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# SOIL AND FOLIAR APPLICATION OF MOLYBDENUM ON YIELD, BIOCHEMICAL QUALITY OF GREEN GRAM (*VIGNA RADIATA* L.) GROWN IN Fe RICH SOILS

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## Abstract

More than 70 % soils of Odisha are acidic with dominance of Fe and Al where Mo deficiency in soils affects the yield of rabi green gram which is much below than the national average. With this background an experiment was conducted by soil application four dose of molybdenum (0, 250, 500, 750 g/ha) and two foliar spraying of molybdenum @0.1% Mo ($F_1$) and 0.2% Mo ($F_2$) on the variety IPM 02-14. A light texture acidic sandy loam soil of central farm, OUAT, Bhubaneswar which is dominated by micronutrients like Fe, Mn, Al and deficient in molybdenum was selected for the experiment. It was observed that growth and yield attributing characters increased with the increase in foliar spraying (FS) of molybdenum as well as combined application of foliar and soil application up to a dose of (250 g/ha soil application with 0.2% foliar application of Mo) after which a decrease in all the attributes was observed. The highest yield of green gram was 549 kg/ha at combined application of 250 g/ha soil with 0.2% foliar spray of molybdenum. Uptake of major nutrients (N,P and K)was increased and the highest uptake was at $Mo_3F_2$. Improvement in soil fertility was observed in post-harvest soil with a positive balance in availability of nitrogen after meeting the crop requirement. Therefore, application of both soil and foliar spray (250 g/ha soil with 0.2%) was optimum dose of Mo for green gram grown in low fertile and Fe rich acidic soil.

## Introduction

Different types of pulses are important ingredient in human diet to ensure nutritional security of poor population and ICMR recommended a daily consumption of 50 g/day.

In Odisha, pulses are mainly cultivated as pre rabi or pre summer crop on residual moisture after harvesting of rice. Pulse seeds are directly sown in rice fallows without proper agronomic practices which results in a very poor production of green gram (450kg/ha) and average productivity remained much below the national average of 980 kg/ha (2015-16).

In Odisha, 70% soil is acidic with rich in iron, manganese containing mineral .Available nitrogen status is very less and molybdenum deficiency is wide spread in soil which indirectly affects pulse production and poor fertile soil with respect to nitrogen. Singh *et al.* (2008) reported molybdenum deficiency in acidic soils of India. When plants are under Mo deficiency activity of the molybdoenzymenitrate reductase enzymes reduces. Flemming (1980) reported that small amount of molybdenum often can produce significant increase in yield by application through soil, foliar or seed treatments which enhances the biochemical attributes of plants, thereby enhancing the physiological process of plants resulting in higher crop yield. Loss of NR activity is associated with increased tissue $NO_3^-$ concentration, decrease in plant growth and yield (Unkles *et al.* 2004). To increase efficiency of the bacteria rhizobium in poor acid soil, molybdenum application is inevitable.Molybdenum (Mo) is one of the most limiting factors in green gram production and is deficient in many areas under pulse cultivation. Therefore in the present investigation effects of different levels of Mo application on green gram yield and soil fertility were evaluated.

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**Materials and Methods**

The present study was carried out on Rabi 2020-21 at E block, Central farm of OUAT, Bhubaneswar to know the impact of molybdenum fertilization on growth and yield of green gram along with changes in soil fertility. The experiment was conducted in completely randomized design (CRD) in polypots by taking one light texture acidic soil deficient in molybdenum, nitrogen and a nutrient poor soil. For this two doses of molybdenum such as 0.1 and 0.2% were selected as foliar spraying at 30 days after sowing and four doses of molybdenum such as 0,250,500,750 g/ha molybdenum as $MoO_3$ as basal application along with recommended dose of fertilizer. Complete randomized design was carried out in pot by taking eight treatments and three replications .So total 24 pots were taken .Each pot was filled with 5 kg soil with recommended dose of fertilizer 20:40:40 N, $P_2O_5$, $K_2O$ kg/ha. Full dose of P, half dose of N & K along with soil application dose of Mo were applied as basal. Remaining half of K and N were top dressed at 30 DAS. Six seeds of Green gram were sown in each pot. After germination seedlings were thinned to 4 plants per pot . Foliar spraying of Mo was undertaken at 30 DAS. Green gram variety (*IPM -02 14*) of 75 days duration was taken as test crop. Different growth and yield attributing characters like plant height, number of leaves, root length ,pod length ,no of pods per plant, no of seeds per pod ,pod yield, seed yield ,biochemical parameters like nitrate reductase activity, chlorophyll a , chlorophyll b content , before spraying and after spraying of molybdenum along with nutrient content of seed and plant were estimated. After crop maturity post-harvest soils were analysed for soil fertility study.

Biochemical parameters like activity of enzyme nitrate reductase was estimated as per the method of Smarrelli and Campbell (1980) and expressed as mg of $NO_2$-/g.Chlorophyll content was estimated after extraction in acetone as per the method described by Arnon (1949). Plant tissues and seeds were analysed for total nutrient content (Jackson 1976) and molybdenum for uptake computation. Post-harvest soils were analysed for available major nutrients N as per the method of Subbiah and Asija (1956),P and K as described by Jackson (1973). Nitrogen balance in post-harvest soil was estimated to know the impact of Mo on nitrogen fixation. Before starting of the experiment soil was analyzed for various physic-chemical properties (Table 1).

**Results and Discussion**

Soil of the experimental site was strongly acidic, non-saline, low in organic carbon content, light texture, low in available nutrients like nitrogen, available phosphorus, available potassium and molybdenum content but rich in micronutrients Fe, Mn.

Number of leaves varied from 10.1 to 13.4. Highest number of leaves (13.4) was found in $Mo_1F_1$ treatment which received both 250 g of Mo as soil application with 0.1% foliar spraying. Due to only foliar spraying, number of leaves increased from 12 to 12.8. Further increase in number of leaves was observed when soil application was combined with foliar spraying and increase was from 13.2 to 13.4 which was at par with each other. Root length of green gram varied from 10.1 cm to 14.6cm due to molybdenum application with recommended dose of fertilizer either by foliar spraying or by combined application of both foliar spraying with soil application. Highest root length (14.6 cm) was found in the treatment $Mo_1F_2$ which received combined application of 250 g molybdenum soil application and foliar spraying @0.2% Mo. The influence of Mo on root elongation is associated with the stimulation of ABA production. Similar effect was observed by Majda *et al.* (2019). Results of yield attributing parameters like pod length, pods/plant, seeds/pod, pod weight were recorded and presented in Table 3 showed highest pod length (6.07 cm) was observed in the treatment of $Mo_1F_2$ by combined application of both 250 g Mo/ha to soil and 0.2% foliar spraying of Mo twice. By application of only foliar spraying @

0.1%, lowest number of pods were observed per plant. When foliar spraying increased to double dose @0.2%, no of pods per plant significantly increased up to 4.6 which was 31.4% more than 0.1 % foliar spraying ($Mo_0F_1$). Highest number of pods per plant (7.1) was noticed in the same $Mo_1F_2$ treatment.

**Table 1. Initial soil properties of experimental soil.**

| Parameters | Value | Inference |
|---|---|---|
| pH (1:2.5) | 4.6 | Strongly acidic |
| EC (dS/m) | 0.091 | Non saline |
| OC (g/kg) | 3.0 | Low |
| Clay (%) | 12.5 | |
| Texture | Sandy loam | Light texture |
| Av.N (kg/ha) | 132.6 | Low |
| Av.P2O5 (kg/ha) | 11.5 | Low |
| Av.K20 (kg/ha) | 50.0 | Low |
| *Ex* Ca (cmol (P+)/kg) | 4.5 | |
| *Ex* Mg (cmol (P+)/kg) | 2.4 | |
| DTPA Fe (ppm) | 250 | Very high |
| DTPA Mn (ppm) | 50 | High |
| Mo (ppm) | 0.045 | Low |

**Table 2. Growth attributing characters of Green gram.**

| Treatments | Plant height(cm) | No of leaves per plant | Root length(cm) |
|---|---|---|---|
| $Mo_0F_1$ | 13.91 | 12.0 | 10.7 |
| $Mo_0F_2$ | 14.07 | 12.8 | 12.9 |
| $Mo_1F_1$ | 15.86 | 13.2 | 13.5 |
| $Mo_1F_2$ | 16.08 | 13.4 | 14.6 |
| $Mo_2F_1$ | 14.72 | 10.9 | 13.0 |
| $Mo_2F_2$ | 14.08 | 10.1 | 12.1 |
| $Mo_3F_1$ | 14.79 | 11.9 | 10.2 |
| $Mo_3F_2$ | 14.81 | 12.5 | 10.1 |
| SEM (±) | 0.85 | 0.95 | 0.83 |
| C.D. (0.05) | 2.59 | 2.87 | 2.53 |

**Table 3.Yield and yield attributing characters of green gram in response to Mo fertilization.**

| Treatments | Pod length cm | No of pods/plant | No of seeds /pod | Pod yield kg/ha | Seed yield | %Increase /decrease |
|---|---|---|---|---|---|---|
| $Mo_0F_1$ | 4.00 | 3.5 | 8.5 | 627 | 460 | - |
| $Mo_0F_2$ | 5.38 | 4.6 | 9.3 | 643 | 478 | 3.99 |
| $Mo_1F_1$ | 5.48 | 6.2 | 9.8 | 653 | 517 | 12.46 |
| $Mo_1F_2$ | 6.07 | 7.1 | 10.3 | 680 | 549 | 15.36 |
| $Mo_2F_1$ | 5.77 | 6.9 | 10.2 | 717 | 526 | 14.35 |
| $Mo_2F_2$ | 5.73 | 6.8 | 9.8 | 720 | 522 | 9.42 |
| $Mo_3F_1$ | 5.00 | 5.6 | 9.7 | 725 | 521 | 13.33 |
| $Mo_3F_2$ | 4.03 | 5.2 | 9.7 | 700 | 520 | 8.99 |
| SEM(±) | 0.18 | 0.25 | 0.17 | 13 | 8.0 | |
| C.D. (0.05) | 0.53 | 0.76 | 0.51 | 42 | 25.0 | |

No of seeds per pod varied from 8.5 to 10.3 by application of both soil and foliar application. Lowest number of seeds per pod (8.5)was observed in the treatment of foliar spraying @ 0.1% and significantly increased to 9.3 by application of double dose of foliar spraying @0.2%. The treatment receiving both soil and foliar application number of seeds per pod significantly increased by15.29% than only foliar spraying @0.1%.Highest number of seeds (10.3) was observed at $Mo_1F_2$ treatment (250 g soil and 0.2% foliar application of molybdenum).

Green gram Pod yield varied from 627 to 725kg/ha due to different molybdenum fertilization. Only spraying of molybdenum@ 0.1% produced lowest pod yield of 627 kg/ha which increased non significantly to 643 kg/ha by increasing the foliar concentration from 0.1 to 0.2%. Combined application of both soil and foliar application of lowest dose of molybdenum 250g/ha +0.1% FS with Mo. Pod yield further increased to 653kg/ha and showed an increasing trend in response to increase in molybdenum fertilization. Highest pod yield of 725 kg/ha was noticed at molybdenum dose of $MO_3F_1$ (750g Mo +0.2% foliar spraying Mo) . Thus, increased pulse yield in low Mo soils could be attributed to improve nutrient availability such as increased N fixation by the application of Mo which eventually increased plant growth (Velmurugan2015).

Green gram seed yield due to different molybdenum fertilizer varies from 460 to 549kg/ha. Lowset yield was observed at 0.1% molybdenum and highest yield was obtained at $MO_1F_2$i.e 250 g of molybdenum with 0.2% foliar spraying. Green gram seed yield decreased when molybdenum dose increased from 500 g to 750 g along with foliar spraying

Mean seed yield of Green gram only due to foliar spraying of Mo was 469 kg/ha .Soil application of Mo @250 g/ha enhanced the Green gram mean seed yield by 13.6% irrespective of the dose of foliar spraying (Table 4).Thereafter by further doubling the soil application dose of Molybdenum mean seed yield though decreased but 11.7 % increase was observed over only foliar spraying .Similar trend was observed at Mo3 i.e. 750 g/ha of Mo .only 2% increase in seed yield was observed by increasing the foliar spraying @ from 0.1 % Mo to 0.2% Mo.

Decrease in seed yield beyond certain dose of Mo might be due to both low and excess molybdenum which affects the quality of seed by lowering sugars, starch, protein ,nitrogen content ,leaching rate and electrical conductivity of seed. Application of molybdenum either in excess or deficient resulted light weight immature seeds, poor vigour content and low germination

potential of seeds. These findings are in agreement with the findings of Gopal *et al.* (2016) who also found similar result .

**Table 4. Mean Seed yield of green gram.**

| Treatments | $F_1$ | $F_2$ | Mean | % increase |
|---|---|---|---|---|
| $Mo_0$ | 460 | 478 | 469 | |
| $Mo_1$ | 517 | 549 | 533 | +13.64% |
| $Mo_2$ | 526 | 522 | 524 | +11.72% |
| $Mo_3$ | 521 | 520 | 521 | +10.98% |
| Mean | 506 | 517 | 511.6 | |
| % Increase | | +2.17 | | |

**Table 5.Effect of molybdenum fertilization on biochemical attributes of green gram.**

| Treatments | NR | Chlorophyll a (mg/g fresh weight) | | Chlorophyll b (mg/g fresh weight) | |
|---|---|---|---|---|---|
| | (mg of $NO_2$-/gm) | Pre flowering | Pod development | Pre Flowering | Pod development |
| $Mo_0F_1$ | 0.58 | 0.07 | 0.14 | 0.05 | 0.23 |
| $Mo_0F_2$ | 0.60 | 0.13 | 0.17 | 0.12 | 0.32 |
| $Mo_1F_1$ | 0.68 | 0.18 | 0.26 | 0.15 | 0.45 |
| $Mo_1F_2$ | 1.16 | 0.14 | 0.16 | 0.13 | 0.27 |
| $Mo_2F_1$ | 1.09 | 0.17 | 0.22 | 0.16 | 0.39 |
| $Mo_2F_2$ | 0.59 | 0.31 | 0.21 | 0.27 | 0.37 |
| $Mo_3F_1$ | 0.52 | 0.34 | 0.24 | 0.30 | 0.44 |
| $Mo_3F_2$ | 0.51 | 0.37 | 0.24 | 0.31 | 0.48 |
| SEM(±) | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 |
| C.D. (0.05) | 0.11 | 0.04 | 0.03 | 0.03 | 0.03 |

Results of estimation of biochemical parameters like activity of nitrate reductase and chlorophyll content showed that treatment receiving only foliar spraying of Mo @ 0.1 % NR activity was 0.58 mg $NO_2$-/gm fresh weight per hour .NR activity further increased to 0.6 by @0.2% foliar spraying of molybdenum which was at par with 0.1 % foliar spraying (Table 5). Combined application of molybdenum *i.e.* soil @ 250 g/ha with 0.1 % foliar spraying of Mo further increase in NR activity was observed. Highest significant increase in NR activity was observed by soil application @ 250 g Mo/ha + foliar spraying @ 0.2 % Mo. Thereafter a declining trend was observed in NR activity with increase in dose of molybdenum with a lowest value of 0.51 mg of $NO_2^-$/g of fresh weight per hour at highest molybdenum soil application dose of 750 g with 0.2% foliar spraying of molybdenum.

Since molybdenum plays a significant role in chlorophyll formation .Hence to know the effect of molybdenum ,chlorophyll in plant was analyzed twice, one at before flowering (pre flowering) and second at pod development stage. Both chlorophyll a and b were estimated as per the method of Arnon (1949).Results presented in Table 4 showed that increase in chlorophyll a content was observed from pre flowering to pod development stage but up to a certain dose of molybdenum. At pod development stage, chlorophyll a varied from 0.14 to 0.26 mg per g fresh weight. Lowest value was observed by only foliar spraying of molybdenum at lower dose of 0.1%. Highest content of 0.26 mg per g fresh weight chlorophyll a content at $Mo_1F_1$ treatment which was at par with $Mo_3F_1$ or $Mo_3F_2$ treatment.

With combined application of both soil and foliar spraying, chlorophyll b content was found to increase over foliar spraying only as well as with increase in soil application dose of molybdenum. Highest significant chlorophyll b content observed at treatment Mo3F2 which was 0.31 mg/g fresh weight. Chlorophyll b content at this stage was lower than chlorophyll a content.

**Table 6. Effect of molybdenum fertilization on uptake of major nutrients by green gram seed.**

| Treatments | N | P | K |
|---|---|---|---|
| | | Kg/ha | |
| $Mo_0F_1$ | 9.1 | 1.47 | 4.02 |
| $Mo_0F_2$ | 9.9 | 1.68 | 4.62 |
| $Mo_1F_1$ | 13.0 | 1.85 | 5.81 |
| $Mo_1F_2$ | 16.1 | 2.14 | 7.01 |
| $Mo_2F_1$ | 14.3 | 1.84 | 5.45 |
| $Mo_2F_2$ | 15.1 | 1.90 | 4.92 |
| $Mo_3F_1$ | 12.4 | 1.91 | 3.90 |
| $Mo_3F_2$ | 11.9 | 1.75 | 5.17 |
| SEM(±) | 0.71 | 0.09 | 0.11 |
| C.D. (0.05) | 2.15 | 0.28 | 0.32 |

Uptake of major nutrients by green gram crop in different molybdenum treatments are presented in Table 6. Significant increase in major nutrient uptake was observed in response to molybdenum fertilization, highest uptake being in the treatment of combined application of soil and foliar spraying of Mo at an optimum dose of 250 g + 0.2 % FS of Mo (Mo1F2).

After harvest of plants post-harvest soil samples were collected and nitrogen balance was computed. Table 7 revealed that initial available nitrogen content of experimental soil was 133 kg/ha which was low. Significant increase in nitrogen status was observed in post-harvest soil when soil application @250 g with 0.1% foliar spraying of Mo was done which was 160.5 kg/ha. After this dose of molybdenum, available nitrogen content was found to decrease with lowest nitrogen content of 125.7 kg/ha at $Mo_3F_2$ treatment due to fixation of nitrogen by native rhizobium bacteria. Available nitrogen decreases due to available nitrogen responds more in soil application of molybdenum as compared to foliar spraying. Similar improvement in soil status was also reported by Serawat *et al.* (2018). Nitrogen balance calculated showed that an increase in available nitrogen content in soil from 7.34 to 50.01 kg/ha added probably due to fixation of atmospheric nitrogen.

**Table 7. Nitrogen balance in post-harvest soil.**

| Treatments | Initial Soil N | Added N fertilization | Total N input | Total N uptake/removal from soil | Balance N | PHS Av. N | N fixation/ gain |
|---|---|---|---|---|---|---|---|
| | | | | Kg/ha | | | |
| Mo0F1 | 133 | 20 | 153 | 28.25 | 124.75 | 134.8 | 10.09 |
| Mo0F2 | 133 | 20 | 153 | 31.06 | 121.94 | 148.0 | 26.08 |
| Mo1F1 | 133 | 20 | 153 | 39.67 | 113.33 | 160.5 | 47.20 |
| Mo1F2 | 133 | 20 | 153 | 47.18 | 105.82 | 155.8 | 50.01 |
| Mo2F1 | 133 | 20 | 153 | 44.0 | 109 | 148.0 | 39.02 |
| Mo2F2 | 133 | 20 | 153 | 44.6 | 108.4 | 127.7 | 19.27 |
| Mo3F1 | 133 | 20 | 153 | 36.9 | 116.1 | 158.2 | 42.14 |
| Mo3F2 | 133 | 20 | 153 | 34.68 | 118.32 | 125.7 | 7.34 |

Green gram responded positively and significantly to both foliar and soil application with foliar spraying of molybdenum by producing highest growth attributes and yield attributes at a dose of combined application of molybdenum i.e. $Mo_1F_2$ (250g Mo/ha soil application with foliar spraying @0.2%Mo twice). Biochemical attributes such as nitrate reductase activity significantly increased with increase in molybdenum fertilization with highest value of 1.16mg of $NO^{2-}$/g fresh weight per hour recorded in the same treatment of $Mo_1F_2$. An Increase in nitrogen status in post harvest soil was observed indicating the improvement in soil fertility due to nitrogen fixation aided by molybdenum fertilization. Hence inclusion of molybdenum fertilization for plant nutrition and soil health in nutrient poor acidic soils for pulse cultivation is recommended as a dose of 250 g Mo/ha with 0.2% Mo FS twice .

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