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Effect of phosphorus and plant growth regulators on growth and yield of blackgram

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Abstract
A field experiment was conducted during *Zaid* season 2023 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Sciences and Technology. To determine "Effect of phosphorus and plant growth regulators on growth and yield of Blackgram". The result revealed that treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)] recorded significantly higher plant height (32.47 cm), higher plant dry weight (12.36 g), maximum number of pods/plant (17,01), maximum number of seeds/pod (7.53), higher seed yield (907.30 kg/ha) and higher stover yield (1890.50 kg/ha). Highest gross return (80146.00 INR/ha), net return (51442.30 INR/ha) and B:C ratio (1.79) was recorded in treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)] was found to be productive as well as economically feasible.

Keywords: Blackgram, phosphorus, naphthalic acetic acid (NAA), GA3 and salicylic acid, productivity and economics

Introduction
Blackgram is a most extensively grown pulse crop in the India. It is a highly priced pulse, very rich in phosphoric acid. In the global scenario, the total area under pulse production is 959.68 lakh ha. Total production of pulses is 973.92 lakh tonnes and the average productivity is 1015 kg/ha. (FAO, 2022). The nutritional value per 100 g of Blackgram is Crude protein 26.2%, Fat 1.2%, Carbohydrate 56.6%, Ca 185 mg/100 g, Fe 8.7 mg/100 g and P 345 mg/100 g. India currently represents the largest producer of black gram accounting for more than 70% of the global production. In India, blackgram is grown in 48.38 lakh ha area and with a production of 27.28 lakh tonnes and a productivity of 564 kg/ha. Uttar Pradesh is one of the major Blackgram producing state in India. In Uttar Pradesh, blackgram is grown in area of 5.72 lakh ha with production of 2.99 lakh tonnes and the average productivity is 522 kg/ha (GOI, 2022) [3].

Phosphorus application has been demonstrated to be very successful in all types of soil and is considered to be a crucial component of raising yield. Phosphorus is necessary not only for roots to form and flourish, but it also fosters the growth of Rhizobium bacteria, which fixes nitrogen in a biological way and improves the soil-restoring abilities of pulses (Charel *et al*. 2006). Phosphorus provides the double benefit of raising the yield of subsequent crops as well as the main crop. In addition, the synthesis of nucleic acids, photosynthesis, glycolysis, respiration, redox processes, membrane formation and integrity, enzyme activation or inactivation, carbohydrate metabolism, and signalling all depend on phosphorus generation. Therefore, insufficiency of phosphorus levels in the soil will greatly affect the growth and development of crops (Hussain, 2017) [6].

Naphthalene acetic acid (NAA) is a synthetic plant hormone in the auxin family and is an ingredient of commercial plants used for the vegetative propagation. Its application improves the plants' morphological, physiological, and biochemical traits. Applying NAA can enhance the ratio of fruit setting, stop fruit from dropping, and increase the flower sex ratio. Foliar application of NAA has also found to increase plant height, number of leaves per plant, fruit size with consequent enhancement in seed yield in different crops (Parmar *et al*. 2012) [10].

Gibberellic acid is an important phytohormone which induces metabolic activities and regulating nitrogen utilisation that is responsible for plant growth and development (Sure *et al*. 2012) [15]. It also involves in seed germination, endosperm mobilisation, stem elongation, leaf expansion, reducing the maturation time and increasing flower and fruit set and their composition. GA3 delays senescence, improves growth and chloroplasts development, and intensifies photosynthetic efficiency which could lead to increased yield (Tiwari *et al*. 2020) [14].

Salicylic acid has an impact on transpiration, ion uptake and transport, photosynthesis, and plant growth and development. A phenolic phytohormone called salicylic acid also causes certain modifications to the structure of chloroplasts and the anatomy of leaves. When salicylic acid is applied to plants, both their biotic and abiotic stress tolerance increases. The positive impacts on the productivity as well as the nutritional value of blackgram get through manipulating the levels of salicylic acid in plant through its exogenous application. **(**Hasan and Rasul, 2022) [5]. Keeping in view the above facts, the present experiment was undertaken to find out the “Effect of phosphorus and plant growth regulators on growth and yield on blackgram”.

Materials and Methods

The experiment was conducted during *Zaid* season 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P.). The soil of the experimental field was sandy loam in texture, with soil 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) and zinc (2.32 mg/kg). The treatment consists of three levels of phosphorus along with the combination of three levels of plant growth regulators. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T1 - Phosphorus - 30 kg/ha + NAA– 50 ppm, T2 - Phosphorus - 30 kg/ha + GA3– 10 ppm, T3 - Phosphorus - 30 kg/ha + Salicylic acid – 100 ppm, T4 - Phosphorus - 40 kg/ha + NAA– 50 ppm, T5 - Phosphorus - 40 kg/ha + GA3– 10 ppm, T6 - Phosphorus - 40 kg/ha + Salicylic acid – 100 ppm, T7 - Phosphorus - 50 kg/ha + NAA– 50 ppm, T8 – Phosphorus - 50 kg/ha + GA3– 10 ppm, T9 - Phosphorus - 50 kg/ha + Salicylic acid – 100 ppm and T10 – Control N:P:K (20:40:20 kg/ha). Data recorded on different aspects of crop, *viz*., growth, yield attributes and yield were subjected to statistically analysed by analysis of variance method as described by Gomez and Gomez (1976) [4].

Results and Discussion

Plant height (cm): At 60 DAS, significant and higher plant height (32.47 cm) was shown in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. The significant and higher plant height was with the application of phosphorus (50 kg/ha) might be due to phosphorus which stimulates cell division which may have helped in enhancing plant growth, root nodules, might have helped in attaining higher plant height. Similar result was also reported by Yadav *et al*. (2022) [16]. Further, foliar application of GA3 (10 ppm) gave higher plant height possibly due to the beneficial effects of GA3, on cell elongation and cell division of blackgram. Similar finding was also reported by Dawar *et al*. (2020) [2].

Number of nodules/plant: At 60 DAS, significant and higher number of nodules/plant (16.87) was observed in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. The significant and higher number of nodules/plant was with the application of phosphorus (50 kg/ha) may be due to better root development as levels of phosphorus increased as phosphorus being a component of nucleic acids and various forms of proteins, which could have stimulated cell division, resulted with increased of nodules/plant. Similar result was also reported by Niraj and Prakash (2015) [8]. Further, significant and higher root nodules/plant was observed with GA3 (10 ppm), the efficient nutrient application enhanced the root growth there by colonizing the more rhizobacteria that helped for better root development and nodulation, resulted in increasing number of nodules/plant. Similar results was also reported by Revanth *et al*. (2021) [17].

Plant dry weight (g): At 60 DAS, significant and higher plant dry weight (12.36 g) was observed in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] and treatment 4 [Phosphorus (40 kg/ha) + NAA (50 ppm)] were found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. The significant and higher plant dry weight was obtained with application of phosphorus (50 kg/ha) might be due to the cumulative effect of increasing in plant height, number of leaves, enhanced the activity of rhizome, increased the formation of root nodule, that may have helped in fixing more of atmospheric nitrogen in root nodule, resulted in increased dry matter production of plant. Similar result was reported by Masih *et al*. (2020) [7] in green gram. Further, significantly higher dry weight of blackgram was found with application of GA3 (10 ppm) which might be due to beneficial effects of GA3 on increasing the photosynthetic activity and better food accumulation resulting in higher dry weight of plant. Similar results were obtained by the Pasarla *et al*. (2021) [11].

Number of pods/plant: Significant and maximum number of pods/plant (17.01) was observed in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. Significant and maximum number of pods/plant was with the application of phosphorus (50 kg/ha) as the symbiotic nitrogen fixation process is stimulated by phosphorus because it makes bacterial cells more mobile, which is necessary for their migration to nodulation in root hair which may have increased the number of pods/plants. Similar result was also reported by Parashar *et al*. (2020) [9]. Further, significant and higher number of pods/plant was with application of GA3 (10 ppm) may be due to the foliar application of GA3 at flowering stage (30 DAS) may have improved the reproductive development of the crop and supported efficient translocation of photosynthates from source to sink, this might have significantly increased the number of pods/ plant. Similar result was also reported by Dawar *et al*. (2020) [2].

Number of seeds/pod: Significant and maximum number of seeds/pods (7.53) was observed in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. Significant and maximum number of seeds/pod was with the application of phosphorus (50 kg/ha) might be due to increase in vegetative development and reproductive attributes under proper phosphorus availability and improved soil physical properties. Similar result was also reported by Singh *et al*. (2020) [7, 31, 14]. Further, significant and higher number of seeds/pod was with application of GA3 (10 ppm) might be due to increased nodulation, an extensive root system, enhanced metabolite synthesis, and greater translocation to different sinks, especially the fruiting structures (pods and seeds), each plant may have produced more pods in proportion to its overall development. Similar results were also reported by Charles and Dawson (2023) [1].

Test Weight (g): Significant and higher test weight (36.43 g) was shown in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. Significant and higher test weight was with application of phosphorus (50 kg/ha) might be due to increased availability of nutrients in the soil, enhanced the plant's ability to photosynthesize, which in turn allowed photosynthates from source to sink to be effectively assimilated during the post-flowering period. Similar results were also reported by Singh *et al*. (2020) [[7, 31, 14]. Further, significant and higher test weight was with application of GA3 (10 ppm) might be due to GA3 takes place in many physiological processes of plant such as chlorophyll formation, stomatal regulation, starch utilization which may have enhanced test weight. Similar result was also reported by Ravi *et al*. (2022) [12].

Seed yield (kg/ha): Significant and higher seed yield (907.30 kg/ha) was recorded in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. Significant and higher seed yield was with phosphorus (50 kg/ha) might be due to better nodulation and efficient functioning of nodule bacteria for fixation of N to be utilized by plants during grain development stage in the synthesis of protein as reflected in N uptake which in turn led to increase in seed yield. Similar result was reported by Singh *et al*. (2020) [7, 31, 14]. Further, significantly higher seed yield of blackgram was increased due to cumulative effect of yield attributing characters, enhanced photosynthetic efficiency and improvement in the capacity of the reproductive sinks to utilize the incoming assimilates due to the foliar application of GA3. Similar results were observed by Dawar *et al*. (2020) [2].

Stover yield (kg/ha): Significant and higher stover yield (1890.50 kg/ha) was recorded in the treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. However, treatment 5 [Phosphorus (40 kg/ha) + GA3 (10 ppm)] was found to be statistically at par with treatment 8 [Phosphorus (50 kg/ha) + GA3 (10 ppm)]. Significant and higher seed yield was with phosphorus (50 kg/ha) which might be due to their well-developed root system and nodules allow them to utilize large amounts of nutrients, which may have improved growth and yield of blackgram, this could be the cause of the synergistic effect of phosphorus. Similar result was reported by Niraj and Prakash (2015) [8]. Further, significant and higher stover yield was with application of GA3 (10 ppm) might be due to GA3 have distinct impact on the distribution of assimilators between vegetative and reproductive organs, which may have helped in the building up of photo assimilates and their separation into the storage parts of the plant. Similar results were observed by Pasarla *et al*. (2021) [11].

Table 1: Influence of phosphorus and plant growth regulators on growth attributes of blackgram

S. No.	Treatments	Plant height (cm)	Number of nodules/plant	Dry Weight (g)
1.	Phosphorus - 30 kg/ha + NAA– 50 ppm	30.73	15.07	10.78
2.	Phosphorus - 30 kg/ha + GA3 – 10 ppm	29.77	15.27	10.37
3.	Phosphorus - 30 kg/ha + Salicylic acid – 100 ppm	30.60	14.00	10.75
4.	Phosphorus - 40 kg/ha + NAA– 50 ppm	30.80	15.00	11.36
5.	Phosphorus - 40 kg/ha + GA3 – 10 ppm	30.97	16.27	12.31
6.	Phosphorus - 40 kg/ha + Salicylic acid – 100 ppm	30.57	15.20	10.84
7.	Phosphorus - 50 kg/ha + NAA– 50 ppm	30.10	15.27	10.90
8.	Phosphorus - 50 kg/ha + GA3 – 10 ppm	32.47	16.87	12.36
9.	Phosphorus - 50 kg/ha + Salicylic acid – 100 ppm	28.70	13.27	10.78
10.	Control (RDF) 20-40-20 kg N-P-K/ha	31.60	15.13	10.49
	F – test	S	S	S
	S Em (±)	0.54	0.50	0.40
	CD (p=0.05)	1.62	1.50	1.18

Table 2: Influence of phosphorus and plant growth regulators on yield attributes and yield of blackgram

S. No.	Treatments	Number of Pods/plant	Number of Seeds /Pod	Test Weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
1.	Phosphorus - 30 kg/ha + NAA– 50 ppm	15.00	6.53	32.30	741.37	1704.63
2.	Phosphorus - 30 kg/ha + GA3 – 10 ppm	15.13	5.87	33.20	832.60	1719.37
3.	Phosphorus - 30 kg/ha + Salicylic acid – 100 ppm	15.33	5.93	32.73	818.10	1734.63
4.	Phosphorus - 40 kg/ha + NAA– 50 ppm	15.67	6.40	33.50	833.97	1711.27
5.	Phosphorus - 40 kg/ha + GA3 – 10 ppm	16.73	7.27	35.43	878.23	1808.03
6.	Phosphorus - 40 kg/ha + Salicylic acid – 100 ppm	14.53	6.13	32.60	781.20	1805.10
7.	Phosphorus - 50 kg/ha + NAA– 50 ppm	14.60	6.07	33.27	799.37	1777.73
8.	Phosphorus - 50 kg/ha + GA3 – 10 ppm	17.01	7.53	36.43	907.30	1890.50
9.	Phosphorus - 50 kg/ha + Salicylic acid – 100 ppm	14.53	6.33	32.13	832.33	1757.63
10.	Control (RDF) 20-40-20 kg N-P-K/ha	15.00	6.13	32.67	805.70	1705.87
	F – test	S	S	S	S	S
	S Em (±)	0.46	0.31	0.80	21.27	36.75
	CD (p=0.05)	0.31	0.94	2.39	63.19	109.19

Table 3: Influence of phosphorus and plant growth regulators on economics of blackgram

S. No.	Treatments	Total cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1.	Phosphorus - 30 kg/ha + NAA– 50 ppm	27834.00	66127.87	38293.87	1.38
2.	Phosphorus - 30 kg/ha + GA3 – 10 ppm	27704.00	73485.47	45781.47	1.65
3.	Phosphorus - 30 kg/ha + Salicylic acid – 100 ppm	27754.00	72386.53	44632.53	1.61
4.	Phosphorus - 40 kg/ha + NAA– 50 ppm	28334.00	76391.73	48057.73	1.70
5.	Phosphorus - 40 kg/ha + GA3 – 10 ppm	28204.00	77490.80	49286.80	1.75
6.	Phosphorus - 40 kg/ha + Salicylic acid – 100 ppm	28254.00	69716.40	41462.40	1.47
7.	Phosphorus - 50 kg/ha + NAA– 50 ppm	28834.00	71060.27	42226.27	1.46
8.	Phosphorus - 50 kg/ha + GA3 – 10 ppm	28704.00	80146.00	51442.00	1.79
9.	Phosphorus - 50 kg/ha + Salicylic acid – 100 ppm	28754.00	73617.20	44863.20	1.56
10.	Control (RDF) 20-40-20 kg N-P-K/ha	28074.00	71946.13	43872.13	1.54

Conclusion

It is concluded that in Blackgram (Treatment 8) with the combination of phosphorus (50 kg/ha) along with the GA3 (10 ppm) was observed highest grain yield and benefit cost ratio.

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