acid

Table 2. Dry weight and N uptake of safflower seedlings, as affected by Fe chelate, CCC and rate and source of nitrogen

| | Source of N | | | |
|---|---|---|---|---|
| | Calcium nitrate | | Ammonium sulfate | |
| Treatment | Dry wt of shoots (g/plant) | N uptake (mg/plant) | Dry wt of shoots (g/plant) | N uptake (mg/plant) |
| Control | 2.1 | 38 | 1.9 | 37 |
| Fe chelate | 2.3 | 40 | 2.1 | 44 |
| CCC | 2.1 | 38 | 2.2 | 49 |
| 0.6 gN | 2.8 | 59 | 2.2 | 45 |
| 0.6 gN+Fe chelate | 2.6 | 61 | 2.5 | 54 |
| 0.6 gN+CCC | 2.6 | 56 | 2.3 | 50 |
| 0.6 gN+CCC+Fe chelate | 2.5 | 56 | 2.4 | 54 |
| 1.2 gN | 2.6 | 56 | 2.5 | 50 |
| 1.2 gN+Fe chelate | 2.5 | 59 | 2.9 | 60 |
| 1.2 gN+CCC | 2.5 | 59 | 3.1 | 62 |
| 1.2 gN+Fe chelate+CCC | 2.3 | 54 | 3.1 | 64 |
| LSD, 0.05 | 0.4 | 5.9 | 0.3 | 4.8 |

Table 3. Height, dry weight and N uptake of safflower seedlings, as affected by CCC and two nitrogen sources

| Treatment | Plant height (cm) | Dry wt of shoots (g/plant) | N uptake (mg/plant) |
|---|---|---|---|
| Control | 34 | 1.5 | 35 |
| CCC (soil application) | 36 | 1.6 | 39 |
| CCC (leaf application) | 38 | 1.9 | 45 |
| Ammonium sulfate | 38 | 1.8 | 53 |
| Ammonium sulfate+CCC (soil application) | 35 | 1.8 | 54 |
| Ammonium sulfate+CCC (leaf application) | 36 | 1.8 | 53 |
| Calcium nitrate | 37 | 2.0 | 53 |
| Calcium nitrate+CCC (soil application) | 33 | 1.5 | 45 |
| Calcium nitrate+CCC (leaf application) | 37 | 1.8 | 50 |
| LSD, 0.05 | 2.7 | 0.2 | 3.7 |

producing fertilizer.

It has also been suggested that $NH_4^+$ ions may increase the availability and stability of $Fe^{2+}$ ions; this may also have reduced chlorosis because of the role of ferrous ions in chlorophyll synthesis [10].

Addition of 138 Fe chelate and CCC increased dry matter yield of safflower with both types of N fertilizers, especially with the higher rate of ammonium sulfate (Table 2).

Increase in the N uptake through application of 138 Fe chelate was not significant, but the combined effect of N with either 138 Fe chelate or CCC significantly increased the N uptake.

Application of CCC to safflower leaves did not have the usual dwarfing effect (Table 3). The tallest plants resulted with CCC applied as a leaf spray and the shortest with calcium nitrate plus CCC applied to the soil.

Slight increases in seedling height and dry matter yield were observed when CCC was applied to the leaves of safflower. An increase in N uptake when CCC was applied alone or with both N fertilizers may be due to an improved N utilization in the CCC-treated seedlings. Similar findings were obtained by Farrahi-Aschtiani [5] and Jung and El-Fouly [7] who reported an increase in N content of wheat (*Triticum aestivum* L.) seedlings treated with CCC.

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