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**Pravesh Kumar**
Department of Agronomy, BAU, Sabour, Bihar, India

**Ajay Yadav**
Department of Agronomy, Banaras Hindu University, Varanasi, Uttar Pradesh, India

**JS Bohra**
Department of Agronomy, Banaras Hindu University, Varanasi, Uttar Pradesh, India

**Anil Kumar Singh**
Bihar Agricultural University, Sabour, Bihar, India

**Hari Om**
Department of Agronomy, BAU, Sabour, Bihar, India

**Sunil Kumar**
Department of Agronomy, BAU, Sabour, Bihar, India

**Suborna Roychaudhary**
Department of Agronomy, BAU, Sabour, Bihar, India

**Anupam Das**
Department of SSAC, BAU, Sabour, Bihar, India

**Mandhata Singh**
KVK, Deoria, Uttar Pradesh, India

**Neha Pareek**
Department of Agronomy, BAU, Sabour, Bihar, India

**SK Pathak**
Bihar Agricultural University, Sabour, Bihar, India

**SK Pandey**
Department of Statistics, RKPG College, Shamali, Uttar Pradesh, India

**Corresponding Author:**
**Neha Pareek**
Department of Agronomy, BAU, Sabour, Bihar, India

# Interaction effect of different phosphorus levels and varieties of mungbean under custard apple based agri-horti system

**Pravesh Kumar, Ajay Yadav, JS Bohra, Anil Kumar Singh, Hari Om, Sunil Kumar, Suborna Roychaudhary, Anupam Das, Mandhata Singh, Neha Pareek, SK Pathak and SK Pandey**

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**Abstract**
Field experiment was carried out to evaluate the effect of different phosphorus levels and varieties of mungbean in a custard apple based agri-horti system. In this experiment, mungbean was imposed in a factorial randomized block design with three phosphorus levels (34, 46, and 58 kg $P_2O_5$/ha) and three varieties (HUM-12, Kavita, and Samrat). The treatments were replicated thrice. The result of the experiment recorded the highest grain yield due to the application of 58 kg $P_2O_5$/ha in the combination of the variety HUM-12 (1003 kg/ ha).

**Keywords:** Agri-horti system, mungbean, custard apple, phosphorus level, varieties

## Introduction
Agri-horti system markedly increases the return per unit of land mainly during early stage of horticultural fruit trees. Fruit treebased Agroforestry involves intentional and simultaneous association of annual or perennial crops with perennial fruit producing trees on the same land unit (Kumar and kher, 2021) [10]. Aonla, ber, citrus, custard apple, guava etc. are major promising fruit crop suitable for agri-horti system (Kumar *et al.*, 2015) [11] and (Pal *et al.*, 2014) [14]. Fruit crops are first preference of farmers under agroforestry system due to short gestation period, regular income, risk cover and aesthetic value. Agri-horti system is an improved indigenous cropping system in India for full utilization of the growing season and markedly increasing the return per unit area per unit time.

Among the pulse crops, mungbean has special importance in intensive crop production of the country for its short growing period. Crop is potentially useful in improving cropping pattern as it can be grown as catch crop and early maturing characteristics. Cultivation of Mungbean between the rows of guava tree increases the overall income of farmers and also better utilization of land resource. This system markedly increases the return per unit of land mainly during early stage of horticultural fruit trees. Fruit treebased Agroforestry involves intentional and simultaneous association of annual or perennial crops with perennial fruit producing trees on the same land unit (Kumar and Kher, 2021) [10].

Phosphorus is a vital macronutrient that is required to meet global food supplies and make crop production lucrative (Raj and Tripathi, 2005) [22]. Phosphorus mainly plays an important role in physiological activities including sugar metabolism, enzymatic reaction, energy metabolism and photosynthesis. In plants, P deficiency mainly leads to dark green foliage, high root to shoot ratio, stunted growth and delayed maturity of plants (Malhotra *et al.*, 2018) [12]. The yield of pulses is greatly influenced by application of phosphorus. It plays a key role in various physiological processes like root growth and dry matter production, nodulation and nitrogen fixation and also in metabolic activities especially in protein synthesis. It also helps in establishing seedling quickly and also hastens maturity as well as improves the quality of crop produce (Parashar and Tripathi, 2020) [20].

It functions as one of the key elements in the process of photosynthesis, nutrient transport, and energy transfer (Klimek-Kopyra *et al*., 2016) [9].

Phosphorus is less available for plant uptake in most tropical soils mainly because of its fixation with Ca in alkaline soils and Fe and Al oxides in acidic soils. Moreover, the majority of applied phosphorus fertilizers in these soils are fixed and made unavailable for plant uptake (Marschner, 1995) [13]. In soil, the large amount of P is fixed inthe form of organic P fractions or inorganic complexes with aluminium/iron in acid soils or with calcium in alkaline soils. So in most of the soils, P is least mobile and less available to plants. However, P limitation is overcome by applying P fertilizers to the soils. The main source of P fertilizer is rock phosphate, which is minable only in a few countries of the world. So, by expecting future scarcity, it is time to think about the development of phosphorus use efficiency (PUE) of crop plants. PUE depends on the complex set of plant traits. For P, external application of P fertilizer is the main option (Singh *et al*. 2021). To avoid this, the development of cultivars with improved ability to absorb more P and their efficient utilization is one of the ways to solve the problem sustainably.

In India, many factors are responsible for improper growth and low yields of mungbean. Out of that use of old varieties and imbalanced application of fertilizers are some of the major factors, which adversely affect the growth of mungbean (Patil *et al*., 1985). Inclusion of only quality seed of improved varieties in its cultivation leads to increase of 15-20% seed yield. Availability of quality seed of improved variety at a reasonable price to the door of potential growers is still a big challenge. Because apart from the genetic constitution, a number of physiological, biochemical and lack of required packages of practices during the critical stages of crop growth have found to be some of the yield barriers of mung bean (Ahlawat and Rana, 2002) [1].

The development of phosphorus efficient genotypes with a great ability to grow and yield in soils with limited phosphorus supply improves the sustainability of crop production (Ozturk *et al*., 2005) [18]. This also reduces production costs associated with phosphorus fertilizer applications and minimizes environmental pollution resulting from run-off and leaching of excess phosphorus fertilizer (Sattelmacher *et al*., 1994) [23]. Phosphorus efficiency of the genotype can be due to its ability to acquire P from limited soil P supply and/or its ability to produce high yield per unit of phosphorus acquired (Fohse *et al*., 1998) [6].

The differences in phosphorus uptake involve the differences in changing rhizosphere pH, release of organic compounds and root surface area (Gahoonia and Nielsen, 2004) [7] as well as production and secretion of phosphatase to the rhizosphere (Wasaki *et al*., 2003) [30] On the other hand, the differences in the use of internal phosphorus may be related to the ability of plants to translocate and use it in dry matter production (Caradus and Snaydon, 1987) [4].

Suitability of varieties to a particular climate is most important factors for determining yield, the GE interaction should be maintain to high level. The variety that have proper response to fertilizer for proper nutrient uptake is highly necessary for enhancing the yield. So, it is important to find out the correct dose of phosphorus for maximum yield (Aryal *et al*., 2021) [3]. Even though, genotypic variation in phosphorus efficiency has been reported in several crops such as wheat (Ozturk *et al*., 2005) [18] maize (Hussein, 2009) [8] and rice (Fageria and Baligar, 1997) [5], the information in mungbean is scanty. This experiment was therefore carried out to investigate the role of phosphorus supply and varietal differences in relation to grain yieldand to investigate for some other parameters in mungbean under custard apple based agri-horti system.

## Materials and Methods

The experiment was carried out at the Agronomy Farm of Rajiv Gandhi South Campus, Barkachha (BHU), Mirzapur which is situated in *Vindhyan* region of district Mirzapur (25º 10' latitude, 82º 37' longitude) occupying over an area of more than 1000 ha where variety of crops like agricultural, horticultural, medicinal and aromatic plants are grown. *Vindhyan* soil comes under rainfed and invariably poor fertility status. This region comes under agro-climatic zone III A (semi-arid eastern plain zone). The climate of Barkachha is typically semi-arid, characterized by extremes of temperature both in summer and winter with low rainfall and moderate humidity. Maximum temperature in summer is as high as 39.8 °C and minimum temperature in winter falls below 9 °C. The annual rainfall of locality was 209 mm, of which nearly 90 per cent is contributed by South West monsoon between July to September. The total rainfall during the crop duration was 104.2 mm; maximum and minimum temperature fluctuated between 32.9 °C and 21.3 °C, and relative humidity between 86.5 and 55.9 per cent. The soil of the experimental field was sandy loam in texture with low drainage. It was acidic in reaction, poor in nitrogen as well as phosphorus and potash. The experiment was conducted in Factorial Randomized Block Design two factors having three levels which were replicated thrice. These treatments were different doses of phosphorus viz. 34, 46 and 58 kg/ha. The fertilizer application was done with fixed doses of nitrogen @ 20 kg/ha and phosphorus at 40 kg/ha. Phosphorus application was done according to the treatments. All the nutrients were applied as basal and the sources of N, P and K were Urea, DAP and MOP respectively. Varieties under study was HUM-12, Kavita and Samrat. The seeds were sown manually in the furrow opened by *kudal* at a row distance of 30 cm as per treatment. Seed rate 20 kg/ha was used for proper maintenance of plant population. A plant spacing of 10 cm within the row was maintained by thinning done about 10 days after sowing. First weeding was done manually by *khurpi*at 20 days and second weeding 30 days after sowing to control weeds. To protect the crop, mainly from leaf caterpillar, *Kranti* (Carpet hydrochloride 50% SP) @ 250 ml/ha was sprayed at 25 days after sowing. The interaction effect of growth and yield attributes i.e. leaf dry matter/ plant(g), pod length (cm), grain weight/ plant (g), grain, straw and biological yield (kg/ha) were taken into consideration.

## Results and Discussion

Phosphorus dose of 58 kg $P_2O_5$/ha which was on par with 46 kg $P_2O_5$/ha with Samrat produced significantly more dry matter in leaves than 34 kg $P_2O_5$/ha. An increase in the plant dry matter will ultimately lead to an increase in the seed yield of mungbean (Uddin *et al*., 2008) [29]. Kavita and HUM-12 which were at par produced significantly more dry matter in leaves than Samrat at 58 kg $P_2O_5$/ha. With 46 kg $P_2O_5$/ha Kavita produced significantly more dry matter in leaves than the remaining varieties (Table 1). The significant interaction between phosphorus and varieties indicated that Samrat which was at par with HUM-12 produced significantly more dry matter in the pod than Kavita with 58 kg $P_2O_5$/ha while all the varieties with the rest of the phosphorus levels when comprised at the same dose were found at par (Table 2). This indicates the wide variation of cultivars for dry matter in response to P deficiency in mungbean. In soybean, higher P application significantly increased the plant dry matter than normal and low P application (Taliman *et al.*, 2019) [28].

Kavita though remains comparable between 58 and 46 kg $P_2O_5$/ha and produced significantly longer pods than other combinations of mungbean varieties and phosphorus levels. The pod length of mung bean was significantly affected by different levels of phosphorus. Among different levels of phosphorus, a significantly higher pod length was recorded from treatment 60 kg $P_2O_5$/ha. Nevertheless, Samrat at 34 kg $P_2O_5$/ha application resulted in the shortest pod length (Table 3). It was observed that, pod length due to varieties showed a significant difference. It is evident from the results of Nadeem *et al*. 2003, that, pod length increases with increase in the phosphorus levels. Similar results were also obtained by Shamim *et al.,* 2023 [24].

Significant interaction between phosphorus levels and varieties for grain weight/ plant was observed. With increasing levels of phosphorus Samrat and HUM-12 produced significantly more grain yield/ plant however, Kavita remained at par at different phosphorus levels (Table 4).

Different phosphorus doses found significantly different amongst themselves for all the varieties and 58 kg $P_2O_5$/ha produced highest grain yield/ha. Mungbean yield was higher with 60 kg $P_20_5$ $ha^{-1}$ than with the lower levels of P (Singh *et al.* 2006) [25]. Singh (2010) [27] also found the similar results. The enhancement in mung bean yield with the application of phosphorus might be owing to increase in phosphorus availability that lead to better translocation of photosynthesis towards sink with consequent improvement in yield attributes (Muhammad *et al*., 2004) [15]. As to the present experiment, the increase in P rate increased grain yield because P is involved in several energy transformation and biochemical reactions for plant growth and development. It has also been reported that when the supply of one nutrient is increased, the genetic potential of the plants become the limiting factors (Marschner, 1995) [13]. In present experiment, the yield increase with the increase in P rate was related tothe increase in total biomass and seed weight/plant.

Kavita produced significantly higher grain yield than Samrat and HUM-12 at the lowest dose of phosphorus. It has also been reported that high nutrient efficiency is generally obtained at low soil nutrient supplies or when the rate of nutrient application is not too high (Mengel and Kirby, 1987) [14]. Kavita and Samrat being at par recorded significantly lower grain yield than HUM-12 at 46 kg $P_2O_5$/ha. All the varieties were found significantly different amongst themselves with the highest phosphorus dose and followed the trend HUM-12> Samrat> Kavita (Table 5). Singh (2011) also found significant differences inyields of different mung bean cultivars in response to phosphorus application. These results are in agreement with (Naeem *et al.* 2000) [17] who reported that differences among the yield in these cultivars might be due to hereditary superiority, growth rate, crop yield potential, higher nutrient translocation, assimilation and dry matter partitioning. The interaction between phosphorus x varieties indicated that all mungbean cultivars produced maximum grain yield with increasing phosphorus level.

Different levels of phosphorus were significantly different for all the varieties. A phosphorus level of 58 kg $P_2O_5$/ha produced the highest straw yield/ ha in different varieties. Singh (2010) [27] revealed that application of phosphorus @ 60 kg $P_2O_5$/ha registered significantly more straw yield of mungbean. Different levels of phosphorus application showed significant difference on straw yield of mung bean (Shamim *et al.*, 2023) [24]. Samrat being at par with Kavita produced the highest straw yield than HUM-12 (Table 6). It was observed that, the straw yield showed significant difference due to varieties (Shamim *et al.*, 2023) [24]. The same trend was observed in biological yield as in straw yield except at 58 kg $P_2O_5$/ha where Samrat being at par with HUM-12 produced significantly higher biological yield than Kavita and HUM-12 (Table 7).

**Table 1:** Interaction between phosphorus levels and varieties for dry matter accumulation in leaves at 15 DAS in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | **Samrat** | **Kavita** | **HUM-12** |
| 34 | 0.19 | 0.41 | 0.33 |
| 46 | 0.29 | 0.45 | 0.35 |
| 58 | 0.35 | 0.62 | 0.68 |
| | | S.Em. ± | CD at 5% |
| For comparing phosphorus levels at same or different varieties | | 0.02 | 0.07 |
| For comparing varieties at same phosphorus levels | | 0.02 | 0.07 |

**Table 2:** Interaction between phosphorus levels and varieties for dry matter accumulation in pod at 45 DAS in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | **Samrat** | **Kavita** | **HUM-12** |
| 34 | 2.05 | 1.97 | 2.46 |
| 46 | 2.72 | 2.82 | 2.81 |
| 58 | 5.68 | 3.13 | 5.21 |
| | | S.Em. ± | CD at 5% |
| For comparing phosphorus levels at same or different varieties | | 0.23 | 0.68 |
| For comparing varieties at same phosphorus levels | | 0.23 | 0.68 |

**Table 3:** Interaction between phosphorus levels and varieties for pod length (cm) in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | Samrat | Kavita | HUM-12 |
| 34 | 5.77 | 7.10 | 6.07 |
| 46 | 5.98 | 7.82 | 6.15 |
| 58 | 6.78 | 7.91 | 7.19 |
| | | S.Em. ± | CD at 5% |
| For comparing phosphorus levels at same or different varieties | | 0.08 | 0.24 |
| For comparing varieties at same phosphorus levels | | 0.08 | 0.24 |

**Table 4:** Interaction between phosphorus levels and varieties for grain weight/plant (g) in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | Samrat | Kavita | HUM-12 |
| 34 | 2.37 | 2.55 | 2.38 |
| 46 | 2.74 | 2.65 | 3.09 |
| 58 | 3.11 | 2.73 | 3.35 |
| For comparing phosphorus levels at same or different varieties | | 0.07 | 0.21 |
| For comparing varieties at same phosphorus levels | | 0.07 | 0.21 |

**Table 5:** Interaction between phosphorus levels and varieties for grain yield (kg/ha) in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | Samrat | Kavita | HUM-12 |
| 34 | 411 | 503 | 431 |
| 46 | 666 | 629 | 755 |
| 58 | 918 | 837 | 1003 |
| | | S.Em. ± | CD at 5% |
| For comparing phosphorus levels at same or different varieties | | 21.8 | 65.4 |
| For comparing varieties at same phosphorus levels | | 21.8 | 65.4 |

**Table 6:** Interaction between phosphorus levels and varieties for straw yield (kg/ha) in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | Samrat | Kavita | HUM-12 |
| 34 | 1269 | 1750 | 1233 |
| 46 | 1969 | 2012 | 1952 |
| 58 | 2745 | 2621 | 2505 |
| | | S.Em. ± | CD at 5% |
| For comparing phosphorus levels at same or different varieties | | 53.4 | 160 |
| For comparing varieties at same phosphorus levels | | 53.4 | 160 |

**Table 7:** Interaction between phosphorus levels and varieties for biological yield (kg/ha) in mungbean under custard apple based agri-horti system.

| Phosphorus (kg/ha) | Varieties | | |
|---|---|---|---|
| | Samrat | Kavita | HUM-12 |
| 34 | 1680 | 2260 | 1630 |
| 46 | 2635 | 2641 | 2707 |
| 58 | 3670 | 3457 | 3508 |
| | | S.Em. ± | CD at 5% |
| For comparing phosphorus levels at same or different varieties | | 78.6 | 236 |
| For comparing varieties at same phosphorus levels | | 78.6 | 236 |

## Conclusion
It is inferred from the above experimentation that the variety HUM-12 produced the maximum grain yield when applied with the phosphorus @ 58 kg $P_2O_5$/ha.

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