

The effects of Copper levels and Nitrogen sources on nodulation, dry matter yield, Copper and Nitrogen contents of Vicia faba under greenhouse condition.

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Summary

A pot experiment was conducted in a greenhouse, at Heliopolis - Egypt, using a loamy sand soil deficient in Nitrogen and Copper to study the effect of various levels of Cu and different nitrogen sources on nodulation, dry matter yield, Cu and nitrogen content of Vicia faba.

The sources of nitrogen used were $\text{Ca}(\text{NO}_3)_2$, NH_4Cl and NH_4NO_3 , applied in amounts necessary to establish 120 ppm of soil nitrogen and using a control (0 ppm N). Copper was applied as copper sulphate to give soil Cu levels of 0, 5, 10 and 20 ppm.

Dry matter yields, N and Cu concentrations in shoots and roots and available soil N after harvest of the plants, followed the order $\text{Ca}(\text{NO}_3)_2 > \text{NH}_4\text{NO}_3 > \text{NH}_4\text{Cl}$. Up to a level of 5 ppm Cu, the dry matter yields of shoots and roots increased, but decreased at higher levels of Cu. Increasing Cu levels significantly decreased the available soil nitrogen after harvest and also the concentration of N in the plants. At the same time Cu concentration in shoots and roots was increased. Thus, these two elements were found to have an antagonistic effect on each other's concentration in the plants.

Introduction

Among various factors contributing to plant growth, nutrient availability plays a vital role, however, these may interact synergistically or antagonistically either in soil, in plant or at absorption sites (Gupta and Ramkala, 1980). Copper and nitrogen both of which are essential nutrient for plants and animals find an important place in the use of micro-nutrients for increasing legume production.

Mineral nutrition of many legumes have received much attention. Its response to the essential elements are well known and deficiency symptoms have been comprehensively described and illustrated by many authors (Greenwood and

Hallsworth, 1960; Hallsworth et al. , 1964; Gartwright and Hallsworth, 1970; Gupta and Mehla, 1970 and Gupta and Ramkala, 1980) . While mineral nutrition of cereals (Tills and Alloway, 1981; Cheshire et al; 1982 and Antil et al, 1988) and wheat (Morad, 1986; Gardner and Flynn, 1988; Hargrove et al, 1988 and Kumar et al, 1990) have also been investigated .

Different sources of nitrogen have been reported to behave differently in affecting plant Yield and the superiority of nitrate over ammonium as a source of N for maize and wheat has been reported by several workers (Cox and Reinenauer, 1973, Hargrove et al, 1988 and Kumar et al, 1990). On the contrary, Sing and Sing (1975) have reported that different sources of N behaved similarly in their effect on wheat yield. Since N is applied as nitrate, ammonium and both nitrate and ammonium combined these forms of N are supposed to behave differently as far as their effect on crop yield and contents of N and Cu are concerned (Kumar et al, 1990).

Materials and Methods

The experiment was conducted in 25 cm diameter plastic pots. The pots were filled with 4 Kg soil collected from cultivated area near Heliopolis. The soil was loamy sand in texture with pH 8.3, Ec 0.065, organic matter 1.05%, available N 0.07% and available Cu 0.36 ppm.

The treatments consisted of three forms of N, $\text{Ca}(\text{NO}_3)_2$, NH_4NO_3 applied either at 120 ppm or 0 ppm N (control), Copper was applied at 0, 5, 10 and 20 ppm as copper sulphate this constituted sixteen treatments, replicated 3 times in completely randomised block design. Eight seeds of Vicia faba Giza var. 2 were sown in each pot after thoroughly mixing with Rhizobium leguminosarum specific to Vicia faba plant. Seedlings after germination were thinned to four healthy plants which were grown for 60 days. At harvest, shoots and roots were collected separately. The samples were washed with running water several times. Samples were first dried in air then in an oven at 65°C and the dry weights were recorded. The plant samples were ground in a stainless steel grinder and analysed for N and Cu . Nitrogen in the samples and soil was determined by the microkjedahl method and Cu by atomic absorption spectrophotometry.

Results :

Dry matter yield of shoots and roots

The effects of the treatments on the growth and dry matter yield of roots and shoots are given in Table (1) and Fig (1). $\text{Ca}(\text{NO}_3)_2$ gave the greatest dry matter yield either in shoots or roots while NH_4Cl gave the least one. It was found that low Cu level (5 mM) significantly increased dry matter yield but higher levels decreased it (10 & 20 mM). Increase in dry matter yield due to Cu application occurred because the soil was deficient in Cu. The effect of different nitrogen sources on dry matter yields of shoot and root of plant followed the order $\text{Ca}(\text{NO}_3)_2 > \text{NH}_4\text{NO}_3 > \text{NH}_4\text{Cl}$. Superiority of NO_3 over NH_4 containing sources indicated the preferential absorption of NO_3 over NH_4 by the plant.

Interactions of N sources and Cu levels Fig (1) indicated that the dry matter yields of roots with applications of 5 ppm Cu increased by 46.15, 44.44 and 33.33 percent in $\text{Ca}(\text{NO}_3)_2$, NH_4NO_3 and NH_4Cl treated pots respectively. Further applications up to 20 ppm Cu decreased the yields when $\text{Ca}(\text{NO}_3)_2$ and NH_4Cl were the N sources, whereas there was no significant decrease in the NH_4NO_3 treatment. On the other hand at 0 ppm N, the dry matter of root yield was not significantly affected by Cu levels up to 10 ppm although 20 ppm Cu decreased it significantly over the 0 ppm Cu treatment. Thus highest dry matter yield was obtained with $\text{Ca}(\text{NO}_3)_2$ at 5 ppm Cu level and lowest dry matter yield in NH_4Cl at 20 ppm Cu treated pots.

Plant nitrogen concentration

Nitrogen application increased the concentration of N in shoots and roots Fig. (2) and Table (2). The concentration of N was significantly affected by N sources. The increase of N content in shoots over 0 ppm N (control) was 101.95, 54.63 and 50.73 percent due to application of 120 ppm N as $\text{Ca}(\text{NO}_3)_2$, NH_4NO_3 and NH_4Cl , and 125.47, 104.45, 97.45 percent in roots respectively. Application of 5, 10 and 20 Cu ppm decreased the concentration of nitrogen compared with 0 ppm Cu treatment by 5.93, 10.97, 13.64 in shoot and 4.07, 5.55, 7.40 in root respectively. It indicated that Cu had an antagonistic effect on the concentration of N in plants.

Plant copper concentration

The effect of three nitrogen sources on copper uptake is shown in Fig(3) and Fig(4). This shows that the source of nitrogen affected the copper concentration being

greatest in the nitrate supplied plant and least in the ammonium supplied plants, irrespective of the level of copper supplied. A similar pattern was found in the roots. The roots were found to accumulate a larger concentration of copper than the shoots, the difference being more marked where copper was supplied. Copper concentrations were about two times higher in roots than in shoots at 0 ppm Cu and at applications of 5, 10 and 20 ppm Cu, roots had about more than ten times Cu than shoots.

Available N in soil after harvest

Nitrogen application increased the available N content of soil analysed after the harvest of the plant. Among the N treatment, highest available nitrogen was found with $\text{Ca}(\text{NO}_3)_2$, followed by NH_4NO_3 and NH_4Cl treatment (Fig 5). Copper application decreased the available N content in soil. With no added N, application of 10 and 20 ppm Cu decreased the available N significantly as compared to 0 ppm Cu. However, there were no significant differences in the 10 and 20 ppm Cu treatments.

Discussion

Yield response of a plant to the supply of a given element may depend on the levels of other nutrient available, and many interactions of one nutrient on another have been reported (Greenwood and Hallsworth, 1960). It is not always possible from the information given to propose a mechanism for these, since the interaction may simply be an indirect effect of altered growth rate (Greenwood and Hallsworth, 1960).

This study was undertaken to evaluate the effect of copper levels and nitrogen sources on dry matter yield, Cu and N content of faba. However, limited work, as far as the author is aware, has been done on copper-nitrogen relationship on this legume. This stimulated interest to throw some light upon these aspects.

The obtained data illustrated that application of N (120 ppm) as $\text{Ca}(\text{NO}_3)_2$, NH_4Cl and NH_4NO_3 increase dry matter yields of plant shoots and roots. However, the increase was more pronounced in case of $\text{Ca}(\text{NO}_3)_2$ than in NH_4NO_3 and NH_4Cl treatments. This might be due to the preferential absorption of NO_3 over NH_4 by plant. Increase in dry matter yields in wheat shoots and roots by application of different nitrogen sources was however postulated by several authors (Kumar et al., 1990; Cox and Reisenauer, 1973 and Hargrove et al., 1988). These authors found that $\text{Ca}(\text{NO}_3)_2$ was a better source of N for wheat than other fertilisers.

Dry matter yield of shoots and roots of faba plant without application of N (0 ppm N) was found relatively high (Table 1 and Fig 1). As faba is a leguminous plant, relative high N concentration at 0 ppm N was due to nitrogen fixation process. Data obtained by Kumar et al. (1990) on wheat revealed relatively low N concentration in shoots and roots cells without nitrogen application and consequently noticeably low dry matter yield. As wheat is non leguminous plant, it did not receive any amount of nitrogen through nitrogen fixation. Nodulation in faba was affected by application of different nitrogen sources at different Cu levels and nodule numbers were progressively depressed.

The number of nodules were greatly reduced by copper at 10 mM, and it is possible that those present developed from the pre-treatment infection as few nodules were restricted to the upper primary roots. No juvenile nodules were present on younger roots (Hallsworth and Greenwood, 1964).

faba plant could utilise NO_3 more efficiently than NH_4 . Utilisation of NO_3 over NH_4 could be a pH sensitive. Tills and Alloway (1981) found that at pH of 6.8 ammonium was more easily absorbed by plant roots than nitrate but this was depressed as the root medium pH decrease (Blair et al., 1970 and Dijkshoorn and Ismanadja, 1972). On the other hand this study was carried out at pH of 8.3, this might explain the depression of ammonium and elevation of nitrate absorption by plant roots. Other workers (Cox and Reisenauer 1973; Cox and Reisenauer, 1977 and Kirkby, 1968) have used far lower pH's (pH 4-6) which are unlikely to be encountered in agriculturally productive soils.

Applications of nitrogen sources as ammonia, nitrate or combination of both even at very low concentration clearly increased dry matter yield (Tills and Alloway, 1981). This is expected since nitrogen is an essential element, being an integral part of nucleic acids, protein, chlorophyll and various coenzymes. Without an adequate source of nitrogen plant root uptake mechanism is seriously disrupted and yield is reduced due to nitrogen deficiency (Tills and Alloway, 1981). Increase in dry matter yields due to Cu application (5 mM) occurred because the soil was deficient in Cu. Similar increase in plant yield due to (5 mM) Cu applications has also been reported by (Gupta and Mcleod, 1970; Dwiredi and Shankar, 1975; Morad, 1986 and Gardmer and Flynn, 1988). Application of Cu (10 and 20 mM) was found inhibitory. Higher Cu concentrations of roots than shoots by application of different nitrogen sources indicated slow mobility of Cu from roots to shoots. Morad (1986) found higher Cu concentrations in roots than the shoots of durum wheat. The higher Cu concentrations in shoots and roots, due to $\text{Ca}(\text{NO}_3)_2$ application over NH_4Cl treatment, may be due

to a dilution effect, as the dry matter yield was high with $\text{Ca}(\text{NO}_3)_2$ application. The second possibility may be that NH_4 ions interfere with the absorption of Cu at root absorption sites as NH_4 and Cu are both cations, whereas with NO_3 source no such inhibition is expected. Tills and Alloway (1981) who reported similar results found higher concentrations of Cu in wheat plant with NO_3 than with NH_4 applications.

The antagonistic effects of N application on Cu concentration in wheat and raya crops have also been reported by Chandhary and Loneragan, 1970 and Antil et al., 1988. From the above results one can conclude that $\text{Ca}(\text{NO}_3)_2$ was a better source of N than NH_4NO_3 and NH_4Cl . Applications of 5 ppm Cu with adequate supplies of N was sufficient for faba plant in Cu deficient soil. N and Cu had an antagonistic effect on concentrations of each other.

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Table 1 :
Effect of N Sources and Cu levels on shoot dry matter yield of Vicia Faba .

Sources of N	Yield	Levels of Cu (ppm)	Yield
oppm N	4	0	4
Ca(NO ₃) ₂	6.2	5	5.2
NH ₄ NO ₃	5.3	10	5
NH ₄ Cl	5	20	4.2
MEAN	5.12		4.6

Table 2 :
Effect of N Sources and Cu levels on the concentration of N% in root of Vicia Faba .

Sources of N	Conc. of N%	Levels of Cu (ppm)	Conc. of N%
oppm N	1.57	0	2.7
Ca(NO ₃) ₂	3.54	5	2.59
NH ₄ NO ₃	3.21	10	2.52
NH ₄ Cl	2.58	20	1.59
MEAN	2.79		2.35

Fig. 1 :

Effect of N sources & Cu levels on root dry matter yield (g pot⁻¹) Vicia faba .

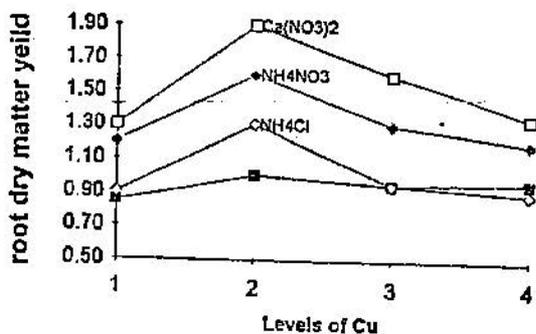


Fig. 2 :

Effect of N sources & Cu levels on the concentration of N(%) in shoot of Vicia faba.

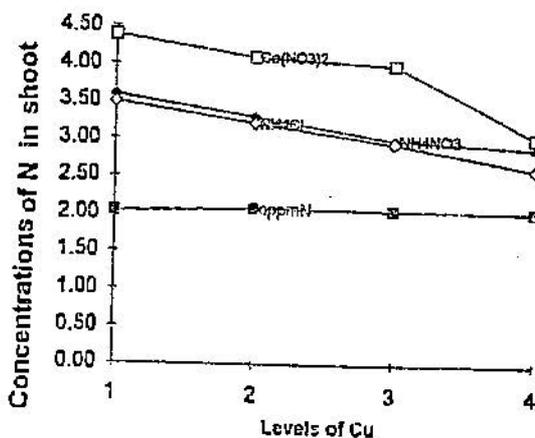


Fig. 3 :

Effect of N sources & Cu levels on Cu Concentrations in Vicia faba shoot .

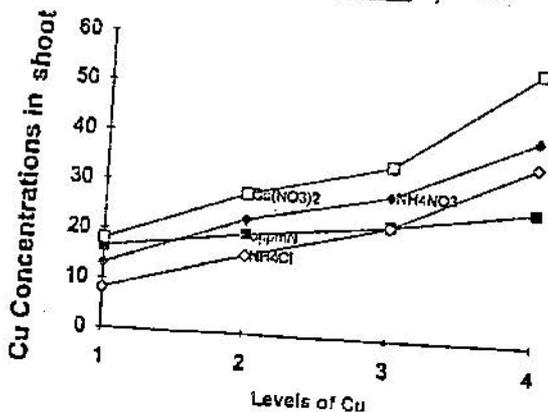


Fig. 4 :
Effect of N sources & Cu levels on Cu
Concentration (ppm) in Vicia faba root .

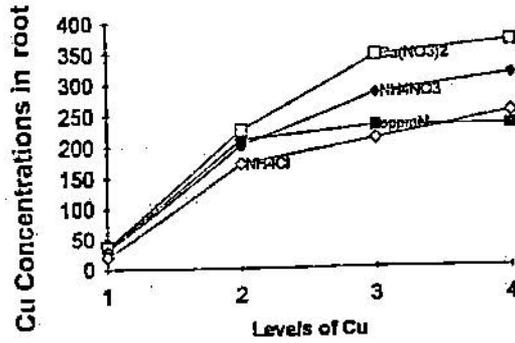


Fig. 5:
Effect of N sources and Cu levels on available
N% in soil .

