

Effectiveness of GA₃ and Humic Acid Foliar Sprays on Crop Yield and Growth Parameters in Rabi Season of Mustard (*Brassica* spp.)

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Abstract

The research conducted to investigate effect of foliar spray of hormones during rabi, 2023-24 at Research farm, Vivekananda Global University, Jaipur and designed in a randomized block design with ten treatments and each one replicated thrice. The treatments comprised were : T1- RDF, T2- RDF + foliar spray of GA₃@ 50 ppm at flowering), T3- RDF + foliar spray of GA₃@ 50 ppm at pod development, T4- RDF + foliar spray of GA₃@ 50 ppm at flowering and pod development, T5- RDF + foliar spray of humic acid @ 1.5% at flowering, T6- RDF + foliar spray of humic acid @ 1.5% at pod development, T7- RDF + foliar spray of humic acid @ 1.5% at flowering and pod development, T8- RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering, T9- RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at pod development and T10-RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development. Highest seed yield (2083.90 kg ha⁻¹) and stover yield (5796.08 kg ha⁻¹) were recorded with the application of T10 which were at par with the application of T8. Application of RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T10) and RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T8) were at par with each other in all the aspects and resulted significant increase in different growth, yield attributes, yield.

Although T10 and T8 gave the similar results, the B:C ratio of T8 was higher as the cost of cultivation for it is lower than that of T10. So, T8 (RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering) is regarded as the best treatment.

Keyword: Foliar spary, GA₃ humic acid and yield

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Introduction

In the world, Indian mustard, or *Brassica juncea* (L.) Czernj. & Cosson, ranks third in importance for edible oils, behind oil palm and soybeans [1]. One of the main oilseed crops grown in India for rabi is Indian mustard (*Brassica juncea*). Indian mustard (*Brassica juncea* L.) is the most important oilseed crop of India, occupying the first rank in area and second in production next to China. In India, mustard is cultivated on an area of 8.06 million hectares with production of 11.75 million tonnes and productivity of 1458 kg/ha [2]. Rajasthan is leading state particularly Indian mustard, it occupies 3.94 million ha area and produces 6.26 million tonnes yield with productivity of 1587 kg/ha [3].

Being a significant crop of Rabi oilseed and benefiting from soil moisture retention during the monsoon, it has a greater potential to raise the amount of edible oil produced domestically that is available. Due to a variety of biotic and abiotic stresses as well as India's domestic price support programme, rapeseed-mustard production and yield have been found to be unstable in India, despite the crop's superior quality oil and meal as well as its broad adaptability for a variety of agro-climatic conditions. On the other hand, the crop could ensure nutritional security and support livelihood security. Mustard is the crop which is grown mostly under cool temperate climates. It is also cultivated as a cold weather crop in some of the tropical and subtropical regions.

Gibberellic acid is a crucial phytohormone that is required in small amounts and at low concentrations to accelerate the growth and development of plants. It is one of these plant growth regulators that work with different crops to control different growth and development phenomena. GA₃ promotes stem elongation and increases plant growth activities. It is sprayed on crops, orchards, and ornamental plants, where it contributes to the following processes: flowering [4], stem elongation [5], abiotic stress response, barley malting [6], and other physiological effects that arise from its interaction with other phytohormones. A number of researchers emphasised the advantages of applying humic acid to higher plants [7]. Additionally, humic acids lessen the harmful effects of salts on dicots, such as rapeseed, and monocots. It is also widely known that applying humic acid to plants increases their uptake of

nutrients [8]. Similarly, its application has been shown to increase the yield of numerous crops, such as potatoes, onions, tomatoes, brassica, and other leafy vegetables. The problem of mustard crop is seed shattering. In order to prevent the loss due to seed shattering and improve the yield, the hormones are sprayed in the form of foliar spray.

Material and Methods

A field experiment was conducted during Rabi 2023-24 at Research farm, Vivekananda Global University, Jaipur, the study area is located at 74° 89' East longitudes, at 29° 22' North latitude on vertisol having pH 8.10 and EC 0.25 dS m⁻¹. The soil organic carbon content was low to medium (0.27 %) and available P₂O₅ (16.3 kg ha⁻¹), and available N is low (137.8 kg ha⁻¹) with high available K₂O content (250.12 kg ha⁻¹). There are 10 treatments combinations were laid out in Randomized Block Design with 3 replications and Treatments details of experiment are presented in **Table 1**.

Table 1 Details of treatments

Treatments	Symbols
RDF	T ₁
RDF + foliar spray of GA3@ 50 ppm at flowering	T ₂
RDF + foliar spray of GA3@ 50 ppm at pod development	T ₃
RDF + foliar spray of GA3@ 50 ppm at flowering and pod development	T ₄
RDF + foliar spray of humic acid @ 1.5% at flowering	T ₅
RDF + foliar spray of humic acid @ 1.5% at pod development	T ₆
RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	T ₇
RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering	T ₈
RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at pod development	T ₉
RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	T ₁₀

Note - recommended dose of N, P and K are applied to all treatment except control.

Treatments application

The dose of nitrogen (N), phosphorus (P) and potash (K) were applied as per treatment recommendations (60:40:40 N, P₂O₅, K₂O kg ha⁻¹) as basal application at the time of sowing.

Gibberellic acid

The trade name of the chemical used is TAG-GIBB. It is a white powder with a composition of 90% w/w of gibberellic acid and 10% of related impurities. Gibberellic acid was sprayed @ 50 ppm at flowering and pod development.

Humic acid

Humic acid contains 51% to 57% C, 4% to 6% N and 0.2% to 1% P and other micronutrients in minute amounts. A granular commercial product was obtained from the market with 58% humic acid. Humic acid was sprayed @ 1.5% at flowering and pod development stages. Seeds of mustard variety "DRMRIJ-31" were sown manually at rate of 5.0 kg ha⁻¹ maintaining row to row distance of 30 cm and plant to plant distance of 10 cm placed at depth of 3-4 cm and sowing was done at 20th October 2023. The growth, yield attributes and yield observations were recorded from the net plots and seed yield was converted to hectare basis in quintal. The economics of each treatment was computed with prevailing market prices of the corresponding year. Standard method of "Analysis of variance" was used for analysing the data [9].

Result and Discussion

Growth parameters

Growth parameters viz., plant height and dry matter accumulation were significantly influenced by spray of GA3 and humic acid at 90 DAS and harvest (Table 2). Highest plant height (at 60 DAS- 101.20 cm, at 90 DAS-170.25 cm and at harvest stage- 187.55 cm), number of primary branches plant-1 (7.13), secondary branches plant-1 and dry matter accumulation (at 60 DAS- 126.83 g m⁻², at 90 DAS-195.88 g m⁻² and at harvest stage- 218.18 g m⁻²) were recorded with the application of T10 (RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development) which were on par with the application of T8-RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering in most of the cases. On the whole, the highest plant height at 90 DAS and harvest was recorded with the application of GA₃ and humic acid. GA₃ is known to promote growth by

improving nutrient absorption, nitrogen utilization efficiency, and cell development by inducing the breakdown of proteins that inhibit growth. The findings are consistent with the [10] and [11]. The main source of the nutrients N, P, and K is humic acid. When these nutrients are applied topically, the plant's vegetative parts absorb them fast and remobilize them to other parts of the plant. The use of GA₃ and humic acid during flowering and pod development resulted in the highest value of dry matter at 60 DAS, 90 DAS, and harvest. The effect of GA₃ on various plant processes has affected the source-sink relationship [12]; in mustard, an increase in the source-sink relationship was the primary factor contributing to the GA₃-mediated increase in the photosynthesis process [13].

Table 2 Effect of GA₃ and humic acid spray on plant population, plant height and dry matter accumulation of mustard

Treatments	Plant population per meter row length			plant height (cm)			Dry matter accumulation (g m ⁻²)		
	20 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	
T ₁ RDF	8.09	8.04	97.21	145.10	175.50	122.84	170.73	201.13	
T ₂ RDF + foliar spray of GA ₃ @ 50 ppm at flowering	8.35	8.28	98.50	158.25	178.50	124.13	183.88	204.13	
T ₃ RDF + foliar spray of GA ₃ @ 50 ppm at pod development	8.34	8.30	96.20	146.50	177.20	121.83	172.13	202.83	
T ₄ RDF + foliar spray of GA ₃ @ 50 ppm at flowering and pod development	8.40	8.20	99.90	159.25	182.80	125.53	184.88	208.43	
T ₅ RDF + foliar spray of humic acid @ 1.5% at flowering	8.40	8.32	96.00	159.25	178.60	121.63	184.88	204.23	
T ₆ RDF + foliar spray of humic acid @ 1.5% at pod development	8.50	8.30	96.40	146.25	178.10	122.03	171.88	205.73	
T ₇ RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	8.45	8.42	97.40	161.25	179.80	123.03	185.88	215.43	
T ₈ RDF + foliar spray of GA ₃ @ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering	8.60	8.50	100.89	168.59	182.70	126.52	190.22	210.33	
T ₉ RDF + foliar spray of GA ₃ @ 50 ppm fb humic acid @ 1.5% with 2 days interval at pod development	8.60	8.54	97.54	147.62	183.55	123.17	173.25	212.18	
T ₁₀ RDF + foliar spray of GA ₃ @ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	8.70	8.55	101.20	170.25	187.55	126.83	195.88	218.18	
S.Em.±	0.34	0.36		2.540	2.914	2.976	4.25	4.538	
C.D. at 5%	NS	NS		NS	6.12	6.25	NS	9.53	

Yield and yield attributes parameters

It is evident the results (Table 3) that effect of foliar application of GA₃ and humic acid was significant on yield and yield attributes like number of siliquae per plant, seed yield, stover yield and biological yield. The maximum siliquae plant per plant (198) seeds per siliquae (10.28), test weight (3.83 g), seed yield (2083.90 kg ha⁻¹), stover yield (5796.08 kg ha⁻¹) and biological yield (7879.98 kg ha⁻¹) was obtain under treatment of T₁₀ - RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development, however most of the traits show at par with treatment of T₈-RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering.

Table 3 Effect of GA3 and humic acid spray on branches per plant, yield contributing traits and yields of mustard

Treatments		branches per plant		Yield contributing traits			Yields			
		Primary branches per plant	Secondary branches per plant	Number of siliquae per plant	Number of seeds per siliqua	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T ₁	RDF	5.78	10.87	160.38	9.82	3.27	1419.91	3943.20	5363.11	26.48
T ₂	RDF + foliar spray of GA3@ 50 ppm at flowering	6.03	11.15	171.58	9.89	3.37	1571.86	4379.92	5951.78	26.41
T ₃	RDF + foliar spray of GA3@ 50 ppm at pod development	5.90	11.01	164.68	9.85	3.35	1485.03	4201.84	5686.87	26.11
T ₄	RDF + foliar spray of GA3@ 50 ppm at flowering and pod development	6.52	11.87	186.25	9.99	3.54	1781.28	5293.64	7074.92	25.18
T ₅	RDF + foliar spray of humic acid @ 1.5% at flowering	6.40	11.44	180	9.96	3.49	1718.71	4315.26	6033.97	28.48
T ₆	RDF + foliar spray of humic acid @ 1.5% at pod development	6.27	11.30	173.40	9.93	3.46	1625.49	4149.90	5775.39	28.15
T ₇	RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	6.64	12.16	187.50	10.04	3.61	1847.67	4427.62	6275.29	29.44
T ₈	RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering	7.13	12.73	195.25	10.13	3.76	2000.90	5623.30	7624.20	26.24
T ₉	RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at pod development	6.89	12.30	191.20	10.08	3.68	1908.97	5461.12	7370.09	25.90
T ₁₀	RDF + foliar spray of GA3@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	7.13	12.73	198	10.28	3.83	2083.90	5796.08	7879.98	26.45
S.Em.±		0.34	0.586	0.586	17.141	5.7	0.23	89.643	268.381	360.771
C.D. at 5%		NS	1.23	1.23	35.9964	NS	NS	188.25	563.60	757.62

The highest number of siliquae was observed with the application of GA3 and humic acid at flowering and pod development. Gibberellic acid is very important PGR that improves the growth cascades of plants by stimulating the stem and internode elongation, enzyme activation, and the fruit setting. Thus, it improves the siliquae [14]. The application of GA₃ and humic acid during flowering and pod development resulted in the highest seed yield. The actual yield is increased by the plant growth regulators, which direct photosynthates away from the harvested product [15]. Increased uptake of mineral nutrients has been linked to humic acid's stimulating effect on yield and yield attributes. This could also be explained by the fact that humic acid contains a wealth of minerals that are vital to plant

growth, increasing both the quality and quantity of yield. Plant growth is impacted by humic acid in both direct and indirect ways. It is increased due to collective effect of yield attributing characters, enhanced photosynthetic efficacy and enhancement in the capacity of the reproductive sinks to utilize the incoming assimilates due to the spray application of GA₃. Similar results were observed by [16-17]. It was found that applying GA₃ and humic acid during flowering and pod development produced the maximum stover yield. Due to its auxin activity, hormone-induced effect on respiratory catalytic activity, increased permeability of cells, and enhanced nutrient uptake, humic acid may have increased plant height and dry matter accumulation, which in turn increased stover yield. Similar findings that humic acid application increases biological yield were reported by [18-20]. The results showed that the application of RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T₁₀) obtained significantly higher net returns, gross return and benefit cost ratio over the control. 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 (Table 4). This might be due to achieved higher productivity as well as lower cost of cultivation owing to increased economic returns. These results are in accordance with the findings of [21-22].

Table 4 Effect of GA₃ and humic acid spray on economics of mustard

Treatments		Cost of cultivation (Rs ha ⁻¹)	Gross Income (Rs ha ⁻¹)	Net Income (Rs ha ⁻¹)	B:C Ratio
T ₁	RDF	29300	72,967	43,017	2.44
T ₂	RDF + foliar spray of GA ₃ @ 50 ppm at flowering	30278	80,783	48,877	2.53
T ₃	RDF + foliar spray of GA ₃ @ 50 ppm at pod development	30278	76,352	44,446	2.39
T ₄	RDF + foliar spray of GA ₃ @ 50 ppm at flowering and pod development	31260	91,711	57,841	2.71
T ₅	RDF + foliar spray of humic acid @ 1.5% at flowering	31383	88,093	53,977	2.58
T ₆	RDF + foliar spray of humic acid @ 1.5% at pod development	31383	83,349	49,233	2.44
T ₇	RDF + foliar spray of humic acid @ 1.5% at flowering and pod development	33470	94,597	56,307	2.47
T ₈	RDF + foliar spray of GA ₃ @ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering	32361	102,857	66,785	2.85
T ₉	RDF + foliar spray of GA ₃ @ 50 ppm fb humic acid @ 1.5% with 2 days interval at pod development	32361	98,179	62,107	2.72
T ₁₀	RDF + foliar spray of GA ₃ @ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development	35430	107,093	64,883	2.54
S.Em.±		-	3535.857	1582.238	0.086
K8C.D. at 5%		-	7425.30	3322.70	0.18

Conclusion

Application of RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering and pod development (T₁₀) and RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering (T₈) were at par with each other in all the aspects and resulted significant increase in different yield attributes, yield. Although T₁₀ and T₈ gave the similar results, the BC ratio of T₈ was higher as the cost of cultivation for it is lower than that of T₁₀. So, T₈ (RDF + foliar spray of GA₃@ 50 ppm fb humic acid @ 1.5% with 2 days interval at flowering) is regarded as the best treatment.

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Publication History

Received	08.08.2024
Revised	18.09.2024
Accepted	20.09.2024
Online	30.09.2024