Original Research Article

“Impact of phosphorus fertilizer and spacing on growth and yield of cowpea (*Vigna unguiculata* (L.) Walp.)”

ABSTRACT

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P). To determine the "Impact of phosphorus fertilizer and spacing on growth and yield of cowpea (*Vigna unguiculata* (L.) Walp)". The results showed that treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] recorded significantly higher plant height (60.3 cm), higher number of branches/plant (7.40), higher plant dry weight (16.47 g), higher number of nodules/plant (10.00). Where as, maximum number of pods/plant (15.07), maximum number of seeds/pod (10.87), higher test weight (13.30 g), higher seed yield (1.05 t/ha), higher stover yield (1.60 t/ha), was recorded in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)]. Similarly, maximum gross returns (89,050.00 INR/ha), higher net returns (57,832.40 INR/ha) and highest benefit cost ratio (1.85) was also recorded in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] as compared to other treatments.

Keywords: phosphorus, spacing, growth, yield and economics

INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is one of the most important vegetable crops grown as pulse, vegetable and fodder. It is poor man's protein source and considered one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times **(Ng and Marechal, 1985).** As it is a warm season crop, it is grown throughout the semi-arid regions of the tropics and sub tropics. It is known for its versatility as it is used for grain, leaf and forage, cover crop and green manure crop. Being a leguminous pulse, it has high nutritive value and high palatability **(Whitebread and Lawrence, 2006).** It can be consumed in all stages of its growth and can be used to prepare delicious dishes and animal feed. It is well-known for its smothering nature, drought tolerant character, soil restoring properties and multiple uses. It is also known as "vegetable meat", because it is a rich source of protein and other nutrients and minerals like calcium and iron. On dry weight basis, cowpea seeds contain 23.4% protein, 1.8% fat, 60.3% carbohydrate, 3.4% fibre, 3.3% ash and 9 to 11% moisture **(Kashinath *et al.,* 2022).**

The world's total production of cowpea covers around 3 million tons, of which Nigeria is the leading producer contributing 2.1 million tons. Highest cowpea production nations are Nigeria, India and Brazil. Annual global production is 2 million tons from an area of 5 million ha. In India, cowpea is grown in almost 1.3 million ha area with an average productivity of 600-700 Kg grains/ha, particularly in western, central and peninsular region (FAO, 2012). It is an annual multipurpose grain legume **(Ovalesha *et al.,* 2017).**

In India pulses are grown nearly in 25.43 m ha with an annual production of 17.28 m t and productivity of 679 kg/ha. The per capita availability of pulses in India is 35.5g/day as against the minimum requirement of 7g/day/capita as advocated by Indian council of Medical Research. Cowpea grown across the world on an area 14.5 m ha of land planted each year and the total annual production is 6.2 m t. In India during 2020-21 cowpea is grown in about 13.3 m ha with an annual production of 8.06 m t and productivity of 596 kg/ha. Some of the states like Uttar Pradesh is about 2.38 m ha with an annual production of 2.56 and productivity of 1079 kg/ha major producer of cowpea in India as advocated by Ministry of Agriculture & Farmers welfare **(GOI 2020-2021).**

In India, despite the fact that a large number of varieties/hybrids and agrotechniques have been developed, the productivity of cowpea has still not reached the desired level. Uttar Pradesh, the largest vegetable-producing state in the country in area and production. A significant gap exists between the yields of farmers and experimental fields **(Singh *et al.,* 2007).**

The main reason for low productivity of pulses is the fact that most of the land that is used for growing pulses are of the marginal nature or not so well endowed, while the best lands are used for growing rice, wheat and sugarcane. Another aspect is the low seed-replacement ratio, though it has increased to 20–35%, most farmers use their own seeds **(Singh *et al.,* 2013).**

Phosphorus plays key roles in many plant processes such as energy metabolism, the synthesis of nucleic acids and membranes, photosynthesis, respiration, nitrogen fixation and enzyme regulation **(Raghothama, 1999).** Phosphorus is limiting factor to plant growth and productivity on 40% of the Worlds arable soil **(Vance, 2001).** Application of phosphorus has been reported by several authors to improve yield of cowpea. Therefore, governed by number of factors which have a direct or indirect impact. Among these factors are yield components such as number of pods/plant, number of seeds/pod and 100-seed weight over a given land area **(Cobbinah *et al.,* 2011).**

Phosphorus deficiency in soil is widespread and crops grown under deficient situation show significant response to fertilizer phosphorus. At several places normal yield of crops could not be achieved despite judicious use of NPK fertilizers due to deficiency of micronutrients in soil, in general, that of Zn in particular. The knowledge regarding the use of optimum dose of nutrients especially Phosphorus and Zinc is of serious concern. **(Kumar *et al.,* 2015).**

Plant population density is a key factor affecting growth and yield of crops. High population densities may affect light interception, nutrient uptake and water availability of crops. Optimum population densities for different crop varieties need to be determined in different agroclimatic zones and soil types to improve crop productivity. It is the most important non-monetary input, which can be manipulated to attain maximum production/unit area **(Giridhar *et al.,* 2020).**

In the last fifteen years the production and yield has been deteriorated due to the main problems limiting production and expansion of cowpea these problems are: Low yield potential of existing varieties (poor genetic stock), scarcity and reliability of rainfall, limited use of certified seed by the cowpea growers due to deficient marketing and failure to convince the farmers about the advantages of adopting certified seed versus their own seeds, poor cultural practices. The most of traditional farmers sowing cowpea in a very wide space which affect the total production of cowpea, Cowpea is considered as a possible future crop in Sudan, because of its natural production without using chemical fertilizers and insecticides **(El Naim *et al.*, 2010).** Keeping in view the above facts, the present investigation was undertaken to find out "Impact of phosphorus fertilizer and spacing on growth and yield of cowpea (*Vigna unguiculata* L.).

MATERIALS AND METHODS

The experiment was conducted during the *Zaid* season 2022 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 kg/ha), P (38.2 kg/ha), K (240.7 kg/ha). The treatment consists of three different levels of phosphorus *viz,* 30kg/ha, 40kg/ha, 50kg/ha with combination of different spacings *viz*, 20cm×20cm, 30cm×30cm, 40cm×40cm. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T1 – Phosphorus (30kg/ha) + (20cm×20cm), T2 – Phosphorus (30kg/ha) + (30cm×30cm), T3 – Phosphorus (30kg/ha) + (40cm×40cm), T4 – Phosphorus (40kg/ha) + (20cm×20cm), T5 – Phosphorus (40kg/ha) + (30cm×30cm), T6 – Phosphorus (40kg/ha) + (40cm×40cm), T7 – Phosphorus (50kg/ha) + (20cm×20cm), T8 – Phosphorus (50kg/ha) + (30cm×30cm), T9 – Phosphorus (50kg/ha) + (40cm×40cm), T10 – Control (40kg/ha) + (45cm×15cm). The growth parameters and yield attributes were recorded at harvest from randomly selected plants in each plot. The data was computed and analyzed by following statistical method of Gomez and Gomez (1984).

RESULT AND DISCUSSION

Growth parameters

Plant height (cm)

The data recorded that significant and higher plant height (60.3 cm) was observed in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)]. However, treatment 4 [Phosphorus (40kg/ha) + (20cm×20cm)], treatment 5 [Phosphorus (40kg/ha) + (30cm×30cm)], treatment 6 [Phosphorus (40kg/ha) + (40cm×40cm)], treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)], and treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table1]. Significant and higher plant height was observed with application of phosphorus (50kg/ha) might be due to stimulation of biological activities by adequate supply of phosphorus. Similar findings have been reported by **Sonet *et al.* (2020)** in lentil. Further, higher plant height was observed with spacing (30cm×30cm) might be due to plant get sufficient space under wider spacing for light, air and nutrition for better growth and development. Similar results have been reported by **Kasula *et al.* (2022)** in chickpea.

Number of branches/plant

The data revealed that significant and higher number of branches/plant (7.40) was observed in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)]. However, treatment 5 [Phosphorus (40kg/ha) + (30cm×30cm)], treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)] and treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 1]. The significant and maximum number of branches/plant was with application of Phosphorus (50kg/ha) might be due to efficient utilization of nutrients, which resulted in attaining better crop canopy and simulation of root growth. Similar results have been reported by **Sirisha *et al.* (2022).** Further, maximum number of branches/plant was observed with spacing (30cm×30cm) might be due to optimum plant spacing between plants resulted in enhanced space, sunlight, nutrients and soil moisture for increased photosynthesis, and metabolic activities which resulted in higher number of branches. Similar results have been reported by **Jasper *et al.* (2022)** in black gram.

Number of nodules/plant

Data was found that significantly higher number of nodules/plant (10.00) was obtained in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)]. However, treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 1]. Application of phosphorus (50kg/ha) showed that maximum number of nodules/plant that increased in nodulation might be due to stimulates root and plant growth, initiates nodule formation as well as influences the general efficiency of the rhizobium-legume symbiosis, thereby optimizes the Biological Nitrogen Fixation system of legume. Similar results have been reported by **Ndor *et al.* (2013).** Further, higher number of nodules/plant was observed with spacing (30cm×30cm) might be due to wider spacing there is less competition for space, moisture and nutrient might have probably increased root nodule as compared to close spacing. Similar results have been reported by **Murade *et al.* (2014)** in urdbean.

Plant dry weight (g)

Significant and higher plant dry weight (16.47 g) was recorded in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)]. However, treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha + 30cm×30cm)] [Table 1]. Significant and maximum plant dry weight was observed with application of phosphorus (50kg/ha) might be due to the increase in vegetative development and reproductive attributes under proper availability of phosphorus and better physical condition of soil. Similar results have been reported by **Singh *et al.* (2018)** in summer green gram. Further, higher plant dry weight was observed with spacing (30cm×30cm) might be due to greater exposure to light and increased availability of nutrients to plants have also resulted in higher root dry weight on the plants. Similar results have been reported by **Wali *et al.* (2021)** in green gram.

Crop growth rate (g/m^2/day)

The data revealed that during 45-60 DAS, treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)] recorded significantly higher crop growth rate (1.95 g/m$^{2/}$day), However, treatment 4 [Phosphorus (40 kg/ha) + (20cm×20cm)] were statistically at par with the treatment 7 [Phosphorus (30kg/ha) + (20cm×20cm)] [Table 1]. The significant and higher crop growth rate with the application of phosphorus (50kg/ha) might be due to superior nodulation and its weight/plant, these result in better acquisition of P and other nutrients, thereby increasing the crop growth. Similar results have been reported by **Singh *et al.* (2016)** in lentil. Further, increase in crop growth rate was observed with spacing (20cm×20cm) might be due to closer crop geometry with more population/unit area. Similar results have been reported by **Kumar *et al.* (2017)** in black gram.

Relative growth rate (g/g/day)

The data revealed that during 45-60 DAS, treatment 5 [Phosphorus (40kg/ha) + (30cm×30cm)] recorded higher relative growth rate (0.0060 g/m/day) and though there was no significant difference among the treatments [Table 1].

Yield attributes

Number of pods/plant

The data showed that treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] recorded significantly higher number of pods/plant (29.4). However, treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)], and treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 2]. The significant and increase in number of pods/plant was observed with application of phosphorus (50kg/ha) might be due to enhances the root elongation, leaf expansion and photosynthesis efficiency per unit of chlorophyll and helps in cell division, cell elongation, translocation and respiration process. Similar results have been reported by **Singh *et al.* (2007).** Further, maximum number of pods/plant was observed with spacing (30cm×30cm) might be due to wide crop geometry is to better absorption of moisture and nutrients by the individual crop. Similar results have been reported by **Bhavana *et al.* (2019)** in horse gram.

Number of seeds/pod

The data found that significant and higher number seeds/pod (10.87) was recorded in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)]. However, treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)], and treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 2]. The significant and maximum number of seeds/pod was with the application of Phosphorus (50kg/ha) might be due to plant growth, photosynthesis, flowering, seed setting and nitrogen fixation which ultimately resulted in enhancement of yield attributes. Similar results have been reported by **Sahu *et al.* (2021)** in green gram. Further, increase in number of seeds/pod was observed with (30cm×30cm) might be due to more space per plant ultimately enhanced availability of nutrients, moisture and light consequently better development of yield attributes. Similar results have been reported by **Kumar *et al.* (2018)** in black gram.

Test weight (g)

The data recorded that no significant difference among all the treatments. However, highest test weight (13.60 g) was observed in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 2].

Seed yield (t/ha)

The significant and higher seed yield (1.05 t/ha) was recorded in treatment 8 [Phosphorus (50kg/ha) +(30cm×30cm)]. However, treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm) and treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 2]. The highest seed yield with the application of Phosphorus (50kg/ha) might be due to root proliferation leads to nitrogen fixation for better crop production. Similar results have been reported by **Abraham *et al.* (2021)** in black gram. Further, increase in seed yield was observed with spacing (30cm×30cm) might be due to optimum spacing helped plant to receive sufficient amount of heat, water and nutrients from soil. Similar results have been reported by **Pandey *et al.* (2022)** in black gram.

Stover yield (t/ha)

Results revealed that treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] recorded significantly higher stover yield (1.60 t/ha). However, treatment 5 [Phosphorus (40kg/ha) + (30cm×30cm)], treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)] and the treatment 9 [Phosphorus (50kg/ha) + (40cm×40cm)] were statistically at par with the treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] [Table 2]. Maximum stover yield was significantly influenced by the application of Phosphorus (50kg/ha) that increased the production of plant biomass, nodule number and weight and chlorophyll content in leaf exhibited significant positive correlation with grain and stover yield. Similar results have been reported by **Prajapati *et al.* (2022)** in green gram. Further, increase in stover yield was observed with spacing (30cm×30cm) might be due optimum row spacing have effectively utilized the growth resources, particularly solar radiation. Similar results have been reported by **Devi *et al.* (2022)** in lentil.

Harvest Index (%)

The data showed that no significant difference among all the treatments. However, maximum harvest index (41.0%) was recorded in treatment 7 [Phosphorus (50kg/ha) + (20cm×20cm)] [Table 2].

Economics

The result revealed that maximum gross return (89,050.00 INR/ha), higher net returns (57,832.40 INR/ha), and highest benefit cost ratio (1.85) was recorded in treatment 8 [Phosphorus (50kg/ha) + (30cm×30cm)] as compared to other treatments [Table 3]. Higher gross returns, net returns, benefit cost ratio was recorded with application of Phopshorus (50kg/ha) might be due to higher growth and yield attributes resulting in more seed and stover yield with recommended dose of phosphorus. Similar results have been reported by **Bhat *et al.* (2013)** in field pea.

Table 1. Impact of phosphorus fertilizer and spacing on growth parameters of cowpea.

S No	Treatments	Plant height (cm)	Number of branches/ plant	Number of nodules/ Plant	Plant dry weight (g)	CGR ($g/m^2/day$)	RGR (g/g/day)
1.	Phosphorus 30kg + 20cm×20 cm	58.1	5.53	7.00	13.10	1.06	0.0034
2.	Phosphorus 30kg + 30cm×30 cm	58.5	6.47	8.07	13.97	0.47	0.0030
3.	Phosphorus 30kg + 40cm×40 cm	58.4	6.40	7.50	13.63	0.27	0.0032
4.	Phosphorus 40kg + 20cm×20 cm	59.5	6.67	8.60	14.40	1.17	0.0034
5.	Phosphorus 40kg + 30cm×30 cm	59.7	7.07	8.80	15.53	0.99	0.0060
6.	Phosphorus 40kg + 40cm×40 cm	59.5	6.73	8.73	14.83	0.29	0.0031
7.	Phosphorus 50kg + 20cm×20 cm	60.0	7.13	9.13	15.87	1.95	0.0050
8.	Phosphorus 50kg + 30cm×30 cm	60.3	7.40	10.00	16.47	0.32	0.0017
9.	Phosphorus 50kg + 40cm×40 cm	60.1	7.27	9.27	16.20	0.15	0.0015
10.	Control (Phosphorus 40kg + 45cm×15 cm)	58.2	5.67	7.07	13.20	0.59	0.0032
	F-test	S	S	S	S	S	NS
	Sem±	0.38	0.22	0.27	0.14	0.27	0.0010
	CD at 5%	1.14	0.64	0.80	0.43	0.79	-

Table 2. Impact of phosphorus fertilizer and spacing on yield attributes of cowpea.

S No	Treatments	Number of pods/plant	Number of seeds/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Phosphorus 30kg + 20cm×20 cm	10.13	8.00	12.33	0.89	1.28	41.0
2.	Phosphorus 30kg + 30cm×30 cm	12.40	9.27	12.70	0.91	1.34	40.5
3.	Phosphorus 30kg + 40cm×40 cm	11.53	9.20	12.60	0.89	1.30	40.7
4.	Phosphorus 40kg + 20cm×20 cm	13.60	9.40	12.83	0.92	1.39	39.8
5.	Phosphorus 40kg + 30cm×30 cm	14.40	9.80	13.10	0.95	1.43	39.9
6.	Phosphorus 40kg + 40cm×40 cm	14.27	9.60	12.90	0.94	1.39	40.4
7.	Phosphorus 50kg + 20cm×20 cm	14.60	10.20	13.10	1.00	1.44	41.0
8.	Phosphorus 50kg + 30cm×30 cm	15.07	10.87	13.30	1.05	1.60	39.6
9.	Phosphorus 50kg + 40cm×40 cm	14.73	10.40	13.20	1.02	1.52	40.4
10.	Control (Phosphorus 40kg + 45cm×15 cm)	10.60	8.73	12.57	0.82	1.26	39.6
	F-test	S	S	NS	S	S	NS
	Sem±	0.18	0.30	0.22	0.02	0.06	0.94
	CD at 5%	0.53	0.88	--	0.05	0.17	--

Table 3. Impact of phosphorus fertilizer and spacing on economics of greengram.

S No	Treatments	Total cost of cultivation (INR/ha)	Gross Returns (INR/ha)	Net Returns (INR/ha)	B:C ratio
1	Phosphorus 30kg + 20cm×20cm	30468.40	74490.00	44022.40	1.44
2	Phosphorus 30kg + 30cm×30cm	29968.40	76570.00	46602.40	1.55
3	Phosphorus 30kg + 40cm×40cm	29468.40	74750.00	45282.40	1.53
4	Phosphorus 40kg + 20cm×20cm	31093.40	78390.00	47297.40	1.52
5	Phosphorus 40kg + 30cm×30cm	30593.40	81120.00	50527.40	1.65
6	Phosphorus 40kg + 40cm×40cm	30093.40	79170.00	49077.40	1.63
7	Phosphorus 50kg + 20cm×20cm	31718.40	83720.00	52002.40	1.63
8	Phosphorus 50kg + 30cm×30cm	31218.40	89050.00	57832.40	1.85
9	Phosphorus 50kg + 40cm×40cm	30718.40	86060.00	55342.40	1.80
10	Control (Phosphorus 40kg + 45cm×15cm)	30593.40	69680.00	39087.40	1.27

*Data was not subjected to statistical analysis.

CONCLUSION

Based on the above findings it can be concluded that application of Phosphorus 50kg/ha with the spacing 30cm×30cm has performed better in growth parameters and yield attributes of cowpea *(Ankur Gomati V U 89)* and also proven profitable.

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