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Effect of Soil and Foliar Application of Humic Acid and Brassinolide on Morpho-physiological and Yield Parameters of Black Gram (*Vigna mungo*)

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ABSTRACT

During the Kharif season of 2022-2023 at Lovely Professional University, Jalandhar, Punjab, a field experiment was conducted to investigate the "Effect of soil and foliar application of humic acid and brassinolide on morpho-physiological and yield parameters of Black gram (*Vigna mungo*)." The experiment was designed using a Randomised Block Design (RBD) with three replications and eight treatments. Compared to the other treatments, RDF + humic acid 0.1% + brassinolide 0.1ppm (foliar application) was the optimal treatment for most morphological and yield parameters. Plant height (cm), number of primary branches per plant, number of secondary branches per plant, dry matter accumulation (g), chlorophyll Index (SPAD), and leaf area (cm^2) were highest under T_7- RDF + humic acid 0.1%+brassinolide 0.1ppm (foliar applied) conditions. Minimum phenological observations were recorded for soil and foliar applications of brassinolide, including days to first flowering, days to 50 percent flowering, and days to pod initiation. Number of pods /plant, pod length(cm), pod weight (g), no. of seeds /pod, test weight (g), seed yield (q/ha), stover yield (q/ha), and harvest index (%) were significantly influenced by the T_7 and recorded higher values. The increased seed yield may be attributable to plants treated with growth regulators remaining physiologically more active to accumulate sufficient food reserves for developing blossoms and seeds.

INTRODUCTION

Pulses are commonly rich in protein, fiber, vitamins, and minerals and have been designated as the primary source of protein for humans. After cereals, it is the second most essential component of the Indian diet. By fixing atmospheric nitrogen, pulses enhance soil fertility. In India, pulses are cultivated on an area of approximately 28.83 million hectares, with an annual production of approximately 25.72 million tonnes and a productivity of approximately 892 kg/ha (Rajender et al. 2020). Cultivating black gram (*Vigna mungo*) is vital to Indian agriculture. Black gram has 2n=22 chromosomes and belongs to the Leguminaceae and Papilionaceae families. Black gram is a short-duration pulse crop with a yield of 32.84 lakh tonnes and a productivity of 652 kg/ha (Ministry of Agriculture and Farmer Welfare, India). In Punjab, black gram is grown on 2,000 hectares during the 2019-20 season, with a total production of 1,200 tonnes and an average crop yield of 5.78 quintals per hectare.

Crop yield depends on the soil's nutrient content to provide humans with essential nutrients. Several techniques, such as rotation planting, various plowing techniques, and applying fertilizers, can be used to increase the organic matter content of soils for crop production. In addition to these methods, organic mineral fertilizers have increased in agriculture in recent years. Humic acid is one of the commonly used organic mineral fertilizers. Humic acid is one of the humic substances' primary components. The humic matter is produced through the chemical and biological humification of plant and animal matter and the biological activity of microorganisms. Both humic and fulvic acids play vital functions in soil fertility and plant nutrition (Lavanya et al. 2020, Patial et al. 2020). Humic compounds are composed of humic and fulvic acids. Humic acid (HA), a key component of most organic fertilizers and one of the most active soil and organic matter components, may be beneficial in overcoming these production limitations in pulse crops. Humic acid promotes plant development by enhancing oxygen absorption. Improved root growth leads to enhanced nutrient and water absorption. According to Sani (2014), foliar application of humic acid may reduce nitrogen administration to the soil. Humic acid stimulates plant growth and yield by increasing nutrient uptake and influencing various processes, including cellular respiration, photosynthesis, protein synthesis, and enzyme activity. Despite abundant flowering, the crop suffers from excessive vegetative growth, a low harvest index, and a low yield due primarily to inadequate pod setting (Badhe et al. 2021).

Flower and pod loss is common in this legume crop, as sink realization indicates. If these prospective yield barriers could be eliminated, yield enhancement and quality improvement of black gram could be accomplished. It has been known for a long time that pollen is rich in hormones and other growth substances; consequently, hormones play an essential role in plant reproduction. Numerous plant growth regulators have been shown to increase crop yields. Brassinolide, a newly discovered plant growth-promoting steroidal lactone isolated from rape pollen, exhibited distinct plant growth responses under various test conditions. Brassinolide (BR), a plant-based steroidal hormone derived from the pollen of the *Brassica napus* plant, is widely used in agriculture to increase crop yield. Although the significance of NPK in plant metabolism is well-documented, the role of BR on NPK content in plants and nutritional components of seeds is not. Brassinolide-induced plant growth has been correlated with increased metabolic activities such as photosynthesis, nucleic acid, and protein synthesis (Matwa et al. 2017). A growth-regulating substance is known to influence a wide variety of physiological parameters, including plant architecture modification, assimilate partitioning, photosynthesis promotion, nutrient uptake (mineral ions), nitrogen metabolism enhancement, flowering promotion, uniform pod formation, increased mobilization of assimilates to defined sinks, induction of synchrony in flowering and delayed senescence of leaves, and improved seed quality (Sharma et al. 2002). Therefore, examining the impact of brassinolide and humic acid on the development and yield of black gram was deemed beneficial.

MATERIALS AND METHODS

Preliminary Information

The field investigation was conducted at Lovely Professional University in Phagwara, India, during Kharif 2022. At 31.25°N75.7°E was the experimental location. It has a subtropical monsoon climate with an average annual precipitation of 600 millimeters and is situated in the central plains of Punjab. The experimental design consisted of a randomized block with eight treatments and three replications. The total number of plots was 24, with plot dimensions of 5 × 4 m and row-to-row and plant-to-plant distances of 30 cm and 10 centimeters, respectively. The natural soil type at the experimental site was sandy loam. The initial nutrient status of the soil was determined by analyzing the soil before the experiment. On August 15, 2022, the MASH-114 variety was planted. The treatments were: T_0-Control, T_1-(100% RDF), T_2-RDF + humic acid 20 kg.ha^{-1} (soil-applied), T_3-RDF + humic acid 0.1% (foliar applied), T_4-RDF + brassinolide 0.25ppm (soil-applied), T_5-RDF + brassinolide 0.1ppm (foliar applied), T_6- RDF + humic acid 20 kg.ha^{-1}+ brassinolide 0.25ppm (soil-applied), T_7-RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied). The recommended fertilizer ratio for black gram is 25:50:25 (N: P_2O_5: K_2O) (kg.ha^{-1}). Urea, SSP, and MOP were the sources of NPK in that order.

Time and Method of Application

At 25 DAS and 15 days after the initial spray, humic acid was applied as soil and foliar, while Brassinolide was applied at 30 DAS and 45 DAS. The soil application of humic acid and brassinolide was carried out using the soil drench method with a knapsack sprayer, and the foliar application of humic acid and brassinolide was also carried out with a knapsack sprayer.

Morpho-Physiological Attributes

Standard protocol was used to measure the different morphological and physiological observations, such as plant height, number of primary branches, number of secondary branches, fresh weight of the plant, dry weight of the plant, and leaf area. Five randomly chosen plants from each plot were used to measure the morphological attributes, and the average value was used to determine what the data meant concerning the treatments.

Chlorophyll index: The Soil Plant Analysis Development (SPAD) meter was used to determine the chlorophyll index by looking at the green leaves. The fully grown leaf was chosen to measure the amount of chlorophyll. Take the value from a single leaf with the SPAD meter three times, then take the average of these three numbers as the chlorophyll content (Arregui et al. 2006).

Crop growth rate (CGR, g.m^{-2}.day): CGR is the increase in dry weight of plant materials per unit area per unit time. It can be calculated by formulae given by Watson (1952).

Relative growth rate (RGR, g.g^{-1}day^{-1}): The RGR term was coined by Williams in 1946. It is the total growth in a plant's dry weight between two points in time. It can be written as one unit of dry weight per unit of dry weight per unit of time (g.g^{-1}.day^{-1}).

Phenological Parameters

Days to first flowering, days to 50% flowering, and days to pod initiation were also recorded.

Yield Attributes

Yield attributing traits, i.e., number of pods per plant, number of seeds per pod, pod length, pod weight, test weight, seed yield, straw yield, and harvest index (%), were recorded at the maturity stage using the standard procedures.

Statistical Analysis

With the SPSS 22 version of the software, the generalized linear model under univariate techniques with two factors was used to determine the differences between the means. A mean separation method was used to find the best treatment with a probability of $p<0.05$ and Duncan's multiple range test (DMRT). Fisher's LSD test was used as a posthoc test to see if there was a big difference between the means. The calculations were based on the LSD (least significant difference) at a 5% significance level.

RESULTS AND DISCUSSION

Growth Attributing Parameters

The results obtained from the above study in terms of growth studies are presented in Table 1.

Plant height: The highest plant height (62.78 cm) was recorded in RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied), followed by (59.40 cm) in T_6-RDF + humic acid 20 kg.ha^{-1} + brassinolide 0.25 ppm (soil-applied). Minimum height (41.69 cm) was observed in T_0-control. This rise in plant height could have been caused by humic acid and the right amount of nutrients, which helped the plant absorb more nutrients and grow at the top. Brassinolide causes plants to grow taller because it makes plant cells grow longer and divide, boosts the activity of DNA polymerase and RNA polymerase, and speeds up the production of nucleic acids and proteins in legumes. It also helps symbiotic nitrogen fixation. Similar results have been reported by Netwal et al. (2022), Dixit and Elamathi (2007), and Umar et al. (2008).

Number of primary and secondary branches per plant: Maximum no. of primary branches (12.5) and secondary branches (43.33) recorded in T_7-RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied) which was at par with T_6- RDF + humic acid 20 kg.ha^{-1} + brassinolide 0.25 ppm (soil-applied) with (11.3, 42.00) branches. Minimum no. of primary and secondary branches (7.4, 29.04) recorded in T_0-Control. The rise in the number of branches on plant^{-1} may have been caused by humic acid, which sped up the plant's metabolic and physiological processes. This led to more growth from the main nutrients and, in the end, more branches. The results of this study agree with Tripura et al. (2016) and Padghan et al. (2018). These results match those of Netwal et al. (2022), who found that giving the Indian bean brassinolide at a concentration of 1.0 ppm greatly impacted the number of shoots on each plant. This could be because brassinosteroid speeds up the process of cell division and cell growth. Similar results were found by Bera et al. (2013), who said that the highest branches were found in crops that were sprayed twice with homo-brassinolide at the pre-flowering and pod growth stages.

Chlorophyll Index (SPAD): In the present investigation, it was observed that plant growth regulators and micronutrients had profound effects on chlorophyll content. Significant differences were noticed among the treatments with respect to mean total chlorophyll at all growth stages in black gram. There was significant variation recorded in the chlorophyll index. T_7-RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied) recorded the highest value (52 SPAD). The minimum chlorophyll index (24.56 SPAD) was recorded in T_0 - Control. When humic acid is given, the amount of chlorophyll in the plant increases because of increased oxygen consumption. It has been said that brassinolide may have made more assimilates available, which may have caused chlorophyll production to last longer. The results of the present investigation conform with the findings of Maity and Bera (2009) in green gram and Rao et al. (2016) in mung bean.

Dry matter accumulation (g): The plants' build-up of dry matter indicates how they use light to make food. When dry matter output goes up, nutrients are used better, and more solar energy is produced. The maximum dry matter accumulation (18.41g) was recorded in T_7- RDF + Humic acid 0.1%+ Brassinolide 0.1ppm (Foliar applied). The second highest dry matter accumulation (16.08 gm) was recorded in T_6- RDF + Humic acid 20 kg.ha^{-1} + Brassinolide 0.25 ppm (soil-applied). Whereas the remaining treatments showed statistically significant variations among themselves. The minimum dry matter accumulation (8.86g) was recorded in T_0-Control. Boosted dry matter production might be attributed to soil and foliar nutrient delivery, which boosted the pace of the photosynthetic process, resulting in greater dry matter production by the plant at each stage of growth. Increased plant height, more trifoliate leaves, and a larger leaf area index because of foliar fertilizer administration may have increased dry matter accumulation per plant. Similar results were also recorded by Surender et al. (2013) in black gram, Sengupta & Tamang (2015) in green gram, and Marimuthu & Surendran (2015) in black gram.

Leaf area (cm^2): The highest leaf area (157.3 cm^2) was recorded in T_7- RDF + Humic acid 0.1%+ Brassinolide 0.1ppm (foliar applied) followed by T_6- RDF + Humic acid 20kg/ha + Brassinolide 0.25ppm (soil-applied) with (151.86 cm^2). The minimum leaf area (121.56 cm^2) was observed in T_0-Control. Results confirm the findings made by Maity and Bera (2009) in green gram and Surender et al. (2013) in black gram. The results align with Sani (2014), who observed that leaf area increased significantly by 1 ppm foliar spray of brassinolide over control in (*Vigna radiata*).

CGR (gm^2.day^{-1}) and RGR (g.g^{-1}.day^{-1}): The maximum

CGR (0.343 $g.m^{-2}.day^{-1}$) was recorded in T_7- RDF + Humic acid 0.1% + Brassinolide 0.1 ppm (foliar applied) followed by T_6- RDF + Humic acid 20 $kg.ha^{-1}$ + Brassinolide 0.25 ppm (soil-applied) with (0.253 $g.m^{-2}.day^{-1}$). The lowest CGR (0.113 $g.m^{-2}.day^{-1}$) was recorded in T_4-RDF + Brassinolide 0.25 ppm (Soil applied). The highest RGR (0.053 $g.g^{-1}.day^{-1}$) was recorded in T_1-100% RDF. The minimum RGR (0.018 $g.g^{-1}.day^{-1}$) was observed in T_2-RDF + Humic acid 20 $kg.ha^{-1}$ (Soil applied). Rajavel and Vincent (2009) and Sengupta and Tamang (2015) also reported that the foliar application of growth regulators and nutrients significantly increased the mean RGR in black gram.

Phenological Parameters

The results obtained from the above study regarding phenological parameters are presented in Fig. 1.

Days to first flowering: There was significant variation observed in days to first flowering. The first flowering (32 days) was observed in T_7- RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied). The maximum days required for first flowering (39 days) was observed in T_0-Control depicted in Fig. 1. This result conforms with the findings of Maity & Bera (2009) who reported that foliar application of BR (0.25 ppm) and SA (1000 ppm) on green gram plant once at pre-flowering (30 DAS) and second time at flowering stage (40 DAS) could be beneficial for improving the nutritional quality of green gram and thus hold promise for farmers.

Days to 50% flowering and days to pod initiation (days): Days to 50% flowering is the number of days required to initiate flowering, not less than 50% of plants. The 50% flowering (34 days) was first observed in T_7-RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied). The maximum number of days required for 50% flowering was (42 days) observed in T_0-Control. The pod initiation (45 days) was observed in RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied), which was at par with T_6- RDF + Humic acid 20 $kg.ha^{-1}$ + Brassinolide 0.25 ppm (Soil applied) with 46 days respectively. The maximum days required for pod initiation (55 days) were observed in T_0-Control. The results conform with Ananthi & Gomathy (2011), who reported that foliar application of 0.1% humic acid with 0.1 ppm brassinosteroid improved blooming days to 50% in green gram. Sumathi et al. (2018) reported that among different PGRs tested, the application of BR induces pollen tube growth and germination, which induces early flowering and fruit set, proving its worthiness in days to 50% blooming.

Yield Attributing Parameters

The results obtained from the above study regarding yield parameters are presented in Table 2.

Number of pods/plants: The highest no. of pods/plant (25.33) was recorded in T_7-RDF + Humic acid 0.1%+ Brassinolide 0.1ppm (Foliar applied). The minimum no. of pods/plant (12.84) was recorded in T_0-control. These findings could be attributable to humic acid, a rich supply of nitrogen and phosphorus for early-stage growth, increased blooming, and increased pod number. These results conform with the findings of Sritharan et al. (2015) and Jeyakumar et al. (2008) reported that among the treatments, brassinolide @ 0.1 ppm resulted in a greater number of pods per plant in black gram.

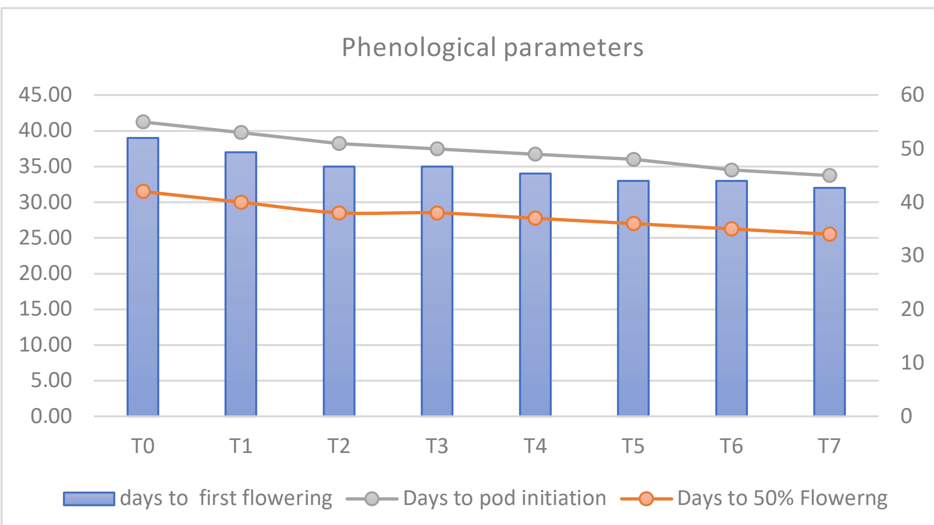

Fig. 1. Phenological response of black gram towards humic acid and brassinolide.

Table 1: Effect of humic acid and brassinolide on growth parameters of black gram.

Treatments	Plant height [cm]	No. of primary branches per plant	No. of secondary branches per plant	Dry matter accumulation [g]	Chlorophyll Index (SPAD)	Leaf Area [cm^2]	CGR [gm^2. day^{-1}]	RGR [$g.g^{-1}$. day^{-1}]
T_0-Control	41.69±0.92g	7.40±0.44e	29.04±0.41f	8.86±0.36g	24.56±0.73f	121.56±0.87g	0.182±0.028bc	0.046±0.007a
T_1-(100%RDF)	46.57±0.78f	8.33±0.47de	32.33±0.47e	10.81±0.49f	28.60±0.86e	131.06±1.19f	0.254±0.050ab	0.053±0.010a
T_2-RDF + Humic acid 20 $kg.ha^{-1}$ (Soil applied)	53.81±0.95d	8.80±0.21cd	35.33±0.47cd	13.59±0.75de	38.56±0.77d	137.36±0.94e	0.125±0.025c	0.018±0.004b
T_3-RDF + Humic acid 0.1% (Foliar applied)	54.97±0.26 cd	9.40±0.57cd	36.66±0.47c	15.75± 0.74bc	46.60±1.23c	142.53±0.54d	0.156±0.050bc	0.019±0.006b
T_4-RDF + Brassinolide 0.25 ppm (Soil applied)	51.73± 0.66e	8.73±0.53cd	34.33±1.25d	12.83± 0.41e	39.06±1.03d	132.60±0.77f	0.113±0.063c	0.018±0.010b
T_5-RDF + Brassinolide 0.1 ppm (Foliar applied)	56.57±0.84c	9.83±0.84c	38.95±0.07b	14.56± 0.38cd	49.79±1.23b	145.20±0.77c	0.160±0.029bc	0.021±0.004b
T_6-RDF + Humic acid 20 $kg.ha^{-1}$ +Brassinolide 0.25 ppm (Soil applied)	59.40±0.36b	11.33±0.47b	42.00± 1.41a	16.08± 0.33b	47.73±1.30bc	151.86±0.33b	0.253±0.028ab	0.027±0.02b
T_7-RDF + Humic acid 0.1%+ Brassinolide 0.1 ppm (Foliar applied)	62.78±0.35a	12.50±0.46a	43.33±1.25a	18.41±0.45a	52.66±1.19a	157.30±0.65a	0.343±0.048a	0.031±0.006b

*The mean followed by different letters was significantly different at $p<0.05$ according to DMRT (Duncan's multiple range test).

Table 2: Effect of humic acid and brassinolide on yield parameters of black gram.

Treatments	No. of pods / plant	Pod length [cm]	Pod weight [g]	No. of seeds /pod	Test weight [g]	Seed Yield [$q.ha^{-1}$]	Stover yield [$q.ha^{-1}$]	Harvest index [%]
T_0-Control	12.84±0.60f	4.1±0.132e	12.84±0.60f	4.55±0.35e	41.44±0.67f	6.51±0.295e	14.69±0.55d	30.70±1.42a
T_1-(100%RDF)	14.19±0.34e	4.3±0.094e	14.19±0.34e	5.53±0.49d	44.53±0.47e	7.11±0.458d	15.68±0.31c	31.15±0.95a
T_2-RDF + Humic acid 20 $kg.ha^{-1}$ (Soil applied)	19.17±0.36d	4.8±0.085cd	19.17±0.36d	6.02±0.13cd	48.03±0.62d	8.13±0.132c	19.17±0.54b	29.78±0.84a
T_3-RDF + Humic acid 0.1% (Foliar applied)	22.41±0.53c	5.1±0.205bc	22.41±0.53c	7.19±0.08b	51.27±0.65c	8.44±0.151bc	19.44±0.23b	30.26±0.43a
T_4-RDF + Brassinolide 0.25 ppm (Soil applied)	18.47±0.74d	4.7±0.205d	18.17±0.74d	6.48±0.45c	47.65±0.44d	8.08±0.142c	19.21±0.25b	29..60±0.12a
T_5-RDF + Brassinolide 0.1 ppm (Foliar applied)	23.44±0.19bc	5.2±0.272bc	23.44±0.19bc	7.38±0.06b	52.10±1.09c	8.66±0.159bc	19.47±0.24b	30.63±0.43a
T_6-RDF + Humic acid 20 $kg.ha^{-1}$ +Brassinolide 0.25 ppm (Soil applied)	24.43±0.54ab	5.4±0.094ab	24.43±0.54ab	7.41±0.21b	53.93±0.47b	8.81±0.215ab	20.34±0.15a	30.23±0.42a
T_7-RDF + Humic acid 0.1%+ Brassinolide 0.1 ppm (Foliar applied)	25.33±0.57a	5.7±0.124a	25.33±0.57a	8.18±0.47a	55.48±0.57a	9.28±0.162a	20.55±0.24a	31.104±0.62a

*The mean followed by different letters were significantly different at $p<0.05$ according to DMRT (Duncan's multiple range test).

The increased pods and seeds could be attributed to improved nutrition and assimilation transfer to reproductive areas.

Pod length (cm) and pod weight (g): Pod length is the main yield contributing character. There was a significant difference recorded in the case of pod length. Maximum pod length (5.7 cm) recorded in T_7-RDF + Humic acid 0.1%+ Brassinolide 0.1 ppm (foliar applied). Minimum pod length (4.80 cm) recorded in T_0-Control. The highest pod weight (27.2 gm) was recorded in T_1-RDF + humic acid 20 kg.ha^{-1} (Soil applied). The lowest pod weight (14.5 gm) was recorded in T_0-Control. The increase in pod length and weight might be due to more translocation of nutrients from source to sink. These results conform with the findings of Sritharan et al. (2015).

Number of seeds/pods: A significant variation was recorded in no. of seeds/pods. At the same time, all treatments showed superiority over control. The maximum (8.18 seeds/pod) recorded in T_7-RDF + Humic acid 0.1%+ Brassinolide 0.1 ppm (Foliar applied). The second highest (7.41 seeds/pod) was recorded in T_6- RDF + Humic acid 20 kg.ha^{-1} + Brassinolide 0.25ppm (Soil applied). The minimum number of seeds/pod was recorded (4.55 seeds/pod) in T_0- Control. More seeds per pod may be linked to growth regulators since plants treated with growth regulators remained physiologically more active to build sufficient food reserves for growing blooms and seeds (Hamed & Abdullah 2022).

Test weight (g): The highest test weight (55.48 g) was recorded in T_7- RDF + humic acid 0.1%+ brassinolide 0.1 ppm (foliar applied). Followed by T_6- RDF + Humic acid 20 kg.ha^{-1} + Brassinolide 0.25 ppm (soil-applied). The lowest test weight (41.44 gm) was recorded in T_0- Control. This might be due to the use of humic acid as soil and foliar spray, which boosted seed weight by improving nutrient mobilization (Jat et al. 2012)

Seed yield and stover yield (q.ha^{-1}): There was significant variation in the seed yield. All treatments showed superiority over control. The maximum seed yield (9.28 q.ha^{-1}) was recorded in T_7- RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied). The second maximum seed yield (8.81 q.ha^{-1}) was recorded in T_6- RDF + humic acid 20 kg.ha^{-1} + brassinolide 0.25 ppm (soil-applied). Minimum seed yield (6.51 q.ha^{-1}) was recorded in T_0-Control. The highest stover yield (20.55 q.ha^{-1}) was recorded in T_7- RDF + humic acid 0.1%+ brassinolide 0.1ppm (foliar applied), which was statistically non-significant with T_6- RDF + humic acid 20 kg.ha^{-1} + brassinolide 0.25 ppm (soil-applied). The minimum stover yield (14.69 q.ha^{-1}) was recorded in T_0-Control. This could be attributable to increased photosynthetic activity and rapid photosynthesis or nutrient transfer to the grain (Mishra 2016, Padghan et al. 2018). Similarly, Hamed and Abdullah (2022) reported that plants sprayed with 1.5 mg.L^{-1} concentration of brassinolide achieved the highest weight of total seed yield of sunflowers. There was non-significant variation recorded in the harvest index.

Regression Analysis

The impact of plant height (cm), number of pods per plant, and number of days to 50% flowering on black gram seed yield were predicted using quadratic response regression analysis, and the results showed that increasing these parameters significantly improved black gram seed yield, as shown in Figs. 2, 3, 4 with the R^2 value and polynomial equation. The final crop yield is the sum of the effects of growth qualities, and treatments that change favorable

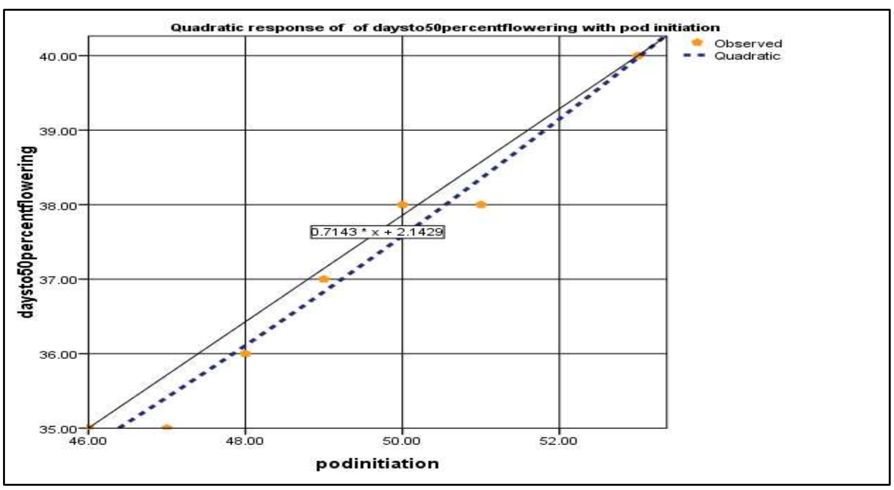

Fig. 2: Regression analysis of pod initiation vs. days to 50% flowering.

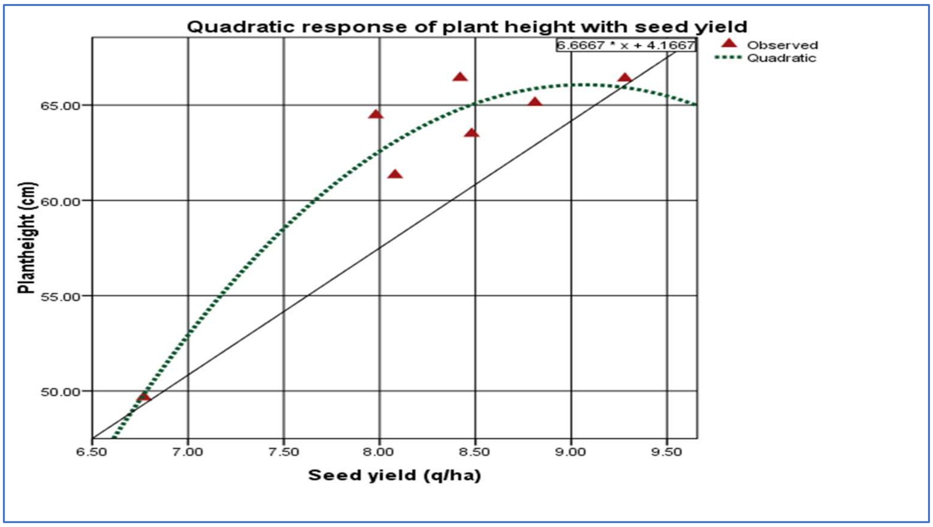

Fig. 3: Regression analysis of plant height vs. seed yield.

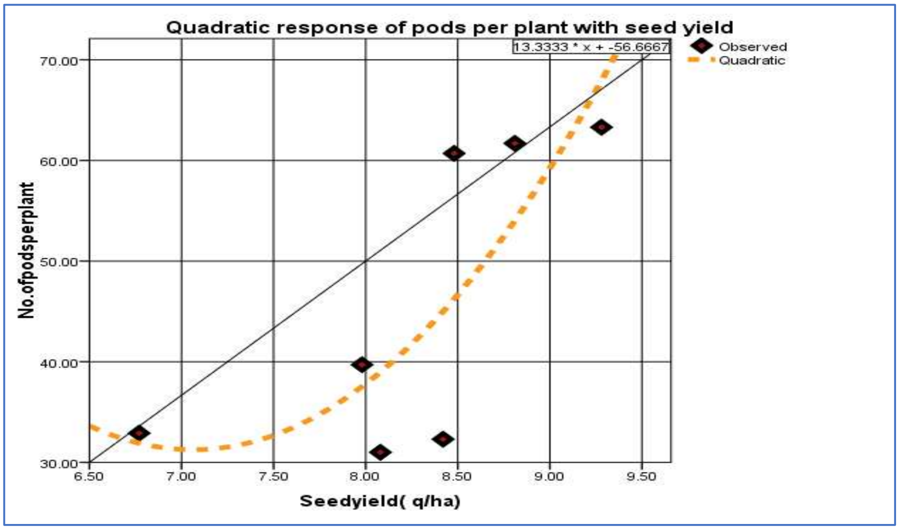

Fig. 4: Regression analysis of No. of pods vs. seed yield.

parameters may result in a positive association with increased productivity, as demonstrated in the current study.

CONCLUSION

The current study concluded that humic acid and brassinolide are key components in organic fertilizers and plant growth regulators. Applying humic acid and brassinolide improved black gram's overall crop performance and productivity in this study. Among the several treatments, foliar application of humic acid and brassinolide was the most effective. As a result, T7- RDF + Humic acid 0.1%+ Brassinolide 0.1 ppm (foliar applied) may be the best alternative for enhancing black gram productivity and quality.

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