



## Effect of nutrient omission on growth, yield attributes, nutrient uptake and soil properties of Nagaland after crop harvest in black gram (*Vigna Mungo* L.)

Siddharth Choudhary<sup>1\*</sup>, Y.K. Sharma<sup>1</sup> and Charan Singh Choudhary<sup>1</sup>

<sup>1</sup>*Department of Soil Science and Agricultural Chemistry,  
SAS, Nagaland University, Medziphema, Nagaland*

**Abstract :** A pot experiment was conducted at the instructional farm, Department of Soil Science, SAS, Nagaland University, during the 2022 Kharif season to study the effect of nutrient omission on the performance of black gram (*Vigna mungo* L.). The experiment was laid out in a completely randomised design (CRD) with three replications and nine treatments, viz. T1 All (N, P, K, S, B, lime, PSM & Rhizobium) T<sub>2</sub> (All- N), T<sub>3</sub> (All-P), T<sub>4</sub> (All-K), T<sub>5</sub> (All-S), T<sub>6</sub> (All-B), T<sub>7</sub> (All-Lime), T<sub>8</sub> (PSM) and T<sub>9</sub> (Rhizobium). The growth, yield attributes and yield of black gram were found to be superior in the treatment where all nutrients (N, P, K, S, B, Lime, PSM & Rhizobium) were applied. It was observed that the most limiting nutrient for the growth of black gram was reported nitrogen followed by phosphorus and potassium and most limiting nutrient for yield of black gram was phosphorus followed by nitrogen and PSM. Omission of phosphorus reduced seed and stover yield by 36.02% and 25.6%, respectively over T1 treatment. The nutrient contents and uptake by black gram were found significantly higher in the treatment with all nutrients. Omission of various nutrients significantly reduced the nutrient content and uptake by black gram. The available nitrogen, phosphorus, potassium, sulphur, exchangeable calcium and magnesium, available boron in post-harvest soil (soil after the crop has been harvested) were found significantly higher under the treatment which contains all nutrients. Therefore, application of N, P, K, S, B, Lime, PSM & Rhizobium (20, 45, 45, 30, 0.5, 400 kg ha<sup>-1</sup> and 20, 20 g kg<sup>-1</sup> seed, respectively) is recommended for getting better yield of black gram under acidic soil condition of Nagaland.

**Keywords:** *Black gram, nutrient omission, growth, yield, nutrient contents and uptake*

### Introduction

Pulses, a crucial group of crops within the Leguminosae family, hold immense importance in India's food production landscape. Pulses enhance the soil's nitrogen status, long-term fertility, and crop sustainability, all of which contribute to better soil health (Anonymous, 2011). Pulses play a significant role in Indian agriculture because they are the only source of high protein in the normal Indian diet (Phogat et al., 2020).

Black gram (*Vigna mungo* L.), a member of the Leguminosae family, is the cornerstone of Indian pulse crops, both in terms of productivity and total cultivated area. As per Vavilov's classification, it is a significant pulse crop. In India, black gram is cultivated across 4.6 million hectares, yielding 2.45 million tonnes, with an average productivity of 533 kg ha<sup>-1</sup> in 2020-2021 (www.agricoop.nic.in). This crop is a treasure trove of essential nutrients, including proteins (25-26%), carbohydrates (60%), fats (1.5%), minerals, amino acids,

---

\*Corresponding author: (Email: Siddharth3103choudhary@gmail.com)

and vitamins, making it a vital component of the Indian diet.

In Nagaland, black gram is an important pulse crop. The grains are used as dal or made into flour. It is generally sown in the months of June and July for the *kharif* crop, in September or October for the rabi crop, and for the spring crop, the crop is sown by February 15 and harvested by the middle of May. Black gram is cultivated as a pulse crop during the *kharif* season, covering an area of 830 ha and producing 680 MT with an average yield of 10 q ha<sup>-1</sup>. (Directorate of Economics and Statistics, Government of Nagaland, 2017-2018).

Efficient nutrient management is crucial for enhancing the productivity of black gram, as nutrient deficiencies are a significant limiting factor in pulse production. Nutrient omission studies, which systematically exclude individual nutrients, are effective tools for diagnosing site-specific nutrient constraints, understanding crop nutrient requirements, and formulating balanced fertiliser recommendations. These studies also help evaluate residual soil fertility and guide sustainable nutrient management practices. Additionally, bio-fertilizers, consisting of beneficial microorganisms such as nitrogen-fixers and phosphate-solubilising bacteria, offer eco-friendly and cost-effective alternatives for improving nutrient availability and maintaining soil health (Barroso et al., 2006; Alikhani et al., 2006).

Given the significance of black gram in enhancing nutritional security and sustaining soil productivity, a systematic evaluation of the effects of nutrient omission on crop performance and soil properties is critical for Nagaland. The objectives of the present study were (i) to evaluate the effect of individual nutrient omissions on the growth and yield attributes of black gram (*Vigna mungo* L.) under the agro-climatic conditions of Nagaland, (ii) to assess the influence of

nutrient omission on nutrient uptake and nutrient-use efficiency in black gram and (iii) to study the residual effects of nutrient omission on soil chemical properties and fertility status after crop harvest.

## Materials And Methods

A pot experiment was carried out in the Department of Soil Science, School of Agricultural Sciences (SAS), Nagaland University Campus Medziphema, during the *kharif* season of 2022. The experimental site is situated at the foothill of Nagaland, at an altitude of 310 meters above mean sea level, with a geographical location of 25°43.923' to 25°50.569' North latitude and 93°37.645' to 93°55.202' East longitude. The climatic conditions of the experimental site are characterised by a sub-humid tropical climate, with high humidity, moderate temperatures, medium to high relative humidity, and medium to high rainfall. The average annual rainfall varies between 2000 and 2500 mm. The mean temperature ranges from 21°C to 32°C during summer and rarely drops below 8°C in winter, due to high atmospheric humidity. A pot experiment using soil collected from the SAS farm was conducted at the Department of Soil Science in a completely randomised design (CRD) with three replications and nine treatments, namely T<sub>1</sub>All (N, P, K, S, B, lime, PSM & Rhizobium), T<sub>2</sub>(All-N), T<sub>3</sub> (All-P), T<sub>4</sub> (All-K), T<sub>5</sub> (All-S), T<sub>6</sub> (All-B), T<sub>7</sub> (All-Lime), T<sub>8</sub> (PSM) and T<sub>9</sub> (Rhizobium) (Table 1). The growth, yield attributes and yield of black gram were found to be superior in the treatment where all nutrients (N, P, K, S, B, Lime, PSM, and Rhizobium) were applied. The available nitrogen, phosphorus, potassium, sulphur, exchangeable calcium and magnesium, and available boron in post-harvest soil were found to be significantly higher under the treatment that contained all nutrients.

**Table 1:** Details of treatment and fertilizer used

| Symbol         | Treatment             | Fertilizer used |       |       |         |       |
|----------------|-----------------------|-----------------|-------|-------|---------|-------|
|                |                       | For N           | For P | For K | For S   | For B |
| T <sub>1</sub> | All                   | Urea, DAP       | DAP   | MOP   | ES      | Borax |
| T <sub>2</sub> | All- N                | -               | SSP   | MOP   | ES, SSP | Borax |
| T <sub>3</sub> | All- P                | Urea            | -     | MOP   | ES      | Borax |
| T <sub>4</sub> | All- K                | Urea, DAP       | DAP   | -     | ES      | Borax |
| T <sub>5</sub> | All- S                | Urea, DAP       | DAP   | MOP   | -       | Borax |
| T <sub>6</sub> | All- B                | Urea, DAP       | DAP   | MOP   | ES      | -     |
| T <sub>7</sub> | All- lime             | Urea, DAP       | DAP   | MOP   | ES      | Borax |
| T <sub>8</sub> | All- PSM              | Urea, DAP       | DAP   | MOP   | ES      | Borax |
| T <sub>9</sub> | All- <i>Rhizobium</i> | Urea, DAP       | DAP   | MOP   | ES      | Borax |

Where, (All=N-20, P-45, K-45, S-30, B-0.5, lime-400 kg ha<sup>-1</sup> and PSM & *Rhizobium* 20 g kg<sup>-1</sup> seed),  
 ES- Elemental sulphur, MOP- Muriate of potash, DAP- Di-ammonium Phosphate.

The pots used for the experiment were cleaned and left for 2 days to dry in sunlight. Then the collected soil was filled up in the pots @ 15 kg pot<sup>-1</sup>. The full dose of fertilisers was applied at sowing time as a basal application. Lime (CaCO<sub>3</sub>) was applied 2 days before sowing as basal. Bio-fertiliser was applied as a seed treatment. Five seeds in each pot were sown at a depth of 1.5 cm. After 15 days of sowing, three plants were maintained in each pot. For controlling weeds, time-to-time hand weeding was done, and for controlling the biting and chewing type insects, neem oil was sprayed in the experimental pots in order to protect the crop. Harvesting of pods was done in two to three pickings. After the final pickings of the pods, the crop was harvested from the ground level to record the stover yield. Pods were dried after harvesting and threshed. After threshing, the seeds were separated out and cleaned manually. From each pot, one plant was selected and tagged for measurement of the plant height from the ground level to the tip of the plant at harvest. The number of leaves per plant was counted from one of the tagged plants in each pot at harvest. The total number of pods plant<sup>-1</sup> was calculated from the tagged plant. A total of

five pods were taken from the tagged plant in each of the treatments, and the length of each pod was measured in centimetres; the average length of the five pods was calculated. Five numbers of pods, which were taken for the measurement of pod length, were used to calculate the number of seeds in those pods, and the average was calculated. One hundred seeds were counted and their weight was taken by an electric balance, then the weight of one hundred seeds was multiplied by 10 to convert it into 1000 seed weight. The pods were picked separately according to the treatments and then dried, threshed, and cleaned. The seed yield from each pot was recorded separately. The Stover was sun-dried properly after harvest, and the pot-wise yield was recorded. Nitrogen in plant samples was determined by the modified Kjeldhal method as described by Black (1965). The plant materials were digested with concentrated sulphuric acid in the presence of the digestion mixture. Phosphorus was determined by the Vanadomolybdate yellow colour method as outlined by Jackson (1973). Potassium was determined by flame photometry as described by Chapman and Pratt (1961). The samples were separately digested in a di-acid mixture (Baruah & Barthakur, 1997).

The calcium and magnesium content in the seed and stover was determined by the Versenate method. The di-acid ( $\text{HNO}_3\text{-HClO}_4$ ) digested plant sample was titrated against versenate (EDTA) as outlined by Cheng and Bray (1951). Sulphur content in plant material was

determined turbidimetrically as described for soil sulphur (Chesnin & Yien, 1951). Boron was determined by the Azomethine-H method (Berger & Troug, 1939) of ashing of plant sample using a spectrophotometer as described by Gupta (1967).

#### Nutrient uptake

Nutrient uptake was calculated using the following formula:

$$\text{Nutrient uptake (mg/pot)} = \text{yield (g pot}^{-1}\text{)} \times \text{Nutrient content (\%)} \times 10$$

$$\text{Boron uptake (}\mu\text{g pot}^{-1}\text{)} = \text{Yield (g pot}^{-1}\text{)} \times \text{B content (mg kg}^{-1}\text{)}$$

The soil sample was collected from the experimental farm of the Department of Horticulture of the SAS farm at a depth of 0-15 cm. A homogeneous composite

sample was prepared and analysed for various soil parameters. Details of the initial soil status are given in Table 2.

**Table 2:** Initial soil fertility status of the experimental field

| Soil Parameters                                                      | Value           | Method employed                                                                            |
|----------------------------------------------------------------------|-----------------|--------------------------------------------------------------------------------------------|
| pH                                                                   | 4.6             | Glass electrode pH meter (Richards, 1954)                                                  |
| EC ( $\text{dSm}^{-1}$ )                                             | 0.04            | Conductivity Meter (Richards, 1954)                                                        |
| Organic carbon ( $\text{g kg}^{-1}$ )                                | 10.2            | Rapid titration method (Walkley and Black, 1934)                                           |
| Available N ( $\text{kg ha}^{-1}$ )                                  | 288.3           | Alkaline Potassium Permanganate method (Subbiah and Asija, 1956)                           |
| Available P ( $\text{kg ha}^{-1}$ )                                  | 27.0            | (Bray and Kurtz, 1945)                                                                     |
| Available K ( $\text{kg ha}^{-1}$ )                                  | 125.6           | Neutral normal ammonium acetate method (Jackson, 1973)                                     |
| Available S ( $\text{kg ha}^{-1}$ )                                  | 20.1            | Turbidimetric method (Chesnin and Yien, 1951)                                              |
| Exchangeable Ca [ $\text{cmol (p+)} \text{ kg}^{-1}$ ]               | 1.35            | Versenate method (Richards, 1954)                                                          |
| Exchangeable Mg [ $\text{cmol (p+)} \text{ kg}^{-1}$ ]               | 0.65            | Versenate method (Richards, 1954)                                                          |
| Exchangeable $\text{Al}^{+3}$ ( $\text{cmol (p+)} \text{ kg}^{-1}$ ) | 0.87            | NaF solution (4%) in 1N KCl extract titrated against 0.1N HCl (Baruah and Barthakur, 1997) |
| Available Boron ( $\text{mg kg}^{-1}$ )                              | 0.35            | Azomethine-H method (Gupta, 1967)                                                          |
| Particle size distribution (%)                                       |                 | International pipette method (Piper, 1966)                                                 |
| i) Sand                                                              | 53.4            |                                                                                            |
| ii) Silt                                                             | 23.9            |                                                                                            |
| iii) clay                                                            | 22.7            |                                                                                            |
| Textural Class                                                       | Sandy Clay Loam |                                                                                            |

## Results And Discussion

### Effect on growth attributes

Omissions of various nutrients significantly affect the plant height of black gram (Table 3). At harvest, the maximum height of the plant (29.83 cm) was observed in  $T_1$ , which received all the nutrients (N, P, K, S, Lime, B, PSM & *Rhizobium*) followed by B-omitted  $T_6$  (27.97 cm), meanwhile the minimum height of the plant was observed in N- omitted pot  $T_2$  (19.27 cm). At harvest, omission of nitrogen reduced plant height by 35.4%, while omission of phosphorus reduced the plant height by 27.35% over the  $T_1$  treatment. It was observed that the most limiting nutrient for the growth of black gram crop was N, followed by phosphorus and potassium. The growth of the plants was significantly hampered when nitrogen nutrient was lacking, even though other nutrients were present at optimal levels in the 'SSNM-N' treatment combination. The results also indicate the importance of nitrogen in the vegetative growth phase. This was in conformity with Mandal *et al.* (2009) and Singh *et al.* (2012). The number of leaves per plant was not affected significantly at harvest. However, the highest number of leaves per plant was observed in  $T_1$ : All (N, P, K, S, B, Lime, PSM, *Rhizobium*) (41), while the lowest number of leaves per plant was observed in  $T_2$ : All-N (17) at harvest.

### Effect on yield attributes

The number of pods per plant was found to be significantly influenced by nutrient omission. The data were recorded and presented in Table 3. Application of all nutrients in  $T_1$ : All (N, P, K, S, B, Lime, PSM, and *Rhizobium*) gave the maximum number of pods per plant (15.00), while the lowest number of pods per plant was observed in  $T_3$ : All- P (10.00). Phosphorus was reported as the most limiting nutrient in terms of the number of pods per plant, followed by nitrogen and sulphur. The pod length of black gram was found to be significantly highest (4.33 cm) with  $T_1$ , which received all nutrients, and lowest (3.90 cm) with omission of P treatment ( $T_3$ ). Maximum decrement in pod length was recorded with omission of P, and minimum reduction

was observed with potassium omission, indicating that phosphorus is a very important plant nutrient for legume crops. The provision of adequate phosphorus to the crop likely played a crucial role in facilitating plant growth, photosynthesis, flowering, seed formation, and nitrogen fixation, ultimately leading to improvements in yield-related characteristics. These findings align with the research of Singh *et al.* (2018) and Taliman *et al.* (2019). The treatment that received all the nutrients ( $T_1$ ) produced the highest number of seeds per pod (6.33), and the omission of P ( $T_3$ ) produced the lowest (5.93). The omission of P and N limited the number of seeds per pod<sup>-1</sup>, while efficient supplies of all nutrients at optimal rates yielded the highest number of seeds per pod. As phosphorus is recognised for its ability to stimulate flowering and fruiting, this phenomenon could have prompted the plants to generate additional pods, fostering greater overall plant growth and an increased yield of seeds per pod. The similar results were reported by Shah *et al.* (2000) and Harika *et al.* (2023). The treatment which received all the nutrients ( $T_1$ ) recorded the highest (62.23 g) and omission of P ( $T_3$ ) recorded the lowest (53.70 g) test weight, respectively. Omission of phosphorus reduced the test weight more than other nutrients, indicating phosphorus is the most limiting nutrient in the case of test weight. A comparable outcome was noted by Parashar *et al.* (2020) and Harika *et al.* (2023). The seed yield of black gram varied from 7.37 to 11.52 g pot<sup>-1</sup> irrespective of the treatments. The highest seed yield was recorded in  $T_1$  with all the nutrients provided (11.52 g pot<sup>-1</sup>), followed by  $T_6$  with omission of B (9.69 g pot<sup>-1</sup>). The lowest seed yield was found in  $T_3$  with the omission of P (7.37 g pot<sup>-1</sup>). The reductions in seed yield were high with the omission of P (36.02%), followed by N (27.6%), and the minimum reduction was recorded with the omission of the boron treatment (15.9%). P was the most critical nutrient for optimum seed yield of the crop. The increase in yield attributed to phosphorus can be attributed to its promotion of robust root development, enhanced nitrogen fixation, its accessibility to plants, and the favourable conditions it creates within the *rhizosphere*. These findings are in conformity with Paese (2010) and Anand *et al.*

(2022). The data revealed that the stover yield of black gram varied from 9.70 to 13.03 g pot<sup>-1</sup>. The highest stover yield was recorded in T<sub>1</sub>, which received all nutrients (13.03 g pot<sup>-1</sup>), followed by T<sub>6</sub> with omission of B (11.78 g pot<sup>-1</sup>), which was statistically at par with T<sub>7</sub> with omission of lime (11.25 g pot<sup>-1</sup>). The lowest stover yield was recorded in T<sub>3</sub> with omission of P (9.70 g pot<sup>-1</sup>). The reductions in stover yield were high with the

omission of P (25.6%), followed by N (21.9%), and the minimum reduction was recorded with the omission of boron treatment (9.6%). Nitrogen was found next to phosphorus in limiting the stover yield. It was observed that phosphorus was the most limiting nutrient for yield in black gram. This finding is in conformity with those of Manpreet *et al.* (2004) and Bhuiyan *et al.* (2008).

**Table 3:** Effect of nutrient omission on growth and yield of black gram

| Treatment                                                          | Plant height (cm) | Number of leaves plant <sup>-1</sup> | Number of pods plant <sup>-1</sup> | Pod length (cm) | Number of seeds pod <sup>-1</sup> | Test weight (g) | Seed yield (g pot <sup>-1</sup> ) | Stover yield (g pot <sup>-1</sup> ) |
|--------------------------------------------------------------------|-------------------|--------------------------------------|------------------------------------|-----------------|-----------------------------------|-----------------|-----------------------------------|-------------------------------------|
| T <sub>1</sub> : All (N, P, K, S, B, Lime, PSM, <i>Rhizobium</i> ) | 29.83             | 41.00                                | 15.00                              | 4.33            | 6.33                              | 62.23           | 11.52                             | 13.03                               |
| T <sub>2</sub> : All- N                                            | 19.27             | 17.00                                | 11.00                              | 3.93            | 6.00                              | 55.00           | 8.34                              | 10.18                               |
| T <sub>3</sub> : All- P                                            | 21.67             | 20.33                                | 10.00                              | 3.90            | 5.93                              | 53.70           | 7.37                              | 9.70                                |
| T <sub>4</sub> : All- K                                            | 22.00             | 24.00                                | 11.67                              | 4.30            | 6.20                              | 59.08           | 9.22                              | 11.09                               |
| T <sub>5</sub> : All- S                                            | 22.07             | 25.67                                | 11.00                              | 4.07            | 6.10                              | 56.99           | 8.60                              | 10.67                               |
| T <sub>6</sub> : All- B                                            | 27.97             | 36.33                                | 13.33                              | 4.27            | 6.27                              | 60.17           | 9.69                              | 11.78                               |
| T <sub>7</sub> : All- Lime                                         | 25.87             | 35.00                                | 13.00                              | 4.10            | 6.13                              | 57.90           | 8.79                              | 11.25                               |
| T <sub>8</sub> : All- PSM                                          | 22.23             | 26.67                                | 12.67                              | 4.00            | 6.07                              | 55.82           | 8.42                              | 10.28                               |
| T <sub>9</sub> : All- <i>Rhizobium</i>                             | 23.13             | 29.67                                | 13.00                              | 4.07            | 6.10                              | 56.19           | 8.49                              | 10.53                               |
| ...                                                                | 1.75              | 5.59                                 | 0.86                               | 0.10            | 0.08                              | 1.02            | 0.67                              | 0.41                                |
| CD(P=0.05)                                                         | 5.21              | NS                                   | 2.56                               | 0.29            | 0.23                              | 3.05            | 2.01                              | 1.22                                |

#### Nutrient uptake

The effect of nutrient omission on total nutrient uptake showed significant variation among different treatments (Table 4). Maximum reduction (35.62%) in total nitrogen uptake was recorded with N omission, followed by omission of P treatment (34.4%), and minimum reduction (16.41%) was obtained with boron

omission pots. This increase in N uptake might be attributed to increased N content and dry matter yield. These results are in line with those of Upadhyay (2013), Singh and Sharma (2016). Maximum reduction (48.1%) in total phosphorus uptake was recorded with P omission, followed by omission of PSM treatment (35.7%), and minimum reduction (17.8%) was obtained with boron

omission pots. Reduction in phosphorus uptake may be due to decreased seed and stover yields resulting from the omission of nutrients. P omission had a far greater impact on the uptake of nutrients by the crop. This was because the P omission strongly depressed the seed and stover yields of the crop (Singh, 2017). Maximum reduction (43%) in total potassium uptake was recorded with K omission, followed by omission of P (36.2%), and a minimum reduction (17.2%) was obtained with boron omission treatment. This may be due to a reduction in yield as well as K content resulting from the omission of various nutrients. These results are in confirmatory with Singh (2017). Similar data were also observed by Brar *et al.* (2004). Maximum reduction (49.4%) in total Sulphur uptake was recorded with S omission, followed by omission of P treatment (41.7%), and minimum reduction (24.6%) was obtained with boron omission treatment. The significant uptake of sulphur by both black gram seeds and plant residue could be attributed to the alkaline effects of liming, which counteracts soil acidity. This process promotes the breakdown of organic matter and contributes to the

sulphur reservoir, ultimately leading to an elevated absorption of sulfur by the crops. Furthermore, the omission of various nutrients reduced seed and stover yield and S content, ultimately decreasing sulphur uptake. These results are consistent with Rathod *et al.* (2017) and Patil *et al.* (2018). Omission of lime significantly decreased the uptake of calcium and magnesium by black gram (seed and stover). The application of lime to acidic soil likely deactivated exchangeable aluminium present in the moderately acidic soils used for crop cultivation. This process resulted in increased adsorption of calcium and magnesium onto the exchangeable complex, followed by their subsequent release to the crops. Similar results were documented by Rathod *et al.* (2017). Maximum reduction (34.7%) in total boron uptake was recorded with B omission, followed by omission of P treatment (33.03%), and minimum reduction (19.6%) was obtained with K omission treatment. Debnath *et al.* (2018) noted that the addition of boron alongside the recommended fertiliser dosage resulted in an augmentation of boron uptake in cowpea seeds. Similar results have also been reported by Raj (2019).

**Table 4:** Effect of nutrient omission on nutrient uptake of black gram

| Treatment                                                          | Nutrient uptake (mg pot <sup>-1</sup> ) |        |        |       |       |       | B<br>(µg pot <sup>-1</sup> ) |
|--------------------------------------------------------------------|-----------------------------------------|--------|--------|-------|-------|-------|------------------------------|
|                                                                    | N                                       | P      | K      | S     | Ca    | Mg    |                              |
| T <sub>1</sub> : All (N, P, K, S, B, Lime, PSM, <i>Rhizobium</i> ) | 713.04                                  | 130.7  | 105.49 | 59.1  | 56.8  | 44.21 | 448.34                       |
| T <sub>2</sub> : All- N                                            | 459.03                                  | 88.35  | 71.89  | 40.29 | 36.84 | 27.24 | 321.5                        |
| T <sub>3</sub> : All- P                                            | 467.85                                  | 67.83  | 67.29  | 34.47 | 31.26 | 23.95 | 300.25                       |
| T <sub>4</sub> : All- K                                            | 559.28                                  | 105.01 | 60.13  | 43.15 | 41.23 | 30.08 | 360.31                       |
| T <sub>5</sub> : All- S                                            | 524.4                                   | 93.01  | 76.11  | 29.88 | 40.92 | 28.91 | 344.09                       |
| T <sub>6</sub> : All- B                                            | 597.92                                  | 107.45 | 87.33  | 44.53 | 41.65 | 30.73 | 292.68                       |
| T <sub>7</sub> : All- Lime                                         | 531.09                                  | 85.49  | 80.13  | 40.95 | 26.54 | 22.46 | 349.7                        |
| T <sub>8</sub> : All- PSM                                          | 496.04                                  | 84.03  | 69.38  | 35.3  | 33.63 | 24.92 | 326.06                       |
| T <sub>9</sub> : All- <i>Rhizobium</i>                             | 519.79                                  | 89.42  | 74.36  | 38.18 | 38.12 | 28.5  | 334.52                       |
| SEm±                                                               | 20.26                                   | 4.38   | 2.91   | 2.29  | 2.37  | 1.68  | 15.91                        |
| CD(P=0.05)                                                         | 60.20                                   | 13.03  | 8.65   | 6.81  | 7.05  | 4.98  | 47.27                        |

### *Effect on soil properties*

A perusal of data showed that no significant effect on the omission of nutrients was observed on the soil pH, EC and organic carbon after the harvest of the crop (Table 5). The highest available nitrogen was observed in all nutrient treatments,  $T_1$  ( $324.93 \text{ kg ha}^{-1}$ ), and the lowest was recorded in the all minus N treatment,  $T_2$  ( $316.70 \text{ kg ha}^{-1}$ ). It was observed that the available soil nitrogen status reduced significantly with the exclusion of nitrogen ( $T_2$ ). The elevated availability of nitrogen is attributed to the increased activity of nitrogen-fixing bacteria, resulting in a significant increase in nitrogen content within the soil (Singh & Mukherjee, 2009). The highest available soil phosphorus ( $32.76 \text{ kg ha}^{-1}$ ) was recorded in  $T_1$  (all nutrients). The lowest available soil phosphorus ( $26.70 \text{ kg ha}^{-1}$ ) was recorded in the P-omitted ( $T_3$ ) treatment. Omission of phosphorus and lime significantly reduced the available phosphorus of the post-harvest soil. Similar results were obtained by Jamir *et al.* (2013), who observed an enhancement in phosphorus availability resulting from the judicious application of chemical fertilisers. The highest available potassium in the soil ( $151.30 \text{ kg ha}^{-1}$ ) after crop harvest was recorded in  $T_1$ , and the lowest available soil K was recorded in  $T_4$  ( $121.88 \text{ kg ha}^{-1}$ ). The significantly low availability of potassium in the soil after harvest was evident in treatments without potassic fertilisers. Similar observations were also reported by Arbad and Ismail (2011). The highest available sulphur in the soil ( $22.53 \text{ kg ha}^{-1}$ ) after crop harvest was recorded in  $T_1$ , and the

lowest available soil S was recorded in  $T_5$  ( $19.07 \text{ kg ha}^{-1}$ ), where sulphur was omitted. These results conformed to the findings of Kumar *et al.* (2014). All nutrients treatment  $T_1$  [ $1.40 \text{ cmol(p}^+) \text{ kg}^{-1}$ ] and all minus B treatment  $T_6$  [ $1.40 \text{ cmol(p}^+) \text{ kg}^{-1}$ ] recorded the highest exchangeable calcium in the soil, while lime omitted treatment  $T_7$  [ $1.32 \text{ cmol(p}^+) \text{ kg}^{-1}$ ] recorded the lowest. Since no lime application was made, the lime-omitted treatment resulted in a significantly lower exchangeable calcium status in the post-harvest soil. Similar observations were also reported by Miller (2000) and Lalfakzuali and Sharma (2021). The highest exchangeable magnesium in the soil [ $0.72 \text{ cmol(p}^+) \text{ kg}^{-1}$ ] was recorded in  $T_1$  and all-B treatment  $T_6$  [ $0.72 \text{ cmol(p}^+) \text{ kg}^{-1}$ ], while lowest exchangeable magnesium was recorded in  $T_7$  [ $0.63 \text{ cmol(p}^+) \text{ kg}^{-1}$ ] (All-Lime). Caires *et al.* (2008) demonstrated that the application of lime elevated calcium concentration and decreased exchangeable aluminium levels. Similar observations were also reported by Lalfakzuali and Sharma (2021). All nutrients treatment  $T_1$  ( $0.39 \text{ mg kg}^{-1}$ ) was superior to all other treatments, whereas boron omitted treatment  $T_6$  ( $0.29 \text{ mg kg}^{-1}$ ) recorded the least available boron after crop harvest. Similar results have also been reported by Singh *et al.* (2014). It can be observed that there was no significant difference in the exchangeable aluminium status of the soil after crop harvest. However, a lesser amount of exchangeable  $\text{Al}^{3+}$  was observed in lime-omitted pots.

**Table 5:** Effect of nutrient omission on soil properties after crop harvest

| Treatment                                                          | pH   | EC<br>(dSm <sup>-1</sup> ) | OC<br>(g kg <sup>-1</sup> ) | Available (kg ha <sup>-1</sup> ) |       |        |       | Ex. [cmol(p <sup>+</sup> ) kg <sup>-1</sup> ] |      |      | Av. B<br>(mg kg <sup>-1</sup> ) |
|--------------------------------------------------------------------|------|----------------------------|-----------------------------|----------------------------------|-------|--------|-------|-----------------------------------------------|------|------|---------------------------------|
|                                                                    |      |                            |                             | N                                | P     | K      | S     | Ca                                            | Mg   | Al   |                                 |
| T <sub>1</sub> : All (N, P, K, S, B, Lime, PSM, <i>Rhizobium</i> ) | 4.63 | 0.05                       | 10.75                       | 324.93                           | 32.76 | 151.30 | 22.53 | 1.40                                          | 0.72 | 0.88 | 0.39                            |
| T <sub>2</sub> : All- N                                            | 4.62 | 0.05                       | 10.43                       | 316.70                           | 31.55 | 148.57 | 21.84 | 1.38                                          | 0.71 | 0.86 | 0.34                            |
| T <sub>3</sub> : All- P                                            | 4.62 | 0.05                       | 10.46                       | 320.43                           | 26.70 | 147.23 | 21.25 | 1.37                                          | 0.70 | 0.86 | 0.35                            |
| T <sub>4</sub> : All- K                                            | 4.61 | 0.05                       | 10.53                       | 322.97                           | 31.78 | 121.88 | 21.94 | 1.38                                          | 0.70 | 0.87 | 0.36                            |
| T <sub>5</sub> : All- S                                            | 4.61 | 0.04                       | 10.56                       | 321.57                           | 31.97 | 147.20 | 19.07 | 1.39                                          | 0.70 | 0.87 | 0.36                            |
| T <sub>6</sub> : All- B                                            | 4.60 | 0.04                       | 10.73                       | 323.73                           | 32.50 | 150.20 | 22.24 | 1.40                                          | 0.72 | 0.88 | 0.29                            |
| T <sub>7</sub> : All- Lime                                         | 4.61 | 0.04                       | 10.69                       | 323.47                           | 31.27 | 148.11 | 22.61 | 1.32                                          | 0.63 | 0.85 | 0.33                            |
| T <sub>8</sub> : All- PSM                                          | 4.62 | 0.04                       | 10.60                       | 322.47                           | 31.00 | 147.80 | 22.42 | 1.38                                          | 0.70 | 0.87 | 0.34                            |
| T <sub>9</sub> : All- <i>Rhizobium</i>                             | 4.63 | 0.05                       | 10.67                       | 323.10                           | 31.41 | 148.53 | 22.57 | 1.39                                          | 0.71 | 0.88 | 0.36                            |
| SEm±                                                               | 0.03 | 0.005                      | 0.34                        | 1.52                             | 0.65  | 2.04   | 0.63  | 0.01                                          | 0.01 | 0.01 | 0.01                            |
| CD(P=0.05)                                                         | NS   | NS                         | NS                          | 4.51                             | 1.94  | 6.05   | 1.87  | 0.02                                          | 0.02 | NS   | 0.04                            |

## Conclusion

The nutrient omission study on black gram (*Vigna mungo* L.) under Nagaland conditions clearly demonstrated that balanced and adequate nutrient supply is vital for optimising crop growth, yield attributes, and nutrient uptake. Omission of essential nutrients, particularly nitrogen, phosphorus, and potassium, resulted in significant reductions in plant height, branches, pods per plant, seed yield, and biomass production, underscoring their critical role in black gram productivity. Nutrient uptake patterns reflected the nutrient supply, with omission plots showing marked declines in macro- and micro-nutrient accumulation. Post-harvest soil analysis revealed that continuous nutrient omission led to a depletion of soil fertility, with significant reductions in available nitrogen, phosphorus, and potassium, as well as slight acidification in some treatments. Balanced nutrient application not only sustained higher yields but also maintained or improved

soil fertility, highlighting the importance of integrated and site-specific nutrient management strategies. Overall, the findings emphasised that nutrient omission leads to sub-optimal yields and soil nutrient mining, while appropriate nutrient management enhances productivity and sustains soil health. The study recommends adopting balanced fertilisation combined with biofertilizers and site-specific nutrient management (SSNM) practices to improve black gram yield, nutrient-use efficiency, and long-term soil fertility in Nagaland's agro-ecosystems.

## References

- Alikhani H. A., Saleh-Rastin N. and Antoun H. (2006). Phosphate solubilization activity of rhizobia native to Iranian soils. *Plant and Soil*. **287**: 35–41.
- Anand A., Umesha C. and Sanodiya LK. (2022) Effect of phosphorus and molybdenum on yield and economics of black gram (*Vigna mungo* L.). *The Pharma Innovation Journal*. **11**(5): 1417-1420.

- Anonymous. (2011). Agricultural Statistics at Glance, Ministry of Agriculture, Government of Nagaland.
- Arbad B. K. and Ismail S. (2011). Effect of integrated nutrient management on soybean (*Glycine max*) – safflower (*Carthamustinctorius*) cropping system. *Indian Journal of Agronomy*. **56**(4): 340-345.
- Barroso C. V., Pereira, G T. and Nahas, E. (2006). Solubilization of  $\text{CaHPO}_4$  and  $\text{AlPO}_4$  by *Aspergillus niger* in culture media with different carbon and nitrogen sources. *Brazilian Journal of Microbiology*. **37**: 434-438.
- Baruah T. C. and Barthakur H P. (1997) A textbook of soil analysis. Vikas Publishing House Private Limited, New Delhi.
- Berger K. C. and Truog, E. (1939). Boron determination in soil and plants. Industrial and Engineering Chemistry Analytical Edition. **11**: 540-545.
- Bhuiyan M.M.H., Rahman M M., Afroze F., Sutradhar G N C. and Bhuiyan M S I. (2008). Effect of phosphorus, molybdenum and *Rhizobium* inoculation on growth and nodulation of mung bean. *Journal of Soil and Nature*. **2**(2): 25-30.
- Black C. A. (1965). Methods of soil analysis volume I. American Society of Agronomy, Madison, Wisconsin, USA.
- Brar M.S., Kaur N. Rachna and Sharma, A. (2004). Effect of graded doses of potassium on pea (*Pisum sativum* L.). *Journal of Potassium Research*. **20**: 100-108.
- Bray R. H. and Kurtz L. T. (1945) Determination of total, organic and available forms of phosphorus in soils. *Soil Science*. **59**(1): 39-46.
- Bruulsema T.W., Fixen P. E. and Sulewski G. D. (2012). 4R Plant Nutrition Manual: A Manual for Improving the Management of Plant Nutrition. International Plant Nutrition Institute (IPNI), Norcross, GA, USA.
- Caires E. F., G Barth, F. J. Garbuio and Churka S. (2008). Soil acidity, liming and soybean performance under no-till. *Scientia Agricola*. **65**(5): 532-540.
- Chapman H. D. and Pratt P. F. (1961). Methods of analysis of soils, plants and water. University of Agricultural Sciences, USA: 5-8 and 56-58.
- Cheng K. L. and Bray R. H. (1951). Determination of calcium and magnesium in soil and plant material. *Soil Science*. **72** (6): 449-458.
- Chesnin L. and Yien C. H. (1951). Turbidimetric determination of available sulfates. *Soil Science Society of America Journal*. **15**(C): 149-151.
- Debnath P., Pattanaik S. K., Sah D., Chandra G. and Pandey A. K. (2018). Effect of boron and zinc fertilization on growth and yield of cowpea (*Vigna unguiculata* Walp.) in Inceptisols of Arunachal Pradesh. *Journal of the Indian Society of Soil Science*. **66**(2): 229-234.
- Directorate of Economics and Statistics, Government of Nagaland, 2017-2018.
- Gupta P. K. (2007). Soil, plant and fertilizer analysis. Agrobios Publication, Jodhpur.
- Gupta U. C. (1967). A simplified method for determining hot-water soluble boron in podzol soils. *Soil Science*. **103**(6): 424-428.
- Harika D., Debbarma V. and Thrupthi M. G. (2023). Influence of phosphorus and bio-fertilizers on growth and yield of black gram (*Phaseolus mungo* L.). *International Journal of Plant and Soil Science*. **35**(13): 43-51.
- Jackson M.L. (1973). Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.
- Jamir S, Singh V.B, Kanaujia S. P. and Singh A. K. (2013). Effect of integrated nutrient management on growth, yield and quality of onion (*Allium cepa* L.). *Progressive Horticulture*. **45**(2): 373-380.
- Kumar R., Lal J. K., Kumar A., Agrawal B. K. and Karmakar S. (2014). Effect of different sources and levels of sulphur on yield, S uptake and protein content in rice and pea grown in sequence on an acid Alfisol. *Journal of the Indian Society of Soil Science*. **62**(2): 140-143.
- Lalfakzuali M. and Sharma Y. (2021). Effect of omission of nutrients on productivity, uptake of nutrients in maize (*Zea mays* L.) and residual soil fertility in Dystrudept of Nagaland. *Annals of Plant and Soil Research*. **23**(4): 397-401.

- Mandal M.K., Pati R., Mukhopadhyay D. and Majumdar K. (2009). Maximising yield of cowpea through soil test-based nutrient application in terai alluvial soils. *Better Crops-India*. 28.
- Manpreet S., Sekhon H. S. and Jagrup S. (2004). Response of integrated nutrient management on summer mungbean (*Vigna radiata* L. Wilczek). *An international journal of soil fertility*. **14**(7): 365-372.
- Miller P.R. (2000). Effect of varying seeding date on crop development, yield and yield components in canary seed. *Canadian Journal of Plant Science*. **80**(1): 83-86.
- Paese R. (2010). Effect of different levels of phosphorus and potassium on growth and development of mungbean. (*Vigna radiata* L.) Wilczek. *Indian Journal of Agriculture Research*. **11**(4): 56-61.
- Parashar A. Jain M. and Tripathi L. (2020). Effect of sulphur and phosphorus on the growth and yield of black gram (*Vigna mungo* L.). *Indian Journal of Pure and Applied Bioscience*. **8**(5): 276-280.
- Patil D. H., Shankar M. A., Krishnamurthy N., Shadakshari Y. G. and Parama, V. R. (2018). Studies on site specific nutrient management (SSNM) on growth and yield of groundnut (*Arachis hypogaea*) under irrigation in southern Karnataka. *Legume Research-An International Journal*. **41**(5): 728-733.
- Phogat M., Rai A.P. and Kumar S. (2020). Interaction effect of phosphorus and sulphur application on nutrient uptake, yield and yield attributing parameters of black gram [*Vigna mungo* (L.) Hepper]. *Legume Research-An International Journal*. **43**(2): 212-220.
- Piper C. S. (1966). Soil and plant analysis. Hans Publisher, Bombay pp. 135-136.
- Raj A B. (2019). *Seed invigouration for yield enhancement in grain cowpea (Vigna unguiculata L. walp)*. Doctoral dissertation, Department of Agronomy, College of Agriculture, Vellayani.
- Rathod P. K., Meshram N. A., Patil M. and Bhalerao G.A. (2017). Effect of lime, zinc and boron on yield and nutrient uptake by soybean in lateritic soil. *Agriculture Update*. **12**(8): 2338-2342.
- Richards L.A. (1954). Diagonosis and Improvement of Saline and Alkaline Soils. (Ed) USDA. Handbook No. 60. Oxford and IBH Publishing Co., New Delhi.
- Shah S. H., Mahmood M. Y. and Zameer M. I. (2000). Qualitative and quantitative response of three cultivars of lentil (*Lens culinaris* Medic.) to phosphoric application. *International Journal of Agriculture and Biology*. **2**(3): 248-250.
- Singh A. K., Bhatt B. P., Sundaram P. K., Kumar S., Bahrati R. C., Chandra N. and Rai M. (2012). Study of site specific nutrients management of cowpea seed production and their effect on soil nutrient status. *Journal of Agricultural Science*. **4**(10): 191.
- Singh H. and Sharma A. K. (2016). Short communication response of lucerne to sulphur application in alluvial soil. *Annals of Plant and Soil Research*. **18**(3): 298-299.
- Singh R. K. and Mukherjee D. (2009). Effect of biofertilizers, fertility levels and weed management on chickpea under late sown condition. *Journal of food legumes*. **22**(3): 216-218.
- Singh R., Singh P., Singh V. and Yadav R. A. (2018). Effect of phosphorus and PSM on yield attributes, quality and economics of summer green gram (*Vigna radiata* L.). *Journal of pharmacognosy and phytochemistry*. **7**(2): 404-408.
- Singh S. P. (2017). Effect of micronutrients on nodulation, growth, yield and nutrient uptake in black gram (*Vigna mungo* L.). *Annals of Plant and Soil Research*. **19**(1): 66-70.
- Singh S., Singh H., Seema, Singh J. P. and Sharma VK. (2014). Effect of integrated use of rock phosphare, molybdenum and phosphate solubilizing bacteria on lentil (*Lens culinaris*) in an alluvial soil. *Indian Journal of Agronomy*. **59**(3): 433-438.
- Subbiah B. V. and Asija G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. **25**: 259-260.

- Taliman N. A., Dong Q., Echigo K., Raboy V. and Saneoka H. (2019). Effect of phosphorus fertilization on the growth, photosynthesis, nitrogen fixation, mineral accumulation, seed yield, and seed quality of a soybean low-phytate line. *Plants*. **8**(5): 119.
- Upadhyay A.K. (2013). Effect of sulphur and zinc nutrition on yield, uptake of nutrients and quality of lentil in alluvial soils. *Annals of Plant and Soil Research*. **15**(2):160-163.
- Vavilov N.I. (1951). The Origin, variation, immunity and breeding of cultivated plants. Ed. Tranil, K.S. Chester, Roland Press Company, New York. pp. 45-47.
- Walkley A. and Black I. A. (1934). An examination of different method for determining organic carbon in soil: effect of variation in digestion conditions and of inorganic soil constituents. *Soil Science*. **63**: 251-263.

---

Received: September 2024    Accepted: November 2024