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Effect of humic acid on nutrient content and uptake by mustard (*Brassica juncea* L.)

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Abstract

An experiment was conducted in the *rabi* season of 2023-24 at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, India. The soil of experimental field is loamy sand in texture, a neutral pH, low organic carbon and available nitrogen; and medium levels of available phosphorus, potash, and sulphur. The experiment was conducted in randomized block design with three replications. In which, sixteen treatment combinations were tested, consisting of four levels of soil application of humic acid (S_0: 0 kg/ha, S_1: 10 kg/ha, S_2: 20 kg/ha, S_3: 30 kg/ha) 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 revealed that significantly higher seed yield (1740 kg/ha), stover yield (4359 kg/ha), K content in seed (0.725%) and stover (1.404%), higher NPKS uptake by crop and K_2O status after harvest in soil (255.7 kg/ha) recorded with soil application of humic acid @ 30 kg/ha. Foliar spray of humic acid (60 ppm) secured significantly (mentioned level of significance) higher seed yield (1694 kg/ha), stover yield (4299 kg/ha) and NPKS uptake.

Keywords : *Humic acid, mustard, seed yield, stover yield, nutrient content and uptake*

Introduction

Oilseeds sector plays a pivotal role in forming the economy of nation. In the world's vegetable oil economy, India comes in fourth place, behind the United States, China and Brazil. India is one of the largest oilseeds producing country that covers one fifth of the entire area oilseed and produces one-fifth of the total oilseed production in the world. Despite these statistical facts India still continuous to be a major importer of edible oils to meet the demands of nations ever burgeon-ing population. Over the past three decades, India's edible oil consumption has been rising due to the country's growing population and rising purchasing power brought on by economic expansion. Rapeseed-mustard has become a key strategic element in increasing domestic production of edible oils and oilseeds due to its adaptability to a variety of agroclimatic conditions and traits like minimal input requirements.

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, respectively (Anonymous, 2024). In Gujarat state mustard growing districts are Kachchh, Sabarkantha, Banaskantha, Ahemdabad, Mehsana and Patan. In spite of these farmer's field average yield of mustard is much lower due to lack of improved agricultural techniques of which different bio-regulators application is an important determinant for better performance of mustard. Reports so far been made to indicate promising results on yield of mustard and other oilseed crops due to the use of bio-chemical substances such as humic acid (Nasiri *et al.*, 2017 and Rajpar *et al.*, 2011). Humic acid is mostly produced by the chemical and biological breakdown of plant and animal waste as well as by the synthesis of various micro organisms. After enriches into the soil it facilitates fertilizer nutrients to reach their maximum potential in improving plant growth (Duary, 2020). The main advantages of humic acid can be attributed to chelating properties of a element such as sodium, potassium, magnesium, zinc, calcium, iron, copper and other elements which compensates nutrient deficiency and as a result promotes fertility and production (Verlinden *et al.*, 2009). The role of humic acid is well known for improving soil health and nutrient uptake by plants, mineral availability and fruit quality (Mauromicale *et al.*, 2011). Humic acid-based fertilizers increase crop yield and improve soil fertility (Mart, 2007 and Mohamed *et al.*, 2009).

Materials and Methods

An experiment was carried out at the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, India during the *rabi* season 2023-24. It is located in the North Gujarat Agro-climatic region at 24°19' North latitude and 72°19' East longitude with an elevation of 154.52 m above sea level. The composite soil samples were collected at the depth of 0-15 cm and analysed for physico-chemical properties of soil. The values were obtained and the methods used to determine them are presented in Table 1.The soil in the experimental field had a loamy sand in texture and slightly alkaline pH (7.32), with an electrical conductivity of 0.14 dS/m. The soil was reported with low organic carbon content (0.26%) and available nitrogen (156.3 kg/ha), medium levels of available P_2O_5 (36.54 kg/ha) and available K_2O (256.2 kg/ha). An experiment followed a randomized block design with three replications. There were sixteen treatment combinations comprising four levels of soil application of humic acid (S_0: 0 kg/ha, S_1: 10 kg/ha, S_2: 20 kg/ha, S_3: 30 kg/ha) 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]. Foliar spray of humic acid was performed at 30 and 50 DAS as per treatments. All of the plots received uniform applications of the recommended dosages of 50 kg nitrogen/ha, 50 kg phosphorus/ha, and 40 kg sulphur/ha. Humic acid, full doses of phosphorus and sulphur, and half doses of nitrogen were applied to the soil at the time of sowing. The remaining half dose of nitrogen was top dressed in field at 30 to 35 days after sowing. Urea, diammonium phosphate, bentonite sulphur and potassium humate were the sources of nitrogen, phosphorus, sulphur and humic acid, respectively. Mustard crop variety (GDM-4) was raised as per the package and practices of agronomy.

At maturity, representative samples of mustard seed and stover were drawn from each plot,and used for chemical analysis. Samples were oven dried at 70°C for 24 hours and crushed by mechanical willey grinder.These samples were analysed for N, P, K and S content in seed and stover as per the prescribed procedure given in Table1.

The uptake of nitrogen, phosphorus, potassium and sulphur by mustard was calculated by using the following formula :

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg/ha)}}{100}$$

Analysis of variance techniques were used to statistically analyse of data on different parameters of the mustard crop in accordance with the randomised block design procedure as depicted by Gomez and Gomez (1984). The significance of the treatment was calculated at 5 percent level of significance.

Results and Discussion

Seed and stover yield

The characteristics and production of mustard were greatly affected by the application of humic acid to the soil. The seed (1740 kg/ha) and stover yield (4359 kg/ha) significantly ($p<0.05$) increased with soil application of 30 kg/ha humic acid respectively, which was comparable to the results of using 20 kg/ha of humic acid. Lowest seed yield (1471 kg/ha) and stover yield (3725 kg/ha) was recorded with control

Table 1 : Initial physico-chemical properties of the experimental site

Parameters	Soil depth 0-15 (cm)	Methods employed
Soil pH (1: 2.5, Soil: Water ratio)	7.32	Potentiometric method (Jackson, 1973)
Electrical conductivity (dS/m)	0.14	Schofield method (Jackson, 1973)
Organic carbon (%)	0.26	Walkley and Black's method (Jackson, 1973)
Available N (kg/ha)	156.3	Alkaline potassium permanganate method(Subbiah & Asija, 1956)
Available P_2O_5 (kg/ha)	36.54	Olsen's method (Olsen *et al*., 1954)
Available K_2O (kg/ha)	256.2	Flame photometric method (Jackson, 1973)
Available S (mg/kg)	9.21	Turbidimetric method (Chaudhary and Cornfield, 1966)

Table 2 : Methods followed for plant analysis

Determination	Method	References
Plant analysis		
Nitrogen	Micro-Kjeldahl's digestion and distillation method	Waranke and Barber(1974)
Phosphorus	Vanadomolybdo phosphoricacid yellow colour	Jackson(1973)
Potassium	Flamephotometricmethod	Jackson(1973)
Sulphur	Turbidimetric method	Chaudhary and Cornfield (1966)

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

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)
Soil application of humic acid (S)		
S_0: 0 Kg/ha	1471	3725
S_1: 10 Kg/ha	1548	3997
S_2: 20 Kg/ha	1631	4250
S_3: 30 Kg/ha	1740	4359
S.Em.±	44.2	115.5
CD at 5%	127.7	333.5
Foliar spray of humic acid (F)		
F_0: Control (water spray)	1502	3829
F_1: 20 PPM	1553	4045
F_2: 40 PPM	1642	4159
F_3: 60 PPM	1694	4299
S.Em.±	44.2	115.5
CD at 5%	127.7	333.5

(Table 3). These results are in close agreement with the findings of Rajpar *et al., (*2011) in mustard, Ahmad *et al., (*2016) in canola and Akter *et al., (*2023) in mustard.

The foliar spray of humic acid @ 60 ppm at 30 and 50 DAS produced the highest seed yield (1694 kg/ha) and stover yield (4299 kg/ha) compared to the other treatments; however, the seed yield was at par with foliar spray of humic acid @ 40 ppm, and the stover yield was at par with foliar spray of humic acid @ 40 ppm and 20 ppm (Table 3). Similar results were also reported by Barekati *et al., (*2019) in canola and Reddy*et al., (*2021) in sesame.

Nutrient Content in seed and stover

Addition of humic acid to the soil did not have a significant impact on the levels of nitrogen, phosphorus and sulphur in both the seed and stover. However, applying 30 kg/ha of humic acid resulted in higher potassium content in both the seed (0.725 %) and stover (1.404 %), which was higher than 20 kg/ha of humic acid applied treatment. Levels of foliar spray of humic acid did not have a statistical impact on the content of N, P, K and S (%) in both seed and stover (Table 4). The use of humic compounds enhanced the development of lateral root along with increase in the number of secondary roots and better availability of nutrients. Since humic acid is an excellent source that enhanced nutrient absorption, enhances the nutrient availability through chelating, hence increasing their uptake and content. Similar conclusions were also made by Mahmoud *et al.* (2011) in soybean, Aisha *et al.* (2014) in turnip and Ahmad *et al.* (2016) on canola.

Table 4 : Nutrient content in seed and stover of mustard as influenced by soil and foliar application of humic acid

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Sulphur content (%)	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Soil application of humic acid (S)								
S_0: 0 Kg/ha	2.416	1.219	0.418	0.187	0.681	1.259	0.313	0.135
S_1: 10 Kg/ha	2.479	1.239	0.421	0.188	0.696	1.338	0.324	0.137
S_2: 20 Kg/ha	2.515	1.251	0.428	0.191	0.703	1.357	0.328	0.140
S_3: 30 Kg/ha	2.540	1.273	0.436	0.195	0.725	1.404	0.335	0.141
S.Em.±	0.039	0.021	0.005	0.002	0.008	0.019	0.005	0.002
CD at 5%	NS	NS	NS	NS	0.024	0.055	NS	NS
Foliar spray of humic acid (F)								
F_0: Control (water spray)	2.457	1.220	0.423	0.188	0.696	1.321	0.323	0.137
F_1: 20 PPM	2.458	1.241	0.425	0.189	0.698	1.325	0.325	0.138
F_2: 40 PPM	2.508	1.247	0.427	0.191	0.704	1.330	0.326	0.139
F_3: 60 PPM	2.527	1.274	0.429	0.192	0.708	1.381	0.327	0.140
S. Em.±	0.039	0.021	0.005	0.002	0.008	0.019	0.005	0.002
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

Nutrients uptake by seed and stover

Soil applications of humic acid significantly increase N, P, K and S uptake by seed and stover of mustard. A notable increment in N (44.22 and 55.54 kg/ha), P (7.59 and 8.49 kg/ha), K (12.62 and 61.19 kg/ha) and S (5.83 and 6.14 kg/ha) uptake by mustard seed and stover was observed with soil application of 30 kg/ha of humic acid, similar to the results seen with 20 kg/ha application (Table 5). This could be because of correct absorption, translocation and assimilation of multiple plant nutrient sources occurs from the balanced and simultaneous usage of those

Table 5 : Nutrient uptake by seed and stover of mustard as influenced by soil and foliar application of humic acid

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Sulphur uptake (kg/ha)	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Soil application of humic acid (S)								
S_0: 0 Kg/ha	35.59	45.35	6.15	6.96	10.04	46.98	4.61	5.03
S_1: 10 Kg/ha	38.44	49.58	6.53	7.52	10.78	53.55	5.02	5.50
S_2: 20 Kg/ha	41.02	53.27	6.98	8.09	11.48	57.67	5.35	5.95
S_3: 30 Kg/ha	44.22	55.54	7.59	8.49	12.62	61.19	5.83	6.14
S.Em. ±	1.315	1.710	0.200	0.223	0.353	1.749	0.159	0.169
CD at 5%	3.798	4.940	0.577	0.643	1.021	5.050	0.459	0.489
Foliar spray of humic acid (F)								
F_0: Control (water spray)	36.97	46.81	6.37	7.21	10.46	50.59	4.86	5.24
F_1: 20 PPM	38.21	50.25	6.60	7.66	10.84	53.80	5.04	5.60
F_2: 40 PPM	41.28	51.95	7.03	7.94	11.59	55.54	5.37	5.77
F_3: 60 PPM	42.82	54.72	7.25	8.25	12.03	59.44	5.55	6.01
S.Em. ±	1.315	1.710	0.200	0.223	0.353	1.749	0.159	0.169
CD at 5%	3.798	4.940	0.577	0.643	1.021	5.050	0.459	0.489

Table 6 : Available nutrients status in soil as influenced by soil and foliar application of humic acid

Treatments	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	S (mg/kg)
Soil application of humic acid (S)				
S_0: 0 Kg/ha	151.0	34.4	239.7	8.4
S_1: 10 Kg/ha	152.4	35.1	247.6	8.5
S_2: 20 Kg/ha	153.2	35.5	250.4	8.7
S_3: 30 Kg/ha	155.7	36.4	255.7	9.0
S.Em. ±	2.19	0.57	3.81	0.16
CD at 5%	NS	NS	11.00	NS
Foliar spray of humic acid (F)				
F_0: Control (water spray)	151.8	35.0	246.4	8.4
F_1: 20 PPM	153.1	35.4	248.0	8.5
F_2: 40 PPM	153.5	35.4	249.2	8.8
F_3: 60 PPM	153.8	35.6	249.8	8.9
S.Em. ±	2.19	0.57	3.81	0.16
CD at 5%	NS	NS	NS	NS

sources. Nutrients boosting dry-matter and nutritional availability as a result of increased elemental nutrient absorption in the plant. The results are close conformity with the finding of Mahmoud *et al., (*2011), Paramasivan *et al., (*2015) and Ahmad *et al., (*2016).

Significantly greater uptake of N (42.82 and 54.72 kg/ha), P (7.25 and 8.25 kg/ha), K (12.03 and 59.44 kg/ha), and S (5.55 and 6.01 kg/ha) by mustard seed and stover was observed in response to foliar spray with humic acid at 60 ppm at 30 and 50 DAS. K uptake by seed and stover and N, P and S uptake by seed were found to be comparable to foliar spray of humic acid at 40 ppm at 30 and 50 DAS. However, at 30 and 50 DAS N, P and S uptake by stover was found to be comparable to foliar spray of humic acid at 40 ppm and 20 ppm (Table 5). The higher the seed and stover yields, the higher was the nutrient uptake by seed and stover. Similar results were reported by Ananthi and Vanangamudi (2014) and Paramasivan *et al., (*2015).

Available Nutrients status in soil after harvest

Available nutrient content in soil after harvest of crop shows increasing trend with soil application of humic acid. Regarding the various soil applications of humic acid N, P_2O_5 and S were found to be non-significant; however, soil applications of humic acid at 30 kg/ha recorded significantly higher available K_2O (255.7 kg/ha), which remained statistically equivalent to soil applications of humic acid at 20 kg/ha and 10 kg/ha. Foliar spray of humic acid did not exert significant effect on available N, P_2O_5, K_2O and S after harvest (Table 6).

Higher available K_2O under soil could be because the increase in CEC by humic acid application. The results are conformity with the finding of Mahmoud *et al.* (2011) and Paramasivan *et al.* (2015).

Conclusion

Based on one year experiment it can be concluded that soil application of humic acid @ 30 kg/ha as basal and foliar spray of 60 ppm humic acid along with RDF (50:50:00:40 kg/ha N: P_2O_5: K_2O: S) produced higher yield of mustard.

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