

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.910.373>

Effect of Levels of Phosphorus and Zinc on Growth and Yield of Greengram (*Vigna radiata* L.)

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A B S T R A C T

Keywords

Phosphorus, Zinc,
Greengram,
Vigna radiata

Article Info

Accepted:
24 September 2020
Available Online:
10 October 2020

The present investigation titled “Effect of levels of phosphorous and zinc on growth and yield of Greengram (*Vigna radiata* L.)” was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during zaid season of 2019. Samrat variety was selected for conducting the trial. The experiment was laid out in Randomized Block Design consisting of 9 treatments replicated thrice with the treatment combination of three levels of phosphorus viz., P₁ - 45 kg ha⁻¹, P₂ - 60 kg ha⁻¹, P₃ - 75 kg ha⁻¹ and three levels of zinc viz., Z₁-15 kg ha⁻¹, Z₂- 20 kg ha⁻¹, Z₃- 35 DAS and 45 DAS (0.5% foliar spray). The results revealed that the treatment T₆ [P at 60 kg ha⁻¹+ Zn at 35 DAS and 45 DAS (0.5% foliar spray)] recorded maximum plant height (45.37 cm), number of branches per plant (13.07), number of nodules per plant (16.22), dry weight (10.55 g plant⁻¹), Crop Growth rate (0.299 g m⁻² day⁻¹), number of pods per plant (27.16), number of grains per pod (13.64), grain yield (2.18 t ha⁻¹), stover yield (5.15 t ha⁻¹) and protein content (25.41%). Maximum gross return (₹ 108777.7 ha⁻¹), net return (₹ 71992.72 ha⁻¹) and B:C ratio (2.96) was recorded with the treatment T₆ [P at 60 kg ha⁻¹+Zn at 35 DAS and 45 DAS (0.5% foliar spray)].

Introduction

Pulses are one of the important segments of Indian agriculture after cereals in production (Singh *et al.*, 2017). Total Pulses production during 2017-18 (as per 4th Advance Estimates) is estimated at record 25.23 million tonnes which is higher by 2.10 million tonnes than the previous year's production of 23.13 million tonnes (Directorate of Pulse development, Annual report 2018-19). The word “pulse” is derived from the Latin word

“puls” means pottage, i.e. seed boiled to make porridge or thick soup. Pulses play an important source of dietary protein, energy, minerals and vitamins for the mankind. Pulses provide 25% of protein requirements of predominantly vegetarian population. The lysine rich protein of pulses is considered as the supplement for the deficiency of this amino acid in cereal dietaries and brings at par with milk’s protein in the terms of biological efficiency. It is because of this reason that pulses have also been called the

“Poor man’s meat” (Patel *et al.*, 2017). Pulses play an important role in Indian Agriculture as they restore soil fertility by fixing atmospheric nitrogen through biological nitrogen fixation (BNF) in association with root nodule bacteria. That is why pulses can also be referred to as mini fertilizer factory. Pulses are less water requiring crop and prevent soil erosion due to their deep root system and good ground coverage, because of these good characters; pulses are called as “Marvel of Nature”.

Greengram is considered to be the hardest of all pulse crops. It belongs to family Leguminosae. It is the third most important pulse crop of India in terms of area cultivated and production next to chickpea and pigeon pea (Singh *et al.*, 2017). In India greengram is grown on 3.38 m ha area with an average productivity of 474 kg/ha. In Uttar Pradesh it is grown on 25.9 thousand ha with a productivity of 659 kg/ha (Anonymous 2014). Greengram has many local names “mung bean, mash or golden gram”. It is short duration pulse crop which contains 25 per cent protein of high digestibility and has appreciable amount of riboflavin and thiamine (Lokhande *et al.*, 2018). The mature seeds contains about 20.97–31.32% protein content (Anwar *et al.*, 2007), 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively (Fraque *et al.*, 2000). When grown in summer season it gives better yield than the crop grown in rainy season, as summer crop is almost free from infestation of insects, pest and diseases. Still productivity of summer mungbean is low due to major constraint of nutrient availability (Singh *et al.*, 2018). In addition to being an important source of human food, it also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. More than 70% of total

world greengram production is from India (Anonymous, 2016).

Among different production practices, fertilizer management is one of the important agronomic practices for increasing crop yield and maintaining soil fertility. Phosphorus (P) is one of the most important elements among the three macronutrients that plants must require for the better growth and development. Phosphorus is essential constituent of majority of enzyme which are of great importance in the transformation of energy in carbohydrates metabolism and also in respiration. P is closely related to cell division and development. Addition of P fertilizer also enhances root development, which improves the supply of other nutrients and water to the growing parts of the plants, resulting in an increased photosynthetic area and thereby more dry matter accumulation. It helps in better nodulation and efficient functioning of nodule bacteria for fixation of N which will be utilized by plants during grain- development stage, and in turn lead to increased green yield (Singh *et al.*, 2018). Micronutrients are also essential for plant growth. Zinc influences the formation of growth hormones and it plays a helpful role in reproduction of certain plants (Patel *et al.*, 2017). Zinc is necessary to activate many enzymes like Tryptophan synthetase, superoxide dismutase and dehydrogenases. Lack of zinc causes deficiency in formation of RNA and protein. Therefore, the plant with lack of zinc is poor in amount of protein (Singh *et al.*, 2018). Rengel (2001) showed that zinc fertilizer application causes root and shoot growth during the growing season and therefore, lead to increased seed yield.

It has been well established that most of the plant nutrients are absorbed through the leaves and absorption would be remarkably rapid and nearly complete. If foliar nutrition is combined with basal application, it reduces

the cost of cultivation which in turn reduces the amount of fertilizer thereby reducing the loss and also economizing crop production. Foliar nutrition can be adopted wherever possible except for unavailable circumstances where soil application is only feasible. Information on effect of application of Phosphorus along with basal or foliar spray of Zinc on growth and yield of Greengram is rather limited. Hence the present investigation titled "Effect of levels of Phosphorous and Zinc on growth and yield of Greengram (*Vignaradiata L.*)" was conducted.

Materials and Methods

A field experiment was conducted during *zaid* season of 2019 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. Samrat variety of Greengram was selected for conducting the trial. Total 9 treatment combination comprising of three levels of phosphorus *viz.*, $P_1 - 45 \text{ kg ha}^{-1}$, $P_2 - 60 \text{ kg ha}^{-1}$, $P_3 - 75 \text{ kg ha}^{-1}$ and three levels of Zinc *viz.*, $Z_1 - 15 \text{ kg ha}^{-1}$, $Z_2 - 20 \text{ kg ha}^{-1}$ and $Z_3 - 35 \text{ DAS and 45 DAS (0.5\% foliar spray)}$ were evaluated in Randomized Block Design with three replications. The soil of the experimental plot was Sandy loam in texture having medium to good drainage, EC 0.224 dS m⁻¹, and soil pH 7.1. The chemical analysis of soil revealed the following values - organic carbon was estimated to be 0.692%, nitrogen 187 kg ha⁻¹, phosphorus 22.6 kg ha⁻¹, potassium 268.2 kg ha⁻¹ and zinc 0.98 ppm. Greengram seeds were sown at 30 cm × 15 cm spacing according to the seed rate of 20 kg ha⁻¹. The recommended dose of nitrogen (20 kg ha⁻¹) and potassium (20 kg ha⁻¹) was applied as basal dose just before sowing and phosphorus and zinc were applied as per the treatments. Urea, DAP, MoP and Zinc powder were taken as fertilizer sources for N, P, K and Zn respectively.

Results and Discussion

Growth attributes

Data presented in Table 1 shows effect of levels of phosphorus and zinc on growth attributes of Greengram such as plant height, number of branches, number of nodule, plant dry weight, crop growth rate (CGR) and relative growth rate (RGR). Among different phosphorus and zinc levels, the highest values were recorded with the application of P at 60 kg ha⁻¹ along with Zn at 35 DAS and 45DAS (0.5% foliar spray). All growth parameters were significantly influenced except RGR. The results revealed that the treatment T_6 [P at 60 kg ha⁻¹+Zn at 35 DAS and 45DAS (0.5% foliar spray)] recorded maximum plant height (45.37 cm), number of branches per plant (13.07), number of nodules per plant (16.22), dry weight (10.55 g plant⁻¹) and Crop Growth rate (0.299 g m⁻² day⁻¹). Phosphorus increases yield due to its well-developed root system, increased N fixation, its availability to the plants and favourable environments in the rhizosphere by reducing the pH leading to higher nutrient availability of various insoluble inorganic and organic phosphorus present in the soil. Similar results were also reported by Balai *et al.*, (2017). Application of phosphorus help in efficient utilization of nutrients, which resulted in attaining better crop canopy and further increased absorption and utilization of radiant energy resulting in higher effective and total nodules (Patel *et al.*, 2017). Higher dry weight may be due to the cumulative effect of increasing in plant height and number of branches which resulted in increasing the dry matter production of plant. Phosphorus also enhances the activity of rhizobia and increase the formation of root nodule and there by helps in fixing more of atmospheric nitrogen in root nodule (Das, 2017). Zinc application helps in absorption of water and nutrients from the soil and thus promotes growth and yield of the plant,

indicating that the flowering and fruiting process are greatly improved under severe Zn application. The results are in conformity with those of Hafeez *et al.*, (2013). The increase in growth of plants under zinc treatment may also be due to its effect in the metabolism of

growing plants, which may effectively explain the observed response of zinc application. Favourable responses of zinc application on plant height are similar in findings of Khalil and Prakash (2014) and Shanti *et al.*, (2008).

Table.1 Effect of Levels of Phosphorus and Sulphur on growth attributes of Greengram

Treatment No.	Treatments combination	Plant height at 60 DAS (cm)	Branches plant ⁻¹ at 60 DAS (No.)	Nodules plant ⁻¹ at 60 DAS (No.)	Dry Weight at 60 DAS (g/plant)	Crop Growth Rate at 45-60 DAS (g m ⁻² day ⁻¹)	Relative Growth Rate at 45-60 DAS (mg g ⁻¹ day ⁻¹)
1	P at 45kg ha ⁻¹ + ZnSo ₄ at 15kg ha ⁻¹	32.17	9.53	10.55	6.32	0.172	0.0431
2	P at 45kg ha ⁻¹ + ZnSo ₄ at 20kg ha ⁻¹	39.20	11.13	15.22	7.84	0.269	0.0614
3	P at 45kg ha ₋₁ + ZnSo ₄ at 35 DAS and 45 DAS (0.5% foliar spray)	43.07	11.13	14.78	9.10	0.243	0.0389
4	P at 60kg ha ⁻¹ + ZnSo ₄ at 15kg ha ⁻¹	44.77	11.33	13.22	7.50	0.201	0.0350
5	P at 60kg ha ⁻¹ + ZnSo ₄ at 20kg ha ⁻¹	41.20	11.00	15.22	8.28	0.255	0.0413
6	P at 60kg ha ⁻¹ + ZnSo ₄ at 35 DAS and 45DAS (0.5% foliar spray)	45.37	13.07	16.22	10.55	0.299	0.0372
7	P at 75kg ha ⁻¹ + ZnSo ₄ at 15kg ha ⁻¹	38.93	10.60	15.44	6.17	0.222	0.0364
8	P at 75kg ha ₋₁ + ZnSo ₄ at 20kg ha ⁻¹	36.13	10.13	12.33	6.70	0.220	0.0476
9	P at 75kg ha ⁻¹ + ZnSo ₄ at 35 DAS and 45 DAS (0.5% foliar spray)	43.10	10.76	11.21	6.94	0.184	0.0335
F- test		S	S	S	S	S	NS
S. Ed. (\pm)		3.597	0.728	1.921	0.597	0.056	0.021
CD (P = 0.05)		7.626	1.542	4.073	1.265	0.119	-

Table.2 Effect of Levels of Phosphorus and Zinc on yield and quality attributes of Greengram

Treatment No.	Treatments combination	Pod plant ⁻¹ (No.)	Grains Pod ⁻¹ (No.)	Test weight(g)	Grain yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Protein content (%)
1	P at 45kg ha ⁻¹ + ZnSo ₄ at 15kg ha ⁻¹	16.07	10.04	11.38	1.09	3.83	18.67
2	P at 45kg ha ⁻¹ + ZnSo ₄ at 20kg ha ⁻¹	19.33	10.91	25.66	1.39	4.72	21.22
3	P at 45kg ha ₋₁ + ZnSo ₄ at 35 DAS and 45 DAS (0.5% foliar spray)	20.58	11.65	32.17	1.91	4.73	21.29
4	P at 60kg ha ⁻¹ + ZnSo ₄ at 15kg ha ⁻¹	20.92	11.96	22.85	1.44	4.63	21.92
5	P at 60kg ha ⁻¹ + ZnSo ₄ at 20kg ha ⁻¹	22.27	11.53	22.18	1.45	4.28	21.50
6	P at 60kg ha ⁻¹ + ZnSo ₄ at 35 DAS and 45DAS (0.5% foliar spray)	27.16	13.64	34.55	2.18	5.15	25.41
7	P at 75kg ha ⁻¹ + ZnSo ₄ at 15kg ha ⁻¹	23.81	12.43	23.78	1.87	4.28	23.99
8	P at 75kg ha ₋₁ + ZnSo ₄ at 20kg ha ⁻¹	24.19	12.19	25.05	1.49	5.09	23.53
9	P at 75kg ha ⁻¹ + ZnSo ₄ at 35 DAS and 45 DAS (0.5% foliar spray)	20.50	11.50	24.90	1.41	5.04	22.65
F- test		S	S	NS	S	S	-
S. Ed. (\pm)		1.171	0.415	4.541	0.094	0.261	-
CD. (P = 0.05)		2.481	0.880	-	0.199	0.554	-

Table.3 Effect of Levels of Phosphorus and Zinc on economics of Greengram

Treatment No.	Treatments combination	Cost of Cultivation (₹ ha^{-1})	Gross Returns (₹ ha^{-1})	Net Returns (₹ ha^{-1})	Benefit Cost Ratio
1	P at 45kg ha^{-1} + ZnSO_4 at 15kg ha^{-1}	37514.95	54518.46	17003.51	1.45
2	P at 45kg ha^{-1} + ZnSO_4 at 20kg ha^{-1}	37839.95	69740.67	31900.72	1.84
3	P at 45kg ha^{-1} + ZnSO_4 at 35 DAS and 45 DAS (0.5% foliar spray)	36539.95	95333.24	58793.29	2.61
4	P at 60kg ha^{-1} + ZnSO_4 at 15kg ha^{-1}	37749.95	72111.04	34361.09	1.91
5	P at 60kg ha^{-1} + ZnSO_4 at 20kg ha^{-1}	38074.95	72703.63	34628.68	1.91
6	P at 60kg ha^{-1} + ZnSO_4 at 35 DAS and 45DAS (0.5% foliar spray)	36784.95	108777.7	71992.72	2.96
7	P at 75kg ha^{-1} + ZnSO_4 at 15kg ha^{-1}	38102.45	93333.24	55230.79	2.45
8	P at 75kg ha^{-1} + ZnSO_4 at 20kg ha^{-1}	38427.45	74703.63	36276.18	1.94
9	P at 75kg ha^{-1} + ZnSO_4 at 35 DAS and 45 DAS (0.5% foliar spray)	37140.15	70481.41	33341.26	1.90

Yield and quality attributes

Data presented in Table 2 shows that the combined effect of phosphorus and zinc significantly influenced all the yield parameters except test weight. Among different phosphorus and zinc levels, the highest number of pods per plant (27.16), number of grains per pod (13.64), grain yield (2.18 t ha^{-1}), stover yield (5.15 t ha^{-1}) and protein content (25.41%) was recorded with the application of P at 60 kg ha^{-1} along with Zn at 35 DAS and 45DAS (0.5% foliar spray). Phosphorus application may mobilize the photosynthates from growing organs to grains, consequently increasing their number and size (Singh *et al.*, 2017). Phosphorus resulted in higher rate of dry matter accumulation which might be due to the increase in vegetative development and reproductive attributes under proper availability of phosphorus and better physical condition of soil. Positive responses in terms of yield attributes due to application of phosphorus have also been reported by Gupta *et al.*, (2006), Gangaiah and Ahlawat (2008), Patil *et al.*, (2011), Kumar *et al.*, (2012), Patel

et al., (2013). Higher number of pods per plant with zinc application could possibly be explained by the fact that zinc application increased the realisation of flower into pods. Zinc application on straw yield of green gram might be due to its direct influence on auxin production which in turn enhanced the elongation processes of plant development (Patel *et al.*, 2017).

The increase in yield attributes might also have been due to application of nutrients in adequate quantity and easily available form to plant through foliar spray which favourably influenced on yield attributes. The combined application of different level of phosphorus along with zinc also enhanced the protein content of greengram. Protein content is essentially the manifestation of nitrogen content in seed. Hence, increase in nitrogen content of seed might have increased the protein content with increasing levels of phosphorus application. The increase in protein content with Zn addition may be attributed to its involvement in N metabolism (Lokhande *et al.*, 2018).

Economics of treatment

Economic evaluation of the treatments was done on the basis of gross return, net return and benefit: cost ratio (Table 3). It was observed that the treatment receiving P at 60 kg ha⁻¹ along with Zn at 35 DAS and 45DAS (0.5% foliar spray) registered highest gross return (₹108777.7 ha⁻¹), net return (₹71992.72 ha⁻¹) and benefit cost ratio (2.96). This might be due to higher yield in this treatment compared to other treatments.

It is concluded that in the experiment on Greengram, the treatment number 6 in which Phosphorus was applied at 60kg ha⁻¹ along with Zn at 35 DAS and 45DAS (0.5% foliar spray) recorded higher plant growth (like plant height (45.37 cm), number of branches per plant (13.07), number of nodules per plant (16.22), dry weight (10.55 g plant⁻¹) and Crop Growth rate (0.299 g m⁻² day⁻¹)) and yield attributes (namely number of pods per plant (27.16), number of grains per pod (13.64), grain yield (2.18 t ha⁻¹), stover yield (5.15 t ha⁻¹) and protein content (25.41%)) with highest Net Returns (₹ 71992.72 ha⁻¹) and B:C ratio (2.96).

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How to cite this article:

Ashish Masih, Joy Dawson and Richa Evelyn Singh. 2020. Effect of Levels of Phosphorus and Zinc on Growth and Yield of Greengram (*Vigna radiata* L.). *Int.J.Curr.Microbiol.App.Sci*. 9(10): 3106-3112. doi: <https://doi.org/10.20546/ijcmas.2020.910.373>