Effect of B, Co and Mo on nodulation, growth and yield of cowpea (*Vigna unguiculata*)

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ABSTRACT

A series of experiments was conducted to study the effect of different concentrations of micro-nutrients (i.e. "B", "Co" and "Mo") on nodulation, growth and yield of two cowpea varieties, MI 35 and Bombay. In all experiments, "B" was applied as H_3BO_4, "Co" as Co $(NO_3)_2$ and "Mo" as NH_4 $MO_7O_{24}.4H_2O$. Nodule number and nodule fresh weight were recorded as nodule parameters while shoot and root dry weights were recorded as growth parameters at two different stages of 30 and 50 (at physiological maturity) days after planting. Seed yield was recorded at harvest.

There was no consistent trend observed in the effect of micro-nutrients (i.e. "Mo", "Co" and "B") on nodule and growth parameters of cowpea varieties, MI 35 and Bombay. Growth and nodule parameters of MI 35 cowpea showed no response to different concentrations of "Mo", "Co" and "B" except at 2 ppm concentration, which significantly increased the dry matter (DM) production at physiological maturity. But, variety Bombay reported different response. Application of "Co" increased nodulation and plant DM production in Bombay and the best response was observed at 6 ppm concentration. "B" application had no beneficial effect on DM production of Bombay cowpea except at very low concentration (i.e. 2 ppm), but the effect of "B" on nodulation of Bombay was beneficial upto 4 ppm and it was negative with further increase of "B" concentration.

"Mo" increased nodulation of Bombay and it had no clear effect as plant DM production but at 4 ppm of "Mo" concentration, it gave a yield increase. No nodulation and growth increase of Bombay cowpea were reported with different concentrations of "Co" used.

Key words: *Boron* ("B"), *Molybdenum* ("Mo"), *Cobalt* ("Co"), *Vigna unguiculata, Nodulation*

INTRODUCTION

Micro-nutrients, especially Boron ("B"), Cabalt ("Co") and Molybdenum ("Mo") play an important role in N fixation of legumes, which has a positive effect on growth and yield of legumes. Boron plays an important role in the growth and development of crops. Its deficiency leads to sterility in plants by malformation of reproductive tissues affecting pollen germination, resulting in reduced fruit set which is most common in crops like grain legumes. Agbening et al (1990) reported that B application consistently reduced grain yield. B had no effect on N, P, K concentrations of index leaves and the critical level of B toxicity in index leaves was approximately 21 ppm under field condition. Francois (1989) reported that relative yield of *P. vulgaris* decreased by 12.1% and cowpea seed yield decreased by 11.5% with each unit of "B" increase in soil solution (Bsw) above 1 and 2.5 mg B/litre, respectively. Reduced yields of *P. vulgaris* pods and Cowpea seeds were attributed primarily to a reduction in pod number. Increasing Bsw significantly reduced plant size in both species of *P. vulgaris* and cowpea. Several researchers reported that "Mo" had beneficial effect on legumes. Selveraj and Kumari (1999) reported that "Mo" had little effect on NAR in green gram, increased it slightly in black gram and cowpea and increased it 3 fold in cluster beans. There was a significant influence of "Mo" on plant height, number of branches, pods per plant, biomass per plant, seeds per pod and 1000 grain weight (Chowdhury et al, 1996). Singh and Singh (1996) reported that dry matter yield of cowpea/pot increased up to 5mg Mo/kg of soil. Each element decreased uptake of other elements. Soils in the dry zone of Sri Lanka, which is the major area of growing grain legumes, where farmers do not apply any micro-nutrients. However, their effect on grain legumes has not yet been exploited in this region. Therefore it was very important to study the effect of micro nutrients (i.e. B, Co and Mo) on nodulation, growth and yield of cowpea.

MATERIALS AND METHODS

A series of pot experiments were conducted to study the effect of "B", "Mo" and "Co" on nodulation, growth and yield of two cowpea varieties, MI 35 and Bombay. All experiments were conducted at the seed farm of the Department of Agriculture, Bata atha, Hungama, dry zone of Sri Lanka. The soil of the area is Reddish Brown Earth (Rhodusfalfs). In experiment 1, three types of micro-nutrients, "B", "Co" and "Mo" were applied for cowpea variety MI-35, at three different concentrations (i.e. 0, 2 and 4 ppm) of each nutrient. "B" was applied as H_3BO_3, "Co" applied as Co $(NO_3)_2$ and "Mo" as $NH_4MO_7O_{24}.4H_2O$.

In experiment 2, effects of "Mo" and "B" were studied separately and in combination on nodulation and growth of cowpea var. MI 35 in pots. The treatments were i. Control, ii. "B" - 2 ppm, iii. "Mo" 2 ppm and iv. Mixture of "Mo" 2 ppm + "B" 2ppm. Effect of wider concentrations (0 ppm, 2 ppm, 4 ppm, 6 ppm and 8 ppm) of "MO", "Co " and "B" on nodulation and growth of cowpea var. MI 35 (Experiment 3) and Bombay (Experiment 4) were studied in pots.

The experimental design of all experiments was a RCB with 6 replicates. Number of nodules per plant, Nodule fresh weight and dry matter yield of shoots and roots were determined at 30 and 50 days after planting (at physiological maturity).

RESULTS AND DISCUSSION

Experiment 1

There was no consistent trend or pattern observed in the effect of micro-nutrients on nodulation and growth of cowpea var. MI 35. The highest number of nodules/plant and nodule fresh weight were observed with 4 ppm "Mo" but, still the difference was not statistically significant. Perhaps, it would be advisable to use a wider concentrations to elaborate the effect (Table 1).

Table 1. Number of nodules/ plant, nodule fresh weight and shoot dry weight of Cowpea, variety MI 35 at 50 DAP

Treatment	No. of nodules per plant	Nodule fresh wt.(mg/plant)	Shoot dry wt.(g/plant)
Control	16.90^a	590^a	4.62^a
B - 2 ppm	9.63^a	210^a	2.58^a
B - 4 ppm	14.63^a	460^a	2.50^a
Co - 2 ppm	21.10^a	570^a	4.42^a
Co - 4ppm	18.0^a	440^a	3.87^a
Mo - 2 ppm	16.70^a	400^a	3.63^a
Mo - 4 ppm	31.30^a	720^a	4.29^a

Means with the same letter are not significantly different ($P \leq 0.05$)

Experiment 2

In this experiment, effects of "B" and "Mo" on growth and nodulation of cowpea, (cv MI 35) were studied separately and in combination. Results revealed that, there was no significant effect of tested micro-nutrients alone or in combination expressed in observed parameters. Perhaps, the concentration used may not be effective or the required amount of micro nutrients may be available in the soil which was used to fill the pots. Therefore, it was clear that Mo and B had no significant effect on growth and nodulation of cowpea cv MI 35 at the used concentrations (Table 2). The reason may be due to sufficient micro-nutrients for cowpea var. MI 35 in reddish brown earth in Hambantota district, low country dry zone of Sri Lanka.

Table 2. Shoot dry weight, nodule fresh weight and number of nodules per plant of cowpea variety MI 35 at 50 DAP

Treatment	Shoot dry wt. (g/plant)	Nodule fresh wt.(mg/plant)	No. of nodules per plant
Control	3.17^a	510^a	28.58^a
With B	2.23^a	420^a	27.92^a
With Mo	3.88^a	670^a	36.33^a
With B & Mo	2.53^a	370^a	26.0^a

Means with the same letter are not significantly different ($P \leq 0.05$)

Experiment 3: Effect of different concentrations of "Mo" on nodulation and growth of cowpea, variety MI 35

In the current series of experiments, the effects of "MO", "Co" and "B" were studied in separately by using a wider range of concentrations of each micro-nutrient. Nodule number/plant and nodule fresh weight showed no response to different concentrations of "Mo" But, the highest number of nodules/plant at 30 and 50 DAP and, the nodule fresh weight at 30 DAP were observed with 2 ppm "Mo". Significantly higher dry matter production in leaves, shoots and roots at 50 DAP were observed at 2 ppm "Mo" concentration. This was reflected very clearly in the total dry matter production where 2 ppm "Mo" treatment had gave the highest value. Total dry matter production was significantly lower than the control at 8 ppm "Mo" concentration. Therefore, it was clear that Mo at 2 ppm concentration increased total dry matter production significantly but, when Mo concentration was increased further, it had a negative effect on total dry matter production (Table

3 and 4).

Table 3. Nodule number and mass

Treatment	Nodule number/ plant		Nodule fresh weight (mg/plant)	
	30 DAP	50 DAP	30 DAP	50 DAP
Mo - 0 ppm	26.2^{a}	53.0^{a}	212.6^{a}	1088.0^{a}
Mo - 2 ppm	47.6^{a}	78.4^{a}	482.0^{a}	1402.0^{a}
Mo - 4 ppm	29.0^{a}	42.4^{a}	125.2^{a}	906.0^{a}
Mo - 6 ppm	35.2^{a}	49.6^{a}	136.0^{a}	1196.6^{a}
Mo - 8 ppm	29.2^{a}	38.8^{a}	126.6^{a}	1490.0^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Table 4. Dry matter production

Treatment	Dry weight of Shoots (g/plant)		Dry weight of roots (g/plant)	
	30 DAP	50 DAP	30 DAP	50 DAP
Mo - 0 ppm	0.35^{b}	2.22^{b}	0.16^{a}	1.55^{bc}
Mo - 2 ppm	0.77^{a}	2.68^{a}	0.25^{a}	2.8^{a}
Mo - 4 ppm	0.54^{ab}	1.95^{bc}	0.14^{a}	1.87^{ab}
Mo - 6 ppm	0.61^{ab}	1.54^{cd}	0.26^{a}	2.07^{ab}
Mo - 8 ppm	0.43^{b}	1.43^{d}	0.16^{a}	1.02^{c}

Means with the same letter are not significantly different ($P \leq 0.05$)

Experiment 4: Effect of "Co", B' and 'Mo' on nodulation and growth of cowpea variety Bombay

Nodule fresh weight and dry weight of leaves were significantly higher at 6 ppm "Co" concentration with compared to other concentration at 30 DAP. But dry weight of shoot increased significantly at same "Co" levels (6 ppm) at 50 DAP. Therefore, it was clear that the application of "Co" increased the nodulation and plant dry matter production in Cowpea and the best response was observed at 6 ppm concentration (Tables 5, 6 and 7).

Table 5. Nodule number and mass

Treatment	Nodule number/ plant		Fresh nodule weight (g/plant)	
	30 DAP	50 DAP	30 DAP	50 DAP
'Co' - 0 ppm	30.0^{a}	46.6^{a}	138.8^{b}	996.0^{a}
'Co' - 2 ppm	36.08^{a}	45.4^{a}	247.0^{b}	1150.0^{a}
'Co' - 4 ppm	28.6^{a}	59.0^{a}	359.4^{ab}	1078.0^{a}
'Co' - 6 ppm	51.8^{a}	60.8^{a}	508.4^{a}	1562.0^{a}
'Co' - 8 ppm	36.8^{a}	43.2^{a}	202.6^{ab}	1134.0^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Table 6. Dry matter production (g/plant)

Treatment	Dry Weight of Shoots		Dry Weight of Roots	
	30 DAP	50 DAP	30 DAP	50 DAP
Mo - 0 ppm	0.17^{a}	0.58^{b}	0.19^{ab}	1.84^{a}
Mo - 2 ppm	0.19^{a}	0.52^{b}	0.22^{ab}	2.05^{a}
Mo - 4 ppm	0.14^{a}	0.84^{ab}	0.17^{ab}	2.81^{a}
Mo - 6 ppm	0.24^{a}	1.11^{a}	0.24^{a}	2.71^{a}
Mo - 8 ppm	0.16^{a}	0.84^{ab}	0.15^{b}	1.82^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Table 7. Total dry matter content (g/plant)

Treatment	Total Dry Matter	
	30 DAP	50 DAP
'Co' - 0 ppm	0.71^{b}	4.36^{a}
'Co' - 2 ppm	0.87^{ab}	4.43^{a}
'Co' - 4 ppm	0.75^{b}	5.66^{a}
'Co' - 6 ppm	1.01^{a}	6.61^{a}
'Co' - 8 ppm	0.72^{b}	4.74^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Application of B affected nodulation and plant dry matter production significantly. At 30 DAP, 'B' treatments resulted in a significant reduction of nodule number/plant after 4 ppm concentration. But, at 50 DAP, no significant response was observed compared to control. But, the total dry matter yield responded differently showing a significantly higher value at 4ppm concentration at 30 DAP and at 2 ppm at 50 DAP. Therefore it was clear that effect of B on growth and nodulation of Cowpea was beneficial upto 4 ppm and it was negative with further increase of B concentration (Tables 8, 9 and 10).

Table 8. Nodule number and mass

Treatment	Nodule number/ Plant		Nodules fresh weight(g/plant)	
	30 DAP	50 DAP	30 DAP	50 DAP
B - 0 ppm	40.2^{a}	35.8^{a}	104.0^{a}	1100^{a}
B - 2 ppm	36.6^{a}	73.2^{a}	129.6^{a}	1450^{a}
B - 4 ppm	17.6^{b}	65.4^{a}	127.6^{a}	1030^{a}
B - 6 ppm	16.6^{b}	40.0^{a}	104.6^{a}	780^{a}
B - 8 ppm	9.8^{b}	27.4^{a}	95.2^{a}	800^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Table 9. Dry matter production (g/plant)

Treatment	Weight of Leaves		Weight of Roots	
	30 DAP	50 DAP	30 DAP	50 DAP
B - 0 ppm	0.57^{a}	1.73^{b}	0.17^{ab}	1.64^{a}
B - 2 ppm	0.64^{a}	2.46^{a}	0.2^{a}	2.02^{a}
B - 4 ppm	0.26^{b}	2.22^{ab}	0.12^{abc}	1.74^{a}
B - 6 ppm	0.13^{b}	1.63^{b}	0.08^{c}	1.61^{a}
B - 8 ppm	0.14^{b}	1.79^{b}	0.05^{c}	1.46^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Table 10. Total dry matter production (g/plant)

Treatment	Total dry matter production (g/plant)	
	30 DAP	50 DAP
B - 0 ppm	0.87^{a}	4.13^{b}
B - 2 ppm	1.01^{a}	5.56^{a}
B - 4 ppm	0.51^{b}	4.83^{ab}
B - 6 ppm	0.28^{b}	4.04^{b}
B - 8 ppm	0.26^{b}	3.98^{b}

Means with the same letter are not significantly different ($P \leq 0.05$)

Effect of "Mo" on nodulation, growth and yield of cowpea variety Bombay

Results revealed that nodule parameters (number of nodules/plant and nodule dry weight) showed a consistent increase with increasing levels of Mo, but the dry weight of nodules/plant showed only a marginal increase upto 4 ppm Mo and then dropped. This probably showed the beneficial effect of Mo on nodulation in Bombay cowpea. dry matter content of shoot has not shown a significant response to the application of Mo. An increasing trend in yield was observed in response to Mo, compared to the control but after 4 ppm, response was negative.
Therefore, it was clear that Mo increased number of root nodules/plant and it had no clear effect on plant dry matter production but at 4 ppm, "Mo" concentration, it resulted a yield increase. Results are shown in Table 11 and 12.

Table 11. Nodule dry weight (mg/plant) and no of nodules/plant

Treatment	Dry weight of nodules (mg/plant)	No. of nodules per/plant
'Mo' - 0 ppm	104.7^{a}	57.0^{a}
'Mo' - 2 ppm	106.9^{a}	72.86^{a}
'Mo' - 4 ppm	108.2^{a}	89.27^{a}
'Mo' - 6 ppm	109.2^{a}	99.57^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Table 12. Shoot dry weight (mg/plant) Root dry weight (mg/plant) and yield (g/plant) at Physiological maturity

Treatment	Shoot dry wt. (g/plant)	Root dry wt.(g/plant)	Pod yield (g/plant)
'Mo' - 0 ppm	3.29^{a}	3.56^{a}	18.970^{a}
'Mo' - 2 ppm	2.42^{a}	3.09^{a}	21.320^{a}
'Mo' - 4 ppm	2.57^{a}	3.22^{a}	24.898^{a}
'Mo' - 6 ppm	2.17^{a}	3.18^{a}	20.910^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Effect of Co' on nodulation, growth and yield

Results revealed that effect of Co was somewhat different to that of B on nodulation, dry matter production and yield of cowpea variety, Bombay. Nodule dry weight was decreased with increasing concentration of "Co" and significantly highest nodule dry weight was observed at control (0 ppm Co) treatment. But number of nodules/plant showed no significant difference (Table13).

Table 13. Nodule dry weight (mg/plant) and no. of nodules/plant

Treatment	Dry weight of nodules (mg/plant)	No. of nodule/ plant
C1	217.6^{a}	59.10^{a}
C2	86.6^{b}	64.49^{a}
C3	89.0^{b}	61.93^{a}
C4	89.0^{b}	51.34^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

Shoot dry weight and root dry weight responded in a similar pattern, where a decrease in weight was observed with 2 ppm, compared to the control and as the Co concentration increased, dry matter

Table 14. Shoot dry weight (g/plant), root dry weight (g/plant, pod yield (g/plant) at Physiological Maturity

Treatment	Shoot dry weight (Mg/plant)	Yield (g/plant)
C1	1.890^{a}	19.090^{a}
C2	1.650^{a}	21.050^{a}
C3	2.050^{a}	21.390^{a}
C4	2.710^{a}	20.900^{a}

Means with the same letter are not significantly different ($P \leq 0.05$)

productions also increased, compared to the control. But pod yield showed no considerable response to Co, compared to the control (Table 14).

Therefore, it was clear that Co did not affect nodulation of cowpea variety, Bombay prominently except at 6 ppm concentration which was significantly reduced. Also Plant dry matter production and yield showed no significant response to Co.

CONCLUSIONS

Growth and nodule parameters of Cowpea var. MI 35 were not affected by different concentration of "Mo", "B" and "Co", except "Mo" at 2ppm which gave the highest dry matter production at physiological maturity. But cowpea var. Bombay responded differently by increasing nodulation and plant dry matter production, with increasing level of "Mo" and the best response was recorded at 6ppm concentration. DM production and nodulation of Bombay increased with increasing level of "Co", while 6ppm concentration gave the highest DM. "Bo" did not responsed to DM production of Bombay cowpea, except at very low concentration (i.e. 2ppm) while positive response was reported by cowpea var. Bombay upto 4ppm concentration and higher than that negative response was reported.

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