

Effect of Molybdenum Fertilizer on N₂ Fixation by Some Grain Legume Varieties in Sudano - Sahelian Zone of North Eastern Nigeria

H. Yakubu, J.D. Kwari and M.K. Sandabe

Department of Soil Science, University of Maiduguri, P.M.B. 1069, Maiduguri, Nigeria

Abstract: Nitrogen fixation by grain legumes contributes N to tropical soils. But in Sudano – Sahelian region of Northeastern Nigeria low Molybdenum content of the soil may restrict rhizobia population and legume root development, which in turn, can affect their N₂ fixing potential. A two- year field experiment was conducted at the Department of Soil Science Teaching and Research Farm University of Maiduguri to evaluate the influence of molybdenum (Mo) on N₂ fixation by groundnut (*Arachis hypogaea* L.), cowpea (*Vigna unguiculata* L.) and bambara groundnut (*Vigna subterranean* L.). The legume crops and a sorghum variety were applied 0, 0.25 and 0.5 kg Mo ha⁻¹ and grown for 50 days, after which they were harvested and the amount of N fixed was determined. Mo fertilization significantly increased the amount of N fixed by the crops. Application of 0.5 kg Mo ha⁻¹ increased N fixation in cowpea, groundnut and bambara groundnut by 130, 117 and 59% respectively, over the control. Cowpea differed significantly from groundnut and bambara nut in the amount of N fixed ($P < 0.05$). Cowpea fixed (45.49 kg N ha⁻¹), groundnut (34.94 kg N ha⁻¹) and bambara groundnut fixed (29.74 kg N ha⁻¹). Cultivation of Bornoji red cowpea variety with application of 0.5 kg Mo ha⁻¹ would improve the soil N status.

Key words: Molybdenum fertilizer • N₂-fixation • Grain legumes • Sudano-sahelian

INTRODUCTION

Nitrogen (N) has been gradually depleted from West African soils and now poses serious threats to food production [1]. Thus, N nutrition is one of the major determinants of crop yield in West Africa. Increasing of N application from chemical fertilizers has resulted in significant increase in food production world-wide. Yet Africa's consumption of mineral fertilizers per hectare is the lowest in the world, ranging from 2.2 to 3.9% of the global expenditure [2]. The use of nitrogenous fertilizers in Sudano-Sahelian zone of Nigeria is limited because of high cost, poor economic conditions of the farmers and non-availability of the fertilizers at proper time. This necessitates the inclusion of leguminous crops in our cropping systems as these have the ability of enriching the nitrogen of soil by fixing nitrogen from the air, in addition to improving the productivity of soil. The use of biological N₂-fixation is cheap and environmentally safe. Grain legumes fix substantial amount of N in the tropics [3]. The N₂-fixing potential of cowpea, groundnut and soybean is 9-201; 21-206 and 55-188 kgN/ha/year, respectively [4]. Studies conducted

in Northern Guinea Savanna of Nigeria [5] indicated that cowpea can fix N at the tune of 16-34 kg/ha and soybean fixed between 41- and 50 kgN/ha.

Nitrogen fixation by *Rhizobium*-legume symbioses provides continuous supply of N for plant growth in situ and add organic matter to the soil. The direct availability of the fixed N to the host allows it to grow in environments that are deficient in available N. Inclusion of grain legumes in cropping system, therefore, can play an increasingly important role to maintain soil fertility and sustain crop production.

According to Bationo and Vlek [6], legume-cereal rotation increases not only the yields of succeeding cereal crop but also its nitrogen use efficiency. Reported yield responses to previous legume crops are mainly in the range of 50-80% increases over yields in cereal-cereal sequences [7]. The beneficial effect of legume on succeeding crops is usually exclusively attributed to the increased soil N fertility as a result of N₂-fixation.

Legumes have also been shown to have stimulatory effects on the availability of soil N and fertilizer N to associated grasses. In field experiment, [8] reported that a recovery of applied N was three times greater in the

swards than in the sole grass. This increase in availability of N on introduction of the legumes may result from reduced immobilization of N, or enhanced re-mineralization of N which had been immobilized due to the addition of N rich legume residues to the soil. Thus, the introduction of legumes may improve the economy of the Sudano-Sahelian soil by increasing the release of native organic N from the soil, in addition to the benefits from N_2 -fixation.

In Sudano-Sahelian zone of Nigeria, grain legumes such as cowpea, groundnut and bambara groundnut provide the farming communities with large cash income, cheaper dietary protein and edible oil, and fodder for their livestock, in addition to improving soil fertility and productivity. However, deficiencies of soil Mo in this region [9, 10], may limit nodulation, N_2 -fixation and yields of the legume crops. Despite the importance of these crops, virtually there is no literature available on their Mo requirements for optimum nodulation and nitrogen fixation and excretion in this region. We therefore, initiated this study with a view of evaluating the effect on Mo fertilizer on nodulation and N_2 -fixation by groundnut, cowpea and bambara groundnut.

MATERIALS AND METHODS

A two- year field experiments were conducted on the Department of Soil Science Teaching and Research Farm, University of Maiduguri (11° 51' N, 13° 15' E) during 2005 and 2006 cropping seasons. The total amount of rainfall for 2005 and 2006 were 830 and 423mm, respectively. The soil of the experimental site was classified as *Typic Ustipsamment* following the USDA taxonomy [11].

The treatments consisted of three grain legume varieties; cowpea (var, Bornoji – red); groundnut (var, kolji kanuri); bambara groundnut (var. Mallum Karekare); sorghum (var. Paul Biya) and three levels of Mo fertilizer (0, 0.25, and 0.5 kg Mo/ha). Soil characterization was carried out prior to the treatments application [12]. The treatments were arranged in randomized complete block design and replicated three times. The land was ploughed, harrowed and plots were laid out into plot sizes of 4 m long and 3 m wide. Three seeds were sown per hole according to Borno State Agricultural Development Programme (BOSADP) [13] recommended spacing. Seedlings were thinned down to two per hill one week after sowing. Molybdenum was applied as molybdenum trioxide by banding. Weeding was done with hoe. At 50 days after sowing, the crops were harvested from a 1 m² (quadrant) subplots. Post

harvest soil samples were also taken from each plot and analyzed for total N as described by Van Reeuwijk [12]. Number of nodules was counted and the plant materials were oven dried at 65°C, weighed and analyzed for the N concentrations [14].

The amount of N fixed and percent N derived from biological fixation were estimated by the equations of Mary *et al.* [15].

Collected data were subjected to analysis of variance (ANOVA) and wherever differences between treatments were significant, they were compared using Duncan's multiple range test (DMRT) at 5% probability level [16].

In the second cropping season, the plots of the previous season were maintained in their respective position. Each plot was cultivated separately and its treatments (crop and fertilizer) were repeated. However, all other cultural practices as well as soil, plant and statistical analysis were the same.

RESULTS AND DISCUSSIONS

Texture and Some Chemical Properties of the Soil of the

Experimental Site: The soil of the experimental site is sandy loam in texture and neutral in reaction with low organic carbon (2% organic matter), total N (<1 g/kg soil) and available P (<10 mg/kg soil) according to Fertilizer Procurement and Distribution Division (FPDD) [17] soil fertility ratings (Table 1).

The results of the experiments revealed that Mo fertilization improved the performance of legumes crops (Tables 2 and 3). There was significant difference ($P<0.05$) among the crops in their responses to Mo fertilization. Generally, they performed better in all the parameters tested in the second cropping season. This might be due to residual fertilizer which masked the effect of the rainfall. However, the results in both years followed similar trends.

Table 1: Texture and some selected chemical characteristics of soil of the experimental site

Parameter	Values
Sand (g/kg)	700
Silt (g/kg)	150
Clay (g/kg)	150
Texture	Sandy loam
pH	6.71
Organic carbon (g/kg)	4.40
Total nitrogen (g/kg)	0.50
Available phosphorus (mg/kg)	5.30
*Available B	Traces
**Available Mo (mg/kg)	0.1

* Safyanu [27].

** Sandabe and Bapatel [10]

Table 2: Influence of molybdenum rates on nodulation, N content and nitrogen fixation by cowpea, groundnut and bambara groundnut, 2005

Crops	Rate (kg Mo/ha)			Mean
	0	0.25	0.5	
Nodules/plant				
Cowpea	28.00	30.33	38.33	32.65 ^c
Groundnut	56.33	73.33	75.00	68.22 ^a
Bambara groundnut	27.33	40.00	55.67	41.00 ^b
Mean	37.22 ^c	47.89 ^b	56.67 ^a	
SE±	1.47 (rate)			
SE±	1.47 (crop)			
SE±	2.55 (interaction)			
Total N in plant (kg/ha)				
Cowpea	20.75	44.54	55.58	40.28 ^a
Groundnut	18.88	27.14	30.12	25.38 ^b
Bambara groundnut	11.95	24.77	28.12	21.61 ^b
Sorghum	4.82	7.61	8.11	6.85 ^c
Mean	14.10 ^b	26.01 ^a	30.48 ^a	
SE±	1.93 (rate)			
SE±	2.23 (crop)			
SE±	3.86 (interaction)			
N-fixed (kg/ha)				
Cowpea	16.00	36.90	47.47	33.45 ^a
Groundnut	14.13	19.53	22.01	18.56 ^b
Bambara groundnut	7.20	17.16	20.01	14.79 ^b
Mean	12.44 ^b	24.53 ^a	29.83 ^a	
SE±	2.57 (rate)			
SE±	2.57 (crop)			
SE±	4.45 (interaction)			
% NDFA				
Cowpea	77.04	81.75	85.13	81.31 ^a
Groundnut	72.33	71.35	71.60	71.77 ^b
Bambara groundnut	60.25	68.07	68.50	65.61 ^b
Mean	69.87 ^a	73.73 ^a	75.07 ^a	
SE±	2.40 (rate)			
SE±	2.40 (crop)			
SE±	4.16 (interaction)			
% Soil N				
Cowpea	0.045	0.056	0.062	0.054 ^a
Groundnut	0.047	0.061	0.073	0.051 ^a
Bambara groundnut	0.047	0.056	0.056	0.053 ^a
Sorghum	0.030	0.027	0.027	0.028 ^b
Mean	0.042 ^a	0.050 ^a	0.055 ^a	
SE±	0.003 (rate)			
SE±	0.003 (crop)			
SE±	0.005 (interaction)			

Means in columns and rows followed by similar letter(s) are not significantly different at the 5% probability level of the Duncan's Multiple Range Test (DMRT)

Table 3: Influence of molybdenum rates on nodulation, N content and nitrogen fixation by cowpea, groundnut and bambara groundnut, 2006

Crops	Rate (kg Mo/ha)			Mean
	0	0.25	0.5	
Nodules/plant				
Cowpea	30.67	33.33	44.33	36.11 ^c
Groundnut	60.33	80.33	83.33	74.67 ^c
Bambara groundnut	31.33	46.00	60.00	45.78 ^b
Mean	40.78 ^c	53.22 ^b	62.56 ^a	
SE±	1.65 (rate)			
SE±	1.65 (crop)			
SE±	2.85 (interaction)			

Table 3: Continued

Total N in plant(kg/ha)				
Cowpea	46.59	69.84	99.50	71.98 ^a
Groundnut	35.05	73.49	88.77	65.77 ^b
Bambara groundnut	45.48	59.90	71.34	58.91 ^c
Sorghum	7.45	15.93	19.97	14.45 ^d
Mean	33.64 ^e	54.97 ^b	69.90 ^a	
SE±	1.69 (rate)			
SE±	1.95 (crop)			
SE±	3.38 (interaction)			
N-fixed(kg/ha)				
Cowpea	39.14	53.91	79.53	57.53 ^a
Groundnut	27.60	57.56	68.80	51.32 ^{ab}
Bambara groundnut	38.03	43.98	52.04	44.68 ^b
Mean	34.92 ^c	51.82 ^b	66.79 ^a	
SE±	2.46 (rate)			
SE±	2.46 (crop)			
SE±	4.26 (interaction)			
%NDFA				
Cowpea	83.72	77.07	79.70	80.23 ^a
Groundnut	78.48	78.11	77.25	77.95 ^a
Bambara groundnut	83.42	73.25	71.45	76.04 ^a
Mean	81.94 ^a	76.15 ^b	76.14 ^b	
SE±	1.54 (rate)			
SE±	1.54 (crop)			
SE±	2.66 (interaction)			
% Soil N				
Cowpea	0.056	0.069	0.082	0.069 ^a
Groundnut	0.056	0.071	0.084	0.070 ^a
Bambara groundnut	0.064	0.063	0.073	0.067 ^a
Sorghum	0.029	0.029	0.022	0.026 ^b
Mean	0.051 ^b	0.058 ^{ab}	0.065 ^a	
SE±	0.003 (rate)			
SE±	0.004 (crop)			
SE±	0.006 (interaction)			

Means in columns and rows followed by similar letter(s) are not significantly different at the 5% probability level of the Duncan's Multiple Range Test (DMRT)

Nodulation increased significantly ($P < 0.05$) with increasing the rate of Mo fertilizer. Application of 0.5 kgMo/ha increased the nodules number by 19 and 22/plant, equivalent to 52% and 53% over the control in the years 2005 and 2006, respectively. This result agrees with the reports of Subba Rao [18] which showed that Mo is required for nodulation in legumes. Rahman *et al.* [19] observed a significant increase in nodules number in mungbean as a result of molybdenum application in Bangladesh. Studies conducted under Turkish conditions by Yesim *et al.* [20] have shown seed treatment with molybdenum significantly increased nodules formation in grain legumes. In contrast, Rubens *et al.* [21] did not observe Mo+Co effects on nodulation in soil with established *Bradyrhizobium* population. They also showed that application of Mo+Co on seeds reduced nodules dry weight. In Brazilian soils, Vierar *et al.* [22] found the main effect of Mo on nodulation appears to be the avoidance of nodule senescence, and so maintaining a longer period of effective N_2 fixation. According to Brent *et al.* [23] nodules are strong sinks for Mo and they accumulate significantly more Mo than what is required in

order to support bacterial *nitrogenase* activity and symbiotic nitrogen fixation.

Nitrogen accumulation in the plant tissue increased by 116 and 108 per cent over the control in the year 2005 and 2006, respectively, as a result of application of 0.5 kg Mo/ha. However, there was no significant difference between the effects of 0.25 kg Mo /ha and that of 0.5 kgMo/ha in the year 2005. This indicates that Mo enhanced N metabolism because of its requirement by N assimilation enzymes (*nitrate reductase*) [23]. Accordingly, in most plant species, Mo starvation was shown to reduce the maximum *nitrate reductase* activity (N assimilation) and re-supplying Mo as a foliar spray or in supplemented nutrient solution in most instances will readily recover *nitrate reductase* activity. It was observed by Abd El-Samad *et al.* [24] that Mo application caused a stronger increase in the activity of *nitrate reductase* (N assimilation) compared to *nitrogenase* activity (N_2 -fixation). Since N accumulation is the highest in cowpea, it means the crop is probably the most efficient in absorbing soil Mo to meet the requirement of the molybdoenzymes.

Table 4: Influence of molybdenum rates on nodulation and nitrogen content and fixation by cowpea, groundnut and bambara groundnut, combined for two years

Crops	Rate (kg Mo/ha)			Mean
	0	0.5	1.0	
Nodules/plant				
Cowpea	29.33	31.83	41.83	34.33 ^c
Groundnut	58.33	76.67	79.17	71.39 ^a
Bambara groundnut	29.33	43.00	57.83	43.39 ^b
Mean	39.00 ^c	50.50 ^b	58.62 ^a	
SE±	1.67 (rate)			
SE±	1.67 (crop)			
SE±	2.89 (interaction)			
Total N in plant (kg/ha)				
Cowpea	33.67	57.17	77.54	56.13 ^a
Groundnut	27.00	50.31	59.45	45.58 ^b
Bambara groundnut	28.72	42.34	49.73	40.26 ^c
Sorghum	6.14	11.77	14.04	10.65 ^d
Mean	23.27 ^c	40.40 ^b	50.19 ^a	
SE±	1.27 (rate)			
SE±	1.47 (crop)			
SE±	2.55 (interaction)			
N-fixed (kg/ha)				
Cowpea	27.57	45.41	63.50	45.49 ^a
Groundnut	20.87	38.54	45.41	34.94 ^b
Bambara groundnut	22.62	30.57	36.03	29.74 ^c
Mean	23.68 ^c	38.17 ^b	48.31 ^a	
SE±	1.79 (rate)			
SE±	1.79 (crop)			
SE±	3.11 (interaction)			
% NDFA				
Cowpea	80.48	79.41	82.41	80.77 ^a
Groundnut	75.40	74.74	74.43	74.86 ^b
Bambara groundnut	71.83	70.66	69.98	70.82 ^c
Mean	75.90 ^a	74.94 ^a	75.61 ^a	
SE±	1.39 (rate)			
SE±	1.39 (crop)			
SE±	2.42 (interaction)			
% Soil N				
Cowpea	0.049	0.062	0.072	0.061 ^b
Groundnut	0.051	0.066	0.077	0.065 ^a
Bambara groundnut	0.051	0.059	0.064	0.060 ^b
Sorghum	0.031	0.028	0.025	0.028 ^c
Mean	0.047 ^b	0.054 ^b	0.062 ^a	
SE±	0.02 (rate)			
SE±	0.03 (crop)			
SE±	0.04 (interaction)			

Means in columns and rows followed by similar letter(s) are not significantly different at the 5% probability level of the Duncan's Multiple Range Test (DMRT)

Application of 0.5 kg Mo/ha increased the amount of N₂ fixed by 140 and 91% over the control in the years 2005 and 2006, respectively. This result is in agreement with several reports [25, 26, 23] that Mo fertilization enhances N fixation in nodulated legumes because the element is a constituent of Mo-Fe protein *nitrogenase* and it increases *nitrogenase* activity rate. The Mo requirements for N₂ fixation are greater than those of nodulation. In contrast, Rubens *et al.* [21] reported that soil application of Mo+Co did not supply the Mo necessary to the plant and to the biological N₂ fixation.

They also observed that application of Mo on seeds reduced biological nitrogen fixation in glasshouse experiment. Cowpea consistently fixed the highest amount of N (33.45 and 57.53 kgN/ha) in the years 2005 and 2006, respectively, indicating that the crop is efficient in extracting soil Mo to promote nodular activities.

Treatment effects on the percentage of N derived from fixation were not significant (P>0.05) in the year 2005, but the percentage decreased significantly (P<0.05) when Mo fertilizer was applied in 2006. Treatment had no significant (P<0.05) effects in the levels of soil available N

in the year 2005, but the effect was significant ($P < 0.05$) during the second cropping season. This indicates that Mo fertilization enhanced N_2 fixation and N excretion by legume crops which in turn, increased the N status of the soil. Soil under Mo-treated groundnut contained the highest amount of the available N. It is therefore assumed that groundnut excretes substantial amount of N into the soil. This could be due to its large number of nodules per plant.

The means of the results for the two years (Table 4) showed that application at the rate of 0.5 kg Mo/ha increased the nodules number by 20 per plant; N content and N fixed by 112% and 115%, respectively over the control. Total N content was highest in cowpea (56.13 kgN/ha). Also cowpea fixed the highest amount of N (45.49 kgN/ha). The percentage of N derived from fixation was decreased with increasing the rates of Mo, but the differences were not significant. Among the crops, cowpea had the highest percentage NDFA (80.79%). The amount of available N in the soil increased with increase in the rates of Mo, but there was no significant difference between the control and 0.25 kg Mo/ha treatment. The highest amount of available N was found in the soil under groundnut.

CONCLUSION

The results of this study demonstrate the positive effects of molybdenum application on nodule formation, nitrogen fixation and excretion by grain legumes in sudano-sahelian region. The crops differed significantly in their response to Mo application. Cowpea fixed the highest amount of N and therefore, cultivation of cowpea variety Bornoji-red and application of 0.5 kgMo/ha can improve the N status of the soil in this agroecological region.

REFERENCES

1. Sanginga, N., 2003. Role of biological nitrogen fixation in legume based cropping systems: a case study of West Africa farming systems. *Plant and Soil*, 252: 25-39.
2. Food, Agriculture Organizations (FAO), 2000. *Production Year Book Volume 47*.
3. Yakubu, H., J.D. Kwari and A.L. Ngala, 2008. Screening of Grain Legumes Varieties for Nitrogen Fixation in the Sudano-Sahelian Zone of Northeastern Nigeria. *J. Exoerimental and Applied Biology*, 9(2): 165-171.
4. Giller, K.E., 2001. *Nitrogen Fixations in Tropical Cropping Systems*. 2nd ed. CAB International. Willingford, Oxen, UK.
5. Yusuf, A.A., E.N.O. Iwuafor, O.O. Olufajo, R. Abaidoo and N. Sanginga, 2006. Genotype effects of cowpea and soybean on nodulation, N_2 -fixation and N balance in the northern Guinea Savanna of Nigeria. In *Proceeding of the 31st Annual Conference of the Soil Science of Nigeria 13-17th November 2006*. Ahmadu Bello University Zaria., pp: 147-154.
6. Bationo, A. and P.L.G. Vlek, 1998. The role of nitrogen fertilizers applied to food crops in the sudano-sahelian zone of West Africa. In: G. Renard, A. Neep, K. Becker and M. Open, (eds). *Soil Fertility Management in West African Land Use Systems*. Margrave. Verlag, Weikersheim, Germany, pp: 41-51.
7. Rifat, H., 2005. *Sustainable Legume-Cereal Cropping System Through Management of Biological Nitrogen Fixation in Pothwar, Pakistan*. PhD Thesis, University of Arid Agriculture, Rawalpindi, Pakistan, pp: 171.
8. Giller, K.E. and K.F. Wilson, 1991. *Nitrogen fixation in Tropical Cropping Systems*, pp: 118-154. CAB International.
9. Sandabe, M.K., G.I. Nwaka and F.A. Ajayi, 2000. Profile distribution of available Molybdenum in some soils of Damboa/Chihok plains, Borno State, Nigeria. *J. Arid Agric.*, 10: 163-165.
10. Sandabe, M.K. and U. Bapatel, 2008. The response of tomato to the application of Mo in semi-arid area of north-eastern Nigeria. *International J. Agriculture and Biology*, 10: 78-108.
11. Rayar, A.J., 2000. *Sustainable Agriculture in Sub-Saharan Africa. The Role of Soil Productivity*, pp: 164-188. AJR Publication-Channel, India.
12. Van Reeuwijk, I.P., 1992. *Procedures for soil Analysis*. Technical paper No. 9 (3rd Ed) Inst. Soil reference and information centre, Netherland.
13. Borno State Agricultural Development Programme, (BOSADP) 1993. *Package of cropping recommendations for Borno State*.
14. Marr, L. and M.S. Cresser, 1983. *Environmental Chemical Analysis*. International Textbook Company, U.S.A. Chapman and Hall, New York, pp: 184.
15. Mary, S.V., M.S. Carlos, U. Segundo and M.B. Robert, 1995. Quantification of the contribution of N_2 fixation to tropical forage legumes and transfer to association grass. *Soil Biology and Biochemistry*, 27: 1193-1200.
16. Gomez, K.A. and A.A. Gomez, 1984. *Statistical Procedures for Agricultural Research*. Second Edition. John Wiley, New York, pp: 680.

17. Fertilizer Procurement and Distribution Division (FPDD) 2002. Fertilizer use and Management practices for crops in Nigeria. Series, 2: 163.
18. Subba Rao, N.S. 2001. (Ed). Soil Microbiology, Science Publishers. Inc., pp: 199-231.
19. Rahman, M.M., M.M.H. Buiyan, G.N.C. Sutradhar, M.M. Rahman and A.K. Paul, 2008. Effect of phosphorus, molybdenum and *Rhizobium* inoculation on yield and yield attributes of mungbean. *Int. J. Sustain. Crop Prod.*, 3(6): 26-33.
20. Yesim, T., T. Necat and D. Yusuf, 2008. Research on the effect of phosphorus and molybdenum applications on the yield and yield parameters in lentil (*Lens culinaris*). *African J. Biotechnol.*, 7(9): 1256-1260.
21. Rubens, J.C., U. Albino and M. Hungria, 2002. Importance of Molybdenum and Cobalt to the Biological Nitrogen fixation. *Current Plant Science and Biotechnology in Agriculture*. Vol.38. Springer Netherlands., pp: 597-59.
22. Vierar, F.J., B.N. Cardoso, C. Vieira and T.A. Cassini 1998. Application of molybdenum in common bean. III. Effect on nodulation. *J. Plant Nutrition.*, 2(10): 2153-2161.
23. Brent, N.K., K.L. Gridley, J.N. Brady T. Philips and S.D. Tyerman, 2005. The role of Molybdenum in Agricultural plant production. *Annals of Botany* 96(5): 745-754.
24. Abd El-Samad, H.M. H.M. El-Komy, M.A.K. Shaddad and A.M. Hetta, 2005. Effect of Molybdenum on Nitrogenase and Nitrate reductase activities of wheat inoculated with *Azospirillum brasilense* grown under drought stress. *Gen. Appl. Plant Physiol.*, 31(1-2): 43-54.
25. Tenywa, J.S., 1997. Influence of Molybdenum and Cobalt fertilization on Symbiotic Nitrogen fixation indicators in an oxisol in Uganda. *African Crop Sc. J.*, 5(1): 87-92.
26. Brady, N.C. and R.R. Weil, 2002. *Nature and Properties of Soil*. Pearson Education Ltd., pp: 560.
27. Safyanu, M., 2004. Boron adsorptions in some soils of Borno State, B. Sc. Project, University of Maiduguri, pp: 34.