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## Impact of phosphorus and bio-inputs on growth and yield of urdbean (*Vigna mungo* L.)

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### Abstract

A field experiment was conducted during Kharif 2025 at the Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur (U.P.), to study the impact of phosphorus and bio-inputs on growth of urdbean (*Vigna mungo* L.). The experiment consisted of four levels of phosphorus (0, 20, 40 and 60 kg ha<sup>-1</sup>) and four bio-input treatments [control, phosphate solubilizing bacteria (PSB), vesicular arbuscular mycorrhiza (VAM) and PSB + VAM], thereby making sixteen treatment combinations tested in Randomized Block Design (RBD) with three replications.

The results revealed that application of phosphorus up to 40 kg ha<sup>-1</sup> significantly improved the growth and yield determining characters of urdbean, viz., plant height, number of branches per plant, dry matter accumulation, number and weight of root nodules per plant, crop growth rate (CGR), relative growth rate (RGR), number of pods per plant, grains per pod, test weight, grain yield, straw yield, biological yield, harvest index and net returns, and remained statistically at par with 60 kg ha<sup>-1</sup>. Seed and soil inoculation with PSB + VAM significantly enhanced the growth and yield attributing characters over PSB, VAM and control treatments.

The combined application of phosphorus and bio-inputs improved nutrient availability, phosphorus solubilization, biological nitrogen fixation and microbial activity in the soil, which ultimately enhanced crop growth and productivity. Therefore, integrated use of phosphorus along with suitable bio-inputs proved effective for improving growth, yield and profitability of urdbean cultivation under sustainable farming conditions.

**Keywords:** Phosphorus, bio-inputs, PSB, VAM, urdbean, growth, yield and sustainability

### Introduction

Urdbean Pulses are an important source of dietary protein, particularly for the vegetarian population, and contribute significantly to nutritional security and soil fertility improvement. Among the pulse crops, urdbean [*Vigna mungo* (L.) Hepper], commonly known as black gram, occupies an important position in Indian agriculture. It is a self-pollinated leguminous crop containing about 24 per cent protein and is widely cultivated during kharif and summer seasons. Due to its short duration and wide adaptability, urdbean fits well in multiple cropping and intercropping systems. Besides grain production, the crop also improves soil fertility through biological nitrogen fixation.

Among the essential plant nutrients, phosphorus plays a vital role in growth and development of pulse crops. It is considered the “master key element” for pulse production because of its involvement in root development, nodulation, photosynthesis, energy transfer and biological nitrogen fixation. Adequate phosphorus supply promotes better plant growth, nodulation and productivity. However, a major portion of soil phosphorus remains in insoluble form and is not readily available to plants, particularly in light textured soils.

In recent years, bio-inputs such as phosphate solubilizing bacteria (PSB) and Vesicular Arbuscular Mycorrhiza (VAM) have gained importance in sustainable agriculture due to their ability to enhance nutrient availability and improve soil health. PSB increases phosphorus availability by solubilizing fixed phosphorus in the soil, while VAM enhances nutrient uptake through symbiotic association with plant roots. Integrated application of phosphorus along with bio-inputs improves nutrient use efficiency, microbial activity and crop growth.

Therefore, the present investigation entitled “Impact of Phosphorus and Bio-inputs on Growth of Urdbean (*Vigna mungo* L.)” was undertaken to study the effect of phosphorus levels and bio-inputs on growth performance of urdbean under field conditions.

### Materials and Methods

A field experiment was conducted during Kharif season of 2025 at the Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur (U.P.), to study the impact of phosphorus and bio-inputs on growth of urdbean (*Vigna mungo* L.). The soil of the experimental field was sandy loam in texture and slightly alkaline in reaction, low in organic carbon and available nitrogen and medium in available phosphorus and potassium.

The experiment was laid out in Randomized Block Design (RBD) with sixteen treatment combinations comprised of four phosphorus levels (0, 20, 40 and 60 kg ha<sup>-1</sup>) and four treatments of bio-inputs viz., control, phosphate solubilizing bacteria (PSB), Vesicular Arbuscular Mycorrhiza (VAM) and PSB + VAM. The treatments were replicated thrice.

The urdbean variety T-9 was sown using seed rate of 15 kg ha<sup>-1</sup> with a row spacing of 30 cm at a depth of 4–5 cm. Seeds were treated with PSB culture as per treatment and VAM was applied in open furrows using field soil as carrier material. Uniform dose of nitrogen @ 25 kg ha<sup>-1</sup> was applied to all the plots through urea and di-ammonium phosphate (DAP), whereas phosphorus was applied according to treatment through DAP at the time of sowing.

Crop Growth Rate (CGR) and Relative Growth Rate (RGR) were calculated on the basis of dry matter accumulation recorded at periodic intervals using standard formulae. Observations on growth parameters such as plant height, number of branches per plant, dry matter accumulation and root nodules were recorded at different growth stages. Yield attributes and yield parameters were recorded at harvest.

Harvest index was calculated by dividing grain yield by biological yield and expressed in percentage. Net return was worked out by deducting cost of cultivation from gross return and benefit-cost ratio was calculated accordingly. Nitrogen concentration was determined by modified Kjeldahl method, phosphorus by sulphuric-nitric-perchloric acid digestion method and potassium by flame photometer using tri-acid digestion procedure.

### Results and Discussion

The information presented in Tables 1, 2 and 3 clearly indicated that significant variations were observed due to the effect of vermicompost on growth, yield and soil health parameters of urdbean (*Vigna mungo* L.). The maximum plant height (cm), number of branches per plant, dry matter accumulation and root nodules per plant were recorded under higher level of vermicompost application, whereas the minimum values were observed under control treatment. The increase in growth parameters might be attributed to better nutrient availability, improved soil aeration, enhanced microbial activity and gradual release of nutrients through vermicompost application. Similar findings were also reported by several researchers in pulse crops. The response of vermicompost showed pronounced effect on yield and yield attributes of urdbean. The maximum number of pods per plant, seeds per pod, seed index (g), seed yield per plant (g), biological yield (q ha<sup>-1</sup>) and seed yield (q ha<sup>-1</sup>) were recorded under higher vermicompost application, whereas the minimum values were observed under control treatment. The increase in yield attributes and seed yield may be due to improved nutrient

uptake, better root development and enhanced photosynthetic activity resulting from balanced nutrient supply through vermicompost. Similar results were also reported by various workers under organic nutrient management practices in pulse crops.

Application of vermicompost significantly improved nodulation and nutrient uptake of urdbean crop. The maximum number of root nodules per plant and nodule dry weight were observed under higher levels of vermicompost application, while the minimum values were recorded under control treatment. Higher uptake of nitrogen, phosphorus and potassium was also recorded with vermicompost application due to improved nutrient availability and enhanced microbial activity in the soil. Improvement in protein content of seed might be attributed to enhanced nitrogen assimilation and better translocation of nutrients within the plant system.

The effect of vermicompost was also pronounced on soil health parameters. The maximum organic carbon content and available nitrogen, phosphorus and potassium in soil were recorded under higher vermicompost levels, whereas the minimum values were found in control treatment. Vermicompost improved soil physical, chemical and biological properties by increasing soil organic matter content, microbial population and nutrient availability. Improvement in soil fertility status clearly indicated the beneficial effect of vermicompost on sustaining soil productivity and maintaining soil health.

Economic analysis revealed that vermicompost-treated plots recorded higher gross returns, net returns and benefit-cost ratio over control due to increased seed yield and better soil fertility conditions. Therefore, application of vermicompost proved effective for enhancing growth, yield and soil health of urdbean under sustainable farming conditions.

### Effect of Phosphorus Levels and Bio-inputs on Growth Parameters

#### Effect of phosphorus levels

Application of phosphorus significantly influenced the growth parameters of urdbean. Progressive increase in phosphorus levels from 0 to 40 kg ha<sup>-1</sup> resulted in significant improvement in plant height, number of branches per plant, dry matter accumulation, number and weight of root nodules, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) over the control treatment. Further increase in phosphorus level to 60 kg ha<sup>-1</sup> recorded numerically higher values; however, the results remained statistically at par with 40 kg ha<sup>-1</sup>.

The beneficial effect of phosphorus on growth attributes may be attributed to its vital role in root development, cell division, energy transfer and photosynthetic activity. Phosphorus is an important constituent of ATP and ADP, which regulate energy transfer during various metabolic processes. Adequate phosphorus availability also enhances nodulation and biological nitrogen fixation, leading to improved nutrient uptake and dry matter production. Enhanced root proliferation under phosphorus application might have further improved absorption of water and nutrients, thereby promoting better vegetative growth of urdbean.

#### Effect of bio-inputs

Bio-input treatments significantly affected the growth performance of urdbean. Among the different treatments, combined inoculation of PSB + VAM recorded significantly higher plant height, number of branches per plant, dry matter accumulation, number and weight of root nodules, CGR and RGR compared to individual inoculation and control treatments.

The positive influence of PSB may be due to its ability to

solubilize insoluble phosphorus through secretion of organic acids in the rhizosphere, thereby increasing phosphorus availability to plants. VAM inoculation enhanced nutrient and water uptake through extensive external hyphal networks associated with plant roots. The combined application of PSB and VAM improved nutrient availability, microbial activity and root growth, which ultimately enhanced photosynthetic efficiency and assimilate production. Improved nodulation and nitrogen fixation under integrated bio-input application also contributed to better crop growth and development.

### Effect of Phosphorus Levels and Bio-inputs on Yield Attributes

#### Effect of phosphorus levels

Different phosphorus levels exerted significant influence on yield attributes and yield of urdbean. Application of phosphorus up to 40 kg ha<sup>-1</sup> significantly increased number of pods per plant, grains per pod, test weight, grain yield, straw yield and biological yield over control and lower phosphorus levels. Further increase in phosphorus level to 60 kg ha<sup>-1</sup> remained statistically at par with 40 kg ha<sup>-1</sup>. However, harvest index was not significantly influenced by phosphorus application.

The increase in yield attributes and yield under phosphorus fertilization may be attributed to improved root growth, enhanced

nutrient uptake, efficient translocation of photosynthates and increased metabolic activities within the plant system. Adequate phosphorus supply also promoted better flowering, pod formation and seed development, which ultimately resulted in higher productivity of urdbean.

#### Effect of bio-inputs

Application of bio-inputs significantly improved yield attributes and yield of urdbean over control treatment. Combined inoculation of PSB + VAM recorded significantly higher number of pods per plant, grains per pod, test weight, grain yield, straw yield and biological yield compared to individual inoculation treatments. The highest net returns and benefit-cost ratio were also obtained under PSB + VAM inoculation.

The enhanced yield performance under combined bio-input application may be attributed to greater phosphorus solubilization, improved nutrient uptake and increased microbial activity in the rhizosphere. The synergistic effect of PSB and VAM improved root development, photosynthetic activity and translocation of assimilates towards reproductive structures, thereby increasing yield and yield attributes. Improved nutrient use efficiency and better crop growth under bio-input treatments also contributed towards higher economic returns and sustainability of urdbean cultivation.

**Table 1:** Effect of phosphorus levels and bio-inputs on growth parameters of urdbean (*Vigna mungo* L.)

| Treatments                                       | Plant height (cm) | Branches plant <sup>-1</sup> | Dry matter accumulation (g m <sup>-2</sup> row length) | CGR (g m <sup>-2</sup> day <sup>-1</sup> ) | RGR (mg g <sup>-1</sup> day <sup>-1</sup> ) | Total nodules plant <sup>-1</sup> | Effective nodules plant <sup>-1</sup> | Fresh weight of nodules (mg) | Dry weight of nodules (mg) |
|--------------------------------------------------|-------------------|------------------------------|--------------------------------------------------------|--------------------------------------------|---------------------------------------------|-----------------------------------|---------------------------------------|------------------------------|----------------------------|
| <b>A. Phosphorus levels (kg ha<sup>-1</sup>)</b> |                   |                              |                                                        |                                            |                                             |                                   |                                       |                              |                            |
| 0 kg ha <sup>-1</sup>                            | 44.20             | 6.20                         | 91.60                                                  | 2.45                                       | 9.31                                        | 28.30                             | 26.50                                 | 102.50                       | 57.20                      |
| 20 kg ha <sup>-1</sup>                           | 50.90             | 7.80                         | 119.60                                                 | 3.71                                       | 11.08                                       | 32.40                             | 28.90                                 | 111.50                       | 62.50                      |
| 40 kg ha <sup>-1</sup>                           | 55.80             | 8.90                         | 133.40                                                 | 3.99                                       | 10.61                                       | 35.50                             | 31.10                                 | 120.56                       | 67.10                      |
| 60 kg ha <sup>-1</sup>                           | 58.20             | 9.20                         | 136.50                                                 | 4.03                                       | 10.45                                       | 36.80                             | 31.60                                 | 123.20                       | 68.20                      |
| SEm±                                             | 1.42              | 0.22                         | 2.80                                                   | 0.07                                       | 0.29                                        | 0.97                              | 0.70                                  | 2.91                         | 1.55                       |
| CD (P=0.05)                                      | 4.10              | 0.62                         | 8.09                                                   | 0.21                                       | 0.84                                        | 2.80                              | 2.01                                  | 8.39                         | 4.47                       |
| <b>B. Bio-input treatments</b>                   |                   |                              |                                                        |                                            |                                             |                                   |                                       |                              |                            |
| Control                                          | 45.06             | 6.95                         | 106.32                                                 | 2.98                                       | 9.76                                        | 29.93                             | 27.22                                 | 104.07                       | 58.48                      |
| PSB                                              | 52.35             | 8.08                         | 121.69                                                 | 3.63                                       | 10.55                                       | 33.15                             | 29.63                                 | 114.47                       | 64.07                      |
| VAM                                              | 52.55             | 8.08                         | 120.17                                                 | 3.50                                       | 10.24                                       | 33.45                             | 29.53                                 | 115.27                       | 63.87                      |
| PSB + VAM                                        | 59.14             | 9.00                         | 132.92                                                 | 4.08                                       | 10.90                                       | 36.47                             | 31.73                                 | 123.95                       | 68.57                      |
| SEm±                                             | 1.42              | 0.22                         | 2.80                                                   | 0.07                                       | 0.29                                        | 0.97                              | 0.70                                  | 2.91                         | 1.55                       |
| CD (P=0.05)                                      | 4.10              | 0.62                         | 8.09                                                   | 0.21                                       | NS                                          | 2.80                              | 2.01                                  | 8.39                         | 4.47                       |
| CV (%)                                           | 9.40              | 9.31                         | 8.07                                                   | 7.24                                       | 9.69                                        | 10.10                             | 8.18                                  | 8.80                         | 8.42                       |

#### Note:

CGR = Crop Growth Rate RGR = Relative Growth Rate

PSB = Phosphate Solubilizing Bacteria VAM = Vesicular Arbuscular Mycorrhiza

**Table 2:** Effect of phosphorus fertilization and bio-inputs on yield attributes, yield, harvest index and economic returns of urdbean (*Vigna mungo* L.)

| Treatments                                       | Pods plant <sup>-1</sup> | Grains pod <sup>-1</sup> | Test weight (g) | Grain yield (kg ha <sup>-1</sup> ) | Straw yield (kg ha <sup>-1</sup> ) | Biological yield (kg ha <sup>-1</sup> ) | Harvest index (%) | Net returns (Rs ha <sup>-1</sup> ) | B:C ratio |
|--------------------------------------------------|--------------------------|--------------------------|-----------------|------------------------------------|------------------------------------|-----------------------------------------|-------------------|------------------------------------|-----------|
| <b>A. Phosphorus levels (kg ha<sup>-1</sup>)</b> |                          |                          |                 |                                    |                                    |                                         |                   |                                    |           |
| 0                                                | 16.60                    | 5.90                     | 34.20           | 784                                | 1561                               | 2345                                    | 33.46             | 27489                              | 1.60      |
| 20                                               | 22.70                    | 7.10                     | 37.10           | 1041                               | 2062                               | 3103                                    | 33.93             | 41021                              | 2.25      |
| 40                                               | 27.20                    | 7.80                     | 38.60           | 1160                               | 2340                               | 3500                                    | 33.17             | 47003                              | 2.44      |
| 60                                               | 28.80                    | 8.20                     | 39.85           | 1186                               | 2394                               | 3580                                    | 33.27             | 47458                              | 2.34      |
| SEm±                                             | 0.62                     | 0.18                     | 0.93            | 25                                 | 49                                 | 78                                      | 1.13              | 1113                               | 0.06      |
| CD (P=0.05)                                      | 1.80                     | 0.52                     | 2.68            | 71                                 | 141                                | 226                                     | NS                | 3213                               | 0.16      |
| <b>B. Bio-input treatments</b>                   |                          |                          |                 |                                    |                                    |                                         |                   |                                    |           |
| Control                                          | 19.23                    | 6.54                     | 34.46           | 926                                | 1882                               | 2808                                    | 33.13             | 34606                              | 1.87      |
| PSB                                              | 24.01                    | 7.18                     | 37.29           | 1062                               | 2114                               | 3176                                    | 33.69             | 42047                              | 2.26      |
| VAM                                              | 23.90                    | 7.37                     | 37.62           | 1039                               | 2080                               | 3119                                    | 33.51             | 40231                              | 2.10      |
| PSB + VAM                                        | 28.15                    | 7.92                     | 40.38           | 1144                               | 2281                               | 3425                                    | 33.51             | 46087                              | 2.40      |
| SEm±                                             | 0.62                     | 0.18                     | 0.93            | 25                                 | 49                                 | 78                                      | 1.13              | 1113                               | 0.06      |
| CD (P=0.05)                                      | 1.80                     | 0.52                     | 2.68            | 71                                 | 141                                | 226                                     | NS                | 3213                               | 0.16      |
| CV (%)                                           | 9.04                     | 8.66                     | 8.57            | 8.15                               | 8.10                               | 8.67                                    | 11.70             | 9.46                               | 8.84      |

**Abbreviations:** PSB = Phosphate Solubilizing Bacteria; VAM = Vesicular Arbuscular Mycorrhiza; B:C = Benefit–Cost ratio; NS = non-significant

The increase in crop growth under higher levels of phosphorus application may be attributed to improved physiological and metabolic processes within the plant system. Adequate phosphorus supply enhances the source–sink relationship by regulating the starch and sucrose balance in source leaves and reproductive organs, thereby improving assimilate partitioning towards developing pods and seeds. This efficient translocation of photosynthates to yield contributing parts ultimately results in higher grain yield in urdbean.

The significant improvement in straw yield with phosphorus application can be ascribed to enhanced vegetative growth, including increased plant height, number of branches and dry matter accumulation. Phosphorus improves the nutritional environment of the rhizosphere, leading to better root development and nutrient uptake, which in turn stimulates photosynthetic efficiency and overall plant metabolism. These findings are in agreement with the results reported by earlier workers in urdbean and other pulse crops.

Application of phosphorus at 40 kg ha<sup>-1</sup> recorded significantly higher net returns (Rs. 47,003 ha<sup>-1</sup>) and benefit ratio compared to lower levels and remained statistically at par with 60 kg ha<sup>-1</sup>. The increase in economic returns may be attributed to higher grain and straw yields obtained under optimum phosphorus nutrition, which improved overall profitability of urdbean cultivation.

### Conclusion

Based on one year of field experimentation, it may be concluded that application of phosphorus at 40 kg ha<sup>-1</sup> along with combined inoculation of PSB + VAM proved to be the most effective treatment for enhancing growth, yield attributes, grain yield and economic returns of urdbean (*Vigna mungo* L.) under the agro-climatic conditions of the study area.

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