INTERACTIVE EFFECTS OF PHOSPHORUS AND POTASSIUM ON BIOMASS PRODUCTION AND ACCUMULATION OF NITROGEN IN FIELD GROWN MUNGBEAN (Vigna radiata L.)

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Received 12 March 2019, Revised 23 May 2019, Accepted 24 June 2019, Published online 30 June 2019

Abstract

A field experiment was carried out in the paddy field of Charfession Govt. College, Bhola, Bangladesh during rabi season 2017 to evaluate growth, biomass production and nitrogen accumulation in mungbean plants. The size of the plot was 60 cm x 45 cm. The distance between row to row and plant to plant was 30 cm and 10 cm, respectively. Eight plants were raised per plot. Seven treatments were P1K0 (Control), P1K5, P1K10, P1K15, P10K5, P10K10 and P10K15 kg ha⁻¹. Forty day old plants were harvested as root, stem and leaf. The highest plant height (17.2 cm) and number of leaves (14.3 no. plant⁻¹) were recorded in P1K15 kg ha⁻¹ treatment at harvest. The maximum concentration of nitrogen in root, stem and leaf were 1.59, 2.51 and 3.82% in the treatments of P1K15, P5K15 and P10K15 kg ha⁻¹, respectively. The highest amount of dry matter yield 1.88 g plant⁻¹ was observed in P1K15 kg ha⁻¹ treatment. The overall better dose was P1K15 kg ha⁻¹. Thus, a considerable amount of nitrogen and organic matter might be added to paddy fields through the cultivation of mungbean in the coastal region of Bangladesh.

Keywords: Biomass Production, Mungbean, Nitrogen, Paddy Field.

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Cite this article as: Mohsin, G.M., Alauddin, M., Rahman, M., Uddin, M.K., Meem, F.F., Ali, A.H.M.Z., Rahman, M.S. & Rahman, M.K. (2019). Interactive effects of phosphorus and potassium on biomass production and accumulation of nitrogen in field grown Mungbean (Vigna radiata L.). Int. J. Agril. Res. Innov. Tech. 9(1), 14-17.

Introduction

Mungbean (Vigna radiata L.) is one of the important pulse crops in Bangladesh (Kaul, 1982). It can ideally be fitted for fallow period season rice and wheat production systems. Grown between two cereal crops, mungbean provides additional income for farmers and nutritious food for people. As a legume crop, mungbean associates with nitrogen-fixing bacteria and improve soil fertility, lowering the need for nitrogen fertilizers and increasing yield and quality of subsequent cereal harvests. Bangladesh is facing two opposite natural calamities. One is flood in monsoon and dry in winter. Climate change will affect cropping pattern particularly in coastal belt of Bhola, Patuakhali, Barguna, Satkhira, Laximpur, Noakhali, Feni, Chittagong and Cox’s Bazar regions. Devastating tidal surge like SIDR, excessive rainfall, increase in temperature and salinity, severe thunder storm etc. occurring frequently in Bangladesh, probably the climate is changing. The agricultural production in the coast is characterized by rain-fed cultivation, low nutrient levels in the soil and poor access to agricultural technologies. The organic matter content is low in the seashore and offshore landmass of sand-dominated soils. Growing crops in the coast will not be feasible for lack of sweet water. Plant nutrients are depleting rapidly because farmers are cultivating hybrid seeds of sunflower, soybean, watermelon, capsicum etc. Besides, uptake of plant nutrients from soil will be accelerated when genetically modified (GM) crops would be introduced in the near future. Incorporation of mungbean plants into sandy soil will improve soil properties and minimize nitrate leaching. Phosphorus is involved in several key plant functions, including energy transfer, photosynthesis, transformation
of sugars and starches, nutrient movement within the plant and transfer genetic characteristics from one generation to the next (Anonymous, 1999). Potassium is important in the regulation of stomata, the biochemical reactions, water and nutrient transportation, protein and starch synthesis in plants (Tajer, 2016). A little information is available on the cultivation of mungbean in relation to its incorporation into paddy fields to increase the fertility status in the coastal belt of Bangladesh.

Thus, the objective of the experiment was to evaluate the growth, biomass production and accumulation of N in root, stem and leaf of mungbean as influenced by phosphorus and potassium application.

**Material and Methods**

**Field Experiment**

A field experiment was conducted in the paddy field in front of Charfession Government College, Bhola district of Bangladesh in Rabi season 2017 to evaluate the growth, biomass production and concentration of nitrogen in root, stem and leaf of mungbean. A composite soil sample (0 to 15 cm depth) was collected before ploughing the land and air-dried, ground, and sieved (<2 mm sieve) and kept in polyethylene bags for physicochemical properties analysis (Table 1). The size of the plot was 60 cm x 45 cm. The distance between row to row and plant to plant was 30 cm and 10 cm, respectively. Different doses of phosphorus and potassium in the form of TSP and MOP were 0, 5, 10 kg and 0, 6, 12, 18 kg ha\(^{-1}\), respectively. Seven treatments with three replications were as P\(_6\)K\(_0\) (Control), P\(_6\)K\(_5\), P\(_6\)K\(_10\), P\(_6\)K\(_15\), P\(_6\)K\(_20\), P\(_6\)K\(_25\) and P\(_6\)K\(_30\) kg ha\(^{-1}\). The experiment was arranged in a randomized complete block design (RCBD). Mungbean (BARI mug 6) seeds were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur and sown at the rates of two and finally one seedling was allowed to grow per hole. Total eight plants were raised per plot for 40 days. Different practices viz. weeding, pesticide application, protection etc. were done as and when needed. Plant height and leaf numbers were recorded at harvest.

**Table 1. Some physicochemical properties of the soil used.**

| Characteristics | Values |
|-----------------|--------|
| Moisture content (%) | 19.22 |
| Particle density (g/cc)* | 2.36 |
| Bulk density (%) | 1.35 |
| Particles size (%)* | 3.12 |
| Sand (%) | 12.30 |
| Silt (%) | 54.34 |
| Clay (%) | 33.36 |
| Texture | Silty clay loam |
| pH (i: 2:5 w/v H\(_2\)O) | 8.36 |
| Organic-C (%)* | 0.65 |
| Organic matter (%) | 1.12 |
| Total N (%) | 0.18 |
| Total P (%)* | 0.06 |
| Total K (%) | 1.23 |

*Picnometer method (Blake, 1965), *Hydrometer method (Bouyoucos, 1962), *Wet oxidation method (Walkley and Black, 1934), *Kjeldahl extraction method (Marr and Cresser, 1983), *Vanadomolybdate yellow colour method (Jackson, 1958)

**Harvesting**

Forty days old plants were harvested as root, stem and leaf, washed with tap water and finally with distilled water, and wrapped with soft tissue paper. Immediately after harvest, fresh weight of root, stem and leaf were taken and then air-dried in the room temperature and finally oven-dried at 65°C in the laboratory for two days. Dry weight of the samples were recorded and ground with a mechanical grinder and stored in polythene bags for chemical analysis. For N analysis, the plant samples were digested with concentrated sulphuric and perchloric acid (62%). The digest was cooled and diluted to 100 ml with distilled water (Cresser and Parsons, 1979). LSD test of the results was performed using Microsoft Excel 2013.

**Results and Discussion**

Plant growth and biomass production was evaluated in terms of plant height, leaf number (Table 2) and fresh and dry weight of root, stem and leaf (Table 3). The highest plant height (27.2 cm) was recorded in P\(_6\)K\(_2\) treatments and lowest (9.0 cm) in P\(_6\)K\(_0\) treatment for 40 days old plants. Results varied significantly (p<0.05). Highest number of leaves (14.3 no. plant\(^{-1}\)) was found in P\(_6\)K\(_2\) treatment and lowest (8.6 no. plant\(^{-1}\)) was achieved in P\(_6\)K\(_0\) treatment for 40 days old plants and the values varied significantly (p<0.5). Rahman et al. (2015) conducted an experiment to
study the effects of P and Zn on the growth and yield of mungbean (BARI mug 6) using four levels of P and three levels of Zn. The results revealed that seed and stover yield of mungbean increased with increasing levels of P and Zn up to certain levels. In case of P, the maximum significant seed yield (1.5 ton ha⁻¹) and stover yield (2.47 ton ha⁻¹) were obtained with the treatment of 2.5 kg P ha⁻¹ and the minimum yield was recorded in the control treatment (P₀Zn₀).

Table 2. Effects of phosphorus and potassium on the plant height and leaf number and concentration of nitrogen in root, stem and leaf of mungbean plants grown in paddy field at the coastal belt of Bholaa region in Bangladesh.

| Treatments (kg ha⁻¹) | Plant height (cm) | Leaf (no. plant⁻¹) | Root N conc. (%) | Stem N conc. (%) | Leaf N conc. (%) |
|----------------------|-------------------|--------------------|-----------------|----------------|-----------------|
| P₀K₀ (Control)       | 9.0ᵃ             | 8.6ᵇ              | 0.86ᵃ           | 1.16ᵇ          | 1.95ᵇ           |
| P₀K₆                 | 13.6ᵇ            | 10.3ᵇ             | 1.23ᵇ           | 1.97ᵇ          | 3.48ᵇ           |
| P₀K₁₂                | 17.2ᶜ            | 14.3ᶜ             | 1.59ᶜ           | 2.40ᶜ          | 3.65ᵇ           |
| P₀K₈                 | 13.6ᵇ            | 11.6ᵇ             | 1.32ᵇ           | 1.32ᵇ          | 3.82ᵇ           |
| P₁₀K₆                | 13.5ᵇ            | 11.3ᵇ             | 1.51ᵇ           | 1.92ᵇ          | 3.24ᶜ           |
| P₁₀K₁₂               | 14.3ᵇ            | 11.2ᵇ             | 1.10ᵇ           | 2.51ᵇ          | 3.81ᵇ           |
| P₁₀K₈                | 10.6ᵇ            | 11.6ᵇ             | 1.32ᵇ           | 1.88ᵇ          | 3.79ᵇ           |
| LSD at 5%            | 3.41             | 1.67              | 0.17            | 0.27           | 0.21            |

ᵃᵇ Data bearing different superscripts in the same column differ significantly at 5% level.

Table 3. Effects of phosphorus and potassium on the fresh and dry weights of root, stem and leaf of mungbean plants grown in paddy field at the coastal belt of Bholaa region in Bangladesh.

| Treatments (kg ha⁻¹) | Root fresh weight (g plant⁻¹) | Stem fresh weight (g plant⁻¹) | Leaf fresh weight (g plant⁻¹) | Total fresh weight (g plant⁻¹) | Root dry weight (g plant⁻¹) | Stem dry weight (g plant⁻¹) | Leaf dry weight (g plant⁻¹) | Total dry matter yield (g plant⁻¹) |
|----------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|----------------------------|----------------------------|-------------------------------|-----------------------------------|
| P₀K₀ (Control)       | 0.36ᵃ                        | 1.10ᵇ                        | 1.71ᵃ                        | 3.17                          | 0.18ᵇ                     | 0.36ᵇ                     | 0.49ᵇ                         | 1.03                              |
| P₀K₆                 | 0.44ᵇ                        | 1.20ᵇ                        | 2.10ᵇ                        | 3.74                          | 0.26ᵇ                     | 0.40ᵇ                     | 0.70ᵇ                         | 1.36                              |
| P₀K₁₂                | 0.49ᵇ                        | 1.27ᵇ                        | 2.32ᶜ                        | 4.08                          | 0.26ᵇ                     | 0.54ᶜ                     | 1.08ᵇ                         | 1.88                              |
| P₀K₈                 | 0.50ᵇ                        | 1.29ᶜ                        | 2.45ᵈ                        | 4.24                          | 0.18ᵇ                     | 0.42ᵇ                     | 0.54ᶜ                         | 1.14                              |
| P₁₀K₆                | 0.61ᵇ                        | 1.35ᶜ                        | 2.31ᶜ                        | 4.27                          | 0.31ᶜ                     | 0.53ᶜ                     | 0.89ᶜ                         | 1.73                              |
| P₁₀K₁₂               | 0.55ᶜ                        | 1.32ᵈ                        | 2.52ᵉ                        | 4.39                          | 0.35ᶜ                     | 0.54ᶜ                     | 0.93ᶜ                         | 1.82                              |
| P₁₀K₈                | 0.52ᵈ                        | 1.31ᵉ                        | 2.46ᶠ                        | 4.29                          | 0.17ᵇ                     | 0.33ᵃ                     | 0.50ᵃ                         | 1.00                              |
| LSD at 5%            | 0.096                         | 0.024                        | 0.03                         | -                             | 0.045                     | 0.055                     | 0.058                         | -                                 |

ᵃᵇᵈᵉ>Data bearing different superscripts in the same column differ significantly at 5% level.

Total fresh yields of root, stem and leaf were 3.17, 3.74, 4.08, 4.24, 4.27, 4.39 and 4.29 g plant⁻¹ and total dry matter yields of root, stem and leaf were 1.03, 1.36, 1.88, 1.14, 1.73, 1.82 and 1.00 g plant⁻¹ recorded in P₀K₀ (Control), P₀K₆, P₀K₁₂, P₀K₈, P₁₀K₀, P₁₀K₁₂ and P₁₀K₈ kg ha⁻¹ treatments, respectively (Table 3). The highest dry matter yield was (1.88 g plant⁻¹) obtained in P₁₀K₈ kg ha⁻¹. The values varied significantly (p<0.05). Tisdale et al. (1995) reported that over 50 factors affect crop growth and yield. Factors involved in a crop growth can be classified as genetic or environmental. Among the environmental factors known to influence plant growth probably most important are temperature, moisture supply, radiant energy, composition of the atmosphere and soil.

The concentration of nitrogen was 0.86₁, 1.23₁, 1.59₁, 1.32₁, 1.10 and 1.32₂ in root, 1.16₁, 1.97₁, 2.51₁, 1.32₁, 1.92₁, 2.40₁ and 1.88₂ in stem, and 1.95₁, 3.48₁, 3.65₁, 3.82₁, 3.24₁, 3.8 and 3.79₁ in leaf which were achieved in P₀K₀ (Control), P₀K₆, P₀K₁₂, P₀K₈, P₁₀K₀, P₁₀K₁₂ and P₁₀K₈ kg ha⁻¹ treatments, respectively (Table 2). Results varied significantly (p<0.05). The highest concentration of N was 1.59₁, 2.51₁ and 3.82₁ in root, stem and leaf in P₀K₁₂, P₀K₈ and P₀K₈ kg ha⁻¹ treatments, respectively. Marr and Cresser (1983) concluded that the typical concentrations of elements in dried healthy foliage are N 0.8-3.0%, K 0.5-2.5%, Ca 1.5-2.80%, Mg 0.15-0.45%, P 0.08-0.35%, Fe 40-150 mg kg⁻¹, Mn 30-100 mg kg⁻¹, B 10-50 mg kg⁻¹, Cu 5-12 mg kg⁻¹, Zn 30-200 mg kg⁻¹ and Mo 0.1-1.5 mg kg⁻¹. The results of the concentration of nitrogen of the present experiment are in agreement with Marr and Cresser (1983).
Conclusion

It may be concluded that the combined application of phosphorus and potassium $P_5K_{12}$ kg ha$^{-1}$ was the better dose for growth, biomass production and N accumulation in mungbean and might be incorporated to paddy fields before rice cultivation in the coastal belt of Bangladesh.

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