

# Assessing the effect of Phosphorus, Molybdenum and *Rhizobium* Inoculation on Growth, Yield and Yield attributes of Mungbean (*Vigna radiata* L.) under Rainfed Conditions.

## Abstract

An experiment was carried out during *Kharif* season of 2023 at Pot Culture experimental site, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur Nagar (U.P.). The experiment was laid out in Randomized Block Design with thirteen treatments each replicated thrice. The treatments consist of three levels of phosphorus *viz.*, 20 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and 60 kg ha<sup>-1</sup>, two levels each of molybdenum *viz.* 1.0 kg ha<sup>-1</sup> and 2.0 kg ha<sup>-1</sup> and *Rhizobium viz.* inoculated (Rh<sub>1</sub>) and uninoculated (Rh<sub>0</sub>). Mungbean variety IPM 02-3 was grown with recommended agronomic practices under rainfed conditions. On the basis of the results emanated from the investigation, it is observed that, application of treatment T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>] resulted in significantly higher plant height (58.24 cm), no. of branches plant<sup>-1</sup> (9.82), no. of pods plant<sup>-1</sup> (25.84), length of pod (8.91 cm), no. of seeds pod<sup>-1</sup> (11.45), test weight (49.86 g) and seed yield (11.78 q ha<sup>-1</sup>). While the application of T<sub>13</sub> [P<sub>60</sub> + Mo<sub>2</sub> + Rh<sub>1</sub>] resulted in significantly higher no. of leaves plant<sup>-1</sup> (5.52), no. of nodules plant<sup>-1</sup> (29.6) and stover yield (23.04 q ha<sup>-1</sup>). Thus, it could be concluded that treatment T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>] was found to be superior and subsequently at par with treatment T<sub>13</sub> [P<sub>60</sub> + Mo<sub>2</sub> + Rh<sub>1</sub>] over all the other treatments.

**Keywords:** Growth, Molybdenum, Phosphorus, Rainfed, *Rhizobium*, and Yield.

## 1. Introduction

Mungbean (*Vigna radiata* L.) is the third most important pulse crop in India after chickpea and pigeonpea. It is cultivated across the world while India alone contributes about more than 70% of world's mungbean production (Anonymous., 2023). Primarily being a crop of the rainy season, it is well suited for all rainfed areas with annual rainfall of 600-1000 mm. However, it has proved to be an ideal crop for the spring and summer seasons as well.

Currently, mungbean is cultivated on more than 6 million hectares worldwide (about 8.5% of global pulse cultivation area) and global annual production is 3 million tons (5% of global pulse production). India is the largest mungbean producing country followed by China Myanmar and Indonesia (Bhajan *et.al.*, 2019). In India, mungbean cultivation is substantially concentrated in the states of Gujarat, Orissa, Maharashtra, Madhya Pradesh and

Rajasthan accounting for 70 % of total country's production. It is grown on about 40.38 lakh hectares with a total production of 31.5 lakh tonnes with a productivity of 783 kg ha<sup>-1</sup> and contributes 11 % to the total pulse production in the year 2021 - 22. In *Kharif* 2022 - 23, mungbean production was 17.5 lakh tonnes in an area of 33.37 lakh hectares. In Kanpur Nagar district of Uttar Pradesh, mungbean was cultivated on an area of 562 hectares and total production obtained was 212 tonnes with a yield of 0.38 tonnes ha<sup>-1</sup> in the *kharif* season (**Directorate of Economics & Statistics, DAC & FW2022-2023**).

Mungbean is a popular pulse in the diet and is consumed in combination with cereals because it is easily digestible, rich in protein (20 -24 %), iron (6 mg per 100 g of dry seed) and easy to cook (**Awomiet al., 2012**). Along with being an important source of protein in vegetarian diets, it also has a high quality of lysine (460 mg g<sup>-1</sup> N) and tryptophan (60 mg g<sup>-1</sup> N). Sprouted mungbean contains ascorbic acid (vitamin C) and an increased amount of riboflavin and thiamine. It also contains iso-flavonoids that have antioxidant activities, which prevent many diseases (**Kaprelyntset al., 2003**).

Phosphorus is the second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby atmospheric nitrogen fixation (**Kachaveet al., 2018**). It plays a crucial role in root proliferation, cell division, energy currency of cell (ATP), production and protein metabolism. It also plays a pivotal role in nodule formation indirectly by supplying the required energy necessary for nitrogen fixing bacteria through sugar and energy metabolism (**Dotaniya et al., 2014**). Since P deficiency results in reduced symbiotic N fixation, P fertilization usually results in enhanced nodule number and mass, as well as greater N<sub>2</sub> fixation activity plant<sup>-1</sup> (**Awomiet al., 2012; Seraj and Gyamfi, 2004**).

The importance of molybdenum can be judged from the fact that in the absence of one atom of Mo, 1,000,000 atoms of N and 30,000 atoms of P may become ineffective from the view of plant nutrition. It is a structural component of nitrogenase and nitrate reductase enzymes, which bring about oxidation - reduction reactions in plant cells (**Yadav et al., 2017**). Molybdenum also has a function as a co-factor, i.e., structural and catalytic function, in several enzymes that have been discovered in higher plants. It is widely known that legumes require more Mo than most other plants because of their crucial role in the nitrogen-fixation process (**Mcbride, 2005**).

*Rhizobium* is a small, rod shaped, gram negative symbiotic nitrogen fixing bacteria associated with legumes and is able to form nodules on their host plants, inside of which they fix nitrogen. It has been demonstrated that native soil possesses an inadequate

*Rhizobial* population, resulted in ineffective biological nitrogen fixation. It was observed that inoculation of mungbean with *Rhizobium* sp. increased plant height, leaf area, photosynthetic rate and dry matter production (Iqbal *et al.*, 2012; Mehboob *et al.*, 2012). In mungbean, nitrogen derived from N<sub>2</sub> fixation is 15 – 17 % and total nitrogen fixed is 9 - 137 kg ha<sup>-1</sup> (Singh and Sekhon, 2005).

## 2. Materials and Methods

### 2.1 Experimental Site

The experiment was carried out at Pot Culture experimental site, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur Nagar (U.P.) which lies between 25° 26' and 26° 58' North latitude and 79° 31' and 80° 34' East longitude. It is situated at an elevation of 124 meters above the mean sea level in the alluvial belt of Gangetic plains of central Uttar Pradesh.

### 2.2 Edaphic Condition

The soil present at the experimental site was moist, well drained with uniform plane topography. It was of alluvial origin and falls within the Inceptisol order, characterized by sandy loam texture, being slightly alkaline, having initial values of pH 7.61 ((1:2.5 soil: water suspension method, Jackson, 1973), EC 0.34 dSm<sup>-1</sup> (Conductivity meter method, Wilcox, 1950), low in organic Carbon *i.e.* 4.1 g kg<sup>-1</sup> (Wet oxidation method, Walkley and Black, 1934), low in available nitrogen *i.e.* 203.42 kg ha<sup>-1</sup> (Alkaline permanganate method, Subbiah and Asija, 1956), low in available phosphorus *i.e.* 19.64 kg ha<sup>-1</sup> (Olsen's calorimetrically method, Olsen *et al.*, 1954), medium in available potassium *i.e.* 147.25 kg ha<sup>-1</sup> (Flame photometer method, Hanwey and Heidel, 1952), and low in available molybdenum *i.e.* 0.09 mg kg<sup>-1</sup> (Acid ammonium oxalate method, Grigg, 1953).

### 2.3 Experimental Details

The experiment was laid out in a “Randomized Block Design” with three replications consisting of thirteen treatment combinations. The treatments consisted of a combination of three levels of P and two levels each of Mo and *Rhizobium* as detailed below.

**Table1: Treatment details:**

Phosphorus Levels (as P <sub>2</sub> O <sub>5</sub> )	Molybdenum Levels (as [NH <sub>4</sub> ] <sub>2</sub> MoO <sub>4</sub> )	<i>Rhizobium</i> (as Seed treatment)
1. 20 kg ha <sup>-1</sup> (P <sub>20</sub> ) 2. 40 kg ha <sup>-1</sup> (P <sub>40</sub> )	1. 1.0 kg ha <sup>-1</sup> (Mo <sub>1</sub> ) 2. 2.0 kg ha <sup>-1</sup> (Mo <sub>2</sub> )	1. Uninoculated (Rh <sub>0</sub> ) 2. Inoculated (Rh <sub>1</sub> )

3. 60 kg ha <sup>-1</sup> (P <sub>60</sub> )		
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**Table 2: Treatment combinations:**

S. No.	Treatment Combinations	Symbols
1.	Control	T <sub>1</sub>
2.	P <sub>20</sub> +Mo <sub>1</sub> +Rh <sub>0</sub>	T <sub>2</sub>
3.	P <sub>20</sub> +Mo <sub>2</sub> +Rh <sub>0</sub>	T <sub>3</sub>
4.	P <sub>40</sub> +Mo <sub>1</sub> +Rh <sub>0</sub>	T <sub>4</sub>
5.	P <sub>40</sub> +Mo <sub>2</sub> +Rh <sub>0</sub>	T <sub>5</sub>
6.	P <sub>60</sub> +Mo <sub>1</sub> +Rh <sub>0</sub>	T <sub>6</sub>
7.	P <sub>60</sub> +Mo <sub>2</sub> +Rh <sub>0</sub>	T <sub>7</sub>
8.	P <sub>20</sub> +Mo <sub>1</sub> +Rh <sub>1</sub>	T <sub>8</sub>
9.	P <sub>20</sub> +Mo <sub>2</sub> +Rh <sub>1</sub>	T <sub>9</sub>
10.	P <sub>40</sub> +Mo <sub>1</sub> +Rh <sub>1</sub>	T <sub>10</sub>
11.	P <sub>40</sub> +Mo <sub>2</sub> +Rh <sub>1</sub>	T <sub>11</sub>
12.	P <sub>60</sub> +Mo <sub>1</sub> +Rh <sub>1</sub>	T <sub>12</sub>
13.	P <sub>60</sub> +Mo <sub>2</sub> +Rh <sub>1</sub>	T <sub>13</sub>

#### 2.4 Crop Husbandry:

IPM 02-3 variety of mungbean was used as a test crop. Seeds were treated with *Rhizobium* culture @ 200 g per 10 kg of seeds through standard procedure before sowing as per treatment. The seeds were sown at recommended dose of 20 kg ha<sup>-1</sup> in furrow opened at the depth of about 3-5 cm. in rows at 40 cm. apart under rainfed conditions on 23<sup>rd</sup> June in the year 2023, respectively. All the nutrients were applied as basal dressing before sowing. A uniform dose of 20 kg of N ha<sup>-1</sup> was applied through the application of Urea as the source. Additionally, 40 kg K<sub>2</sub>O was administered in the form of MOP. Phosphorus was introduced via SSP, while Molybdenum was delivered through ammonium molybdate, adhering to specific treatment protocols.

#### 2.6 Harvesting:

The harvesting was done when crop reached to its physiological maturity. The plants from net area were harvested and bundled separately and tagged. The tagged bundles were kept on threshing floor for sun drying and then threshed manually.

## 2.7 Statistical Analysis:

The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant (“F” test), critical differences were worked out at five per cent probability level. The data obtained during the study were analyzed statistically using the methods advocated by Gomez and Gomez (1984).

## 3. Result and Discussion

### 3.1. Growth Parameters:

Data pertaining to growth parameters mainly plant height, no. of leaves plant<sup>-1</sup>, and no. of branches plant<sup>-1</sup> are presented in table 3, which clearly revealed that all these growth parameters were found to be influenced by the various allocated treatments given during the course of investigation and marked significant variations over T<sub>1</sub>[control]. T<sub>13</sub> [P<sub>60</sub> + Mo<sub>2</sub> + Rh<sub>1</sub>] resulted in significantly higher no. of leaves plant<sup>-1</sup> (5.52), which was significantly at par with T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>](5.51). While T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>] resulted in significantly higher plant height (58.24 cm) and no. of branches plant<sup>-1</sup> (9.82) respectively. These findings are further supported by Bhuiyan *et al.* (2008), Prajapati *et al.* (2017), Namakkaet *al.* (2017), Banerjee *et al.* (2021) and Parashraet *al.* (2023).

### 3.2 Yield Attributes:

Data pertaining to yield attributing parameters viz. no. of pods per plant<sup>-1</sup>, length of pod (cm), no. of seeds pod<sup>-1</sup>, test weight (g) and no. of nodules plant<sup>-1</sup> are presented in table 4, which clearly revealed that all these parameters were found to be influenced positively, by the various allocated treatments given during the course of investigation and marked significant variations over T<sub>1</sub>[control] except test weight (g). Significantly highest no. of pods plant<sup>-1</sup> (25.84), length of pod (8.91) and no. of seeds pod<sup>-1</sup> (11.45) were observed under treatment T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>], while the response of the no. of nodules plant<sup>-1</sup> (29.6), was recorded higher under treatment T<sub>13</sub> [P<sub>60</sub> + Mo<sub>2</sub> + Rh<sub>1</sub>]. These findings were closely conforming to the results of Bhuiyan *et al.* (2008), Velmurugan *et al.* (2015), Umaleet *al.* (2018) and Spandana *et al.* (2021).

**Table 3: Effect of P, Mo & Rhizobium Inoculation on growth parameters of mungbean.**

Treatment	Plant Height (cm)	Number of leaves plant <sup>-1</sup>	No. of branches plant <sup>-1</sup>
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T <sub>1</sub>	39.29	3.46	6.25
T <sub>2</sub>	44.83	4.11	7.48
T <sub>3</sub>	46.03	4.31	7.97
T <sub>4</sub>	47.13	4.69	8.11
T <sub>5</sub>	46.60	4.76	7.84
T <sub>6</sub>	53.18	4.87	9.08
T <sub>7</sub>	52.50	4.85	8.69
T <sub>8</sub>	52.10	4.94	9.65
T <sub>9</sub>	49.86	4.96	9.50
T <sub>10</sub>	56.19	5.49	9.79
T <sub>11</sub>	54.01	5.50	9.81
T <sub>12</sub>	58.24	5.51	9.82
T <sub>13</sub>	55.03	5.52	9.80
S.E(m±)	0.49	0.05	0.09
C.D. at 5%	1.42	0.14	0.27

**3.3**  
**Yield:**  
Data pertaining to yield viz. biological cal

yield (q ha<sup>-1</sup>), grain yield (q ha<sup>-1</sup>), stover yield (q ha<sup>-1</sup>) and harvest index (%) are presented in table 5. Obtained data clearly revealed that application of P, Mo and *Rhizobium* inoculation significantly influenced the yield of mungbean over T<sub>1</sub>[control]. Maximum biological yield (34.75 q ha<sup>-1</sup>) and grain yield (11.78 q ha<sup>-1</sup>) was found under treatment T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>], while the stover yield was found highest under treatment T<sub>13</sub> [P<sub>60</sub> + Mo<sub>2</sub> + Rh<sub>1</sub>]. The harvest index (34.55%) showed highest percentage under treatment T<sub>10</sub> [P<sub>40</sub>+Mo<sub>1</sub>+Rh<sub>1</sub>]. These findings were closely justified by Singh *et al.* (2004), Hosseini *et al.* (2014), Movalia *et al.* (2020), Ahmad *et al.* (2021) and Khaleeq *et al.* (2023).

**Table 4: Effect of P, Mo & Rhizobium Inoculation on yield attributes of mungbean.**

Treatment	No. of pods plant <sup>-1</sup>	Length of Pod (cm)	Number of seeds pod <sup>-1</sup>	No. of nodules plant <sup>-1</sup>	Test weight (g)
T <sub>1</sub>	16.20	5.68	5.29	16.4	33.10
T <sub>2</sub>	19.22	7.80	8.85	19.5	42.08
T <sub>3</sub>	20.15	7.89	8.11	20.6	42.67
T <sub>4</sub>	19.79	8.28	8.89	22.0	44.53
T <sub>5</sub>	22.87	8.41	9.71	21.4	45.12
T <sub>6</sub>	23.55	8.69	10.92	22.3	46.33

<b>T<sub>7</sub></b>	21.89	8.55	10.36	23.9	45.98
<b>T<sub>8</sub></b>	24.69	7.95	10.47	27.2	46.11
<b>T<sub>9</sub></b>	23.98	8.15	10.84	27.5	47.24
<b>T<sub>10</sub></b>	25.63	8.88	11.31	28.1	49.72
<b>T<sub>11</sub></b>	25.29	8.79	11.42	28.6	48.91
<b>T<sub>12</sub></b>	25.84	8.91	11.45	28.8	49.86
<b>T<sub>13</sub></b>	25.76	8.84	11.39	29.6	49.64
<b>S.E(m±)</b>	0.27	0.08	0.12	0.29	0.47
<b>C.D. at 5%</b>	0.78	0.23	NS	0.86	NS

**Table 5: Effect of P, Mo & Rhizobium Inoculation on yield of mungbean.**

<b>Treatment</b>	<b>Grain yield (q ha<sup>-1</sup>)</b>	<b>Stover yield (q ha<sup>-1</sup>)</b>	<b>Biological yield (q ha<sup>-1</sup>)</b>	<b>Harvest index (%)</b>
<b>T<sub>1</sub></b>	6.91	16.87	23.78	29.06
<b>T<sub>2</sub></b>	9.80	19.84	29.64	33.06
<b>T<sub>3</sub></b>	10.13	20.21	30.34	33.39
<b>T<sub>4</sub></b>	9.92	20.11	30.03	33.03
<b>T<sub>5</sub></b>	10.24	19.83	30.07	34.05
<b>T<sub>6</sub></b>	10.81	20.78	31.59	34.22
<b>T<sub>7</sub></b>	11.01	21.42	32.43	33.95
<b>T<sub>8</sub></b>	10.19	20.95	31.14	32.72
<b>T<sub>9</sub></b>	10.26	21.53	31.79	32.27
<b>T<sub>10</sub></b>	11.18	21.18	32.36	34.55
<b>T<sub>11</sub></b>	11.63	22.63	34.26	33.95
<b>T<sub>12</sub></b>	11.78	22.97	34.75	33.90
<b>T<sub>13</sub></b>	11.72	23.04	34.73	33.75
<b>S.E(m±)</b>	0.10	0.18	0.32	0.23
<b>C.D. at 5%</b>	0.30	0.52	0.94	NS

## 5. Conclusion:

On the basis of experimental results discussed above, it can be concluded that the treatment, T<sub>12</sub> [P<sub>60</sub> + Mo<sub>1</sub> + Rh<sub>1</sub>] was found to be simultaneously superior and subsequently at par with treatment T<sub>13</sub> [P<sub>60</sub> + Mo<sub>2</sub> + Rh<sub>1</sub>] and could be promoted for the cultivation of

mungbean for utilizing its maximum potential and improving growth, yield and yield attributes of the crop.

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