**Effect of rhizobium and molybdenum inoculation on yield, economics, nodulation and nitrogen uptake in mungbean (Vigna radiata L.)**

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**Abstract**  
The study was carried out through front line demonstrations during *rabi* seasons of 2015-16 and 2016-17 to study the effect of *Rhizobium* and molybdenum inoculation on yield, economics, nodulation and nitrogen uptake in mungbean. The demonstration results showed that the improved practice of seed inoculation with *Rhizobium* and molybdenum recorded 41.6 % higher seed yield (9.82 q ha⁻¹), harvest index (29.74 %), production efficiency(15.11 kg ha⁻¹ day⁻¹) and extension gap(2.89 q ha⁻¹) than farmer’s practice. The same also produced higher plant height (47.0 cm), branches plant⁻¹ (6.0), pods plant⁻¹(26.95), seeds pod⁻¹(9.47), nodules plant⁻¹ (13.06) and nodule dry weight (2.32 mg plant⁻¹) with a mean increase of nitrogen uptake 62.1% and 39.2 % by seed and stover respectively. The improved practice also recorded higher gross return of Rs.50070.75 ha⁻¹, B: C ratio (2.55), profitability (Rs.83.33 ha⁻¹ day⁻¹) with additional net return of Rs.13102.63 ha⁻¹ and can effectively replace the farmer’s practice for higher yield, income, nodulation and nitrogen uptake in mungbean.

**Keywords:** molybdenum, mungbean, nitrogen uptake, nodulation, *rhizobium*, yield

**Introduction**  
Green gram or mungbean (*Vigna radiata* L.) is the third most important food legumes grown and consumed in India including Odisha comparatively of shorter duration and is a good source of proteins and minerals and It is the major pulse crop of Odisha with a total coverage of 0.86 million hectare and the area under greengram crop in Angul district is 0.03 million hectare with a productivity of 0.42 t/ha which is much lower than the potential yield (Samant et al., 2013) [7]. Mungbean can be grown under wide range of soil types. It is grown usually as *rainfed* crop and can also be grown as pre-monsoon and late monsoon crop. Although, chemical fertilizers are playing a crucial role to meet nutrient requirement of the crop. Persistent nutrient depletion is posing a greater threat to the sustainable agriculture. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase in the usage of organics which needed to check the yield and quality levels. Use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient status (Subba Rao and Tilak, 1977) [10]. Therefore, the aforesaid consequences have paved way to grow mungbean using organic and inorganic manures along with biofertilizers. *Rhizobium* spp. invades the root hairs of mungbean and result in formation of nodules, where free air nitrogen is fixed. These bacteria, although present in most of the soils vary in number, effectiveness in nodulation and N-fixation. It has been urged that usual native soil rhizobial populations are inadequate and are ineffective in biological nitrogen fixation. To ensure an optimum rhizobial population in rhizosphere, seed inoculation of legumes with rhizobial strain is necessary. This helps improve nodulation. N₂-fixation solicits crop growth and yield of leguminous crops (Henzell, 1988) [3].  

Although, mungbean crop is capable of fixing atmospheric nitrogen through *Rhizobium* species living in root nodules, however, under our agro ecological situations, the nodulation of the crop is poor and is major cause of lower yield. It was observed that inoculation of mungbean with *Rhizobium* spp. increased plant height, leaf area, photosynthetic rate and dry matter production (Thakur and Power, 1995) [11]. Unfavorable environmental conditions are major cause of poor stand establishment and low crop yield. However rapid germination of seedlings could emerge and produce deep root before the upper layers of the soil are dried and crusted, which may results better crop establishment and higher crop yield.
One way for achieving good crop stand, enhanced Biological Nitrogen fixation (BNF) capacity of legumes and getting more benefit from low fertile soils is seed priming which is a technique in which germination processes begin but radical emergence does not occur. Application of *Rhizobium* with seed priming significantly increased nodulation and nitrogenase activity, but had little effect on yield (Umair et al., 2011) [13]. Therefore, Keeping in view such importance of priming for improved yield, nodulation and nitrogen uptake in mungbean, farmer’s participatory field demonstrations were conducted to study the effect of seed inoculation on yield, economics, nodulation and nitrogen uptake in mungbean.

**Materials and Methods**

The study was carried out through front line demonstrations during *rabi* seasons of 2015-16 and 2016-17 in two villages i.e. Ragudiapada and Baraguania of Angul district in mid central table land zone of Odisha with the active participation of farmers after different extension approaches to study the effect of *Rhizobium* and molybdenum inoculation on yield, economics, nodulation and nitrogen uptake in mungbean. The soil of the study area was slightly acidic in reaction (pH 5.42 to 6.18), loam in texture with medium organic carbon content(0.31 to 0.43 %), medium in nitrogen (189.6 to 290.6 kg ha⁻¹), low in phosphorus (10.3 to 12.7 kg ha⁻¹) and medium in potassium (182 to 278 kg ha⁻¹). Ten farmers were selected and they were supplied with inputs like *Rhizobium* and Sodium molybdate. The mungbean crop was grown with recommended package of practices in 0.1 ha by each farmer during both the year. The farmer’s practices involved indiscriminate use of fertilizers. The improved practice included seed inoculation with *Rhizobium* and sodium molybdate. Mungbean cv. *OBGG 52* was sown 3rd week of December and harvested during 4th week of February in both the years of demonstrations. Observations on different yield parameters were taken and economic analysis was done by calculating cost of cultivation, gross return, net return and B: C ratio. Final crop yield (seed & stover) were recorded and the gross return were calculated on the basis of minimum support price, prevailing market price of the produce. Harvest index is the relationship between economic yield and biological yield (Gardner et al., 1985) [1], and it was calculated by using the Following formula:

\[
\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100
\]

Production efficiency value was calculated with using formula by Tomar and Tiwari, (1990) [12]. Extension gap as calculated by the formula suggested by Samui, et al. (2000) [9].

**Results and Discussion**

**Seed yield, stover yield and harvest index**

Results of front line demonstrations (Table 1) indicated that the improved practice of seed inoculation with *Rhizobium* and molybdenum recorded seed yield 9.82 q ha⁻¹ which was 41.6 % higher than that of farmer’s practice. The improved practice also produced higher stover yield (23.21q ha⁻¹) and harvest index (29.74 % ). The increase in seed and stover yield in mungbean might be attributed to high vegetative growth owing to availability of nitrogen in soil during vegetative growth period. This might be owing to enhanced germination, higher pod and grain production. Similar results were also obtained by Vitnor et al. (2015) [14].

**Production efficiency and extension gap**

The production efficiency (Table 1) was higher in improved practice (15.11 kg ha⁻¹ day⁻¹) in comparison to local check due to more seed yield. Higher extension gap (3.96 q ha⁻¹) was found during 2015-16 and lower (1.81 q ha⁻¹) was during 2016-17. The new improved technologies might have a positive impact on farming community and will eventually lead to the farmers to discontinue the traditional method and to adopt new technology (Samant, 2014) [8].

**Plant height, branches plant⁻¹, pods plant⁻¹, seeds pod⁻¹, nodules plant⁻¹ and nodules dry weight**

The improved practice also produced (Table 2) higher plant height (47.0 cm), branches plant⁻¹ (6.0), pods plant⁻¹ (26.95), seeds pod⁻¹ (9.47), nodules plant⁻¹ (13.06) and nodule dry weight (2.32 mg plant⁻¹) in comparison to farmer’s practice. The increase in nodules per plant due to application of *Rhizobium* inoculation in combination with sodium molybdate (Zammurad et al., 2006) [15]. These observations were also in agreement with findings of Patel et al. (2016) [6].

**Table 1:** Effect of *Rhizobium* and molybdenum inoculation on yield, production efficiency and extension gap of mungbean

<table>
<thead>
<tr>
<th>Year</th>
<th>Seed yield (q ha⁻¹)</th>
<th>Stover yield (q ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>% of increase in seed yield over local check</th>
<th>Production efficiency (kg ha⁻¹ day⁻¹)</th>
<th>Extension gap (q ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IP</td>
<td>FP</td>
<td>IP</td>
<td>FP</td>
<td>IP</td>
<td>FP</td>
</tr>
<tr>
<td>2015-16</td>
<td>12.38</td>
<td>8.42</td>
<td>27.46</td>
<td>22.53</td>
<td>31.07</td>
<td>27.21</td>
</tr>
<tr>
<td>2016-17</td>
<td>7.26</td>
<td>5.45</td>
<td>18.95</td>
<td>12.54</td>
<td>27.7</td>
<td>30.3</td>
</tr>
<tr>
<td>Mean</td>
<td>9.82</td>
<td>6.394</td>
<td>23.21</td>
<td>17.54</td>
<td>29.74</td>
<td>28.34</td>
</tr>
</tbody>
</table>

* IP: Improved technology (*Rhizobium* and molybdenum inoculation in seed); FP: Farmer’s practice (Indiscriminate use of chemical fertilisers)

**Table 2:** Effect of *Rhizobium* and molybdenum inoculation on plant height, no of branches plant⁻¹, pods plant⁻¹, seeds pod⁻¹, nodules plant⁻¹ and nodules dry weight of mungbean

<table>
<thead>
<tr>
<th>Year</th>
<th>Plant height (cm)</th>
<th>No of branches plant⁻¹</th>
<th>No of pods plant⁻¹</th>
<th>No of seeds pod⁻¹</th>
<th>No of nodules plant⁻¹</th>
<th>Nodules dry weight (mg plant⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IP</td>
<td>FP</td>
<td>IP</td>
<td>FP</td>
<td>IP</td>
<td>FP</td>
</tr>
<tr>
<td>2015-16</td>
<td>45.7</td>
<td>38.5</td>
<td>6.3</td>
<td>5.4</td>
<td>26.5</td>
<td>15.3</td>
</tr>
<tr>
<td>2016-17</td>
<td>48.28</td>
<td>45.31</td>
<td>5.7</td>
<td>4.8</td>
<td>27.4</td>
<td>16.34</td>
</tr>
<tr>
<td>Mean</td>
<td>47.0</td>
<td>41.91</td>
<td>6.0</td>
<td>5.10</td>
<td>26.95</td>
<td>15.82</td>
</tr>
</tbody>
</table>
Nitrogen uptake by seed and stover

The improved practice of *Rhizobium* and molybdenum inoculation recorded higher nitrogen uptake by seed as well as stover than farmer’s practice during both the years. Nitrogen uptake by improved practice (Figure 1) found 52.93 and 25.28 kg ha\(^{-1}\) which was 80.5 and 33.5% higher than farmer’s practice during the year 2015-16 & 2016-17 respectively. Over all there was a mean increase of nitrogen uptake 62.1% observed in farmers practice during the study period. This might be due to better root system and nodulation which extracted proper moisture and nutrition for plant growth. Similar trend of nitrogen uptake by stover (Figure 2) was observed during both the year. Improved practice showed 42.7 and 33.6% higher nitrogen uptake as compared to farmer’s practice during the year 2015-16 & 2016-17 respectively. The results obtained in this study were found in accordance with Umair *et al.* (2011)\(^{[13]}\).

**Economics**

Improved practice recorded (Table 3) higher gross return of Rs.50070.75 ha\(^{-1}\) and profitability (Rs. 83.3 ha\(^{-1}\) day\(^{-1}\)) with additional net return of Rs. 13102.63 ha\(^{-1}\) over farmers practice. Higher B: C ratio (2.55) was found in improved practice due to higher net return as compared to local check (1.95) attributed to more seed production. The variation in net return and benefit-cost ratio may be attributed to the variation in the price of agri inputs and produce. Similar types of findings were also obtained by Patel *et al.* (2013)\(^{[5]}\).

![Fig 1: Effect of *Rhizobium* and molybdenum inoculation on nitrogen uptake by seed of mungbean](image1)

![Fig 2: Effect of *Rhizobium* and molybdenum inoculation on nitrogen uptake by stover of mungbean](image2)

**Table 3: Effect of *Rhizobium* and molybdenum inoculation on cost of cultivation, gross return, net return, B: C ratio and profitability of mungbean**

<table>
<thead>
<tr>
<th>Year</th>
<th>Improved practice (Rhizobium and molybdenum inoculation in seed)</th>
<th>Farmer’s practice (indiscriminate use of chemical fertiliser)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost of cultivation (Rs ha(^{-1}))</td>
<td>Gross return (Rs ha(^{-1}))</td>
</tr>
<tr>
<td>2015-16</td>
<td>19250</td>
<td>60313</td>
</tr>
<tr>
<td>2016-17</td>
<td>20050</td>
<td>39828.50</td>
</tr>
<tr>
<td>Mean</td>
<td>19650</td>
<td>50070.75</td>
</tr>
</tbody>
</table>

*Sale price of mungbean seed Rs.4650/q and stover Rs.100/q for the year 2015-16; Sale price of mungbean seed Rs.5225/q and straw Rs.100/q for the year 2016-17*

**Conclusion**

From the results obtained, it can be concluded that the existing farmer’s practice can be effectively replaced by seed inoculation with *Rhizobium* and molybdenum in mungbean for higher yield, economics, nodulation and nitrogen uptake in the existing farming situation.

**Acknowledgement**

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References