

Effect of nutrient management on yield, quality and economics of irrigated Indian mustard (*Brassica juncea*)

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ABSTRACT

A field experiment was carried out during winter seasons of 2004 to 2006 on sandy loam soils of Varanasi to study the effect of different levels of nitrogen (50, 100 and 150 kg N/ha), sulphur (0, 30 and 60 kg S/ha) and zinc (0, 0.5 and 1.0 kg ZnEDTA/ha) on growth, yield attributes, yield, quality and economics of Indian mustard [*Brassica juncea* (L.) Czernj & Coss.]. Significant improvement in growth parameters and seed and stover yields were observed up to 150-30-0.50 kg N-S- Zn EDTA/ha, respectively. The values of oil and protein content, nutrient contents and their acquisition; oil and protein yields had the highest affinity with the highest levels of N, S and Zn. The acid value significantly increased with increasing rates of nitrogen up to 150 kg N /ha and sulphur up to 60 kg S /ha, while decreased with zinc application where highest value was associated with control. The mustard crop fertilized with 150-30-0.50 kg N-S- Zn EDTA /ha fetched the highest net returns with maximum benefit : cost ratio.

Key words: Economics, Indian mustard, Nitrogen, Quality, Sulphur, Yield, Zinc

Oilseeds together occupy 27.45 million ha which accounts for 14% of total cropped area in the country with a production of 24.72 million tonnes, accounting for nearly 5% of the gross national product and 10% of the value of all the agricultural products. Rapeseed and mustard ranks third in area (21%) and production (23%) after groundnut (*Arachis hypogaea* L.) and soybean (*Glycine max* L. Merr) amongst total oilseeds. The per hectare productivity of the crop is quite low in the country (1 152 kg/ha) against the world average of 1400 kg/ha in world (Piri and Sharma 2006). The nutrient requirement of oilseed crops, in general, is very high for almost all the essential mineral nutrients which are to be supplied in sufficient quantities and balanced proportion to harvest genetic potential of the crop. Most of the Indian soils are deficient in organic carbon, nitrogen, sulphur and zinc. Among the major nutrients, nitrogen being deficient in most of the Indian soils and its higher requirement by crop is the

most limiting element in mustard production. Sulphur plays direct and prominent role in fatty acid synthesis. It is a constituent of amino acids, viz cystine, cysteine and methionine and is essential for chlorophyll synthesis and vitamins, like biotine and thiamine. Oilseed crop therefore needs more sulphur for higher oil and protein yield. Zinc cations are held in soils principally on organic or inorganic surfaces or substituted as accessory constituents in common soil minerals and are also present in bivalent states in highly insoluble oxides and phosphates and are much less amenable to leaching. This explains the low concentration of Zn in soils of Gangetic alluvial. Zinc plays vital role in carbohydrate and proteins metabolism as well as it controls the plant growth hormone IAA and is essential component of dehydrogenase, proteinase, peptides enzymes, and promotes starch formation, seed maturation and production. Hence, nutrient management has been identified as one of the critical constraints limiting oilseed productivity. Keeping these facts in view the present investigation was undertaken to study the effect of nutrient management on performance of irrigated Indian mustard [*Brassica juncea* (L.) Czernj and Cosson] under irrigated ecosystem.

MATERIALS AND METHODS

A field experiment was conducted at Varanasi, during winter seasons of 2004 to 06 on Gangetic alluvial (Ustochrept) soil analyzing low in organic carbon (0.42%),

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Table 1 Growth, yield, quality and economics of mustard production as affected by nitrogen, sulphur and zinc levels

Treatment	Leaf area index 90 DAS	Siliqua/plant	Seeds/siliqua	Test weight (g)	Seed yield (tonnes/ha)	Stover yield (tonnes/ha)	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)	Protein content (%)	Acid value	Saponification value	Net returns (Rs/ha)	B: C ratio
<i>Nitrogen (kg/ha)</i>														
50	0.27	230.90	10.01	4.53	1.417	3.542	28.53	37.9	538	21.44	1.51	172.48	12 818	0.77
100	0.35	272.85	11.15	4.81	1.912	4.211	31.18	37.5	718	22.35	1.72	178.97	22 300	1.29
150	0.42	302.74	11.99	4.88	2.010	4.701	29.92	37.0	744	23.06	1.83	176.87	23 768	1.32
CD	0.016	16.40	0.53	0.30	0.083	0.200	1.47	NS	31	1.10	0.08	NS	921	0.06
<i>(P = 0.05)</i>														
<i>Sulphur (kg/ha)</i>														
0	0.31	244.37	10.42	4.56	1.593	4.021	28.29	36.8	585	21.77	1.50	178.99	17 208	1.07
30	0.35	267.51	11.14	4.78	1.840	4.166	30.58	37.5	688	22.30	1.72	175.68	20 833	1.20
60	0.38	294.61	11.59	4.88	1.907	4.268	30.77	38.2	727	22.78	1.84	173.63	20 845	1.11
CD	0.016	16.40	0.53	0.30	0.083	0.200	1.47	NS	31	NS	0.08	NS	921	0.06
<i>(P = 0.05)</i>														
<i>Zinc EDTA foliar spray (kg/ha)</i>														
0	0.31	239.09	9.84	4.22	1.592	3.692	26.64	36.6	593	19.86	1.78	175.13	16 541	1.00
0.50	0.36	279.09	11.47	4.92	1.855	4.310	30.98	37.9	692	23.11	1.68	177.09	21 101	1.20
1.00	0.37	288.31	11.85	5.08	1.892	4.452	32.01	38.0	715	23.88	1.60	176.09	21 243	1.17
CD	0.012	13.93	0.37	0.24	0.061	0.142	0.98	NS	23	0.74	0.09	NS	700	0.04
<i>(P = 0.05)</i>														

Cost of fertilizers (Rs/kg): Urea 5.00, elemental sulphur 36 and Zn EDTA 700

Selling price (Rs/kg): seed 20 and stover 0.30

available nitrogen (195.0 kg/ha), sulphur (18.35 kg/ha) and zinc (0.47 kg/ha) and medium in available phosphorus (10.13 kg P/ha) and potassium (177.5 kg K/ha). The treatment comprised 3 levels each of nitrogen (50, 100 and 150 kg N/ha), sulphur (control, 30 and 60 kg S/ha) and zinc (control, 0.50 and 1.00 kg Zn EDTA/ha as foliar spray). Combinations of nitrogen and sulphur levels formed the main plots, whereas the zinc levels were kept in sub-plot of split-plot design replicated thrice taking 'Varuna' (T 59) mustard cv. as a test crop. Full doses of phosphorus in the form of diammonium phosphate, potassium through muriate of potash and ½ nitrogen through urea and diammonium phosphate as per treatment were applied as basal prior to sowing. Sulphur through elemental sulphur was broadcast to the field 1 month before sowing as per treatment. The remaining half amount of nitrogen as per treatment was top-dressed at 30 days after sowing. Requisite quantity of Zn EDTA/plot was weighed and dissolved in known volume of water to make the concentration of 0.02%. Foliar spray of Zn EDTA (as per treatment) was done at 30 and 45 days after sowing in case of 0.5 kg Zn EDTA/ha spray and at 30, 45 and 60 days after sowing in case of 1.0 kg Zn EDTA/ha. Equal amount of plain water was sprayed in rest of the plots where zinc spray was not done.

Oil content was determined by the Soxhlet's extractor using petroleum ether as extractant and oil yield was determined by multiplying the same with seed yield. Oil from

mustard seeds was extracted with the help of petroleum ether using Soxhlet extraction assembly. Extracted oil was used to assess the quality parameters. Estimation of acid value and saponification value of oil was done according to procedure described by Plummner (1998). Plant samples were collected at post harvest from all treatments and were analyzed for N, P, K, S and Zn as per standard procedures. Economic return was calculated on present market price of output and inputs. The quadratic response function $Y = a + b + cx^2$ was fitted to describe seed yield as a function of fertilizer N, S and Zn.

RESULTS AND DISCUSSION

Growth attributes

Leaf area index (LAI) and dry matter production/plant significantly improved with corresponding increase in nitrogen level up to 150 kg/ha (Table 1). Pronounced effect of sulphur application on LAI was attributed to the role of sulphur in increasing the photosynthetic activity of the plant. LAI at 90 days after sowing increased significantly up to 150 kg N, 60 kg S and 1.0 kg Zn EDTA/ha. Zinc plays a pivotal role in regulating the auxin concentration in plant and nitrogen metabolism and might have improved these growth attributes.

Yield

Siliqua/plant and seeds/siliquae increased significantly

with each increment of nitrogen level up to 150 kg N/ha. An improvement in yield components with increased level of nitrogen might be owing to increased availability of N and other nutrients to plants (Reager *et al.* 2006). Significant increase in seeds/siliquae under 150 kg N/ha was due to greater translocation of photosynthate from source to sink. The test weight and siliqua length was recorded significantly higher with the application of 100 and 150 kg N/ha over the control but was comparable to each other. Increasing levels of nitrogen has asserted significant variation on seed yield up to 150 kg N/ha. The increase in seed yield was a cumulative affect of increase in siliqua/plant, siliqua length, seeds/siliquae and test weight. Application of 100 and 150 kg N/ha resulted in significant increase in seed yield by 34.9 and 41.8% over 50 kg N/ha, respectively.

Increasing sulphur level up to 60 kg S/ha significantly enhanced siliqua/plant seeds/siliquae and test weight improved significantly due to sulphur application up to 30 kg S/ha. Similarly, increasing sulphur rate manifested lucid effect on seed and stover yield and increased significantly up to 30 kg S/ha. Per cent increase in seed yield due to 30 and 60 kg S/ha over control was 15.5 and 19.7, respectively.

Zinc application also exerted significant influence on yield traits and finally on seed yield. The magnitude of significant increase in siliqua/plant and test weight was associated with 0.5 kg ZnEDTA/ha, while seeds/siliqua increased significantly up to 1.0 kg Zn EDTA/ha. The increase in number of seeds/siliquae with increasing zinc levels was due to its role in the metabolism of starch as zinc affected the activity of aldolase in the plant tissue which was involved in the conversion of fructose 1–6 diphosphate to its subsequent compounds. Increasing levels of zinc application significantly influenced the seed yield up to 0.5 kg ZnEDTA/ha. Zinc application had substantial contribution to enhance carbohydrate metabolism, protein synthesis and auxin biosynthesis and these key factors together augmented seed yield. Application of zinc increased seed yield because zinc fed plants absorbed adequate quantity of mineral nutrients through well developed root system. Similar findings were also reported by Chandra and Khandelwal (2009). The per

cent increase in seed yield due to 0.5 and 1.0 kg ZnEDTA/ha over control was 16.52 and 18.84, respectively.

Nitrogen–sulphur interaction: Interaction effect between N×S (Table 2) revealed that significant variation in seed yield was observed up to 100 kg N/ha, irrespective of sulphur levels. The maximum seed yield was associated with 150 kg N + 60 kg S/ha, closely, followed by 150 kg N + 0 kg S/ha and 100 kg N + 30 kg S/ha.

Nitrogen–zinc interaction: Significant increase in seed yield was observed due to zinc application up to 0.5 kg Zn EDTA/ha, irrespective of nitrogen levels (Table 2). Increasing rates of nitrogen application up to 150 kg N/ha resulted in significant improvement in seed yield in case of 0.5 or 1.0 kg Zn EDTA/ha. However, significant increase in seed yield was reordered up to 100 kg N/ha in absence of zinc fertilization.

The response equation $a + bx + cx^2$ for various nitrogen, sulphur and zinc levels were fitted on seed yield (pooled data). The data showed that a quadratic relationship existed between nitrogen and seed yield ($y = 5.23 + 10.92x - 1.99x^2$), sulphur and yield ($y = 15.93 + 3.37x - 0.90x^2$) and zinc and yield ($y = 15.92 + 3.76x - 1.13x^2$). Considering the input: output relationship the most profitable rate of nitrogen, sulphur and Zn EDTA were 129.7, 26.2 and 0.75 kg/ha, respectively. However, for obtaining maximum yield rate of nitrogen, sulphur and zinc were 137, 56.18 and 0.83 kg N, S and Zn EDTA/ha, respectively.

Stover yield increased significantly up to 150 kg N, 60 kg S and 1.0 kg Zn EDTA/ha, respectively. Increasing nitrogen levels caused significant variation in harvest index up to 100 kg N/ha. Sulphur application exerted significant variation in harvest index up to 30 kg S/ha. Harvest index increase with corresponding increase in zinc level, the highest value was associated with 1.0 kg Zn EDTA /ha.

Quality parameters

Variation in oil content in seed due to nitrogen rates was not significant (Table 1). However, nitrogen application brought about significant improvement in oil yield, values being maximum at 150 kg N/ha. Application of 100 and 150

Table 2 Interaction effect between N and S levels and S and Zn levels on seed yield of mustard (pooled data over 2 years)

Treatment	Seed yield (tonnes/ha)					
	Sulphur levels (kg/ha)			Zinc levels (kg Zn EDTA/ha)		
	0	30	60	0	0.5	1.0
Nitrogen levels (kg/ha)						
50	1.269	1.473	1.509	1.294	1.465	1.492
100	1.686	1.995	2.056	1.734	1.983	2.021
150	1.824	2.052	2.155	1.750	2.118	2.163
CD ($P = 0.05$)			0.144	CD ($P = 0.05$) for zinc at the same level of nitrogen		0.106
				CD ($P = 0.05$) for N at the same or different level of zinc		0.120

kg N /ha resulted in 33.45 and 38.28% increase in oil yield compared to 50 kg N/ha. Sulphur application failed to cause and significant effect on seed oil content, but significant increase in oil yield due to sulphur application was recorded up to 60 kg S/ha. Sulphur application @ 60 kg S/ha enhanced oil yield by about 5.56 and 24.27% as compared to that of 30 and 0 kg S/ha, respectively. Similar trend was observed in case of zinc application where zinc could not bring about significant improvement in seed oil content. However, zinc fertilization @ 0.5 and 1.0 kg Zn EDTA/ha significantly increased oil yield by 16.69 and 20.58% over the control, respectively.

Significant increase in protein content in seed was noticed due to application of 150 kg N/ha compared to 50 kg N/ha. The protein content in seed increased with increasing nitrogen levels as increasing levels of nitrogen increases the proteinaceous substance in seed and decreases the oil content in seed (Yadav *et al.* 2010). Successive increase in zinc up to 1.0 kg Zn EDTA/ha caused significant improvement in seed protein content of mustard. Foliar application of Zn EDTA @ 0.50 kg/ha significantly increased protein yield of seed. Zinc enhances the cation-exchange capacity of the roots which in turn enhances the absorption of essential nutrients, especially of nitrogen which is responsible for higher protein content.

Significant increase in the values of acid value was obtained with increasing nitrogen and sulphur levels up to the highest level, while increasing level of zinc application decreased the acid value of oil significantly. The increased acid value at higher sulphur levels established active involvement of sulphur to augment the formation of free fatty acids in oil promoting the rancidity of oil. However, saponification value remained comparable with the application of nitrogen, sulphur and zinc.

Net returns increased significantly with the application of nitrogen, sulphur and zinc up to 150 kg N, 30 kg S and 0.5 kg ZnEDTA/ha. Highest benefit : cost ratio was also associated with 150 kg N/ha, 30 kg S/ha and 0.50 kg Zn EDTA/ha.

Nutrient uptake

Increasing nitrogen levels up to 150 kg N/ha significantly increased total N, P, K and S uptake by biological produce (seed + stover) during both the year of experimentation (Table 3). Total zinc uptake by crop also increased with corresponding increase in nitrogen levels.

Sulphur levels significantly increased the total N, P, S and Zn uptake by biological produce up to of 60 kg S/ha while significant improvement in total potassium uptake due to sulphur rate was recorded up to 30 kg S/ha (Table 3). The increase in nitrogen uptake might be due to increase in sulphur content resulting in the stimulation of protein

Table 3 Effect of nitrogen, sulphur and zinc levels on total nutrient uptake by mustard (pooled over 2 years)

Treatment	Total uptake by biological produce (kg/ha)				
	N	P	K	S	Zn
<i>Nitrogen (kg/ha)</i>					
50	74.39	12.90	52.54	20.02	0.185
100	103.33	17.80	66.11	26.82	0.268
150	115.27	19.53	76.94	30.65	0.316
CD (P=0.05)	4.51	0.77	3.07	1.17	0.012
<i>Sulphur (kg/ha)</i>					
0	86.99	14.86	61.14	22.74	0.227
30	100.21	17.18	66.09	26.28	0.262
60	105.79	18.19	68.36	28.47	0.281
CD (P=0.05)	4.51	0.77	3.07	1.17	0.012
<i>Zinc EDTA foliar spray (kg/ha)</i>					
0	86.74	14.88	57.92	22.94	0.228
0.50	101.46	17.39	67.72	26.83	0.267
1.00	104.79	17.96	69.95	27.72	0.275
CD (P=0.05)	3.37	0.58	2.26	0.89	0.009

synthesis and also due to its synergistic effect on the utilization of nitrogen by mustard plant.

Zinc levels significantly increased the total N, P, K and S uptake by biological produce up to application of 0.5 kg Zn EDTA/ha during both the years. However, significant increase in total zinc uptake was recorded due to zinc application up to 1.0 kg Zn EDTA /ha.

Thus, mustard crop should be fertilized with 150 kg N/ha, 30 kg S/ha and 0.50 kg Zn EDTA/ha as foliar spray along with 40 kg each of P₂O₅ and K₂O/ha for obtaining maximum profit under agro-eco regions identical to eastern Uttar Pradesh.

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