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Research Paper

Research

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Molybdenum application for enhancing growth, yield and soil health on green gram (VignaradiataL.)

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ABSTRACT

A field experiment was conducted to evaluate the effects of molybdenum (Mo) application on greengram (Vamban-2) yield and soil properties during the summer season of 2011 at National Pulses Research Centre, Vamban, Pudukkottai.The treatments comprised of six Mo levels viz., 0,200,400,600,800 and 1000 g sodium molybdate(Na2MoO4.2H2O)per hectare. Soil of the experimental field was sandy clay loam (sand – 56%, silt – 15% and clay – 28%) in texture,low in organic carbon (0.36%) and nitrogen (105.3 kg ha-1),medium in phosphorous (38.40 kg ha-1) and high in potassium (203.64 kg ha-1) with pH 5.61.Results showed significantly higher green gram growth and yield under Mo application @ 1000 g sodium molybdate (Na2MoO4·2H2O) per hectare. Available nitrogen and molybdenum contents in soil increased with increasing levels of Mo. The Highest benefit:cost ratio of 2.79 was recorded with soil application of Mo @ 1000 g sodium molybdate per hectare.

Pulses constitute an important ingredient in the vegetarian diet of developing countries like India and also ensure nutritional security to the poor masses. Besides, being a rich source of protein, pulses have the capacity to fix the atmospheric nitrogen and are well adapted to low fertility and limited soil moisture conditions due to deep root system. Greengram is an excellent source of high quality and digestible proteins (25 per cent). Molybdenum (Mo) is one of the most limiting factor in green gram production, and is deficient in majority of green gram cultivated tracts of India (Soil Survey and Land Use Organization, 2005).Molybdenum (Mo) is an essential component of the major enzyme nitrate reductase (a soluble molybdoflavoprotein) in plants. It occurs in the envelope of chloroplasts in leaves. It is also involved in synthesis of ascorbic acid and in making iron (Fe) physiologically available within the plant. As a fertilizer, Mo is notable for the small quantities that often can produce significant yield increases ie) quantities measured in grams of Mo per hectare (Flemming, 1980).The biological importance of Mo in plants is due to its highly beneficial action in the fixation of nitrogen from the air, by the nitrogen-fixing bacterium (*Azotobacterchroococcum*). Despite the fact that Mo is known to improve the crop yield particularly pulses, detailed study has not been undertaken due to the belief that Mo deficiency occurs primarily in temperate conditions or hilly soils where the soil pH is usually acidic. In Tamil Nadu, some of the low land laterite soils particularly Pudukkottai and Sivagangai Districts where the soils are acidic to highly acidic causing Mo deficiencies in pulses grown there (Soil Survey and Land Use Organisation, 2005). The coarse textured soils of India have also been reported to be widely deficient in important micronutrients *viz.,* Zn and Fe as well as Mo (Singh*et al*, 2008).Therefore, the present investigation was taken to evaluate the different levels of Mo application on crops yield, available Mo status in pulses (green gram) grown in laterite soil of Pudukkottai district.

MATERIALS AND METHODS

A field experiment was conducted at Agronomy Research Farm of National Pulses Research Centre, Vamban, Pudukkottai during kharif2011 to study the influence of molybdenum levels on growth, yield and economics of greengram (Vamban-2) under rainfed condition. The experiment was laid out in a randomized block design with five replications. Treatments comprised of six molybdenum levels *viz*.,0, 200, 400, 600, 800 and 1000 g sodium molybdate ($Na_2MoO_4.2H_2O$)per hectare. The soil of the experimental field was sandy clay loam (sand – 56%, silt – 15% and clay – 28%) in texture, acidic in soil reaction (pH 5.61), low in organic carbon (0.36%), nitrogen (105.3 kg ha^{-1}) and available molybdenum (0.04 mg kg^{-1}), medium in phosphorous (38.40 kg ha^{-1}), high in potassium (203.64 kg ha^{-1}), with bulk density 1.32 Mg m^{-3} and electrical conductivity(0.30 dS m^{-1}). Green gram variety VBN (Gg) 2, a high yielding variety released by National Pulses Research Centre, Vamban was chosen for the study.

Seeds of green gram variety VBN (Gg) 2 were sown on 15.12.11 dibbled with a spacing of 30 × 10 cm. Seed rate of 20 kg $ha^{-1}$was adopted. Uniform fertilizer schedule was followed at the rate of 25: 50: 25 NPK kg ha^{-1}. The entire quantity of fertilizers was applied basally before sowing. Foliar spray of 2 % DAP was given twice at flowering and after 15 days of flowering stages. Six irrigations were given to the crop. Dimethoate was sprayed at the rate of 750 ml ha^{-1} after 30 days of sowing to control pod borer infestation.

Growth and yield observations

In each treatment and replication, five plants were selected and their respective plant height, numbers of branches, root length, shoot and root mass was recorded. The volume of the roots was measured by volume displacement method and expressed as cm^3.

In each treatment and replication, five plants were selected and the number of pods and seeds per plant was recorded. The grains were dried in oven at 70 ± 120^0 C for 24 hours and 100 grain weights for each treatment (in five replications) were recorded. The average was calculated and expressed in grams. The yield of pods $plot^{-1}$ of plot size 20 m^2 of each treatment and replication was recorded from the net plot and expressed as kg ha^{-1}. After drying the pod, weight of the pod, haulm and seed was taken and expressed as kg ha^{-1}.

Economic analysis

Cost of Mo fertilizer @ 1000 rupees per kilogram and farm gate price @ 650 rupees per kilo gram and benefit cost ratio was calculated based on additional return and additional cost.

Soil Analysis

The soil samples were collected from 30 cm depth before the conduct of the experiment and after the harvest of the crop. Samples were air dried, sieved through 2 mm mesh and used for N, P and Mo estimation. The available soil nitrogen was estimated by the method proposed by Subbiah and Asija (1956). Available soil phosphorus was estimated by the procedure outlined by Bray *et al* (1954). Available molybdenum was estimated by ammonium bicarbonate method (AB-DTPA) outlined by Soltanpour and Schwab (1977).

Statistical analysis

The data collected were subjected to statistical analysis in ANOVA (Ranganathan, 1990). Whenever the treatment difference was found significant (F test), critical difference was worked out at 5 per cent probability level and the values were furnished. If there are no significant difference between treatments, it was denoted by the symbol NS.

RESULTS AND DISCUSSION

Growth and yield of greengram

Among the fertilizer levels, fertilizer dose of 1000 g $Na_2MoO_4·2H_2O$ per hectare showed that except plant height and number of branches, other growth parameters were significantly influenced by Mo fertilization (Table 1). As regards to growth parameters, green gram variety VBN (Gg) 2 responded to sodium molybdate linearly. The beneficial response observed was probably due to the formation of effective nodules which are the sites of N-fixation and it is well documented that molybdenum favours N-fixation process which eventually help the plants in growth and yield (Gupta and Potalia, 1987; Anwarulla and Shivasankar, 1989). In particular, significant root growth parameters were significantly root growth parameters were significantly influenced with Mo application. The highest rate (1000 g ha^{-1}) of Mo application recorded 40 per cent increase in pod and seed yield in comparison to control.

Similarly incremental levels of molybdenum application increased both pod and seed yield linearly. The highest pod (954 kg ha^{-1}) and seed yield (609.6 kg ha^{-1}) were recorded under 1000 g $Na_2MoO_4.2H_2Oha^{-1}$(Table 2).The increase in pod and seed yield was to the tune of 40 per cent over the control. Such phenomenal increase was attributed apparently to increased availability of nitrogen in the soil which helped the plants to produce abundance of effective nodules which inturn led to produce huge biomass, pod and seed yield (Reddy *et al.* 2007).

Soil characteristics

Data with respect to available N, P and Mo in soil after crop harvest are presented in Table 3. The plots treated with molybdenum fertilizers (T5-1000 g $Na_2MoO_4·2H_2O$ ha^{-1}) showed higher available nitrogen content in soil as 105.4kg ha^{-1} than control plots as 100.3 kg ha^{-1} (Table 3).It is obvious that soil application of Mo favorably enhanced nodulation in greengram which eventually get decomposed and mineralized and contribute for the available nitrogen. There is a close association between Mo fertilization and availability of nitrogen in soils (Singh *et al*, 2012). Laltlanmawia*et al.*(2004)and Bhattacharya *et al.* (2004) also reported that incremental levels of Mo has correspondingly increased number of nodules which assisted in N-uptake of soybean plants and resulted in higher yield.

Increasing the fertilizer levels of molybdenum increased the available phosphorous content of soil significantly. Fertilizer level of 1000 g $Na_2MoO_4.2H_2O$ ha^{-1}recorded higher available phosphorous content in soil (46 kg ha^{-1}) than control treatment (44 kg ha^{-1}). Mo has synergistic interaction with P due to formation of phosphomolybdate complex which is also readily available form of Mo (Barshad, 1951). Release of organic acids from decomposition of huge root biomass under Mo application might have played role in solubilizing unavailable phosphorous into available forms.

Mo in soil also increased with increasing levels of Mo which is an expected lines. Mo in soil increased from 0.04 mg kg^{-1} under control to 0.14 mg kg^{-1} under highest dose of Mo at the rate of 1000 g ha^{-1}.

Economics of Mo application

Economic viability of crop management is the foremost criteria in transforming new investigations to farmer's field. The results revealed that the highest B:C ratio of 2.79 was obtained under the treatment of 1000 g $Na_2MoO_4.2H_2O$ ha^{-1}(Table 5). Even though the initial cost of molybdenum fertilizers was high, molybdenum fertilization has recorded higher yield and hence increased the B: C ratio.

Based on the above discussion, it can be concluded that application of 1000 g $Na_2MoO_4.2H_2O$ ha^{-1}can be recommended under rainfed condition for maximum productivity and benefit cost ratio in green gram variety VBN (Gg) 2.

Table 1. Effects of Mo application on growth characteristics of green gram (Vamban-2) during 2011

Treatments	Roots			Shoots		
	Dry matter product (g plant^{-1})	Length (cm)	Volume (cm^3)	Height (cm)	No of branches	Dry matter product (g plant^{-1})
M_0(0 g $Na_2MoO_4·2H_2Oha^{-1}$)	0.5	13.8	2	37.2	7	51.9
M_1 (200 g $Na_2MoO_4·2H_2Oha^{-1}$)	0.54	16.5	2.8	38.2	8	58
M_2 (400 g $Na_2MoO_4·2H_2Oha^{-1}$)	0.84	18.7	3	38.5	8	63.9
M_3(600 g $Na_2MoO_4·2H_2Oha^{-1}$)	0.91	21.2	3.5	39.3	8	72.4
M_4 (800 g $Na_2MoO_4·2H_2Oha^{-1}$)	0.93	23.2	4.2	40	9	78.2
M_5 (1000 g $Na_2MoO_4·2H_2Oha^{-1}$)	1.44	27.4	6.1	41	9	95.5
SEd	0.06	0.6	0.3	1.3	1.34	1.02
CD (0.05)	0.13	1.24	0.63	NS	NS	2.12

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Table 2.Effects of Mo application on yield and yield attributes of green-gram (Vamban-2) during 2011

Treatments	Haulm yield	Pod yield	Seed yield
	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})
M_o (0 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	1128	564	330.1
M_1(200 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	1284	642.4	378.3
M_2 (400 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	1388	694.8	413.6
M_3 (600 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	1521	760.9	452.3
M_4 (800 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	1687	843.9	528
M_5 (1000 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	1908	954	609.6
SEd	2.18	10.86	9.07
CD (0.05)	4.55	22.65	18.91

Table 3. Effects of Mo application on soil characteristics at harvest stage during 2011

Treatments	macronutrient		micronutrient
	N	P	Avail. Mo
	(kg ha^{-1})	(kg ha^{-1})	(mg kg^{-1})
Mo (0 g $Na_2MoO_4 \cdot 2H_2O$ ha^{-1})	100.3	44	0.04
M_1 (200 g $Na_2MoO_4 \cdot 2H_2O$ ha^{-1})	101.5	45.8	0.05
M_2 (400 g $Na_2MoO_4 \cdot 2H_2O ha^{-1}$)	102.4	45.4	0.07
M_3 (600 g $Na_2MoO_4 \cdot 2H_2O$ ha^{-1})	103.3	44.8	0.08
M_4 (800 g $Na_2MoO_4 \cdot 2H_2O$ ha^{-1})	104.3	45.4	0.09
M_5 (1000 g $Na_2MoO_4 \cdot 2H_2O$ ha^{-1})	105.4	46	0.14
SEd	0.09	1.21	0.01
CD (0.05)	0.19	NS	0.02

Table 4. Economics of Mo application to green gram during 2011

Treatments	Additional costs (Rs)	Additional Yield (kg ha^{-1})	Additional Returns (Rs)	B:C ratio
M_1 (200 g $Na_2MoO_4.2H_2O$ ha^{-1})	600	48	1440	2.4
M_2 (400 g $Na_2MoO_4.2H_2O$ ha^{-1})	1200	83	2490	2.08
M_3 (600 g $Na_2MoO_4.2H_2O$ ha^{-1})	1800	122	3660	2.03
M_4 (800 g $Na_2MoO_4.2H_2O$ ha^{-1})	2400	198	5940	2.48
M_5 (1000 g $Na_2MoO_4.2H_2O$ ha^{-1})	3000	279	8370	2.79

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