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The Effects of Molybdenum Application on Growth and Yield of Cowpea in Yola, Nigeria

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Abstract: Nigeria produces a lot of cowpea. Most Nigerian farmers practice continuous cropping which depletes the soil nutrients a lot. However most of the soil fertility trials are on macro nutrients. This study was therefore undertaken to investigate the effects of molybdenum levels on the growth and yield of cowpea in Yola, Adamawa State, Nigeria and to identify which molybdenum level is the optimum for the production of cowpea in the state. Field experiments were conducted at the Teaching and Research Farm of the Federal University of Technology, Yola during the 2000 and 2001 cropping seasons. Four levels of molybdenum 0, 0.13, 0.26 and 0.39 kg $Na_2MoO_4.2H_2O$/ha were tested on cowpea variety IAR-48 in a Randomized Complete Block Design and replicated three times. Data were collected on growth and yield parameters. While it took 46 days for plants in the control to attain 50% flowering, plants that received 0.26 or 0.39 kg $Na_2MoO_4.2H_2O$/ha took just 45.3 days to attain 50% flowering. Plants in the control had a mean of 14.5 pods per plant while those in the 0.26 kg $Na_2MoO_4.2H_2O$/ha treatment had 16.7 pods per plant. Grain yield was lowest (1069) at 0 kg $Na_2MoO_4.2H_2O$/ha while plants that received 0.26 and 0.39 kg $Na_2MoO_4.2H_2O$/ha, had grain yield of 1280 and 1250 kg ha^{-1}, respectively. Cowpea growth and yield can be enhanced by applying $Na_2MoO_4.2H_2O$/ha. Farmers can apply 0.26 kg $Na_2MoO_4.2H_2O$/ha to obtain optimum yield.

Key words: Molybdenum · micro-nutrient · cowpea · growth · grain yield

INTRODUCTION

Singh *et al.* [1] reported that cowpea is an important crop to the livelihood of millions of relatively poor people in Nigeria. From production of this crop, rural families derive food, animal feeds and cash, together with spill over benefits to their farmlands. All the plant parts are used for food and are nutritious, providing protein, vitamins and minerals. It is a cheap source of plant protein to many cannot afford enough of the expensive animal protein. However, cowpea yields are generally low as a result of insect pest and diseases, drought, excessive moisture, low fertility, weeds and mixed cropping. Although, there are varieties with High yielding potentials, these high yield potentials are never attained due to the problems earlier stated. Thus grain yield on farmers plots are usually less than 1000 kg ha^{-1}.

The role of macro nutrients like phosphorus in increase yield of cowpea has long been reported by authors like Yayock [2] and Foth and Ellis [3]. Most cowpea producers are aware that application of phosphorus fertilizers will lead to higher grain yields. This however cannot be said of micro nutrients. Not many farmers know the significance of these micro nutrients and the roles they play in increase grain yields. Micro nutrients have not received much research attention as such their role in improving grain yield in cowpea has not been appreciated by many.

According to Tisdale *et al.* [4], molybdenum occurs in the soil in extremely small quantities ranging from 0.2-5 ppm. Similarly, they reported that molybdenum is also found in very small concentrations in plants (usually less than 1 ppm in plants). As a micro-nutrient element, the requirement of molybdenum in terms critical concentration in plant tissue is very low. Nevertheless, molybdenum has been identified as one of the micro nutrient elements necessary for growth and increase in grain yield of leguminous plants [5, 6]. Molybdenum application has been found to significantly increase grain and straw yields of cowpea [6]. In another

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research carried out on soyabeans, Pal *et al.* [7] recorded a significant yield increase (39.6%) over the control at Pankshin in Plateau State Nigeria, following the application of molybdenum to soyabean plants. The functions of molybdenum in leguminous plants include nitrate reduction, nodulation, nitrogen fixation and general metabolism [8]. Molybdenum deficiency leads to nitrate accumulation in plants, as the enzyme activity to convert the nitrate to nitrite is restricted.

Molybdenum deficiency is associated with acid soil conditions and is not generally a problem on adequately limed fields and it's the only essential plant trace element that is less available at low pH [9]. Davies and Jones [5] reported that molybdenum deficiency can normally be corrected in legumes and non legumes by application of sodium or ammonium molybdate at the rate of 50-250 g Mo per hectare and such application will usually last for several years. Archer [9] emphasized that where Mo deficiency is confirmed, soil treatment with sodium ammonium molybdate at 0.03 g per square meter is recommended or foliar drench at 0.25 g L^{-1} if deficiency occurs in the seedling stage. Kubota and Allaway [10] reported that Mo deficiency can also be corrected by application of sodium molybdate, ammonium molybdate, soluble molybdenum trioxide and molybdonized super phosphate to the soil or through the seed coatings prior to planting with 1% solution of molybdate, or dusting with ammonium molybdate at the rate of 100 g ha^{-1} or foliar application with 0.5% ammonium molybdate.

With new cowpea varieties being developed by International Institute of Tropical Agriculture, other research institutes and universities in Nigeria that have higher yielding potentials, these varieties may require adequate macro and micro-nutrient amounts to be able to produce according to their genetic potentials. Also since our soils have now been subjected to continuous cropping with little or no fallow periods, there is the need to find out the molybdenum rates needed to be applied to the soil for optimum cowpea growth and yield in Adamawa State where a lot of cowpea is produced. The objectives of this study therefore were to investigate the effects of molybdenum levels on the growth and yield of cowpea in Adamawa State and to identify which molybdenum level is the optimum for the production of cowpea in the state.

MATERIALS AND METHODS

Field experiment was conducted at the Teaching and Research Farm of the Federal University of Technology, Yola during the 2000 and 2001 cropping seasons. Yola is located on latitude 9° 14'N and longitude 12° 38' E and it falls within the Northern Guinea Savanna ecological zone of Nigeria [11]. Yola has a mean annual rainfall of 950 mm per annum which ranges from 150 to 160 days mostly from May to October [11].

The treatments consisting of four levels of molybdenum 0, 130, 260 and 390 g ha^{-1} using sodium molybdate ($Na_2Mo0_4 2H_20$), which contain 39% Mo were laid out in a Randomized Complete Block Design and replicated three times. The plot size was 3 m x 2 m making up 6 m^2. Walk spaces were created between the replications and between the plots which were 1.5 m between replications and 1 m between the plots. Soil samples were collected from each plot and analysed.

The cowpea variety used was IAR 48 (erect type) which is medium maturing. Planting was carried out using the spacing of 60 cm x 20 cm with 4 seeds planted per hill which were later thinned to 2 plants per stand. Manual weeding was carried out twice. Insect pest were controlled using 800 mL of karate 2.5 EC in 100 L of H_2O per hectare at an interval of ten days for three times. The fertilizer application was carried out through drilling method one day after planting.

Data collected include shoot height (plant height), number of branches and shoot dry weight at 8 WAS. Data collected were subjected to analysis of variance and means that were significantly different were separated using Least Significant Difference (L.S.D) at p=0.05.

RESULTS

The mean squares from the analysis of variance of the data collected shows that there were no significant differences (p=0.05) observed for years in all the parameters measured except 1000-grain weight that was significantly different at p=0.05 (Tables 1-3). Most of the traits showed significant differences among the molybdenum levels either at p=0.01 or p=0.05 except shoot weight at 4 WAS (Table 1), grain number per pod and shelling percentage (Table 3) that showed no significant differences among the molybdenum levels at p=0.05.

The effects of molybdenum levels on the means of growth parameters of cowpea plants sown under four molybdenum levels in 2000 and 2001 are presented in Table 4. Results of the analysed data on shoot height (plant height) show that means of plant height from 0 and 0.13 kg $Na_2MoO_4 2H_2O$ ha^{-1} were not significantly different (p=0.05) at 4 and 6 weeks after sowing (WAS) except at 8 WAS that 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1} gave significantly taller plants (p=0.01) than the control plots.

Table 1: Means squares from analysis of variance of growth parameters of cowpea planted in 2000 and 2001 cropping seasons

Source of variation	df	Shoot height at 4 WAS (cm)	Shoot height at 6 WAS (cm)	Shoot height at 8 WAS (cm)	Shoot weight at 4 WAS (g)	Shoot weight at 6 WAS (g)	Shoot weight at 8 WAS (g)
Year	4	0.027ns	0.135ns	4.770ns	0.167ns	0.020ns	4.682ns
Rep (year)	1	9.422*	4.404*	19.795**	2.128**	12.312*	23.791*
Mo level	3	13.370**	16.654**	40.814**	1.019ns	11.850*	27.684*
Error	15	2.312	1.020	1.905	0.478	3.203	7.579

* = Significantly different at p=0.05, ** = Significantly different at p=0.01, ns = Non-significantly different at p=0.05

Table 2: Means squares of number of branches and days to 50% flowering of cowpea planted in 2000 and 2001 cropping seasons

Source of variation	df	No. of branches at 6 WAS	No. of branches at 8 WAS	Days to 50% flowering
Year	4	0.007ns	0.375ns	0.001ns
Rep (year)	1	0.833*	0.583ns	0.833**
Mo level	3	0.944*	2.042**	0.611*
Error	15	0.244	0.408	0.178

* = Significantly different at p=0.05, ** = Significantly different at p=0.01, ns = Non-significantly different at p=0.05

Table 3: Means squares from analysis of variance of yield parameters of cowpea planted in 2000 and 2001 cropping seasons

Source of variation	df	Pod weight (kg ha^{-1})	Grain yield at maturity (kg ha^{-1})	Grain No. per pod	1000-Grain weight (g)	Shelling %
Year	4	400.98ns	1225.51ns	0.001ns	0.844*	0.484ns
Rep (year)	1	360356.08**	98275.21**	9.250**	1.133ns	155.184*
Mo level	3	147867.21*	72755.61**	1.611ns	1.345**	25.500ns
Error	15	36330.85	12370.72	0.558	0.108	674.371

* = Significantly different at p=0.05, ** = Significantly different at p=0.01, ns = Non-significantly different at p=0.05

Table 4: Effects of Mo levels on means of growth parameters of cowpea grown in Yola over two cropping seasons

Mo levels (kg ha^{-1})	Shoot height at 4 WAS (cm)	Shoot height at 6 WAS (cm)	Shoot height at 8 WAS (cm)	No. of branches at 6 WAS	No. of branches at 8 WAS	Shoot weight at 4 WAS (g)	Shoot weight at 6 WAS (g)	Shoot weight at 8 WAS (g)
0	21.10	31.32	40.83	4.83	5.33	7.93	11.62	27.22
0.13	20.63	32.63	44.73	5.00	5.67	8.67	13.80	29.55
0.26	23.68	34.97	47.07	5.67	6.67	8.82	14.95	31.65
0.39	23.12	34.38	45.03	5.50	6.17	8.18	12.95	31.78
Mean	22.13	33.32	44.43	5.25	5.96	8.40	13.33	30.05
L.S.D	1.871	1.243	1.70	0.608	0.79	0.85	2.203	3.39
P>F	0.01	0.01	0.01	0.05	0.01	ns	0.05	0.05

ns = Non-significantly different at p=0.05

Means of plant height from the 0 and 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1} were the lowest. Increased $Na_2MoO_4.2H_2O$ level resulted in increased plant height with the lightest mean values obtained at the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} thereafter, there was decrease in plant height in all the sampled periods. The highest plant height of 47.1 cm was recorded in the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} at 8 WAS. Plant height values recorded from 0.26 and 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1} did not differ statistically except at 8 WAS that means from 0.26 and 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1} were significantly different. However these $Na_2MoO_4.2H_2O$ levels differed significantly from the control.

Number of branched per plant was lowest in 0 kg $Na_2MoO_4.2H_2O$ ha^{-1} at 6 and 8 WAS with mean values of 4.8 and 5.3, respectively and highest in 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1} (Table 4). Only the number of branches at 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} that significantly differed from the control. The rest were not statistically different from the control. Similarly, the lowest mean values of shoot weight at 4, 6 and 8 WAS were recorded from the 0 kg $Na_2MoO_4.2H_2O$ ha^{-1} with mean values of 7.9, 11.6 and 27.2 g, respectively (Table 4). At 6 WAS, the highest shoot weight of 14.95 g was recorded from the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. Although, the highest mean values of shoot weight per plant were obtained

Table 5: Effects of Mo levels on means of yield parameters of cowpea grown in Yola over two cropping seasons

Mo levels	Days to 50% flowering	Pod weight (kg ha^{-1})	Pod No. per plant	Grain No. per pod	Grain yield at maturity (kg ha^{-1})	1000-Grain weight (g)	Shelling %
0	46.00	1362.9	14.50	10.50	1069.2	18.92	79.39
0.13	45.67	1339.5	15.17	11.33	1082.6	19.32	82.93
0.26	45.33	1655.7	16.67	11.67	1280.1	19.97	78.04
0.39	45.33	1578.4	15.50	11.50	1250.3	19.78	80.21
Mean	45.58	1484.11	15.46	11.25	1170.56	19.50	80.14
L.S.D	0.52	234.60	0.95	0.94	136.90	0.41	8.25
P>F	0.05	0.05	0.01	ns	0.01	0.01	ns

ns = non-significantly different at p=0.05

from 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1} at 8 WAS, there were not significant difference between means of 0.26 and 0.39 kg $Na_2MoO_4 2H_2O$ ha^{-1} at p=0.01. Generally, there was increased in shoot weight with increased levels of $Na_2MoO_4.2H_2O$.

The means of yield parameters of cowpea plants sown under four molybdenum levels in 2000 and 2001 are presented in Table 5. Analysis of data on days to 50% flowering in both cropping seasons indicates that flowering was significantly delayed (p=0.05) most in the control (0 kg $Na_2MoO_4.2H_2O$ ha^{-1}) where it took 46 days for the plants to attain 50% flowering. At 0.26 and 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1}, it took the plants 45.3 days to attain 50% flowering. These values were however not statistically different from the result of 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1}.

Results of dry pod weight per hectare taken at maturity as presented in Table 5 indicated that the control and 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1} had the lowest pod weight of 1362.9 and 1339.5 kg ha^{-1}. These values were however not statistically different at p=0.05. Although, the control and 30 kg P_2O_5 ha^{-1} were not statistically different at p=0.05. The highest mean value of pod weight (1665.7 kg ha^{-1}) was obtained from 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. This was however not different statistically form the mean value obtained from 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1} which was 1578.4 kg ha^{-1}.

The lowest mean value of 14.5 was recorded as the number of pods per plant in the 0 kg $Na_2MoO_4.2H_2O$ ha^{-1} (Table 5). This was not significant different (p=0.05) from the value obtained form the 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1}. Number of pods per plant increased with increased $Na_2MoO_4.2H_2O$ level with the highest men value of 16.7 recorded at 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. This was significantly different from values obtained from all the other molybdenum levels. The same trend was observed for the number of grains per pod (Table 5). However, values of grain number per pod were not significantly different from each other at p=0.05.

The lowest mean value of grain yield (1069 kg ha^{-1}) was recorded from the 0 kg $Na_2MoO_4.2H_2O$ ha^{-1} (Table 5). This was however not statistically different (p=0.05) from the value obtained from 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1}. The highest mean value of grain yield was recorded form the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}, which was 1280 kg ha^{-1}. This was however not different from the mean value obtained from the 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1} which was 1250 kg ha^{-1}. Generally, as molybdenum level increased, grain yield as increased with a peak at 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} and declined with further increased molybdenum level.

The control had the lowest (p=0.05) mean value of 1000-grain weight which was 18.9 g (Table 5). As molybdenum level increased, there was increased 1000 grain weight with the highest mean value of 20 g at 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. Thereafter, there was a decline in 1000-grain weight at 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1}. There was however no significant difference between mean values obtained form 0.26 and 0.39 kg $Na_2MoO_4.2H_2O$ ha^{-1}. Selling percentage was not significantly different among all the molybdenum levels applied.

DISCUSSION

The significantly (p=0.05) lowest mean value of shoot height recorded from the control and 0.13 kg $Na_2MoO_4.2H_2O$ ha^{-1} at 4, 6 and 8 WAS and the subsequent increase in plant height with molybdenum levels is an indication that $Na_2MoO_4.2H_2O$ significantly influenced cowpea growth as measured in the plant height. As early as 4 WAS, the plants needed molybdenum for optimum growth. This agrees with the report of Archer [9] that cowpea need molybdenum at an early stage. Early growth was stimulated with the application of molybdenum which agrees with the findings of Hasuruna [12]. Increased application of $Na_2MoO_4.2H_2O$ resulted in higher values of shoot height up to 0.26 kg $Na_2MoO_4.2H_2O$. This shows that the plants needed more of $Na_2MoO_4.2H_2O$ for growth than what the soil could provide and the optimum rate appears to be 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. This shows that higher doses of $Na_2MoO_4.2H_2O$ than the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} may give rise luxurious consumption. The lowest mean values of shoot height recorded from the control at 4, 6 and 8 week after sowing is an indication that molybdenum is very important for the growth of cowpea. In plants where $Na_2MoO_4.2H_2O$ was not applied, growth (plant height) was significantly reduced and the plants were therefore short. This agrees with the report of Yayock [2], who stated that cowpea plants grown in soils with low or no molybdenum application were stunted. To show that the plants needed more of molybdenum, there was increased height with higher molybdenum levels up to the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} rate applied. Beyond this rate, there was reduced branching with increased molybdenum rate thus indicating that the optimum might have been reached at the 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. Similarly the lowest mean values of shoot dry weight and number of branches at the 0 kg $Na_2MoO_4.2H_2O$ ha^{-1} is an indication that the inadequate amount of $Na_2MoO_4.2H_2O$ in the control led to reduced branching and low dry matter production and accumulation by the plants. With increasing $Na_2MoO_4.2H_2O$ levels, there were more branches per plant, indicating improvement in growth. With higher $Na_2MoO_4.2H_2O$ levels, there was more dry matter produced and stored in the plants. With higher dry matter production, there is tendency for higher productivity as a result of more dry matter available for allocation to the grains.

Apart from improved growth, $Na_2MoO_4.2H_2O$ influenced cowpea phonology as seen in results an days to flowering. When $Na_2MoO_4.2H_2O$ was not applied, flowering was delayed while higher doses of $Na_2MoO_4.2H_2O$ resulted in earlier flowering. The significant increase in the number of pods per plant with the application of $Na_2MoO_4.2H_2O$ over the control is an indication that, $Na_2MoO_4.2H_2O$ increases the sink capacity. This might have either been through the production of more flowers or the reduction in number of aborted flowers. Similarly, the significant increase in the number of grains per pod with the application of $Na_2MoO_4.2H_2O$ over the control is an indication that $Na_2MoO_4.2H_2O$ enabled the genetic potentials of the plants to be fully expressed. This shows that the sink capacity can be expanded in cowpea with the application of higher doses of $Na_2MoO_4.2H_2O$ up to 0.26 kg $Na_2MoO_4.2H_2O$. The increased number of grains per pod might have been partly responsible for the increased pod weight obtained with increasing level of $Na_2MoO_4.2H_2O$ application. Increased number of pods per plant might have also contributed to this.

The significant higher grain yield with $Na_2MoO_4.2H_2O$ application shows that $Na_2MoO_4.2H_2O$ can be used to improve on cowpea yield. The plants needed more $Na_2MoO_4.2H_2O$ for biochemical processes associated with yield. The influence of $Na_2MoO_4.2H_2O$ on number of pods per plant and number of grains per pod must have contributed to this result. Krishnasamy ***et al.*** [6] reported that molybdenum application has been found to significantly increase grain and straw yields of cowpea. The result shows that there is tendency for higher grain yield with application of higher doses of $Na_2MoO_4.2H_2O$ up to 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1}. The higher grain weigh recorded in the 1000-grain weight with the application of higher levels of $Na_2MoO_4.2H_2O$ shows that this also contributed to grain yield. It further shows that bigger and heavier grains were obtained with higher doses of $Na_2MoO_4.2H_2O$. This shows that for healthier and robust seeds, $Na_2MoO_4.2H_2O$ is necessary in cowpea. This shows that there are more grains filled with higher rates of $Na_2MoO_4.2H_2O$ and there is more dry matter allocation to the grains rather the shells covering the grains. It shows how well filled the grains in a pod can be achieved with higher doses of $Na_2MoO_4.2H_2O$.

CONCLUSIONS

Cowpea growth and yield parameters were found to increase with increased molybdenum application. Faster cowpea growth can be achieved with the application of molybdenum. There were responses to the applied molybdenum up to the maximum level of 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} thereafter, increased $Na_2MoO_4.2H_2O$ rates applied resulted in decrease in values of most of the parameters measured thus indicating that higher values than 0.26 kg $Na_2MoO_4.2H_2O$ ha^{-1} may not be economical.

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