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Effect of Hormones on Yield and Economics of Mustard (*Brassica juncea* L.) under Southern Telangana Agro-Climatic Conditions

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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

An experiment was carried out at student farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana, in sandy loam soils during *rabi* 2020 to study the effect of hormones on growth and yield of mustard under Southern Telangana Agro-climatic conditions. The experiment was laid out in randomized block design with ten treatments. The treatments comprised were: T_1-Control (RDF 60:40:40 N, P_2O_5, K_2O kg ha^{-1}), T_2 (RDF + foliar spray of GA_3 @ 45 ppm at flowering), T_3 (RDF + foliar spray of GA_3 @ 45 ppm at pod development), T_4 (RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development), T_5 (RDF + foliar spray of humic acid @ 1.5% at flowering), T_6 (RDF + foliar spray of humic acid @ 1.5% at pod development), T_7 (RDF + foliar spray of humic acid @ 1.5% at flowering and pod development), T_8 (RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering), T_9 (RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development) and T_{10} (RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development). Results indicated that, application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2

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days interval at flowering and pod development (T_{10}) and application only at flowering (T_8) gave the similar and higher yields and economic returns. As the cost of cultivation of T_{10} was higher than T_8, BC ratio was higher for T_8.

Keywords: Flowering; foliar application; GA3; humic acid; mustard; pod development.

1. INTRODUCTION

Rapeseed-mustard (*Brassica spp*.) is one of the most important oilseed crops of the world where India ranks third in area and production in the world [1]. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy [2]. Its seed contains 37 to 49% edible oil [3]. Demand of edible oil has increased with increasing population and improvement in the living standard of the people, resulting thereby in short supply of edible oils which is being met with imports of edible oil worth 44,000 crores per annum. Thus, there is need to boost the oilseed production through area expansion and productivity enhancement. In India, rapeseed-mustard occupy 6.23 million ha area with production and productivity of 9.34 million tonnes and 1499 kg ha^{-1} respectively (India stat 2019-20 [4]). It is a major *rabi* crop. Cultivation of mustard is taken up between October-November and February-March.

Gibberellic acid is a phytohormone that is needed in small quantities at low concentration so as to accelerate the plant growth and development. Because, favourable conditions may be induced by applying growth regulator exogenously in proper concentration at a proper time in a specific crop. It is a diterpenoid carboxylic acid that belongs to the family gibberellins and acts as a natural plant growth hormone, which can manipulate a variety of growth and development phenomena in various crops. GA_3 enhances growth activities of plant, stimulates stem elongation [5]. It is applied to crops, orchards, and ornamental plants, where it plays a role in seed germination, response to abiotic stress, stem elongation, flowering and other physiological effects that occur in its interaction with other phytohormones [6]

Humic acid is an organically charged bio-stimulant that significantly affects plant growth and development and increases crop yield. It has been extensively investigated that humic acid improves physical, chemical and biological properties of soils [7]. Humic acid-based fertilizers increase crop yield, stimulate plant hormones and improve soil fertility ecologically and environmentally. Many studies highlighted the positive benefits of humic acid application on higher plants. Humic acids also reduce toxic effects of salts on monocots [8] and dicots [9], including rapeseed. Enhanced nutrient uptake by plants as a result of humic acid application is also well established. Likewise, the increased yield is also observed in many crops due to its application, including potato, brassica [10], tomato, onions and other leafy vegetables.

2. MATERIALS AND METHODS

The present experiment was conducted at student farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana, India during *rabi* 2020. The soil of experimental plot was sandy loamy and slightly alkaline (pH 7.6), with available nitrogen (128 kg ha^{-1}), phosphorus (61.6 kg ha^{-1}) and potassium (414 kg ha^{-1}) content. Geographically it is situated between $17^{o}19^{1}18.39^{11}$ N latitude and $78^{o}25^{1}38.67^{11}$ E longitude and its mean height above sea level is 534 m. The total rainfall received during the crop growth period was 363.4 mm in 11 rainy days. To study the effect of hormones on growth and yield of mustard (*Brassica juncea* L.) under Southern Telangana Agro-climatic conditions, randomized block design was used with ten treatments replicated thrice. The experimental field was laid out in 30 unit plots, each plot measuring 21.6 m^2 (5.4m x 4.0m). There were thirteen rows of mustard crop in each plot and forty plants in each row. One row of crop from both sides of length and also both sides of breadth were left as guard rows. The net plot consisted of eleven rows with thirty-eight plants per row (4.6m x 3.8m). Seeds of mustard variety Pusa-Agrani were sown @ 5 kg ha^{-1} (250000 plants ha^{-1}), on 9^{th} October 2020 with the spacing of 40 cm between the rows and 10 cm between the plants. A fertilizer dose of 60 kg N, 40 kg P_2O_5 and 40 kg K_2O per ha through urea, single super phosphate and muriate of potash was applied at the time of sowing (basal application) to all the plots.

Foliar application of gibberellic acid and humic acid was done as per the treatments. For the foliar application of gibberellic acid a solution of 45 ppm was prepared by using 45 mg of gibberellic acid along with premix (solvent) dissolved in distilled water and made the volume to 1000ml using volumetric flask. It was utilized for foliar application in the plots which are selected for gibberellic acid spray. For the foliar application of humic acid 15 ml of the solvent was mixed in water and made up to 1000 ml to get 1.5% solution of humic acid. This was sprayed in the plots selected for HA application. Timely recommended plant protection measures for mustard crop were followed to save the crop from pests and diseases. The mustard crop was harvested manually. Different growth and yield components were recorded periodically. Data obtained from various parameters under study were analyzed by the method of analysis of variance (ANOVA) as described by Gomez and Gomez [11]. The level of significance used in the "F" test was given at 5 per cent.

The prices of the inputs prevailed in local market during experimentation were considered for working out the cost of cultivation of Mustard. The gross returns were calculated using the yield of mustard and the market price of the produce at the time of marketing. The net returns per hectare were calculated by deducting the cost of cultivation per hectare from the gross returns per hectare.

Net monetary return = Gross monetary return - Total cost of cultivation Benefit cost ratio was worked out for each treatment by using the formula given by Subba Reddy and Raghuram [12].

Benefit cost ratio = Gross returns (Rs ha^{-1})**/** Cost of cultivation (Rs ha^{-1})

3. RESULTS AND DISCUSSION

3.1 Seed Yield

Seed yield (kg ha^{-1}) was significantly influenced by the spray of hormones (Table 1). Highest seed yield (1632) was observed with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}), which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) (1567). Lowest grain yield (1112) was observed with the application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1), which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (1163). There was increase of 46.7% in the grain yield observed with RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}) as compared to control (T_1).

The highest seed yield was observed with the application of GA_3 and humic acid at flowering and pod development. The PGRs divert the photosynthate towards the harvested product thus enhancing the actual productivity (Abdelgadira *et al*., 2010). The stimulating effect of humic acid on yield and yield components has been related in part to enhanced uptake of mineral nutrients. Also, this could be explained as humic acid is rich in and mineral substances which are essential to plant growth and consequently increase yield quality and quantity. Humic acid influence plant growth both in direct and indirect ways. it increases chlorophyll content, accelerates plant respiration and hormonal growth responses, increases penetration in plant membranes [13]. Humic acid has been shown to stimulate plant growth and consequently yield by acting on mechanisms involved in cell respiration, photosynthesis, protein synthesis and enzyme activities [14]. The application of GA_3 was more effective to reduce yield loss due to siliquae shattering [15]. An increase in vascular capacity brought about by GA_3 under an enhanced sink potential, facilitating increased translocation of photo-assimilates to the developing reproductive organs. The capacity of GA_3 to regulate the induction of fruit set [16] could also have supplemented the other causes to result in an overall enhancement of yield. It is 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 GA_3.

3.2 Stover Yield

Stover yield (kg ha^{-1}) was significantly influenced by the spray of hormones (Table 1). Highest stover yield (5468) was observed with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}), which was on par with RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) (5305). Lowest stover yield (3720) was observed with the application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1) which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) and RDF + foliar spray of humic acid @ 1.5% at pod development (T_6) (3964 and 3915). There was increase of 47.0% in the stover yield observed with RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}) as compared to control (T_1).

The highest stover yield was recorded with the application of GA_3 and humic acid at flowering and pod development. Humic acid with its auxin activity, induced hormonal effect on respiratory catalytic activity, cell permeability and increased nutrient uptake might have contributed to greater plant height and dry matter accumulation, thus increasing the stover yield. Exogenous application of GA_3, N and P played an important role in the development of taller plants with more number of branches and better orientation of leaves facilitating the leaf expansion. This inturn leads to increase of stover yield.

3.3 Economics

Economics of mustard production was significantly influenced by the GA_3 and humic acid application (Table 2). The highest gross returns (78600 Rs. ha^{-1}) was obtained with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}) which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) (75535 Rs ha^{-1}). Application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1) recorded the lowest gross returns (53569 Rs. ha^{-1}), which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (56066 Rs ha^{-1}).

The highest net returns (50550 Rs. ha^{-1}) was obtained with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}) (50547 Rs ha^{-1}). Application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1) recorded the lowest net returns (31645 Rs. ha^{-1}) which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (33165 Rs ha^{-1}).

Highest BC ratio (3.02) was obtained with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8). The lowest BC ratio (2.44) was with the application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1) which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) and RDF + foliar spray of humic acid @ 1.5% at pod development (T_6) (2.45 and 2.55).

The difference in gross, net returns and BC ratio among treatments might be due to the higher nutrient efficiency due to foliar application of hormones, which led to higher yields and thus produced maximum economics. This is due to achieved higher productivity as well as the lower cost of cultivation owing to increased economic returns.

Table 1. Seed and Stover Yield (kg/ha) of mustard as influenced by GA_3 and humic acid spray

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1- RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1})	1112	3720
T_2- RDF + foliar spray of GA_3 @ 45 ppm at flowering	1231	4132
T_3- RDF + foliar spray of GA_3 @ 45 ppm at pod development	1163	3964
T_4- RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development	1395	4994
T_5- RDF + foliar spray of humic acid @ 1.5% at flowering	1346	4071
T_6- RDF + foliar spray of humic acid @ 1.5% at pod development	1273	3915
T_7- RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	1447	4177
T_8- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering	1567	5305
T_9- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @	1495	5152

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)
1.5% with 2 days interval at pod development		
T_{10}-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	1632	5468
SE(m) ±	35.5	88.8
CD(p=0.05)	103	264

Table 2. Economics of mustard as influenced by GA_3 and humic acid spray

Treatments	Cost of cultivation (Rs/ ha)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	B-C Ratio
T_1	21924	53569	31645	2.44
T_2	22902	59315	36414	2.59
T_3	22902	56066	33165	2.45
T_4	23884	67375	43491	2.82
T_5	24007	64637	40630	2.69
T_6	24007	61153	37146	2.55
T_7	26094	69382	43288	2.66
T_8	24985	75535	50550	3.02
T_9	24985	72092	47107	2.89
T_{10}	28054	78600	50547	2.80
SE(m) ±	-	1099	581	0.04
CD(p=0.05)	-	3264	1727	0.12

Market rates of mustard seed @ Rs. 4600/- per quintal; mustard stover @ 50/- per quintal

4. CONCLUSION

The seed, stover yields and economics of the mustard crop are significantly influenced by the foliar application of GA_3 and humic acid. Application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T_{10}) and application RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) gave the higher and similar yields and economic returns. But as the cost of cultivation of T_{10} was higher than T_8, the BC ratio was higher for T_8 (RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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