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Effect of salicylic acid and gibberellic acid on morpho-physiological traits and yield performance of black gram (*Vigna mungo* L.)

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Abstract
At Research farm of Agricultural Botany section, College of Agriculture, Nagpur a field experiment was conducted during *Kharif* 2022. The experiment was carried out in RBD with three replication which constitute of ten number of treatments. The treatments were composed of foliar spray of two plant growth regulators of different concentrations *viz.*, Gibberellic acid (50 ppm, 100 ppm, 150 ppm and 200 ppm) and Salicylic acid (50 ppm, 100 ppm, 150 ppm and 200 ppm) along with untreated control and spraying was done at 25 DAS. Foliar application of salicylic acid and gibberellic acid sprayed at 25 DAS revealed the result that significantly improved growth parameters like plant height, number of branches plant^{-1}, days to 50 percent flowering, total dry weight, leaf area and yield parameters like number of pods plant^{-1}, test weight, seed yield ha^{-1}, harvest index and B:C ratio. Treatment T_6 (Gibberellic acid @ 200 ppm) gave significantly higher results in plant height, total dry weight and leaf area and T_5 (Gibberellic acid @ 150 ppm) in number of branches plant^{-1} and days to 50 percent flowering. Treatment T_9 (Salicylic acid @ 150 ppm) shows significantly higher results in all parameters of yield.

Keywords: ppm, salicylic acid, gibberellic acid, biochemical parameters, yield contributing parameters, growth regulators

Introduction
Black gram (*Vigna mungo* L. Hepper) is one of the most important pulse crop grown throughout India due to its nutritional value. It having chromosomes number 2n = 24 and belongs to the family "Leguminosae" and sub-family "Papilionaceae". Traditionally during *Kharif* it grown in India, but also grown as *Rabi* crop in south. (Gaikwad *et al.* 2022) [2]. It consists of different nutrients, which includes protein about (25-26%), carbohydrate (60%), fat (1.5%), minerals, amino acids and vitamins. vitamin A, B1, B3 and has small amount of thiamine, riboflavin, niacin and vitamin C are also present in black gram. It contains nitrogen in the form of albumin and globulin about 78% to 80%. Higher amount of phosphorous is present in dry seed. (Anonymous, 2020) [1].

The productivity of black gram is unable to fulfill the domestic demand of the fast-growing Indian population. Hence, there is an urgent need for improving its productivity (Jadhav *et al.*, 2020) [7]. When quick supply of nutrient is hindered or the soil condition is not conductive for the absorption of nutrient at this situation to complete the requirement of nutrient foliar application is regarded a preferred solution (Salisbury and Ross 1985) [17].

Salicylic acid affect the plant growth and development, photosynthesis, transpiration, ion uptake and transport. Salicylic acid is a phenolic phytohormone which also induces specific changes in leaf anatomy and chloroplast structure (Hayat *et al.* 2010) [5]. The abiotic as well as biotic stress tolerance increases in the plants induced by application of salicylic acid. The positive impacts on the productivity as well as the nutritional value of black gram get through manipulating the levels of salicylic acid in plant through its exogenous application. (Hasan and Rasul, 2022) [4].

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) [20]. 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 (Roy and Nasiruddin 2011) [16]. GA_3 delays senescence, improves growth and chloroplasts development, and intensifies photosynthetic efficiency which could lead to

increased yield (Yuan and Xu 2001) [23].

Material and Methods

In the *Kharif* 2022 a field experiment was conducted at Research farm of Agricultural Botany section, College of Agriculture, Nagpur to assess the effect of foliar sprays of Salicylic acid and Gibberellic acid on growth parameter and yield performance of black gram. The experiment was laid out in RBD with three replications include ten treatments i. e. T_1 (control), T_2 (Water spray), T_3 (Gibberellic acid @ 50 ppm), T_4 (Gibberellic acid @ 100 ppm), T_5 (Gibberellic acid @ 150 ppm), T_6 (Gibberellic acid @ 200 ppm), T_7 (Salicylic acid @ 50 ppm), T_8 (Salicylic acid @ 100 ppm), T_9 (Salicylic acid @ 150 ppm), T_{10} (Salicylic acid @ 200 ppm). At 25 DAS the foliar application of salicylic acid and gibberellic acid was given on black gram. The observations for morpho-physiological trait like plant height, number of branches plant^{-1}, total dry weight plant^{-1} and leaf area plant^{-1} were recorded at 30, 50 and 70 DAS. Whereas, days to 50 percent flowering was also recorded and yield attributing parameters *viz.* number of pod plant$^{-1,}$ seed yield ha^{-1}, test weight and harvest index were recorded at the time of harvest. Also calculate the B:C ratio. Statistical method suggested by Panse and Sukhatme (1954) [10] were utilized for analysis of data.

Results and Discussion

Plant height

The plant height was recorded at successive stages of crop growth i.e., 30, 50 and 70 DAS. The data regarding plant height represent in Table 1.

The plant height observed with maximum value (25.69, 47.32 and 49.29 cm) with foliar application of T_6 (Gibberellic acid @ 200 ppm) which was superior over all remaining treatments and control which recorded minimum height (18.07, 34.58 and 37.82 cm) at 30, 50 and 70 DAS. Similar results are obtained by Tasnim *et al.* (2019) [21] reported that with 200 ppm of GA_3 foliar application at 30 DAS produced the tallest plant and maximum number of branches plant^{-1}. At 200 ppm of GA_3 application only increased vegetative growth in mung. Giri *et al.* (2018) [3] reported that application of salicylic acid and gibberellic acid through foliar sprays increased plant height. Gibberellic acid shows beneficial effect on cell elongation and cell division, increase in photosynthetic activity and better food accumulation. The results of the present investigation are also similar to the observations recorded by Islam *et al*. (2023) [6] who obtained the results on growth attributing characters such as plant height were recorded significantly higher with application of GA_3 200 ppm. Similarly Rawat *et al.* (2023) [14] who concluded that the in black gram the foliar application of salicylic acid @ 150 ppm significantly increases plant height.

Number of branches plant $^{-1}$

At the growth stages 30, 50 and 70 DAS, data regarding number of branches per plant was recorded and represent in the Table 1.

The maximum number of branches plant^{-1} was observed 6.97 at 30 DAS and 19.33 at 50 and 70 DAS in treatment T_5 (Gibberellic acid @ 150 ppm) over rest of treatments and control. Similar results are obtained to Jadhav *et al*. (2020) [7] who reported that the maximum number of branches with foliar application of GA_3 recorded which might be due to the GA_3 role in enhancing growth and cell division. Sharma *et al.* (2023) [18] reported that the accumulation of auxin and cytokinin which consequently increases the mitotic index of the apical meristems with the application of salicylic acid. The enhancement in mitotic activity subsequently leads to enhanced growth character like plant height, no of branches etc. in french bean. The present investigation are also close to the observations of Tasnim *et al*. (2019) [21] who obtained the results on growth attributing characters such as number of branches plant^{-1} recorded significantly higher with application of GA_3 200 ppm. Rawat *et al.* (2023) [14] who reported that application of salicylic acid 150 ppm to the black gram significantly increased the number of branches plant^{-1}.

Days to 50 percent flowering

The range of days to 50 percent flowering was recorded 33.67-41.33 days (Table 1). Flowering was significantly earlier in treatment T_5 (Gibberellic acid @ 150 ppm) than the T_1 (control) and rest of the treatments. Watanabe *et al*. (1981) [22] reported that the application of salicylic acid reduces the days taken to 50 percent flowering because it enhanced the floral bud emergence by 2-5 days due to its florigenic role. It promotes the movement of solutes to the growing buds which results in better development of the buds and precocious flowering. Similarly, Sharma *et al*. (2023) [18] studied and reported that enhancement in days to 50 percent flowering by the foliar application of salicylic acid treatment. However, the present results are similar with Jadhav *et al*. (2020) [7] who reported that foliar application of GA_3 registered 40.44 days to 50% flowering which is earlier in comparison to control (43.71 days). Induction of early flowering might be due to attainment of phenological stages early in the ontogeny of the crop and also leading to acceleration in growth. Katkar *et al*. (2003) [8] reported that plants sprayed with GA_3 @ 200 ppm recorded minimum number of days to first flower bud emergence (56.26) and days to 50 percent flowering (80.46) in china aster (*Callistephus chinensis*).

Total dry weight plant^{-1} (g)

The observations were taken at. 30, 50 DAS and 70 DAS and recorded data regarding total dry weight per plant (Table 1).

The maximum total dry weight plant^{-1} was observed (6.13, 18.12 and 27.52 g) in treatment T_6 (Gibberellic acid @ 200 ppm), it was found superior over treatment T_1 (control) and remaining treatments.

Similar results obtained by the Pasarla *et al.* (2021) [11] who reported that effect of foliar application of plant growth regulators namely Salicylic acid (100 and 150 ppm) and GA_3 (50 and 100 ppm). Among the different treatments, treatment (GA_3 100 ppm foliar spray at 35 DAS) maximum plant dry weight (6.24 g) in mung bean. Rawat *et al.* (2023) [14] who reported that spraying Salicylic acid @ 150 ppm showed significant increase on dry weight plant^{-1}.

Table 1: Effect of salicylic acid and gibberellic acid on growth character of black gram

Treatments	Plant height (cm)			Number of branches plant^{-1}			Days to 50% Flowering	Total dry weight plant^{-1} (g)			Leaf area plant^{-1}		
	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS		30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS
T_1 (Control)	18.07	34.58	37.82	4.60	8.87	8.87	41.33	3.67	13.13	18.48	2.45	9.78	8.61
T_2 (Water Spray)	18.98	37.12	39.14	5.07	11.17	11.17	40.33	4.05	14.02	18.53	2.74	10.71	9.06
T_3 (Gibberellic acid @ 50 ppm)	20.65	40.27	42.28	5.77	14.27	14.27	38.33	4.41	15.13	22.56	3.15	11.43	10.47
T_4 (Gibberellic acid @ 100 ppm)	22.26	42.32	45.74	6.40	16.59	16.59	36.33	4.97	17.14	23.55	3.33	12.62	11.43
T_5 (Gibberellic acid @ 150 ppm)	23.88	44.48	46.11	6.97	19.33	19.33	33.67	5.96	18.07	24.10	4.24	13.87	11.81
T_6 (Gibberellic acid @ 200 ppm)	25.69	47.32	49.29	6.67	17.63	17.63	35.00	6.13	18.12	27.52	4.26	14.12	12.20
T_7 (Salicylic acid @ 50 ppm)	20.24	38.31	41.05	5.73	12.58	12.58	38.67	4.10	14.90	21.20	3.14	10.63	9.00
T_8 (Salicylic acid @ 100 ppm)	21.89	40.33	44.53	6.19	15.36	15.36	36.67	4.81	16.16	23.70	3.71	11.53	9.67
T_9 (Salicylic acid @ 150 ppm)	23.54	45.01	46.34	6.20	17.95	17.95	36.67	4.97	17.80	25.08	4.01	12.76	11.25
T_{10} (Salicylic acid @ 200 ppm)	22.35	42.67	44.62	5.67	17.18	17.18	35.67	5.10	17.00	26.59	3.79	13.12	11.70
SE (m) ±	1.39	2.46	2.24	0.35	0.88	0.88	0.52	0.31	0.82	1.41	0.23	0.77	0.71
CD at 5%	4.14	7.30	6.65	1.03	2.60	2.60	1.55	0.93	2.44	4.18	0.70	2.30	2.12

Leaf area plant^{-1}

Leaf area per plant was recorded at successive stages of crop growth i.e. 30, 50 DAS and 70 DAS and data regarding about it represent in Table 1. Significant variation were obtained with gradual increase (30, 50 and 70 DAS) was noticed regarding leaf area at all the stages of observations. The maximum leaf area plant^{-1} (4.26, 14.12 and 12.12 dm$^{2)}$ was observed in treatment T_6 (Gibberellic acid @ 200 ppm) was found superior to increase leaf area plant^{-1} when compared with treatment T_1 (control) and remaining of the treatments. Data revealed that leaf area increased from 30 to 50 DAS. Due to leaf fall at this stage 70 DAS the leaf area decreased. Similarly, Rahman *et al*. (2018) [13] reported that GA_3 100 ppm in mung bean attained a maximum leaf area than control and rest of the treatment of gibberellic acid. Rawat *et al*. (2023) [14] reported that the application of Salicylic acid @ 150 ppm significantly increased leaf area of plant in black gram. Hasan and Rasul (2022) [4] reported that application of salicylic acid 150 ppm to the green gram significantly increased the leaf area.

Number of pod plant^{-1}

At the time of harvest total number of pods plant^{-1} was observed in the range of 27.91-49.26. Significantly highest number of pods was found in T_9 (Salicylic acid @ 150 ppm). (Table 2).

According to results of Pasarla *et al*. (2021) [11] provided that significantly higher number of pods per plant was observed with the application of 150 ppm GA_3 in green gram. The findings of the present investigation are also close to the observations provided by Islam *et al*. (2023) [6] who obtained the results on Yield attributing characters such as number of pods per plant were recorded significantly higher with application GA_3 200 ppm. Rawat *et al*. (2023) [14] who observed that the use of Salicylic acid 150 ppm in increase in number of pods plant^{-1} in black gram.

Seed yield plant^{-1} (g), Plot^{-1} (kg) and ha^{-1} (q)

Seed yield consider as the economic yield which is final results of physiological activities of plant. The part of biomass that is converted into economic product is called economic yield (Nichiporovic, 1960) [9]. Significantly maximum seed yield plant^{-1}, plot^{-1} and hectare^{-1} were recorded in treatment T_9 (Salicylic acid @ 150 ppm). The range of increase in seed yield plant^{-1}, plot^{-1} and hectare^{-1} was 4.78 g,0.54 kg and 11.99 q in treatment T_1 (control) and 5.54 g, 0.64 kg and 14.22 q in treatment T_9 (Salicylic acid @ 150 ppm) respectively (Table 2).

Table 2: Effect of salicylic acid and gibberellic acid on yield parameter of black gram

Treatments	Number of pods plant^{-1}	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (kg)	Seed yield ha^{-1} (q)	Test weight (g)	Harvest index (%)	B:C ratio
T_1 (Control)	27.91	4.78	0.54	11.99	4.05	29.96	1.98
T_2 (Water Spray)	28.23	4.85	0.55	12.22	4.07	30.56	1.99
T_3 (Gibberellic acid @ 50 ppm)	34.66	4.89	0.58	12.88	4.28	32.45	2.16
T_4 (Gibberellic acid @ 100 ppm)	39.49	5.09	0.62	13.77	4.49	35.81	2.27
T_5 (Gibberellic acid @ 150 ppm)	46.84	5.48	0.63	13.99	5.02	37.20	2.54
T_6 (Gibberellic acid @ 200 ppm)	44.61	5.21	0.59	13.10	4.65	36.31	2.40
T_7 (Salicylic acid @ 50 ppm)	36.18	4.99	0.57	12.66	4.38	34.43	2.21
T_8 (Salicylic acid @ 100 ppm)	42.76	5.21	0.61	13.55	4.54	36.12	2.38
T_9 (Salicylic acid @ 150 ppm)	49.26	5.54	0.64	14.22	5.23	39.14	2.64
T_{10} (Salicylic acid @ 200 ppm)	44.80	5.29	0.62	13.77	4.78	37.64	2.47
SE (m) ±	1.61	0.14	0.02	0.40	0.19	1.31	-
CD at 5%	4.77	0.43	0.05	1.19	0.56	3.89	-

Similar results obtained to Reddy and Singh (2021) [15] who reported that the significantly higher seed yield was observed with the application of 150 ppm salicylic acid. The application of salicylic acid has a positive effect in ameliorating the oxidative changes in plant and increase the grain yield in green gram.

Pasarla *et al*. (2021) [11] who reported that the highest seed yield was obtained in the treatments where the crop was sprayed with GA_3 100 ppm in green gram. Hasan and Rasul (2022) [4] reported that the maximum seed yield ha^{-1} was

observed at Salicylic acid 150 ppm in green gram than any other treatment.

Test weight

The data regarding test weight was recorded after harvest in the range of 4.05-5.23 g. Significantly T_9 (Salicylic acid @ 150 ppm) showed highest test weight. (Table 2)

Similar result was also reported by Prakash *et al.* (2019) [12] that spraying Salicylic acid 100 ppm showed significant increase on 1000 seed weight in green gram followed by GA_3 100 ppm. The result are in accordance with, Reddy and Singh (2021) [15] who reported that the higher test weight was observed at 150 ppm Salicylic acid in green gram than any other treatment. Islam *et al*. (2023) [6] who obtained the results on yield characters such as test weight were recorded significantly higher with application GA_3 200 ppm.Similarly, Hasan and Rasul (2022) [4] reported that the higher test weight was observed at Salicylic acid 150 ppm in green gram than any other treatment.

Harvest Index

Harvest index obtained in the range was 29.96. in control to 39.14 in treatment receiving Salicylic acid @ 150 ppm. Among all treatments under study significantly more harvest index was exhibited in treatment T_9 (Salicylic acid @ 150 ppm). (Table 2)

The significant effect of GA_3 100 ppm to increase in harvest index of mung bean was confirmed by Pasarla *et al.* (2021) [11]. Rawat *et al.* (2023) [14] reported that the spraying of Salicylic acid 150 ppm provided maximum harvest index in black gram. It is due to uptake of nutrients get increased by effective translocation from sink to reproductive area of crop. It was inferred that application of salicylic acid. Islam *et al.* (2023) [6] who reported the results that highest harvest index were recorded significantly with application GA_3 200 ppm. Similarly, Hasan and Rasul (2023) [4] reported that the higher harvest index was observed at Salicylic acid 150 ppm in green gram than any other treatment.

Benefit cost ratio

Higher Benefit cost ratio have been observed with the treatment T_9 (Salicylic acid @ 150 ppm) over rest of the treatments followed by T_{10} (Salicylic acid @ 200 ppm) and Control (0.97) recorded lower Benefit cost ratio. (Table 2)

Conclusion

Application of Gibberellic acid @ 200 ppm at 25 DAS significantly increases growth characters like plant height, total dry weight and leaf area and foliar spray with Gibberellic acid @ 150 ppm shows result in number of branches per plant and shows minimum days to 50% flowering. The treatment with Salicylic acid @ 150 ppm shows highest result in yield parameters. The application of plant growth regulators helps to overcome the specific occurrence of stress and as a result of maximum vegetative growth due to optimized nutrition of the plant.

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