



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(13): 27-31
Received: 15-05-2026
Accepted: 18-06-2026

Sunil V Wadekar
C. P. College of Agriculture, S.D.
Agricultural University
Sardarkrushinagar, Gujarat, India

AL Jat
ICAR-Research Complex for NEH
Region, Mizoram Centre Kolasib,
Mizoram, India

Sunil Kumar Chongtham
College of Horticulture, Central
Agricultural University, Imphal,
Bermiok, Sikkim, India

JK Malav
College of Agriculture, S.D.
Agricultural University,
Sardarkrushinagar, Gujarat, India

JR Jat
College of Agriculture, S.D.
Agricultural University,
Sardarkrushinagar, Gujarat, India

Yash Patel
College of Agriculture, S.D.
Agricultural University,
Sardarkrushinagar, Gujarat, India

Murari Lal Meena
College of Agriculture, S.D.
Agricultural University,
Sardarkrushinagar, Gujarat, India

Yogesh Kumar
College of Agriculture, S.D.
Agricultural University,
Sardarkrushinagar, Gujarat, India

Corresponding Author:
AL Jat
ICAR-Research Complex for NEH
Region, Mizoram Centre Kolasib,
Mizoram, India

Effect of humic acid on productivity and profitability of Indian mustard

Sunil V Wadekar, AL Jat, Sunil Kumar Chongtham, JK Malav, JR Jat, Yash Patel, Murari Lal Meena and Yogesh Kumar

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i13a.6144>

Abstract

A field experiment was carried out during *rabi* 2023-24 on loamy sand soil of Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The experiment was executed in factorial RBD with three replications. There were sixteen treatment combinations comprising four levels of soil application of humic acid (S_0 : 0 kg ha⁻¹, S_1 : 10 kg ha⁻¹, S_2 : 20 kg ha⁻¹, S_3 : 30 kg ha⁻¹) and four levels of foliar spray of humic acid [F_0 : Control (water spray), F_1 : 20 ppm, F_2 : 40 ppm, F_3 : 60 ppm]. The results of the present study revealed that significantly higher values of plant height at 60 DAS and at harvest (129.6 cm and 184.5 cm), and dry matter accumulation per plant at 60 DAS and at harvest (17.82 g/plant and 57.20 g plant⁻¹), number of secondary branches per plant (14.20), number of siliquae per plant (280.3), seed yield (1740 kg ha⁻¹), stover yield (4359 kg ha⁻¹) and oil yield (673 kg ha⁻¹) was recorded with soil application of humic acid @ 30 kg ha⁻¹. Foliar spray of humic acid @ 60 ppm secured significantly higher plant height at 60 DAS and at harvest (128.7 cm and 182.3 cm) dry matter accumulation at 60 DAS and at harvest (17.13 g plant⁻¹ and 54.70 g plant⁻¹), number of secondary branches per plant (13.61), number of siliquae per plant (267.2), seed yield (1694 kg ha⁻¹), stover yield (4299 kg ha⁻¹) and oil yield (663 kg ha⁻¹).

Keywords: Growth, humic acid, mustard, oil yield and seed yield.

Introduction

In 'Rapeseed-Mustard' group of oil seeds, mustard [*Brassica juncea* (L.) Czernj & Cosson] occupies the prime position in India. Mustard is predominantly cultivated in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat. The cultivation of this crop also occurs in unconventional regions of South India such as Karnataka, Tamil Nadu, and Andhra Pradesh. It is grown in both irrigated and rainfed environments.

Productivity has improved significantly in India over the last ten years and the production of 2022-23 was 126.96 lakh tonne (Anonymous, 2024^a) [1]. Currently the area, production and productivity of rapeseed-mustard in Gujarat was 2.67 lakh ha, 5.35 lakh tonnes and 1999.08 kg ha⁻¹, respectively (Anonymous, 2024^b) [2]. Mustard *Brassica napus*, *Brassica campestris* and *Brassica juncea* are the three species of mustard those produce edible oil. Oil of plant origin constitute important component of human diet, ranking third after cereals and animal products and are nutritionally superior to animal oil (Alam *et al.*, 2015) [3]. Although it is an important crop but the cultivation of mustard has to compete with other crops and it has been shifted to marginal lands of poor productivity. The demand for edible oil is rising as the population grows. Therefore, it is widely acknowledged that there should be a significant increase in the production of edible oil to meet this demand (Meena *et al.*, 2017) [4]. Humic acid efficiently improves soil fertility and crop productivity, especially on poorly fertile and alkaline-calcareous soils (Rajpar *et al.*, 2011) [5]. Humic acid is an organically charged bio-stimulant that significantly affects plant growth and development, yield attributes and increases crop yield. It has been extensively investigated that humic acid improves physical, chemical and biological properties of soils (Keeling *et al.*, 2003 and Mikkelsen, 2005) [6, 7].

Humic acid comprises a mixture of weak aliphatic and aromatic organic acids which are not soluble in water under acid condition but are soluble in water under alkaline condition. Humic

acid also occurs in rotting vegetable matter and can be detected in the black slime of an ordinary compost pit in home garden. In soils it is most likely formed by certain secondary processes like polymerization of polyphenols leached by rain from surface leaf litter and condensation of phenols, quinines and proteins which are provided by the action of soil microorganisms. Humic acid exerts physical, chemical and biological effects on soil quality by serving as soil conditioners, nutrient source and substrate for microorganism. They form complexes with many metals and make them available to plant roots and microorganisms. Stimulate plant growth by increasing biomass production. Increase yield and improve quality of plants.

Materials and methods

A field experiment was conducted during the *rabi* season of the year 2023-24 at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar, Banaskantha, Gujarat. Geographically, Sardarkrushinagar comes under North Gujarat Agro-climatic region situated at 24°19' North latitude and 72°19' East longitude, with an elevation of 154.52 m above the mean sea level.

The soil of experimental field was loamy sand in texture with slightly alkaline in reaction (7.32 pH), electrical conductivity (0.14 dS m⁻¹) within safe limit. The soil was low in organic carbon (0.26%) and available nitrogen (156.3 kg ha⁻¹), medium in available P₂O₅ (36.54 kg ha⁻¹) and available K₂O (256.2 kg ha⁻¹). The RBD layout was used with factorial concept for the experiment and implemented with three replications. There were sixteen treatment combinations comprising four levels of soil application of humic acid (S₀: 0 kg ha⁻¹, S₁: 10 kg ha⁻¹, S₂: 20 kg ha⁻¹, S₃: 30 kg ha⁻¹) and four levels of foliar spray of humic acid [F₀: Control (water spray), F₁: 20 ppm, F₂: 40 ppm, F₃: 60 ppm]. Foliar spray of humic acid at 30 and 50 DAS was applied uniformly to all the treatments. The recommended dose of 50 kg nitrogen ha⁻¹, 50 kg phosphorus ha⁻¹, 40 kg sulphur ha⁻¹ were

applied uniformly to all the plots. Soil application of humic acid, full dose of phosphorus, sulphur and half dose of nitrogen were applied at time of sowing and the remaining half dose of the nitrogen was top dressed at 30-35 DAS in moisturised field. The sources of nitrogen, phosphorus, sulphur and humic acid were urea, Diammonium phosphate, bentonite sulphur and potassium humate. The oil content in mustard seed was determined by FT-NIR (Fourier Transferable near Infra-Red) technique (Model Bruker) as per standard method suggested by Tiwari *et al.* (1994) [8]. The oil yield was computed by multiplying the seed yield with oil content. It was computed by using the following formula

$$\text{Oil yield (kg/ha)} = \frac{\text{Oil content (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

Data on different aspects of mustard crop were subjected to the statistical analysis in accordance with analysis of variation techniques as per procedure of randomized block design suggested by Gomez and Gomez (1984) [9].

Results and Discussion

Effect of humic acid on growth parameter

Soil application of humic acid 30 kg ha⁻¹ recorded significantly higher plant height (129.6 cm and 184.5 cm), dry matter accumulation (17.82 and 57.20 g plant⁻¹) at 60 DAS and harvest and number of secondary branches per plant (14.20) which remained statistically at par with 20 kg ha⁻¹ soil application of humic acid (Table 1). However, the number of primary branches per plant, plant height and dry matter accumulation at 30 DAS were all determined to be non-significant (Table 1). Jape *et al.* (2013) [10] also reported that application of humic acid proved effective on increasing the growth parameter in groundnut.

Table 1: Effect of soil and foliar application of humic acid on growth parameter of mustard

Treatments	Plant height (cm)			Dry matter accumulation (g plant ⁻¹)			No. of primary branches per plant	No. of secondary branches per plant
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest		
Soil application of humic acid (S)								
S ₀ : 0 kg ha ⁻¹	34.6	113.6	154.4	4.29	15.79	48.09	4.95	11.62
S ₁ : 10 kg ha ⁻¹	35.2	119.8	170.1	4.49	16.62	50.91	5.06	11.89
S ₂ : 20 kg ha ⁻¹	37.2	123.8	180.4	4.63	16.92	53.65	5.25	13.99
S ₃ : 30 kg ha ⁻¹	37.7	129.6	184.5	4.72	17.82	57.20	5.38	14.20
SEm±	0.95	3.24	4.79	0.120	0.410	1.315	0.129	0.343
CD at 5%	NS	9.36	13.83	NS	1.184	3.799	NS	0.990
Foliar spray of humic acid (F)								
F ₀ : Control (water spray)	35.3	114.8	162.7	4.39	16.00	49.71	4.92	12.28
F ₁ : 20 ppm	35.6	118.4	167.7	4.45	16.54	51.73	5.08	12.52
F ₂ : 40 ppm	36.8	124.8	176.6	4.58	16.88	53.70	5.24	13.30
F ₃ : 60 ppm	36.9	128.7	182.3	4.72	17.73	54.70	5.41	13.61
SEm±	0.95	3.24	4.79	0.120	0.410	1.315	0.129	0.343
CD at 5%	NS	9.36	13.83	NS	1.184	3.799	NS	0.990

Among different treatments 60 ppm foliar spray of humic acid recorded significantly higher plant height (128.7 and 182.3 cm), dry matter accumulation (17.73 and 54.70 g plant⁻¹) at 60 DAS and harvest and number of secondary branches per plant (13.61). Whereas, plant height at 60 DAS and harvest, dry matter accumulation at 60 DAS and number of secondary branches per plant remained statistically at par with 40 ppm foliar spray of humic acid and 40 ppm and 20 ppm foliar spray of humic acid for dry matter accumulation at harvest (Table 1). The number of primary branches per plant, plant height, and dry matter

accumulation at 30 DAS were all deemed to be non-significant (Table 1). The difference in plant height might be due to humic acid stimulate plant growth by the assimilation of major and minor elements, enzyme activation and/or inhibition, changes in membrane permeability, protein synthesis and finally the activation of biomass production ultimately increased dry matter of plant. These findings are in accordance with those reported by Mahmoud *et al.* (2011) [11], Rajpar *et al.* (2011) [5], Hendawy *et al.* (2015) [12], Bahrun *et al.* (2019) [13] and Chaitra *et al.* (2024) [14].

Effect of humic acid on yield attributes and yield

Yield attributes and yield of mustard was significantly influenced by soil application of humic acid. Significantly higher number of siliquae per plant (280.3), seed yield (1740 kg ha⁻¹) and stover yield (4359 kg ha⁻¹) was recorded with soil application of humic acid @ 30 kg ha⁻¹ was found to be statistically at par with 20 kg ha⁻¹ soil application of humic acid. Lowest number of siliquae per plant (230.2), seed yield (1471 kg ha⁻¹) and stover yield (3725 kg ha⁻¹) was recorded with control

(Table 2). On the other hand, information about the number of seeds per silique, silique length, test weight, and harvest index shown to be non-significant. Increase in yield may be attributed to mineralization of nutrients, which leads to improved growth and better partitioning of assimilates to various metabolic sinks Talavia *et al.* (2007) [15]. Similar finding was reported by Rajpar *et al.* (2011) [5] in mustard, Ahmad *et al.* (2016) [16] in canola, Lotfi *et al.* (2018) [17] in rapeseed (*Brassica napus* L.) and Akter *et al.* (2023) [18] in mustard.

Table 2: Effect of soil and foliar application of humic acid on yield and yield attributes of mustard

Treatments	No. of seeds per silique	No. of siliquae per plant	Length of silique (cm)	Test weight (g)	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)
Soil application of humic acid (S)							
S ₀ : 0 kg ha ⁻¹	12.6	230.2	4.85	4.68	1471	3725	28.36
S ₁ : 10 kg ha ⁻¹	12.9	238.3	4.93	4.80	1548	3997	27.91
S ₂ : 20 kg ha ⁻¹	13.0	268.7	4.99	4.88	1631	4250	27.77
S ₃ : 30 kg ha ⁻¹	13.1	280.3	5.10	5.11	1740	4359	28.50
SEm±	0.34	6.79	0.124	0.108	44.2	115.5	0.383
CD at 5%	NS	19.62	NS	NS	127.7	333.5	NS
Foliar spray of humic acid (F)							
F ₀ : Control (water spray)	12.6	239.9	4.89	4.71	1502	3829	28.17
F ₁ : 20 ppm	12.7	247.4	4.95	4.80	1553	4045	27.75
F ₂ : 40 ppm	13.0	262.9	4.98	4.95	1642	4159	28.33
F ₃ : 60 ppm	13.2	267.2	5.05	5.01	1694	4299	28.29
SEm±	0.34	6.79	0.124	0.108	44.2	115.5	0.383
CD at 5%	NS	19.62	NS	NS	127.7	333.5	NS

The highest number of siliquae per plant (267.2), seed yield (1694 kg ha⁻¹) and stover yield (4299 kg ha⁻¹) was observed with foliar spray of humic acid @ 60 ppm at 30 and 50 DAS over rest of treatments, but number of siliquae per plant and seed yield was at par with foliar spray of humic acid @ 40 ppm and stover yield at par with foliar spray of humic acid @ 40 ppm and 20 ppm (Table 2). Whereas, Data pertaining to seeds per silique, length of silique, test weight and harvest index were found non-significant with foliar spray of humic acid. These results are in close agreement with the findings of Bakry *et al.* (2013) [19], Parihar *et al.* (2013) [20], Deotale *et al.* (2017) [21], Barekati *et al.* (2019) [22], Nandini and Math (2019) [23], Kiran *et al.* (2020) [24]

and Reddy *et al.* (2021) [25].

Effect of humic acid on quality

Soil application of humic acid did not have a significant influence on oil content while exerted significant influence on oil yield. Significantly higher oil yield (673 kg ha⁻¹) was recorded with 30 kg ha⁻¹ soil application of humic acid, which was remained at par with 20 kg/ha soil application of humic acid while least oil yield (564 kg ha⁻¹) was recorded with control (Table 3). This might be due to higher seed yield in soil application of humic acid as compared to control.

Table 3: Effect of soil and foliar application of humic acid on quality of mustard

Treatments	Oil content (%)	Oil yield (kg ha ⁻¹)
Soil application of humic acid (S)		
S ₀ : 0 kg ha ⁻¹	38.28	564
S ₁ : 10 kg ha ⁻¹	38.59	599
S ₂ : 20 kg ha ⁻¹	38.55	631
S ₃ : 30 kg ha ⁻¹	38.64	673
SEm±	0.619	22.6
CD at 5%	NS	65.3
Foliar spray of humic acid (F)		
F ₀ : Control (water spray)	38.18	575
F ₁ : 20 ppm	38.31	597
F ₂ : 40 ppm	38.39	632
F ₃ : 60 ppm	39.17	663
SEm±	0.619	22.6
CD at 5%	NS	65.3

Economics analysis

Maximum economic return with successive increase in soil application of humic acid was noted. Maximum gross return (₹1,02,654 ha⁻¹) and net return (₹54,148 ha⁻¹) were obtained with soil application of humic acid @ 30 kg ha⁻¹. Whereas, the minimum gross return (₹86,824 ha⁻¹) and net return (₹48,269 ha⁻¹)

was observed with control (Table 4). Higher seed and stover yield with increasing soil application of humic acid might be resulted in higher net return. This might be due to fact that increment in soil application of humic acid increase yield. The results are conformity with the finding of Paramasivan *et al.* (2015) [28] and Sai Kumar *et al.* (2015) [29].

Table 4: Effect of soil and foliar application of humic acid on economics of mustard

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross realization (₹ ha ⁻¹)	Net realization (₹ ha ⁻¹)	BCR
Soil application of humic acid (S)				
S ₀ : 0 kg ha ⁻¹	38555	86824	48269	2.25
S ₁ : 10 kg ha ⁻¹	42106	91461	49355	2.17
S ₂ : 20 kg ha ⁻¹	45306	96425	51119	2.13
S ₃ : 30 kg ha ⁻¹	48506	102654	54148	2.12
Foliar spray of humic acid (F)				
F ₀ : Control (water spray)	43039	88666	45627	2.07
F ₁ : 20 ppm	43776	91768	47991	2.10
F ₂ : 40 ppm	43812	96927	53115	2.22
F ₃ : 60 ppm	43847	100004	56156	2.28

Selling price of seed (MSP) = ₹56.50/kg

Selling price of stover = ₹1/kg

Increased economic return with foliar spray of humic acid was observed. foliar spray of humic acid @ 60 ppm to mustard crop recorded maximum gross return (₹1,00,004 ha⁻¹) and net return (₹56,156 ha⁻¹). Whereas, the minimum gross return (₹88,666 ha⁻¹) and net return (₹45,627 ha⁻¹) were observed with water spray (Table 4). This might be due to higher yield under this treatment. The results are conformity with the finding of Metre *et al.* (2013) [30], Parihar *et al.* (2013) [20], Deotale *et al.* (2014) [31] and Ganta *et al.* (2021) [32].

Conclusion

It can be concluded that soil application of humic acid @ 20 kg/ha as basal and foliar spray of 40 ppm humic acid along with RDF (50,50,00,40 kg N, P₂O₅, K₂O, S ha⁻¹) produced higher yield of mustard under loamy sand soil of north Gujarat.

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