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Effect of Hormones on Oil Yield and Nutrient Uptake of Mustard under Southern Telangana Agro-Climatic conditions

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ABSTRACT: Plant hormones are substances present in smaller proportions that regulate plant growth and development, as well as responses to changing environmental conditions. By modifying the production, distribution of these hormones, plants are able to regulate and coordinate both growth and stress tolerance to promote survival or escape from environmental stress. The role of the growth hormones in reducing the shattering losses in mustard is prominent. In this contextan 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 (RDF60:40:40N, 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 days interval at flowering and pod development (T_{10}) and application only at flowering (T_8) gave the similar and higher oil yield and nutrient uptake, while the oil content and nutrient contents were not effected significantly by the application of hormones.

Keywords: Flowering, Foliar application, GA_3, Humic acid, Mustard, Pod development.

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 (DRMR, 2015). 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. Its seed contains 37 to 49% edible oil. 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). 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 (Deotale *et al.,* 1998). 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 (Hedden and Sponsel 2015).

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 (Nardi *et al*., 2004). 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 (Masciandaro *et al*., 2002) and dicots (Ferrara *et al*., 2001), 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, tomato, onions and other leafy vegetables.

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 kgha^{-1}), phosphorus (61.6 kgha^{-1}) and potassium (414 kgha^{-1}) content. Geographically it is situated between 17º19′18.39″N latitude and 78º25′38.67″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 nigra* L.) under Southern Telangana Agro-climatic conditions, randomized block design was used with ten treatments replicated thrice. The experimental field was laid out in 30unit plots, each plot measuring 21.6 m^2 (5.4m × 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 kgha^{-1} (250000 plants ha^{-1}), on 9th 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 (1984). The level of significance used in the "F" test was given at 5 per cent.

The seed samples from the net plot were oven dried at 105°C till constant weight was obtained. The sample was fed to NMR (Nuclear Magnetic resonance spectroscopy). The instrument was standardised with equal quantity of seed sample and the readings obtained were noted as oil per cent.

For estimating nitrogen, phosphorus and potassium content in plants, well dried samples were collected for dry matter accumulation. Samples from each of the plot were collected oven dried, powdered and used for analysis of nitrogen by micro-kjeldahl method (Piper, 1966), Phosphorus by vanado-molybdo phosphoric acid method (Jackson, 1973) using spectrophotometer and potassium by using flame photometer (Jackson, 1967).

The total uptake of nitrogen, phosphorus and potassium at harvest by mustard was calculated by multiplying the biomass yield with the corresponding percentage of nitrogen, phosphorus and potassium and expressed as kg ha^{-1} (Jackson, 1973).

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content}}{100} \times \text{Dry matter accumulation (kg ha}^{-1})$$

RESULTS AND DISCUSSION

Oil content (%) and oil yield (kg ha^{-1}). The results of oil content and oil yield in mustard as influenced by GA_3 and humic acid spray are presented in Table 1.

Study of the data revealed that oil content (%) was not influenced significantly by the spray of hormones. Highest oil content (36.37) 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}). This was found to be on par with all other treatments.

Scrutiny of the data revealed that oil yield (kg ha^{-1}) was significantly influenced by the spray of hormones. Highest oil yield (593 kg ha^{-1}) 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) (568 kg ha^{-1}). Lowest oil yield (390 kg ha^{-1}) was observed with the application of RDF (60:40:40 N, P_2O_5,K_2O 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) (409 kg ha^{-1}). There was increase of 52.1% in the oil 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).

Table 1: Oil content (%) and oil yield ($kgha^{-1}$) in mustard as influenced by GA_3 and humic acid spray.

Treatments	Oil content	Oil Yield
T_1- RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1})	35.05	390
T_2- RDF + foliar spray of GA_3 @ 45 ppm at flowering	35.35	435
T_3- RDF + foliar spray of GA_3 @ 45 ppm at pod development	35.20	409
T_4- RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development	35.87	501
T_5- RDF + foliar spray of humic acid @ 1.5% at flowering	35.64	480
T_6- RDF + foliar spray of humic acid @ 1.5% at pod development	35.49	452
T_7-RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	35.93	520
T_8- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering	36.22	568
T_9-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development	36.08	540
T_{10}-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	36.37	593
SEm ±	0.50	10.8
CD (P=0.05)	NS	32.1

The highest oil yield was recorded with the application of GA_3 and humic acid at flowering and pod development. Improvement in seed oil composition can be credited to the activation of the synthesis of various enzymes which are involved in the fatty acids metabolism (Talaat and Gamal 2007; Dar *et al*., 2015), thus increasing seed oil contents. Application of GA_3 prompted a similar pattern of response, with the oil yield plant per plant being enhanced noticeably. Humic acid application resulted in an increase in oil percentage and oil yield per plant in comparison with control plants. These results are in agreement with the report of Rajpar *et al.* (2011) which showed that application of humic acid had noteworthy effect on oil yield.

Nutrient content (%). The data revealed that nutrient content (%) of the plant was not influenced significantly by the spray of hormones. Highest nutrient content (N, P and K) 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}). This was found to be on par with all other treatments.

Nitrogen uptake (kg ha^{-1}). The results of Nitrogen uptake (kg ha^{-1}) of mustard plants as influenced by GA_3 and humic acid spray are presented in Table 2.

Table 2: Nitrogen uptake (kg ha^{-1}) by mustard plants as influenced by GA_3 and humic acid spray.

Treatments	30 DAS	60 DAS	At Harvest		
			Seed	Stover	Total
T_1- RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1})	1.44	53.6	36.7	26.1	62.8
T_2- RDF + foliar spray of GA_3 @ 45 ppm at flowering	2.18	65.1	41.8	29.8	71.5
T_3- RDF + foliar spray of GA_3 @ 45 ppm at pod development	2.20	54.1	39.6	28.6	68.2
T_4- RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development	1.50	66.8	48.3	37.0	85.3
T_5- RDF + foliar spray of humic acid @ 1.5% at flowering	1.68	58.6	46.1	29.7	75.9
T_6- RDF + foliar spray of humic acid @ 1.5% at pod development	1.64	53.6	44.1	29.4	73.5
T_7- RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	1.54	60.4	50.9	31.8	82.6
T_8- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @1.5% with 2 days interval at flowering	1.68	73.7	54.6	40.0	94.6
T_9- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development	2.06	53.2	52.8	39.7	92.5
T_{10}-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	1.67	75.9	58.2	42.7	100.8
SEm ±	0.24	2.6	2.4	0.9	3.1
CD (P=0.05)	NS	7.8	7.0	2.7	9.3

Data on the nitrogen uptake revealed that at 30 DAS, there is no significant influence of GA_3 and humic acid spray on the N uptake. Highest N uptake (2.2) was recorded with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3). This was found to be on par with all other treatments.

At 60 DAS highest value of N uptake (75.9) was recorded 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) (73.7). Lowest value of N uptake (53.2) was recorded with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development (T_9), which was on par with RDF (60:40:40 N, P_2O_5,K_2O kg ha^{-1}) (T_1), 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) and (53.6, 54.1 and 53.6).

At harvest, the highest value of seed nitrogen uptake (58.2) was recorded 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) and RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development (T_9) (54.6 and 52.8). Lowest value of N uptake in grain (36.7) was recorded 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 flowering (T_2) and RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (41.8 and 39.6).

Data on the nitrogen uptake by stover revealed that, the highest value of nitrogen uptake (42.7) was recorded 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) (40.0). Lowest value of N uptake in stover (26.1) was recorded with the application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1).

The highest value of total nitrogen uptake at harvest (100.8) was recorded 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) and RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_9) (94.6 and 92.5). Lowest value of total N uptake (62.8) was recorded with the application of RDF (60:40:40 N, P_2O_5,K_2O $kgha^{-1}$) (T_1), which was on par with the application of RDF + foliar spray of GA_3 @ 45 ppm at flowering (T_2) and RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (71.5 and 68.2).

Phosphorous uptake (kg ha^{-1}). The results of Phosphorous uptake (kg ha^{-1}) of mustard plants as influenced by GA_3 and humic acid spray are presented in Table 3.

Table 3: Phosphorus uptake (kg ha^{-1}) by mustard plants as influenced by GA_3 and humic acid spray.

Treatments	30 DAS	60 DAS	AT HARVEST		
			Seed	Stover	Total
T_1- RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1})	0.37	10.3	4.3	6.7	11.0
T_2- RDF + foliar spray of GA_3 @ 45 ppm at flowering	0.56	13.1	4.8	7.4	12.2
T_3- RDF + foliar spray of GA_3 @ 45 ppm at pod development	0.55	10.6	4.6	7.5	12.1
T_4- RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development	0.43	13.4	5.8	10.0	15.8
T_5- RDF + foliar spray of humic acid @ 1.5% at flowering	0.44	12.1	5.5	8.2	13.6
T_6- RDF + foliar spray of humic acid @ 1.5% at pod development	0.41	10.5	5.3	8.2	13.5
T_7- RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	0.40	12.7	6.3	9.2	15.5
T_8- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @1.5% with 2 days interval at flowering	0.47	15.8	6.7	12.0	18.7
T_9- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development	0.51	10.4	6.5	11.9	18.4
T_{10}-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	0.46	16.6	7.3	12.6	19.8
SEm ±	0.06	0.5	0.3	0.2	0.5
CD (P=0.05)	NS	1.5	0.9	0.6	1.3

Data on the phosphorous uptake revealed that, at 30 DAS there is no significant influence of GA_3 and humic acid spray on the P uptake. Highest P uptake (0.56) was recorded with the application of RDF + foliar spray of GA_3 @ 45 ppm at flowering (T_2). This was found to be on par with all other treatments.

At 60 DAS highest value of P uptake (16.6) was recorded 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) (15.8). Lowest value of P uptake (10.3) was recorded with the application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1) which was on par with application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3), RDF + foliar spray of humic acid @ 1.5% at pod development (T_6) and RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development (T_9) (10.6, 10.5 and 10.4).

At harvest, the highest value of seed phosphorous uptake (7.3) was recorded 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) and RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval atpod development (T_9) (6.7 and 6.5). Lowest value of P uptake in seed (4.3) was recorded 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 flowering (T_2) and RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (4.8 and 4.6).

Data on the phosphorous uptake by stover revealed that, the highest value of phosphorous uptake (12.6) was recorded 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) (12.0). Lowest value of P uptake in stover (6.7) was recorded with the application of RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1}) (T_1).

The highest value of total phosphorous uptake at harvest (19.8) was recorded 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) (18.7). Lowest value of total P uptake (10.9) was recorded with the application of RDF (60:40:40 N, P_2O_5, K_2O $kgha^{-1}$) (T_1) which was on par with the application of RDF + foliar spray of GA_3@ 45 ppm at flowering (T_2) and RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3) (12.2 and 12.1).

Potassium uptake (kg ha^{-1}). The results of potassium uptake (kg ha^{-1}) of mustard plants as influenced by GA_3 and humic acid spray are presented in Table 4.

Table 4: Potassium uptake (kg ha^{-1}) by mustard plants as influenced by GA_3 and humic acid spray.

Treatments	30 DAS	60 DAS	At Harvest		
			Seed	Stover	Total
T_1- RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1})	1.20	47.2	9.3	38.9	48.1
T_2- RDF + foliar spray of GA_3 @ 45 ppm at flowering	1.90	58.8	10.4	43.7	54.0
T_3- RDF + foliar spray of GA_3 @ 45 ppm at pod development	1.91	46.3	9.8	42.2	52.0
T_4- RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development	1.45	59.9	12.0	54.1	66.1
T_5- RDF + foliar spray of humic acid @ 1.5% at flowering	1.67	53.6	11.5	43.8	55.2
T_6- RDF + foliar spray of humic acid @ 1.5% at pod development	1.53	47.1	11.1	43.1	54.1
T_7- RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	1.35	55.1	12.8	46.7	59.5
T_8- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @1.5% with 2 days interval at flowering	1.61	69.1	13.8	58.7	72.4
T_9- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development	1.65	45.9	13.3	58.2	71.5
T_{10}-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	1.47	70.8	14.8	61.9	76.6
SEm ±	0.24	2.4	0.8	1.3	1.6
CD (P=0.05)	NS	7.1	2.2	3.9	4.7

Data on the potassium uptake revealed that, at 30 DAS there is no significant influence of GA_3 and humic acid spray on the K uptake. Highest K uptake (1.91) was recorded with the application of RDF + foliar spray of GA_3 @ 45 ppm at pod development (T_3). This was found to be on par with all other treatments.

At 60 DAS highest value of K uptake (70.8) was recorded 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) (69.1). Lowest value of K uptake (45.9) was recorded with the application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at pod development (T_9) which was on par with application of RDF (60:40:40 N, P_2O_5,K_2O kg ha^{-1}) (T_1), 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) (47.2, 46.3 and 47.1).

At harvest, the highest value of seed potassium uptake (14.8) was recorded 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 application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) and RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval atpod development (T_9) (13.8 and 13.3). Lowest value of K uptake in seed (9.3) was recorded 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 flowering (T_2) 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) (10.4, 9.8 and 11.1).

The highest value of potassium uptake in stover (61.9) was recorded 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 application of RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T_8) and RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval atpod development (T_9) (58.7 and 58.2). Lowest value of K uptake in straw (38.8) was recorded with the application 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) (42.2).

The highest value of total potassium uptake (76.6) was recorded 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) (72.4). Lowest value of total K uptake (48.1) was recorded 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) (52.0).

Table 5: Dry matter production (kg ha^{-1}) of mustard as influenced by GA_3 and humic acid spray.

Treatments	30 DAS	60 DAS	At Harvest
T_1- RDF (60:40:40 N, P_2O_5, K_2O kg ha^{-1})	104	2667	4852
T_2- RDF + foliar spray of GA_3 @ 45 ppm at flowering	159	3202	5387
T_3- RDF + foliar spray of GA_3 @ 45 ppm at pod development	153	2683	5143
T_4- RDF + foliar spray of GA_3 @ 45 ppm at flowering and pod development	118	3297	6407
T_5- RDF + foliar spray of humic acid @ 1.5% at flowering	127	2858	5437
T_6- RDF + foliar spray of humic acid @ 1.5% at pod development	115	2677	5204
T_7- RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	112	2958	5644
T_8- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @1.5% with 2 days interval at flowering	126	3558	6894
T_9- RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @1.5% with 2 days interval at pod development	145	2633	6668
T_{10}-RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @1.5% with 2 days interval at flowering and pod development	125	3650	7120
SEm ±	18	74.4	117.9
CD (P=0.05)	NS	221	348

On the whole the highest values of N, P and K uptake were recorded with the application of GA_3 and humic acid at flowering and pod development which was on par with the application of GA_3 and humic acid at only flowering.

The enhancing effect of humic acid on N, P and K uptake may be due to better development root systems (David *et al.,* 1994) and increased the permeability of plant membranes (Ulukan, 2008). Furthermore, humic constituents are known to interact with the phospholipid structures of cell membranes and acts as carriers of nutrients, that allows to pass through them. These results are in accordance with those obtained by El-Ghamry *et al.* (2009) who reported that the foliar spray of humic acid caused significant increases in N, P and K contents of bean seeds. When applying humic acid substances to plants some of the humic acid also got sprayed on to the soil. It is assumed that, this also created a synergetic effect during uptake of nutrients by plants from soil (Bakry *et al.,* 2013).

GA_3 is known to promote growth through increased absorption of nutrients (Singh *et al*., 2005) and nitrogen use efficiency (Khan *et al*., 2002). Due to increase in the growth rate, the GA_3 sprayed plants exhibited more nutrient uptake. An increase in membrane permeability due to application of GA_3would facilitate absorption and utilization of mineral nutrients and transportation of assimilates. This would also contribute towards increasing the capacity of the treated plants to improve the leaf NPK content. Combination of $GA_3$with fertilizer dose may be attributed to their ameliorative effect on the primary growth potential and activities of nitrate reductase and carbonic anhydrase enzymes. Thereby, the available nutrients in the growth medium might have been absorbed more swiftly as reflected by increased leaf N, P and K contents which have perhaps led to maximum utilization of absorbed nutrients because of enhancement of vegetative growth and development of more number of pods. These results are agreed with the findings of Field and Mooney (1986); Connor *et al*. (1993).

CONCLUSION

— It was found that quality parameters like oil content and nutrient content (N, P, K) at 30, 60 DAS and harvest were not influenced significantly the spray of GA_3 and humic acid. But nutrient uptake (N, P, K) at 60 DAS and at harvest (grain and stover) and oil yield were significantly influenced by the spray of GA_3 and humic acid.

— The highest oil yield and nutrient uptake were observed with the application of T_{10} (RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development) and this was on par with the application of T_8 (RDF + foliar spray of GA_3 @ 45 ppm fb humic acid @ 1.5% with 2 days interval at flowering).

FUTURE SCOPE

There is a scope for studying the effect of the hormones (GA_3 and humic acid) on mustard, when applied at vegetative stage. Influence of humic acid when it is soil applied can also be studied.

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