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Response of Different Levels of Salicylic Acid on Growth Characteristics, Chlorophyll Content, Yield Attributes and Yield of Black Gram (*Vigna mungo* L.) under Rainfed Condition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To study the response of different levels of salicylic acid on growth characteristics, chlorophyll intensity, yields attributes and yield of black gram (*Vigna mungo* L.) under rainfed conditions. The field experiment was conducted at Department of Crop Physiology, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India during *kharif* season in the year 2017-18. The experiment was laid out in Randomized Block Design (RBD) with 10 Treatments replicated thrice and assigned in 30 plots. The treatment comprised as T1: Control, T2: Foliar application of salicylic acid @ 50 ppm at 20 DAS, T3: Foliar application of salicylic acid @ 50 ppm at 40 DAS, T4: Foliar application of salicylic acid @ 50 ppm at 60 DAS, T5: Foliar application of salicylic acid @ 100 ppm at 20 DAS, T6: Foliar application of salicylic acid @ 100 ppm at 40 DAS, T7: Foliar application of salicylic acid @ 100 ppm at 60 DAS, T8: Foliar application of salicylic acid @ 150 ppm at 20 DAS, T9: Foliar application of salicylic acid @ 150 ppm at 40 DAS, T10: Foliar application of salicylic acid @ 150 ppm at 60 DAS. The results showed significant increments in Growth attributes, relative water content (%), chlorophyll intensity (SPAD meter value), yield and yield attributes viz., plant height (36.50 and 38.10 cm) at 70 DAS and maturity, number of leaves plant^{-1}(8.66, 23.66 and 22.0) at 35, 70 DAS and maturity, number of branches plant^{-1} (3.9, 8.60 and 10.33) at 35, 70 DAS and maturity, dry weight of plant^{-1}(2.76, 6.12 and 5.01 g) at 35, 70 DAS and maturity, dry weight of stem plant^{-1}(2.76, 7.12 and 7.96 g) at 35, 70 DAS and maturity, total dry weight of plant (4.96, 13.24 and 21.97 g) at 35, 70 DAS and maturity, total leaf area plant^{-1} (211.33 and 384.87 cm^{-2}) at pre and post flowering, Relative water content (51.50 and 43.43) at Pre and post flowering, Chlorophyll content (49.93 and 40.90) at pre and post flowering, Number of pods plant^{-1} (46.00) at maturity, Dry weight of pods plant^{-1} (8.99g) at maturity, seed yield plant^{-1} (6.66 g), 100-Seed weight (4.41 g), Harvesting index (30.30%), Grain Yield (10.35 q ha^{-1}) with the foliar application of salicylic acid @ 150 ppm at 60 DAS while minimum in control. The addition of salicylic acid under rainfed conditions resulted in significant increments in growth parameters, chlorophyll intensity, yield and yield attributes of black gram in rainfed conditions. Thus, it may be concluded that the foliar application of salicylic acid @ 150 ppm was found to be optimum concentration in enhancing growth and yield of a black gram over rest of treatment under rainfed conditions.

Keywords: Black gram; urd bean; salicylic acid; rainfed; growth; yield and chlorophyll intensity.

1. INTRODUCTION

"Black gram belongs to the family Fabaceae, sub-family Papilionaceae and the genus Vigna" [1]. "Only seven species of the genus Vigna are cultivated as pulse crops, five Asian species of sub genus Ceratotropis, *Vigna mungo* (urd bean), *Vigna radiata* (mung bean), *V. aconitifolia (moth bean), V. angularis (azuki bean)* and *V. umbellata* (rice bean) and two African species of subgenus Vigna, i.e., *Vigna unguiculata* (cowpea) and *V. subterranean* bambara groundnut" [2]. "Blackgram (*Vigna mungo L. Hepper*) is a member of the Asian Vigna crop group. It is a staple crop in central and South East Asia; however it is extensively used only in India and now grown in the Southern United States, West Indies, Japan and other tropics and subtropics" [3]. "Blackgram is native to India and the progenitor of blackgram is believed to be *Vigna mungo* var. silvestris, which grows wild in India" [4]. "There is a mention of blackgram in Vedic texts such as Kautilya's "Arthashasthra" and "Charak Samhita". The ancient Sanskrit name of blackgram was masha. Even today in Punjab, blackgram is called mash and in West Bengal it is called mash kalaya. In all other Indian languages, the name urd and urdbean is used, which seems to have originated from the Tamil word ulundu. *Vigna mungo* is the Latin name of black gram" [5]. "Urdbean is one of the most highly prized pulse crop, cultivated in almost all parts of India. It has inevitably marked itself as the most popular pulse and can be most appropriately referred to as the "king of the pulses" due to its mouthwatering taste and numerous other nutritional qualities. Whether it be the very special "Dal makhni" of Punjab or the "Vada Sambhar" of South India, the taste rules the hearts of one and all alike. Indian immigrants have popularized the taste worldwide as well" [6]. "In Japan, health conscious people eat these seeds by soaking them in water over night and then serving them as fresh bean sprout salad which is highly nutritious. Black gram is a perfect combination of all nutrients, which includes proteins (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins" [7].

"It stands next to soybean in its dietary protein content. It is rich in vitamin A, B_1, B_3 and has small amount of thiamine, riboflavin, niacin and vitamin C in it. It Introduction 2 contains 78% to 80% nitrogen in the form of albumin and globulin. The dry seeds are good source of phosphorus. It also has very high calorie content; 100g of blackgram has 347 calories. Therefore, black gram is the cheapest available source of protein for the poor and vegetarians" [8]. "The biological value improves greatly, when wheat or rice is combined with black gram because of the complementary relationship of the essential amino acids such as lysine and sulfur containing amino acids methionine and cysteine. In addition, being an important source of human food, it is also used as nutritive fodder, especially for milch animals. Black gram also has medicinal properties, like curing diabetes, sexual dysfunction, nervous disorder, hair disorders, digestive system disorders and rheumatic afflictions. It is valued for its high digestibility and freedom from the flatulence effect" [9]. "Being a proper leguminous crop, it is itself a mini-fertilizer factory, as it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen in symbiotic association with Rhizobium bacteria, present in the root nodules" [10]. It proves to be a great rotation crop enhancing the yield of the main crop as well. It is mainly cultivated in a cereal-pulse cropping system primarily to conserve soil nutrients and utilize the left over soil moisture particularly after rice cultivation. It is short duration pulse crop usually flowering within 30-60 days of sowing and maturing within 60-90 days. It is generally cultivated as *kharif* crop but also does well in the summer season as a catch crop. Black gram is an annual trailing or erect plant with a height of 30-90 cm and profuse branching. The stem is slightly ridged and covered with brown hairs. The leaves are large, trifoliate and hairy generally with a purplish tinge. The flowers are axillary, racemose, complete, self-pollinated and yellow in color. The inflorescence consists of a cluster of 5-6 flowers at the top of the long hairy peduncle. Pods are short, erect to suberect, 4-6 cm long, brown to black in color and hairy containing about 6- 10 seeds. The seeds are generally black or dark brown with smooth seed coats and protruding hilum India is the major pulse growing country of the world, accounting roughly for one third of the total world area under pulses and one-fourth of the total world production. Pulse crops, also called grain legumes have been values as food, fodder and feed and have remained as a mainstay of Indian agriculture for centuries. "Even though India has successfully achieved food security, nutritional security continues to be causes for concern. In spite of the variable uses of pulses in our diet and their importance in improving soil health by way of fixing atmospheric nitrogen the increments in production are not able to maintain the place with population growth" [11].

"Pulses are a wonderful gift of nature with the unique ability of biological nitrogen fixation, deep root system, mobilization of insoluble soil nutrients and bringing qualitative changes in soil properties - which make them known as soil fertility restores" [12]. Black gram is one of the most important pulse crops of rainfed areas grown thought the country. This crop is grown in different cropping system as a mixed crop, catch crop and sequential crop in the country. In India black gram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, U.P., West Bengal, Punjab, Haryana, and Karnataka. It is used as nutritive fodder especially for milch cattle and also used as a green manuring crop. In India total black gram production was estimated at 14.76 million tonnes from 23.63 million hectare area with productivity of 642 kg ha^{-1}. "Under the slogan 'nutritious seeds for a sustainable future,' the United Nations, led by its Food and Agriculture Organization (FAO), today launched the 2016 International Year of Pulses to raise awareness about the protein power and health benefits of all kinds of dried beans and peas, boost their production and trade, and encourage new and smarter uses throughout the food chain" [13]. "Grain legumes occupy a unique position in Indian agriculture as they provide vegetable protein for human diet, pulse is also important in our agriculture system because of their nitrogen fixing ability about 40% of the total nitrogen in the world is added by the leguminous plants" [14]. They can also suit dry farming conditions because of their ability to trap moisture from deep layers of the soil by virtue of their deep penetrating root system.

"The main reason of the low productivity of the green gram is cultivation on marginal and sub-marginal lands with no use of recommended dose of fertilizers" [15]. "Flowering is important parameter that is directly related to yield and productivity of plants. Salicylic acid has been reported to induce flowering in a number of plants. Different plant species including the ornamental plant *Sinningia speciosa* flowered much earlier as compared to the untreated

control, when they received an exogenous foliar spray B of salicylic acid" [16]. "Foliar sprays of salicylic acid in green gram increase seed yield per plant" [17]. "In addition application of salicylic acid at a 100 ppm concentration increase number of pods per plant, number of seeds/pod, seed weight of plant, and seed yield/ha" [18]. Rathinavelu et al. [19] reported that "the application of 125 ppm salicylic acid to black gram plants increases seed yield". "Plant growth regulators are one of the most important factors for increasing higher yield in leafy vegetables. The application of growth regulators has a good management effect on growth and yield of field crops. Hormones regulate the physiological processes and synthetic growth regulators may enhance growth and development of field crops there by increased total dry mass of a field crop" [20]. "These plant growth regulators (PGRs) in general, help to increase the number of flowers on the plant when applied at the time of flowering. The flower and pod drop may be reduced to some extent by spraying various growth regulators on foliage" [21]. "The foliar application of PGRs and urea significantly increased seed yield per plant" [22]. The objectives of the experiments were to study the effects of different foliar applications of Salicylic acid on physiological growth of black gram, to study the effect of foliar application of salicylic acid on yield and yield attributes of black gram and to find out the suitable foliar application of salicylic acid for increasing productivity of black gram.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted in department of crop physiology, during *Rab*i season 2017-18 in the department of Crop physiology, C. S. Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh (Fig. 1).

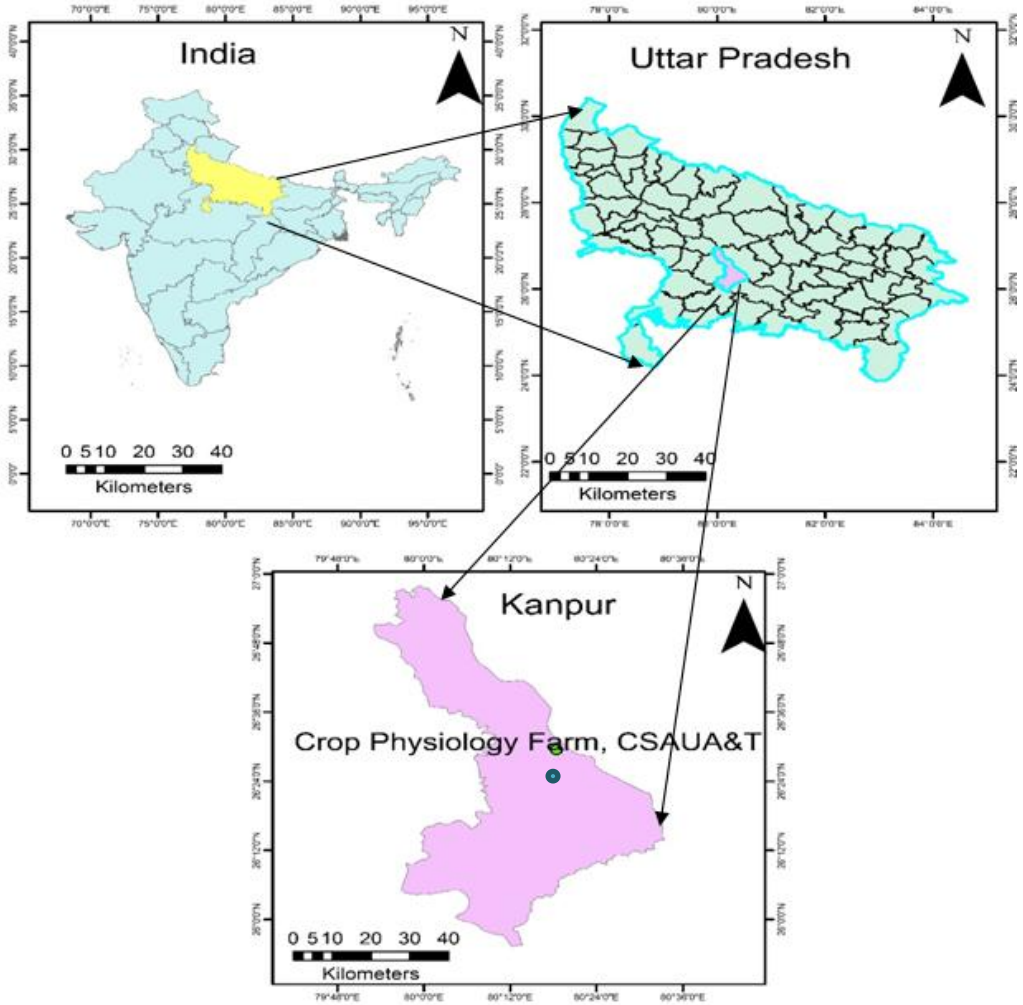

Fig. 1. Location map of the study area

2.2 Climatic Conditions

Geographically, Kanpur is situated in the Central Pain Zone of Uttar Pradesh and subtropical tract of North India between latitudes ranging from 25° 56' to 28° 58' North and longitude 79° 31' to 80° 34' East and is located at an elevation of about 125.9 meters above mean sea level in gangetic plain region. The seasonal rainfall of about 816 mm was received mostly from second Fortnight of June or the first Fortnight of July to mid-October with a few showers in the winter season.

2.3 Experimental Details

The experiment was laid out in Randomized Block Design (RBD) with 10 Treatments replicated thrice and assigned to 30 plots. The treatment comprised T1: Control, T2: Foliar application of salicylic acid @ 50 ppm at 20 DAS (day after sowing), T3: Foliar application of salicylic acid @ 50 ppm at 40 DAS, T4: Foliar application of salicylic acid @ 50 ppm at 60 DAS, T5: Foliar application of salicylic acid @ 100 ppm at 20 DAS, T6: Foliar application of salicylic acid @ 100 ppm at 40 DAS, T7: Foliar application of salicylic acid @ 100 ppm at 60 DAS, T8: Foliar application of salicylic acid @ 150 ppm at 20 DAS, T9: Foliar application of salicylic acid @ 150 ppm at 40 DAS, T10: Foliar application of salicylic acid @ 150 ppm at 60 DAS.

2.4 Fertilization

The experimental field was ploughed once with a soil turning plough and two ploughings with cultivator followed by planking for uniform level field. Basal application of 20 N, 60 P_2O_5 and 20 K_2O Kg ha^{-1} were applied uniformly in the form of urea, DAP and Muriate of potash. The 100% recommended dose of fertilizer (20:60:20 kg NPK ha^{-1}) was applied to the entire plot before sowing. The salicylic acid @ 50, 100 and 150 ppm were sprayed at 20, 40 and 60 days after sowing.

2.5 Seed and Sowing

The Black gram seeds variety Azad urd-3 selected for this study was released from Chandra shekhar Azad University of Agriculture & Technology (U.P.) Kanpur, was sown in well manure field with a spacing of 40×10 cm, depth 5-8 cm below and a plot size of 6 × 4 m.

2.6 Observations Recorded

The observed parameters growth, chlorophyll intensity and yield were characterized as plant height (cm) at 35, 70 DAS and maturity, number of leaves $plant^{-1}$ at 35, 70 DAS and maturity, number of branches $plant^{-1}$ at 35, 70 DAS and maturity, dry weight of leaves $plant^{-1}$ at 35, 70 DAS and maturity, dry weight of stem $plant^{-1}$ at 35, 70 DAS and maturity, total dry weight of plant at 35, 70 DAS and maturity, total leaf area $plant^{-1}$ at pre and post flowering, Relative water content (%) at Pre and post flowering, Chlorophyll intensity (SPAD meter value) at pre and post flowering, Number of pods $plant^{-1}$ at maturity, Dry weight of pods $plant^{-1}$ at maturity, Gran yield (g $plant^{-1}$), 100-Seed weight (g), Harvesting index (%), Grain Yield (q ha^{-1}) had to be determined. Data obtained was exposed to the proper method for statistical analysis of variance difference among mean of different treatments as described by Gomez and Gomez [23]. The treatments means were compared using the Least Significant Differences (LSD) test at a 5% level of probability by using the Randomized Block Design (RBD) model as obtained by SPSS (Statistical Product and Service Solutions) Version 10.0, SPSS, Chicago and IL software.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The perusal of the data reveals that Growth attributes (Table 1) of black gram were observed significantly better with the application of different levels of salicylic acid at different stages under rainfed conditions. The Growth attributes *viz*., plant height (36.50 and 38.10 cm) at 70 DAS and maturity, number of leaves $plant^{-1}$(8.66, 23.66 and 22.0) at 35, 70 DAS and maturity, number of branches $plant^{-1}$ (3.9, 8.60 and 10.33) at 35, 70 DAS and maturity, dry weight of $plant^{-1}$(2.76, 6.12 and 5.01g) at 35, 70 DAS and maturity, dry weight of stem $plant^{-1}$(2.76, 7.12 and 7.96 g) at 35, 70 DAS and maturity, total dry weight of plant (4.96, 13.24 and 21.97 g) at 35, 70 DAS and maturity, total leaf area $plant^{-1}$ (211.33 and 384.87 cm^{-2}) at pre and post flowering were found to be maximum by the foliar application of salicylic acid @ 150 ppm at 60 DAS while minimum in control. Application of salicylic acid under rainfed condition proved to be effective in enhancement of plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, dry weight of $plant^{-1}$, total leaf area $plant^{-1}$,etc. over control. Foliar application of BR and SA might have enhanced the CO_2 fixation, induced activity of carbohydrate synthesizing enzymes coupled with effective partitioning of dry matters into the

reproductive sink as reported earlier (Bera, Maity, & Maumdar, 2008). The significant increase in growth characteristics of black gram might be due to the application of salicylic acid and growth regulator foliar spray which play a major role in growth development and metabolism of black gram under rainfed conditions (Tables 2,3). Similar results, more or less were obtained by Amin et al. [24], Jeyakumar et al. [25], Manjri et al. [26], Sujatha, [27], Hayat et al. [28], Chandra et al. [29] and Mady, [30].

3.2 Relative Water Content (%)

A perusal of data on relative water content (RWC) as presented in Table 4 showed that different levels of salicylic acid significantly increased relative water content over control treatment at Pre and post flowering of black gram under rainfed condition. The Maximum relative water content was recorded by the foliar application of salicylic acid @ 150 ppm at 60 DAS at Pre flowering (51.50%) and post flowering (43.43%). The relative water content is a useful measure of the physiological water status of plants (Gonzalez and Gonzalez-Vilar, 2001). Our results revealed that salt stress caused reduction in relative water content of the leaves at different growth stages However treating the plants with salicylic acid caused an improvement in relative water content, the concentration of salicylic acid @150 ppm being more effective in 100 ppm and 50 ppm salicylic acid treatments induced an increase in leaf relative water content of the stressed plants compared to the non-treated plants. Similar results more or less were obtained by Khan, et al. [31].

3.3 Chlorophyll Content (SPAD Meter Value)

The data showed that the chlorophyll intensity (Table 4) at different growth stage was significant variation observed with the application of different levels of salicylic acid at different stages. The chlorophyll intensity at pre-flowering (49.93) and post-flowering (40.90) was found to be maximum by the foliar application of salicylic acid @ 150 ppm at 60 DAS followed by foliar application of salicylic acid @ 150 ppm at 40 DAS at pre-flowering (49.50) and post-flowering (40.96). Similar results, more or less were obtained by Kuttimani and Velayutham [32], Amin et al. [24], Jaiswal et al. [33], Yildirim et al. [34].

3.4 Yield Attributes

The data showed that the yield attributes (Table 5) of bank gram plants had significantly affected by application of different levels of salicylic acid at different stages under rainfed conditions. Data showed that the highest all yield attributes i.e. number of pods plant^{-1}(46.0), dry weight of pods plant^{-1}(8.99g), seed yield plant^{-1}(6.66g), 100-seed weight (4.41g) were observed in the foliar application of salicylic acid @ 150 ppm at 60 DAS. It may be due to better growth attributes i.e. plant height, number of leaves plant^{-1}, number of branches plant^{-1}, dry weight of leaves plant^{-1}, dry weight of stem plant^{-1}, total dry weight of plant, total leaf area of plant and strong source-sink relationship in Black gram under rainfed condition through application of salicylic acid. Application of salicylic acid at 100 ppm increased the number of pods plant^{-1}, number of seeds pod^{-1}, seed weigh plant^{-1}, and seed yield ha^{-1} [27]. Jeyakumar et al. [25] also reported that the application of 125 ppm salicylic acid to black gram plants increased seed yield. Similar results, more or less were obtained by Matwa et al. [35] and Shweta Jamra, [36].

3.5 Yield

The data showed that the Foliar application of salicylic acid in different treatments had significant variation in the yield (Table 5) of black gram under rainfed conditions. Among the treatments, the foliar application of salicylic acid @ 150 ppm at 60 DAS (flowering stage) recorded significantly higher grain yield (10.35 q ha^{-1}) and harvesting index (30.30 %) and minimum in control. It was comparable with all other treatments the increase in yield might be due to enhanced yield attributes like number of pods plant^{-1}, number of seeds pod^{-1}, Dry weight of pods plant^{-1} at maturity and 100-Seed weight (g). It is due to the increased uptake of nutrients by black gram by effective translocation of nutrients from sink to reproductive area of crop. It was inferred that application of salicylic acid similar result was also reported [17] in seed yield and yield components of mungbean. Similar results, more or less were obtained by, Manjri et al. [26].

Table 1. Effect of salicylic acid on plant height (cm) and number of leaves plant^{-1} at 35 DAS, 70 DAS and at maturity

Treatments	Plant height (cm) at 35 DAS	Plant height (cm) at 70 DAS	Plant height (cm) at maturity	Number of leaves plant^{-1} at 35 DAS	Number of leaves plant^{-1} at 70 DAS	Number of leaves plant^{-1} maturity
T_1	12.80	20.40	23.83	5.33	12.00	11.33
T_2	14.46	22.63	25.86	6.66	13.33	13.00
T_3	13.23	24.23	26.80	6.33	14.33	12.66
T_4	13.20	24.80	27.06	6.66	15.33	14.66
T_5	14.96	25.86	28.93	7.00	16.66	16.33
T_6	13.63	27.83	30.66	7.33	18.00	17.33
T_7	13.56	30.40	31.50	7.66	19.33	18.33
T_8	16.06	34.90	35.36	8.00	21.00	19.66
T_9	13.96	35.23	36.26	8.66	22.33	21.33
T_{10}	14.16	36.50	38.10	8.66	23.66	22.00
CD	1.47	1.85	1.74	1.09	1.67	2.01
SE(D)	0.69	0.87	0.82	0.51	0.79	0.95
CV	6.11	3.79	3.30	8.78	5.50	6.99

Table 2. Effect of salicylic acid on number of branches and dry weight of leaves plant^{-1} at 35, 70 DAS and at maturity

Treatments	Number of branches plant^{-1} at 35 DAS	Number of branches plant^{-1} at 70 DAS	Number of branches plant^{-1} at maturity	Dry weight of leaves plant^{-1}(g) at 35 DAS	Dry weight of leaves plant^{-1}(g) at 70 DAS	Dry weight of leaves plant^{-1}(g) at maturity
T_1	1.27	3.33	4.33	0.84	3.43	3.23
T_2	1.60	4.00	5.33	0.95	3.80	3.43
T_3	2.03	4.33	6.00	1.08	4.18	3.69
T_4	2.36	5.00	6.33	1.11	4.57	3.88
T_5	2.41	5.66	7.33	1.51	4.68	4.18
T_6	2.65	6.33	7.66	1.63	5.03	4.47
T_7	2.96	7.00	8.00	1.86	5.39	4.65
T_8	3.64	7.33	9.00	2.04	5.63	4.81
T_9	3.74	8.33	9.66	2.14	5.79	4.93
T_{10}	3.90	8.66	10.33	2.20	6.12	5.01
CD	0.14	0.97	1.036	0.15	0.39	0.10
SE(D)	0.06	0.45	0.489	0.07	0.18	0.05
CV	3.06	9.35	8.027	5.91	4.62	1.47

Table 3. Effect of salicylic acid on dry weight of stem plant^{-1} and total dry weight of plant at 35, 70 DAS and at maturity

Treatments	Dry weight of stem plant^{-1} (g) at 35 DAS	Dry weight of stem plant^{-1} (g) 70 at DAS	Dry weight of stem plant^{-1} (g) at maturity	Total Dry weight of plant (g) at 35 DAS	Total Dry weight of plant (g) at 70 DAS	Total Dry weight of plant (g) at maturity
T_1	0.84	4.13	4.12	1.68	7.56	12.35
T_2	0.95	4.61	4.68	1.90	8.41	13.72
T_3	1.08	5.22	5.20	2.16	9.40	14.76
T_4	1.11	5.49	5.48	2.23	10.06	15.56
T_5	1.51	5.66	5.74	3.02	10.35	16.29
T_6	1.69	5.88	6.08	3.32	10.91	17.50
T_7	2.26	6.35	6.50	4.12	11.74	18.47
T_8	2.56	6.55	7.04	4.60	12.19	19.76

Treatments	Dry weight of stem plant^{-1} (g) at 35 DAS	Dry weight of stem plant^{-1} (g) 70 at DAS	Dry weight of stem plant^{-1} (g) at maturity	Total Dry weight of plant (g) at 35 DAS	Total Dry weight of plant (g) at 70 DAS	Total Dry weight of plant (g) at maturity
T_9	2.71	6.85	7.53	4.85	12.82	20.86
T_{10}	2.76	7.12	7.96	4.96	13.24	21.97
CD	0.25	0.18	0.27	0.28	0.33	1.98
SE(D)	0.12	0.08	0.13	0.13	0.15	0.93
CV	8.42	1.81	2.63	5.05	1.79	6.68

Table 4. Effect of salicylic acid on total leaf area plant^{-1} (cm^{-2}), relative water content (%) and chlorophyll intensity (SPAD meter value) at pre and post flowering

Treatments	Total leaf area plant^{-1} (cm^{-2}) at Pre flowering	Total leaf area plant^{-1} (cm^{-2}) at Post flowering	Relative water content (%) at Pre flowering	Relative water content (%) at Post flowering	Chlorophyll intensity at pre flowering	Chlorophyll intensity at post flowering
T_1	110.34	179.00	35.46	27.66	38.66	28.58
T_2	120.46	196.03	36.86	34.53	41.33	31.16
T_3	130.76	204.50	38.43	35.20	42.83	32.80
T_4	141.03	226.03	41.83	37.23	44.70	34.48
T_5	145.04	246.03	43.30	38.46	46.30	35.26
T_6	157.74	275.00	44.50	38.80	47.30	36.86
T_7	171.61	295.40	45.66	40.90	48.20	37.40
T_8	191.06	315.70	47.23	41.36	48.93	38.30
T_9	198.90	357.80	49.46	41.93	49.50	39.41
T_{10}	211.33	384.87	51.50	43.43	49.93	40.90
CD	5.51	7.74	3.73	1.14	3.708	1.67
SE(D)	2.60	3.65	1.76	1.01	1.751	0.79
CV	2.01	1.67	4.97	3.27	4.686	2.73

Table 5. Effect of salicylic acid on yield and yield attributes of black gran

Treatments	Number of pods plant^{-1} (g) at maturity	Dry weight of pods plant^{-1} (g) at maturity	Gran yield (g plant^{-1})	100-Seed weight (g)	Harvesting index (%)	Grain Yield (q ha^{-1})
T_1	21.00	5.00	2.44	3.24	18.21	8.20
T_2	23.66	5.61	2.62	3.32	19.08	8.40
T_3	25.00	5.86	2.98	3.52	20.18	8.90
T_4	28.00	6.19	3.23	3.59	20.75	9.30
T_5	30.33	6.36	3.59	3.70	22.02	9.45
T_6	34.66	6.93	3.97	3.76	22.68	9.85
T_7	37.66	7.32	4.52	3.94	24.46	9.95
T_8	41.33	7.90	5.49	4.03	27.77	10.10
T_9	44.33	8.39	6.06	4.27	29.04	10.20
T_{10}	46.00	8.99	6.66	4.41	30.30	10.35
CD	2.50	0.60	0.46	0.14	0.14	0.014
SE(D)	1.18	0.28	0.28	0.06	0.06	0.007
CV	4.36	5.08	6.40	2.20	0.35	0.088

4. CONCLUSION

The results obviously suggest and it may be concluded that foliar application of salicylic acid on black gram (urdbean) variety Azad urd-3 significantly change plant morphology, improvement in vegetative and reproductive growth to enable them for higher yield. These substances judiciously work out and can be employed successfully for yield maximization of black gram under rainfed conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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