Effect of lime coating and molybdenum on the yield and nutrient uptake of green gram (Vigna radiata L.) under mid central table land zone of Odisha

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Abstract
The field experiment was carried out at Regional Research and Technology Transfer Station (OUAT), Mahisapat of Dhenkanal district during kharif season of 2017 and 2018 to study the response of lime coating and molybdenum influencing the yield and nutrient uptake of green gram under Mid Central Table Land zone of Odisha. The experiment was laid out in a randomized block design with four replications comprising of six treatments. The detailed of the treatments are as follows. T1- Soil Test Based Fertilizer Recommendation (STBFR), T2- Soil Test Based Fertilizer Recommendation (STBFR) + Rhizobium inoculation@ 20 kg ha-1 of seed + PSB @4 kg ha-1, T3- Soil Test Based Fertilizer Recommendation (STBFR) + Rhizobium inoculation@ 20 kg ha-1 of seed + PSB @4 kg ha-1 + FYM @5 t ha-1 + Lime 0.2 LR, T4- Soil Test Based Fertilizer Recommendation (STBFR) + Rhizobium inoculation@ 20 kg ha-1 of seed + PSB @4 kg ha-1 + FYM @5 t ha-1 + lime 0.2 LR, T5- Soil Test Based Fertilizer Recommendation (STBFR) + Rhizobium inoculation@ 20 kg ha-1 of seed + PSB @4 kg ha-1 + FYM @5 t ha-1, T6- Soil Test Based Fertilizer Recommendation (STBFR) + Rhizobium inoculation@ 20 kg ha-1 of seed + PSB @4 kg ha-1 + FYM @5 t ha-1 + Molybdenum(lg Ammonium Molybdate per 2.5 kg of seed as seed treatment) + seed coating with lime. It was revealed that T6 recorded significantly higher seed yield (877.50 kg ha-1), 1000 seed weight (37.93 g) and No. of seeds per pod (12.43) followed by T5 with seed concentration of 5.07%, 0.47 % and 1.47 % respectively. The same treatment T6 recorded higher uptake of N, P and K with 35.35, 6.62 and 20.47 kg ha-1 in the harvested seed, respectively.

Keywords: Green gram, FYM, STBFR, molybdenum, PSB (Phosphorus solubilizing bacteria)

Introduction
Pulses are one of the important segments of Indian agriculture after cereals and oilseeds. They are the main source of protein particularly for vegetarians and contribute about 14 percent of the total protein of average Indian diet. Considering the importance of pulses, WHO recommends 80 g of pulse per adult per day in daily diet. The per capita availability of pulse in Odisha is improving gradually as a consequence of increase in cultivated area but not the productivity. Pulses are primarily used as human food and are also used as forage and partial green manure (Pattanayak et al., 2008) [8]. Besides the food pulses fix atmospheric Nitrogen ranging from 25-55 kg ha-1 annum-1 (Pattanayak et al., 2016) [11]. It improves soil organic matter content, soil fertility, limit soil degradation and conserve the soil. The pulse crops are soil recuperative crops, hence cultivated in many cropping situations as a pure crop, intercrop and mixed crop. India is the largest producer (18.5 million tons) as well as importers of pulses which imports around 3.5 million tons annually to meet its over increasing consumption need of around 22.0 million tons. India is contributing around 25 percent of total global consumption. Among pulses chick pea, pigeon pea, green gram and black gram are produced in India.

Green gram is the major pulse crop which ranks third next to gram and red gram and is the third important pulse crop of India, grown in nearly 8% of the total pulse area of the country (GOI, 2013). It has special importance in intensive crop production system of the country for its short growing period. India shares about 35-37% and 27% of the total area and production of pulses, respectively in the world. The calorific value of green gram is 334 calories per 100 g and its chemical composition is as follows: crude protein 24.0%, fat 1.3%, carbohydrate 56.6%, minerals 3.5%, lysine 0.43%, methionine 0.10% and tryptophan 0.04%
(Kachroo, 1970) [6]. In Odisha green gram is cultivated in an area of 8.33 lakh ha with a production of 0.396 million tones and productivity of 476 kg/ha. Out of which Rabi green gram is cultivated in area of 602230 ha with a production of 0.287 million tones and a productivity of 476 kg/ha (OAS, 2012-13). The low yields of green gram are due to imbalance application of fertilizers.

In Odisha more than seventy percent soil is acidic, out of which more than 25 % need immediate liming having pH ≤ 5.5 (Pattanayak and Sarkar, 2016) [12]. In acidic soil crop reaction (pH=5.58) with available N (240 kg ha⁻¹), available experimental site was red, sandy loam in texture & acidic in laterite (Alfisol) and lateritic (Oxisol). The soil of groups of the zone are alluvial (Entisol), black (Vertisol), red-

 geographical parallels between 20°-3’ and 21°-16’ North under Odisha University of Agriculture and Technology Transfer Station situated at Mahisapat of Dhenkanal district in Mid Central Table Land Zone of Odisha which more than 25 % need immediate liming having pH ≤ 5.5.

Results and Discussion

A field experiment was conducted at Regional Research and Technology Transfer Station situated at Mahisapat of Dhenkanal district in MID Central Table Land Zone of Odisha under Odisha University of Agriculture and Technology during kharif season of 2017 & 2018. The farm is located in the geographical parallels between 20°-3’ and 21°-16’ North latitude and 84°6’ and 86°6’ East longitude. The important soil groups of the zone are alluvial (Entisol), black (Vertisol), red-laterite (Alfisol) and lateritic (Oxisol). The soil of experimental site was red, sandy loam in texture & acidic in reaction (pH=5.58) with available N (240 kg ha⁻¹), available P₂O₅ (13.5 kg ha⁻¹) & available K₂O (170 kg ha⁻¹). The experiment was laid out in RBD with six treatments and four replications. The detailed of the treatments are as follows.

| S No | Treatments                                      | Plant height (cm) | No. of branches/plant | No. of pods/plant | No. of seeds/pod | 1000 seed wt. (g) | Yield (kg/ha) | % Increase in yield | B:C               |
|------|------------------------------------------------|-------------------|-----------------------|------------------|-----------------|------------------|---------------|---------------------|-------------------|
| 1    | Soil Test Based Fertilizer Recommendation (STBFR) | 50.15             | 5.90                  | 9.33             | 5.55            | 35.00            | 652.50        | -                   | 1.44              |
| 2    | STBFR + Rhizobium inoculation@ 20kgg⁻¹of seed + PSB @4 kg ha⁻¹ | 51.84             | 6.57                  | 10.28            | 6.47            | 36.28            | 770.00        | 18.1                | 1.60              |
| 3    | STBFR + Rhizobium inoculation@ 20kgg⁻¹of seed + PSB @4 kg ha⁻¹ + FYM @5 tha⁻¹ | 51.96             | 7.35                  | 12.40            | 7.92            | 36.38            | 775.00        | 18.8                | 1.50              |
| 4    | STBFR + Rhizobium inoculation@ 20kgg⁻¹of seed + PSB @4 kg ha⁻¹ + FYM @5 tha⁻¹ + Lime 0.2 LR | 53.36             | 7.87                  | 13.80            | 8.65            | 37.30            | 812.50        | 24.5                | 1.53              |

Materials and methods

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Table 1: Yield and yield attributing characters of green gram (cv. TARM-1) influenced by seed coating and lime application
Molybdenum in T6 contributed towards better availability and uptake of plant nutrients by the crop reflected as increased plant height (54.33 cm), number of branches per plant (8.87), number of seeds per pod (12.43) followed by T6 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + Molybdenum(1g Ammonium Molybdate per 2.5 kg of seed as seed treatment)+ seed coating with lime) having yield of 877.50 kg ha\(^{-1}\) and 1000 seed weight of 37.58 g. Rhizobium inoculation, Phosphorus application and seed treatment with Molybdenum enhance the yield of summer green gram (Bhattacharyya et al., 2001)\(^{[1]}\).

Growth and Yield Attributes

T6 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + Molybdenum(1g Ammonium Molybdate per 2.5 kg of seed as seed treatment)+ seed coating with lime) recorded higher plant height (53.72 cm), 8.50 nos., 16.28 nos. and 8.92, respectively. The cumulative effect of bio-fertilizer, lime coating and Molybdenum performed better as compared to STBFR alone. Similarly T6 was superior over the treatments with higher 1000 seed weight of 37.93 g. This treatment was followed by T5 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + seed coating with lime) having yield of 827.50 kg ha\(^{-1}\) and 1000 seed weight of 37.58 g. Rhizobium inoculation, Phosphorus application and seed treatment with Molybdenum in T6 contributed towards better availability and uptake of plant nutrients by the crop reflected as increased plant height and other growth parameters (Table - 1). This result has been in conformity with Janaki et al., 2018\(^{[3]}\).

Yield

T6 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + Molybdenum(1g Ammonium Molybdate per 2.5 kg of seed as seed treatment)+ seed coating with lime) recorded significantly higher seed yield (877.50 kg ha\(^{-1}\)) with a yield advantage of 34.5 % over T1 (STBFR). The combined effect of (STBFR along with bio-fertilizer, lime coating and Molybdenum performed better as compared to STBFR alone. Similarly T6 was superior over the treatments with higher 1000 seed weight of 37.93 g. This treatment was followed by T5 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + seed coating with lime) having yield of 827.50 kg ha\(^{-1}\) and 1000 seed weight of 37.58 g. Rhizobium inoculation, Phosphorus application and seed treatment with Molybdenum enhance the yield of summer green gram (Bhattacharyya et al., 2001)\(^{[1]}\).

### Economics

The highest B:C (1.76) was obtained from T6 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + Molybdenum(1g Ammonium Molybdate per 2.5 kg of seed as seed treatment)+ seed coating with lime) followed by T6 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\) of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + seed coating with lime) with B:C value of 1.66. However, the lowest B: C was indicated under the treatment only with STBFR (1.44).

### Table 2: Concentration of Nutrients (%) in the Harvested Seed and Stover

| Treatment | N Content (%) | P Content (%) | K Content (%) |
|-----------|---------------|---------------|---------------|
|           | Seed          | Stover        | Seed          | Stover        | Seed          | Stover        |
| T1        | 3.47          | 1.64          | 0.27          | 0.13          | 1.22          | 1.20          |
| T2        | 4.22          | 1.82          | 0.31          | 0.22          | 1.31          | 1.38          |
| T3        | 4.55          | 2.06          | 0.35          | 0.31          | 1.38          | 1.46          |
| T4        | 4.92          | 2.18          | 0.41          | 0.37          | 1.44          | 1.51          |
| T5        | 5.07          | 2.22          | 0.47          | 0.39          | 1.47          | 1.61          |
| T6        | 5.27          | 2.34          | 0.51          | 0.43          | 1.53          | 1.66          |
| S.E m (+) | 0.12          | 0.03          | 0.01          | 0.01          | 0.01          | 0.03          |
| CD (P=0.05) | 0.37        | 0.10          | 0.04          | 0.04          | 0.04          | 0.09          |

The highest available nitrogen, phosphorus and potassium content in the seeds and stover were (5.27% & 2.34 %), (0.51% & 0.43%) and (1.53% & 1.66%) in T6 followed by (5.07% & 2.22 %), (0.47% & 0.39%) and (1.47% & 1.61%) in T1 (Table 2). The lowest NPK content was found in T1 (STBFR). The highest NPK content in the seeds and Stover was found in T6 due to higher assimilation of nutrients in that treatment (Pati et al., 2016)\(^{[13]}\).

### Table 3: Uptake of Nutrients in the Harvested Seed and Stover

| Treatment | N (kg/ha) | P (kg/ha) | K (kg/ha) |
|-----------|-----------|-----------|-----------|
|           | Seed      | Stover    | Seed      | Stover    | Seed      | Stover    |
| T1        | 16.45     | 12.77     | 3.62      | 1.23      | 10.62     | 4.62      |
| T2        | 20.65     | 14.12     | 4.15      | 1.29      | 12.52     | 5.57      |
| T3        | 23.40     | 15.55     | 4.97      | 1.39      | 15.37     | 6.17      |
| T4        | 26.07     | 16.12     | 5.35      | 1.52      | 17.67     | 7.27      |
| T5        | 31.02     | 17.52     | 6.10      | 1.57      | 19.12     | 7.97      |
| T6        | 35.35     | 18.12     | 6.62      | 1.70      | 20.47     | 8.75      |
| S.E m (+) | 0.28      | 0.21      | 0.17      | 0.03      | 0.32      | 0.26      |
| CD (P=0.05) | 0.84    | 0.64      | 0.50      | 0.08      | 0.94      | 0.77      |

Uptake of Nutrients in the Harvested Seed and Stover

Application of different sources like Molybdenum and seed coating with lime enhanced nutrient uptake by green gram crop (Table - 3). T6 (STBFR+ Rhizobium inoculation@ 20 g kg\(^{-1}\)of seed + PSB @ 4 kg ha\(^{-1}\) + FYM @5 t ha\(^{-1}\) + Molybdenum(1g Ammonium Molybdate per 2.5 kg of seed as seed treatment)+ seed coating with lime) recorded higher uptake of N, P and K both in seed and stover with (35.35% & 2.34 %), (0.51% & 0.43%) and (1.53% & 1.66%) in T6 (Table 2). The lowest NPK content was found in T1 (STBFR). The highest NPK content in the seeds and Stover was found in T6 due to higher assimilation of nutrients in that treatment (Pati et al., 2016)\(^{[13]}\).
The results revealed that management of micronutrients, lime and bio-fertilizers in the form of seed treatment with molybdenum and bio-fertilizers and seed coating with lime had prominent effect on availability of major nutrients in the soil. Presence of favourable soil environment and essential macro and micro nutrients might have promoted the nodule bacteria for nitrogen fixation as well as enhanced the availability of nitrogen, phosphorous and potassium in the soil. Srivastava and Varma (1995) recorded increased nitrogen and phosphorus content of soil through addition of nitrogen, phosphorus and molybdenum in the cultivation practice. T6 (STBFR + Rhizobium inoculation @ 20 g kg⁻¹ of seed + PSB @ 4 kg ha⁻¹ + FYM @ 5 t ha⁻¹ + seed coating with lime) recorded higher N, P and K status in the post harvest soil having 281.75, 20.12 and 197.75 kg ha⁻¹, respectively. This result confirmed with the result of Chatterjee et al., 2017.

Conclusion

From the experimental finding it was concluded that STBFR+ Rhizobium inoculation @ 20 g kg⁻¹ of seed + PSB @ 4 kg ha⁻¹ + FYM @ 5 t ha⁻¹ + Molybdenum(1g Ammonium Molybdate per 2.5 kg of seed as seed treatment) + seed coating with lime recorded higher seed yield of 877.50 kg ha⁻¹ and B:C of 1.76 with yield advantage of 34.5 % over STBFR. The nutrient status of the post-harvest soil also improved in the same treatment. Seed coating with lime found to be more effective than that of soil lime application. The same treatment recorded higher uptake of N, P and K both in seed and stover with (35.35 &18.12), (6.62 &1.70) and (20.47 &8.75) kg ha⁻¹, respectively. The treatment T5 (STBFR+ Rhizobium inoculation @ 20 g kg⁻¹ of seed + PSB @ 4 kg ha⁻¹ + FYM @ 5 t ha⁻¹ + seed coating with lime) also recorded N, P, and K uptake both in seed and stover to the tune of (31.02&17.52), (6.10 & 1.57) and (19.12 &7.97) kg ha⁻¹, respectively (Pati et al., 2016).

Nutrient status of post-harvest soil

![Fig. 1: Nutrient status (kg ha⁻¹) of Post-harvest soil](image)

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