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Influence of plant growth regulators and micronutrients on yield and economic of black gram (*Vigna mungo* L.)

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Abstract
A field experiment was conducted during *Zaid* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in Randomized Block Design with Ten treatments each replicated thrice on the basis of one year experimentation. The treatments which are T_1: IAA 600 ppm + Boron 0.5%, T_2: IAA 600 ppm + $FeSO_4$ 0.5%, T_3: IAA 600 ppm + $ZnSO_4$ 0.5%, T_4: GA_3 30 ppm + Boron 0.5%, T_5 GA_3 30 ppm + $FeSO_4$ 0.5%, T_6: GA_3 30 ppm + $ZnSO_4$ 0.5%, T_7: Salicylic acid 100 ppm + Boron 0.5%, T_8: Salicylic acid 100 ppm + $FeSO_4$ 0.5%, T_9: Salicylic acid 100 ppm + $ZnSO_4$ 0.5%, T_{10}: Control are used. The results showed that application of IAA 600 ppm + Boron 0.5% (T_1) was recorded highest No. of pods/plant (63.89), No. of Seeds/pod (7.20), Test weight (35.05 g), Seed yield (1142.12 kg/ha), gross return (68527.2 INR/ha), net return (46871.35 INR/ha) and benefit cost ratio (2.16) as compared to other treatments.

Keywords: Boron, economics, $FeSO_4$, GA_3, IAA, salicylic acid, yield, $ZnSO_4$

Introduction
One of the most significant pulse crops is black gram (*Vigna Mungo* L.). Food legumes, particularly grain or pulses, are a staple in all tropical and subtropical nations, according to Ahmed *et al.*, (2009) [1]. It is grown all over India. Black gram is a commonly produced grain legume that belongs to the family "leguminoseae" and the genus "*vigna*" and plays a significant role in global food and nutritional security. Urdbean, udad dal, or urad are other names for it. It also serves as a cover crop, and its thick root system prevents erosion. By symbiotically fixing atmospheric nitrogen in root nodules, the crop also enhances soil fertility. Furthermore, urdbean green fodder is high in nutrients and is ideal for mulch cattle. Urdbean, as a leguminous plant, may fix atmospheric nitrogen and hence aid in soil fertility restoration. Black gram is cultivated across Asia and Africa. India, Bangladesh, Pakistan, Burma, and Ceylon are among the countries that grow it. It is grown throughout the country, with Madhya Pradesh, Maharashtra, Karnataka, and West Bengal being the primary producers. During the growing season, it demands warm and humid conditions. It is commonly grown as a summer and rainy season crop. Heavy, continuous rains during germination and flowering are damaging to the crop and have a negative impact on yield. Plant growth and production, including straw yield and crude protein in seeds, are influenced by micronutrients. Foliar Zn treatment modifies plant growth and production in mung bean, including straw yield and crude protein in seeds. Boron is one of the essential mineral elements for plant growth. Boron's structural role in cell wall growth, cell division, seed development, and stimulation or inhibition of certain metabolic pathways for sugar transport and hormone generation are regarded to be the most essential actions of boron in plants (Ahmad *et al.*, 2009) [1]. Boron is mostly essential for plant reproduction and pollen grain germination. Salicylic acid is a phenolic phyto hormone that has a role in plant growth and development, as well as photosynthesis, transpiration, and ion uptake and transport. Salicylic acid also affects the anatomy of leaves and the structure of chloroplasts. Salicylic acid (SA) is an endogenous phenolic plant growth hormone containing an aromatic ring and a hydroxyl group that plays an important role in plant growth, ion absorption, and transport (Hayat *et al.*, 2010) [3]. Gibberellic acid (GA_3) is a plant growth regulator that impacts plant growth and development by activating metabolic processes and controlling nitrogen use (Sure *et al.*, 2012) [13].

It also helps in seed germination, endosperm mobilisation, stem elongation, leaf expansion, maturation time reduction, and flower and fruit set, as well as their composition (Roy & Nasiruddin *et al*., 2011) [10].

Material and Methods

The experiment was carried out during *Zaid* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28ºN latitude, 81.54ºE longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of ten treatments with T_1: IAA 600 ppm + Boron 0.5%, T_2: IAA 600 ppm + $FeSO_4$ 0.5%, T_3: IAA 600 ppm + $ZnSO_4$ 0.5%, T_4: GA_3 30 ppm + Boron 0.5%, T_5 GA_3 30 ppm + $FeSO_4$ 0.5%, T_6: GA_3 30 ppm + $ZnSO_4$ 0.5%, T_7: Salicylic acid 100 ppm + Boron 0.5%, T_8: Salicylic acid 100 ppm + $FeSO_4$ 0.5%, T_9: Salicylic acid 100 ppm + $ZnSO_4$ 0.5%, T_{10}: Control were replicated thrice.

The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium available K (213.7 kg ha^{-1}). Nutrient sources were Urea, DAP, and MOP to fulfill the necessity of Nitrogen, phosphorous and potassium. The application of fertilizers were applied as basal at the time of sowing. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height, plant dry weight are recorded. The yield parameters like pods per plant, seeds per pod, length of pod (cm), test weight (1000 seeds) and seed yield (kg/ha) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Result and Discussion

A. Yield

Pods/plant: Significantly Maximum Pods/plant (63.89) was recorded with the treatment of application of IAA 600 ppm + Boron 0.5% over all the treatments. However, the treatments IAA 600 ppm + FeSO4 0.5% (63.39) and IAA 600 ppm + ZnSO4 0.5% (62.80) which were found to be statistically at par with IAA 600 ppm + Boron 0.5%.

The increase in number of Pods/plant due to the soil and foliar application of Boron and positive effect of boron may be due to key role in plant metabolism and in the synthesis of nucleic acid Tahir *et al*., (2012) [14].

Seeds/pod: Significantly highest Seeds/Pod (7.20) was recorded with the treatment of application of IAA 600 ppm + Boron 0.5% over all the treatments. However, the treatments IAA 600 ppm + FeSO4 0.5% (7.12) and IAA 600 ppm + ZnSO4 0.5% (7.04) which were found to be statistically at par with IAA 600 ppm + Boron 0.5%.

Increased pod length and number of seed per pod might be attributed due to influence of GA3 on various morpho physiological characters. The results are in agreement with findings of Jadhav *et al*., (2020) [5].

Test weight: Significantly highest Test weight (37.05 g) was recorded with the treatment application of IAA 600 ppm + Boron 0.5% over all the treatments. However, the treatments with (36.90 g) in IAA 600 ppm + FeSO4 0.5% and (36.49 g) in IAA 600 ppm + ZnSO4 0.5% which were found to be statistically at par with IAA 600 ppm + Boron 0.5%.

Number of pods per plant, seed production per plant, and test weight were all strongly influenced by plant yield attributing factors. This could be attributed to increase the availability of phosphorus and molybdenum with each successive level of micronutrient and its positive effect on growth attributes and subsequently on yield components. Combined application of P and Mo helped in translocation of photosynthesis to pods and seeds. The results were found to be in accordance with Kishore *et al*., (2020) [6].

Grain yield: Significantly highest Seed yield (1142.12 kg/ha) was recorded with the treatment application of IAA 600 ppm + Boron 0.5% over all the treatments. However, the treatments with (1099.76 kg/ha) in IAA 600 ppm + FeSO4 0.5% which were found to be statistically at par with IAA 600 ppm + Boron 0.5%.

Boron and IAA play a vital role in increasing seed yield because GA3 and boron takes place in many physiological process of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhances seed yield. Boron is a required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops. These results are in confirmatory with the work of Humtsoe *et al*., (2018) [4] and Ramesh *et al*., (2019) [9].

Harvest index: There was no significant difference among the treatments of Harvest index. However, highest harvest index (26.42%) was recorded with the application IAA 600 ppm + Boron 0.5%, whereas minimum harvest index (7.59 cm) was recorded with the treatment Control. Application of nutrient and growth regulator increased the grain yield and there by resulting increased HI values. The increased HI might be due to the increased mobilization of metabolites to reproductive sinks. Sritharan *et al*., (2015) [12].

Economics

Gross returns

Higher Gross returns have been recorded with the IAA 600 ppm + Boron 0.5% (68527.2 INR/ha) over rest of the treatments followed by IAA 600 ppm + FeSO4 0.5% (65985.6 INR/ha) whereas minimum gross return was recorded with Control (20755.85 INR/ha).

Net returns

Higher Net returns have been recorded with the treatment IAA 600 ppm + Boron 0.5% (46871.35 INR/ha) over rest of the treatments followed by IAA 600 ppm + FeSO4 0.5% (44704.75 INR/ha) whereas minimum Net returns was recorded with Control (20194.75 INR/ha).

Benefit cost ratio

Higher Benefit cost ratio have been recorded with the treatment IAA 600 ppm + Boron 0.5% (2.16) over rest of the treatments followed by IAA 600 ppm + FeSO4 0.5% (2.10) whereas lower Benefit cost ratio was recorded with Control (0.97). Some of the earlier study also reported that foliar spray of DAP, NAA and micronutrients significantly improved seed yield of green gram and highest benefit cost ratio. Marimuthu *et al*., (2015) [8].

Table 1: Influence of plant growth regulators and micronutrients on yield attributes of black gram.

	Treatments	No. of Pods/Plant	No. of Seeds/Pod	Test Weight (g)	Seed Yield (kg/ha)	Harvest Index (%)
1.	IAA 600 ppm + Boron 0.5%	63.89	7.20	37.05	1142.12	24.26
2.	IAA 600 ppm + FeSO4 0.5%	63.39	7.12	36.90	1099.76	26.09
3.	IAA 600 ppm + ZnSO4 0.5%	62.80	7.04	36.49	1017.21	26.42
4.	GA3 30 ppm + Boron 0.5%	61.73	6.90	35.74	983.16	25.88
5.	GA3 30 ppm + FeSO4 0.5%	61.29	6.84	35.14	928.26	25.25
6.	GA3 30 ppm + ZnSO4 0.5%	60.83	6.77	34.84	869.17	24.33
7.	Salicylic acid 100 ppm + Boron 0.5%	60.41	6.68	34.29	809.02	22.93
8.	Salicylic acid 100 ppm + FeSO4 0.5%	59.89	6.52	34.00	789.52	23.13
9.	Salicylic acid 100 ppm + ZnSO4 0.5%	58.98	6.38	33.42	755.09	22.26
10.	10. Control	56.91	6.07	32.56	682.51	21.43
S. EM (±)		0.37	0.06	0.19	30.76	1.16
CD (P = 0.05)		1.11	0.17	0.58	91.38	-

Table 2: Influence of plant growth regulators and micronutrients on economics of black gram

	Treatments	Cost of cultivation	Gross returns	Net returns	B:C Ratio
1.	IAA 600 ppm + Boron 0.5%	21655.85	68527.2	46871.35	2.16
2.	IAA 600 ppm + FeSO4 0.5%	21280.85	65985.6	44704.75	2.10
3.	IAA 600 ppm + ZnSO4 0.5%	21227.85	61032.6	39751.75	1.86
4.	GA3 30 ppm + Boron 0.5%	21655.85	58989.6	37333.75	1.72
5.	GA3 30 ppm + FeSO4 0.5%	21280.85	55695.6	34414.75	1.61
6.	GA3 30 ppm + ZnSO4 0.5%	21227.85	52150.2	30922.35	1.45
7.	Salicylic acid 100 ppm + Boron 0.5%	21655.85	48541.2	26885.35	1.24
8.	Salicylic acid 100 ppm + FeSO4 0.5%	21280.85	47371.2	26090.35	1.22
9.	Salicylic acid 100 ppm + ZnSO4 0.5%	21227.85	45305.4	24077.55	1.13
10.	Control	20755.85	40950.6	20194.75	0.97

Conclusion

It is concluded that application of treatment IAA 600 ppm + Boron 0.5% was recorded significantly higher Seed yield (1142.12 kg/ha), higher gross returns (68527.2 INR/ha), net returns (46871.35 INR/ha) and benefit cost ratio (2.16) as compared to other treatments. Since, the findings based on the research done in one season.

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