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Nutrient content, Uptake and Nutrient use Efficiency of Indian Mustard as Influenced by Salicylic Acid and Nutrient Sources

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ABSTRACT: A field experiment was conducted to assess the effect of salicylic acid and nutrient sources on nutrient content, uptake and nutrient use efficiency in Indian mustard. Results showed that salicylic acid applied as 200 ppm foliar spray at flower initiation and full bloom stage (F_3) recorded the maximum values of nutrient content, uptake and nutrient use efficiency by mustard crop. However, the treatment of 200 ppm salicylic acid at flower initiation remained equally effective with regard to above parameters. Further, Data showed that the treatment 1/3 each through FYM, vermicompost and biogas slurry (N_5) proved significantly superior over all other treatments with respect to nutrient content, uptake and nutrient use efficiency.

Keywords: Growth, Yield, Indian mustard, Salicylic acid, Nutrient sources.

INTRODUCTION

The name 'mustard' is derived from the Latin word 'mustum' means that of old wine mixed with the crushed seed makes it one of the most important spice in the world. In India, oilseed crops are the important component of the agricultural economy, next to food grains, in terms of area, production and value. The crop can be raised well under both irrigated and rainfed conditions. We are still importing more than 60% of vegetable oils. Furthermore, per capita consumption of edible oil is likely to reach 23.10 kg by 2030 from the present level of 13.40 kg (Singh *et al*., 2014).

Exploitation of genetic yield potentiality of new plant types of mustard although depends on the extent of fertilizer application, the balance, and compatible composition of different nutrient sources is a must to obtain greater nutrient use efficiency. Balance fertilization at right time with proper method and source of nutrients enhance nutrient use efficiency, productivity and uptake of nutrients by grain and by stover in mustard. Organic manures *viz.* FYM, Vermicompost and biogas slurry also play a vital role in enhancing soil fertility, crop productivity and better crop production in agriculture as they are eco-friendly and can be replaced by using 25 percent chemical fertilizers that are not toxic for health and enable farmer to get maximum crop yields. Application of organic manure like FYM, Vermicompost and biogas slurry in addition to chemical fertilizers results in increased mineral content in soil and water holding capacity of field and uptake of nutrients is also increased to a great extent, besides this several other changes such as root development, vegetative growth and nitrogen fixation increases crop yield as reported by Tomar *et al*. (2017 & 2019).

The application of salicylic acid can play alleviating high temperature effect and play an important role in plant response to stress by the activity of antioxidant enzymes. Salicylic acid ($C_7H_6O_3$) has recently been recognized as a growth regulator of phenolic nature, which participates in the regulation of physiological processes in plant, such as stomatal closure, ion uptake, inhibition of ethylene biosynthesis, transpiration and stress tolerance (Shakirove *et al.*, 2003).

MATERIALS AND METHODS

A field experiment was conducted during winter *(rabi)* season of 2018 and 2019 at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar. This place geographically is situated at 29°10'N latitude and 75°46'E longitude at mean elevation of 215.2 meter above mean sea level. The textural class of the experimental soil was a loamy sand with moderately alkaline (pH 8.0) poor in organic carbon (0.35%) and EC 0.24 dSm^{-1}. The total available N, P_2O_5 and K_2O were 128, 15.8 and 270 kg/ha, respectively. The treatments were tested in split plot design and replicated four. The main plot treatment consisted different salicylic acid level (Water spray, 200 ppm Salicylic acid at flower initiation stage, 200 ppm Salicylic acid at full bloom stage and 200 ppm Salicylic acid at flower initiation and full bloom stage) and in sub-plots

treatments in which nutrient sources (RDF-80 kg N and 40 kg P_2O_5 ha^{-1}, 50% RDN through chemical fertilizers + 50% RDN through FYM, 50% RDN through chemical fertilizers + 50% RDN through vermicompost, 50% RDN through chemical fertilizers + 50% RDN through biogas slurry and 1/3 RDN each through FYM, vermicompost and biogas slurry). However, the recommended dose of fertilizer was applied based on treatment needs through urea and SSP. Full dose of nitrogen and phosphorus were applied as basal dose.

Mustard crop were raised with the seed rate of 4.0 kg/ha at a row distance of 30 cm. Sowing of seeds was done by opening with furrow with help of hand plough and cover the soil to ensure moisture loss through evaporation. Plant geometry was maintained by spacing 30 × 10 cm of doing thinning operation at 20 DAS. The foliar spray of SA was applied at flowering and full bloom stage. In view of the above factors, the present investigation was undertaken at Research farm, CCSHAU, Hisar to study the nutrient uptake and nutrient use efficiency in Indian mustard as affected by salicylic acid and different nutrient sources in Western Haryana.

Procedure and techniques

Uptake of NPK (kg ha^{-1}) by seed and Stover. Uptake in stover of each nutrient NPK (kg ha^{-1}) was worked out by multiplying the stover yield (kg ha^{-1}) with their respective NPK content and uptake in grain of each nutrient NPK (kg ha^{-1}) was worked out by multiplying the grain yield (kg ha^{-1}) with their respective NPK content.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient conc. in seed (\%)} \times \text{Grain yield (kg ha}^{-1}\text{)} + \text{Nutrient conc. in straw (\%)} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

Nutrient Use Efficiency

$$\text{NUE (kg ha}^{-1}\text{)} = \frac{\text{N removed from fertilized plot} - \text{N removed from check}}{\text{Quantity of N applied}}$$

RESULTS AND DISCUSSION

Nutritional Content. A perusal of data in Table 1 revealed that nitrogen content in seed and stover increased significantly with the application of salicylic acid as 200 ppm at flower initiation and full bloom stage compared to rest of the treatments during both the experimental years and pooled analysis. The treatment F_3 (200 ppm at flower initiation and full bloom stage) recorded maximum N, P and K in grain 3.97%, 0.57% and 0.61%, respectively as well as in stover 0.64%, 0.28%, 1.45% followed by F_2, all these treatments were significantly at par but superior over control plot. However, the minimum N, P and K content in grain and stover was recorded in water spray.

Significantly improved NPK in seed was noted in N_5 treatment (1/3 RDN Each through FYM, Vermicompost and Biogas slurry) 3.871, 0.510 and 0.548 respectively, However, the maximum NPK content was noted in stover 0.569%, 0.258%, 1.300% under the N_5 treatment followed by N_4, and all these treatments were statistically at par but superior over control plot. However, the minimum N, P and K content in grain and stover was recorded in N_1.

Nutrient uptake and yield. A perusal of data in Table 2 revealed that the uptake of nutrient is the function of dry matter formulation and percentage of nutrient content of the seed. Salicylic acid and nutrient sources had significant effect on nutrient uptake by mustard. The highest total nitrogen, phosphorus and potassium uptake 156.44, 39.65 and 142.57 kg ha^{-1}, respectively was observed with 200 ppm at flower initiation and full bloom stage. These findings are in close conformity of the findings of Hussain *et al.* (2010); Gunes *et al.* (2007); Grown (2012). The minimum uptake of N, P and K was found in control plot.

The highest total nitrogen, phosphorus and potassium uptake 134.08, 32.07 and 114.33 kg ha^{-1}, respectively was found with 1/3 RDN Each through FYM, Vermicompost and Biogas slurry. These results are in line with the finding of Chaurasia *et al*. (2009); Singh *et al.* (2011). The minimum uptake of N, P and K was observed in control plot. The highest nutrient uptake could due to highest total biomass yield, relatively higher nutrient concentration, higher nutrient mobility and its absorption.

The highest seed yield was recorded under treatment 200 ppm salicylic acid at flower initiation and full bloom stage with the respective value of (2516 kg ha^{-1}) followed by 200 ppm Salicylic acid at flower initiation. Hence, the significantly lowest seed yield was noted with the treatment water spray (1807 kg ha^{-1}). These results are in line with the finding of Lakhana *et al*., (2005); Sahu *et al*., (2005).

The highest seed yield was recorded under treatment 1/3 RDN Each through FYM, Vermicompost and Biogas slurry (1807 kg ha^{-1}) followed by 50% RDN through chemical fertilizers + 50% RDN through Vermicompost. The significantly lowest seed yield was noted with the treatment 80 kg N and 40 kg P_2O_5 ha^{-1} (2104 kg ha^{-1}). These results agree with the findings of Singh and Rai (2004); Regar *et al.* (2009); Singh and Pal (2011); Tripathi *et al.* (2011).

Table 1: Effect of foliar spray and nutrient sources on nitrogen, phosphorus and potassium content (%) of mustard.

Treatments	Seed			Stover		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Foliar sprays						
F_0	3.570	0.444	0.486	0.499	0.227	1.181
F_1	3.897	0.499	0.532	0.549	0.248	1.247
F_2	3.854	0.487	0.525	0.542	0.245	1.231
F_3	3.970	0.573	0.613	0.645	0.288	1.451
SEm±	0.021	0.003	0.003	0.004	0.002	0.007
CD (P=0.05)	0.062	0.009	0.009	0.011	0.005	0.021
Nutrient sources						
N_1	3.792	0.492	0.537	0.549	0.250	1.285
N_2	3.804	0.503	0.539	0.554	0.251	1.273
N_3	3.835	0.502	0.538	0.563	0.252	1.271
N_4	3.813	0.497	0.533	0.559	0.248	1.257
N_5	3.871	0.510	0.548	0.569	0.258	1.300
SEm±	0.012	0.002	0.002	0.002	0.001	0.004
CD (P=0.05)	0.033	0.005	0.005	0.007	0.003	0.012

***Note*:** F_0 = Water spray, F_1 =200 ppm Salicylic acid at flower initiation stage, F_2 = 200 ppm Salicylic acid at full bloom stage, F_3 =200 ppm Salicylic acid at flower initiation and full bloom stage; N_1 =Recommended Dose of Fertilizers (RDF: 80 kg N and 40 kg P_2O_5 ha^{-1}), N_2 = 50% Recommended Dose of Nitrogen(RDN) through chemical fertilizers + 50% RDN through FYM, N_3 =50% RDN through chemical fertilizers + 50% RDN through Vermicompost, N_4 =50% RDN through chemical fertilizers + 50% RDN through Biogas slurry, N_5 =1/3 RDN Each through FYM, Vermicompost and Biogas slurry

Table 2: Effect of foliar spray and nutrient sources on nutrient uptake (kg ha^{-1}) and yield (kg ha^{-1}) mustard crop (on the basis of pooled data).

Treatments	Nutrient uptake (kg ha^{-1})									Yield (kg ha^{-1})
	N uptake			P uptake			K uptake			
	By seed	By stover	Total	By seed	By stover	Total	By seed	By stover	Total	Yield
Foliar sprays										
F_0	64.52	26.97	91.50	8.05	12.28	20.32	8.78	63.64	72.42	1807
F_1	87.89	41.22	129.11	11.25	18.60	29.85	12.00	93.46	105.46	2255
F_2	84.83	40.44	125.27	10.72	18.27	28.99	11.56	91.75	103.31	2200
F_3	99.92	56.52	156.44	14.42	25.23	39.65	15.44	127.12	142.57	2516
SEm±	1.02	0.62	1.54	0.15	0.30	0.42	0.15	1.36	1.48	24
CD(P=0.05)	3.05	1.84	4.56	0.44	0.88	1.25	0.45	4.03	4.39	71
Nutrient sources										
N_1	80.20	37.50	117.69	10.49	17.08	27.58	11.43	87.29	98.72	2104
N_2	82.50	40.04	122.54	10.98	18.15	29.13	11.76	91.68	103.44	2158
N_3	85.46	42.82	128.28	11.25	19.12	30.38	12.05	96.42	108.48	2217
N_4	83.87	41.43	125.30	10.96	18.40	29.36	11.75	92.97	104.72	2192
N_5	89.44	44.64	134.08	11.86	20.21	32.07	12.73	101.59	114.33	2301
SEm±	0.60	0.36	0.78	0.08	0.17	0.22	0.08	0.74	0.78	13
CD(P=0.05)	1.68	1.00	2.20	0.23	0.47	0.61	0.23	2.08	2.18	38

***Note*:** F_0 = Water spray, F_1 = 200 ppm Salicylic acid at flower initiation stage, F_2 = 200 ppm Salicylic acid at full bloom stage, F_3 =200 ppm Salicylic acid at flower initiation and full bloom stage; N_1 = RDF(80 kg N and 40 kg P_2O_5 ha^{-1}), N_2 = 50% RDN through chemical fertilizers + 50% RDN through FYM, N_3 = 50% RDN through chemical fertilizers + 50% RDN through Vermicompost, N_4= 50% RDN through chemical fertilizers +50% RDN through Biogas slurry, N_5=1/3 RDN Each through FYM, Vermicompost and Biogas slurry

Nutrient use efficiency. The salicylic acid and nutrient sources had significant effect on nutrient use efficiency by mustard (Table 3). Significantly higher nitrogen, phosphorus and total use efficiency was recorded under treatment 200 ppm salicylic acid at flower initiation and full bloom stage with the respective values of (31.45, 62.90 and 20.97 kg ha^{-1}) followed by 200 ppm Salicylic acid at flower initiation. The minimum of N, P and total use efficiency was observed in control plot.

The highest nitrogen, phosphorus and total use efficiency was observed under treatment 1/3 RDN Each through FYM, Vermicompost and Biogas slurry (28.76, 57.51 and 19.17 kg ha^{-1}) followed by 50% RDN through chemical fertilizers + 50% RDN through Vermicompost. The significantly lowest nitrogen, phosphorus and total use efficiency was noted with the treatment 80 kg N and 40 kg P_2O_5 ha^{-1}.

Table 3: Effect of foliar spray and nutrient sources on nutrient use efficiency (kg ha^{-1}) by mustard crop.

Treatments	Nutrient use efficiency (kg ha^{-1})								
	Nitrogen use efficiency			Phosphorus use efficiency			Total use efficiency		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Foliar sprays									
F_0	22.21	22.96	22.59	44.43	45.92	45.17	14.81	15.31	15.06
F_1	27.96	28.41	28.18	55.92	56.81	56.36	18.64	18.94	18.79
F_2	26.98	28.03	27.50	53.95	56.06	55.01	17.98	18.69	18.34
F_3	30.80	32.03	31.45	61.75	64.05	62.90	20.58	21.35	20.97
SEm±	0.44	0.41	0.30	0.89	0.81	0.60	0.30	0.27	0.20
CD (P=0.05)	1.42	1.30	0.89	2.83	2.59	1.78	0.94	0.86	0.59
Nutrient sources									
N_1	25.60	27.00	26.30	51.20	54.00	52.60	17.07	18.00	17.53
N_2	26.35	27.61	26.98	52.69	55.23	53.96	17.56	18.41	17.99
N_3	27.50	27.93	27.72	55.00	55.87	55.43	18.33	18.62	18.48
N_4	27.18	27.62	27.40	54.35	55.25	54.80	18.12	18.42	18.27
N_5	28.41	29.11	28.76	56.82	58.21	57.51	18.94	19.40	19.17
SEm±	0.26	0.22	0.17	0.51	0.43	0.34	0.17	0.14	0.11
CD (P=0.05)	0.73	0.62	0.47	1.46	1.23	0.94	0.49	0.41	0.31

***Note*:** F_0 = Water spray, F_1 =200 ppm Salicylic acid at flower initiation stage, F_2 = 200 ppm Salicylic acid at full bloom stage, F_3 =200 ppm Salicylic acid at flower initiation and full bloom stage; N_1 =RDF (80 kg N and 40 kg P_2O_5 ha^{-1}), N_2 = 50% RDN through chemical fertilizers + 50% RDN through FYM, N_3 =50% RDN through chemical fertilizers + 50% RDN through Vermicompost, N_4 =50% RDN through chemical fertilizers + 50% RDN through Biogas slurry, N_5 =1/3 RDN Each through FYM, Vermicompost and Biogas slurry

CONCLUSION

The application of salicylic acid and different nutrient sources significantly improved nutrient content, uptake and nutrient use efficiency. On the basis of two years study, it can be concluded that the application of 200 ppm salicylic acid at flower initiation and full bloom stage with 1/3 RDN Each through FYM, Vermicompost and Biogas slurry was the most suitable practice for the Indian mustard in the western Haryana.

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Conflict of Interest. None.

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