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Sangeeta Dwivedi
Upadhi (PG) Mahavidhyalay, Pilibhit, Utter Pradesh, India

Reeta Mishra
RVSKVV-Krishi Vigyan Kendra, Morena, Madhya Pradesh, India

Correspondence
Sangeeta Dwivedi
Upadhi (PG) Mahavidhyalay, Pilibhit, Utter Pradesh, India

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Effect of integrated plant nutrient management practices on quality characteristics of mustard seeds

Sangeeta Dwivedi and Reeta Mishra

Abstract
The present investigation was conducted in order to evaluate the nutrition potential of mustard seeds influenced by integrated plant nutrient management practices. This field experiment was conducted at Regional Agriculture Testing and Demonstration Station Bilwa, Bareilly district of Uttar Pradesh. Fifteen treatments consisting of 100, 75 and 50 % of the recommended dose of fertilizers (RDF) either alone or with successive addition of farmyard manure (FYM 10 t/ ha, sulphur @ 40 kg S/ha, zinc @25 kg $ZnSO_4$/ha, boron@1kg/ B/ha) were tested. Successive decrease in fertility (100, 75 and 50 % recommended fertility) significantly decreased the most undesired erucic acid content and increased palmitic (saturated fatty acid), oleic and linoleic acid. The highest protein content (21.37%) was recorded with treatment T5. Average minimum total carbohydrate content was recorded in 75 % recommended fertility than in 50% and 100%. In the present study, it was found that the application of recommended dose of sulphur, zinc, boron along with farm yard manure increased the maximum nutrients and reduced antinutritional properties.

Keywords: Mustard, nutrient, protein, glucosinolate, erucic, palmitic, oleic acid

Introduction
Mustard seed is the world's second leading source of vegetable oil, after soybean. It is also the second most leading source of protein meal in the world after soybean. It is mainly grown in northern part of India, Rajasthan is the largest producing state followed by Uttar Pradesh (Sodani et.al.2017) [1]. Rapeseed-mustard is one of the most important oilseed crops of India which is grown on an area of 6.70 million ha with 7.88 million t production and the productivity of 1188 kg/ha (Crop Production Statistics Information System, 2016) [2].
Brassica juncea is an economically important plant that has been well-known in India for centuries for its medicinal and nutritive values (Parikh and Khanna, 2014) [3]. Food preparation of Indian mustard leaves is helpful in lowering the cost for diabetic patients suffering with comorbid anxiety disorders (Thakur et.al., 2013) [4]. Oils are being used in various medicinal formulations for years due to their non-toxic effects and pharmaceutical preparations like capsules, creams, emulsions, fragrances, flavors, intramuscular injections, nasal sprays, ointments, plasters, and in a number of cosmetics (Hassan et.al., 2014) [5].

Rapeseed-mustard is an important source of edible oil in Indian diet especially in Eastern and North-Western India. The major fatty acids of rapeseed-mustard oil are oleic, linoleic, linolenic, eicosenoic and erucic acid. Erucic acid in oil of Indian rapeseed-mustard varieties is quite high (Chauhan *et al*., 2007) [6]. Brassica oil production has been considered beneficial due to the presence of nutritionally desirable oleic and linoleic acids. High oleic acid oil offers better taste, good cooking medium due to its high thermostability, cholesterolreducing properties and its use in industrial applications due to high oxidative stability (long shelf-life) (Kaushik and Agnihotri 2000, Cartea *et al*. 2008) [7,8].
The mustard seed is rich in protein. The protein is of excellent nutritional quality, being rich in lysine with adequate amounts of sulfur containing amino acids-limiting amino acids in most of the cereals and oilseed proteins (Sadeghi and Bhagya, 2008) [9]. However, presence of high content (~ 50% of the total fatty acids) of additional long chain unsaturated fatty acids

(LCUFA) viz. eicosenoic acid (C20:1) or erucic acid (C22:1) in different species of Brassica viz. B. carinata, B. juncea, B. napus and B. nigra, which are absent in many commercial plant oils, makes them a poor candidate for human consumption due to antinutritional properties (Kanrar *et al*. 2006, Cartea *et al*. 2008) [10, 8]. Rapeseed-mustard cultivars grown in India also have high level of glucosinolate content (Chauhan *et al*. 2007) [6]. Glucosinolates, a group of plant thioglucosides, found principally among members of family *Brassicaceae* are responsible for the characteristic pungency of rapeseed-mustard oil.

Thus the objective of the present study was to evaluate the influence of fertilization on nutrient characteristics (fatty acid composition, protein content, protein yield, glucosinolate, crude fibre, ash and carbohydrate content) of mustard (Brassica juncea l.) cultivar Kranti.

Materials and Methods

The field study was conducted at Regional Agriculture Testing and Demonstration Station Bilwa, Bareilly district of Uttar Pradesh. The soil of the experimental field belonged to sandy loam. Since the field crops are greatly influenced by the phases of soil series. Thus the composite soil samples from the 0-15 cm and 15-30 cm depths were collected, air dried and processed and used for chemical analysis before sowing. Soil having low to medium fertility status with low organic content, available N, available P and available S were in low range, available K was medium in range, hot water soluble B and DTPA extractable Zn in optimum range and neutral to slightly alkaline in nature.

Field experiment was conducted in randomized block design with three replications. The treatments comprising of 15 different integrated plant nutrient management practices. The other details are as under-

Variety	Kranti
Gross plot size	4.2m x 3.5 m
Net plot size	3.0 m x 2.5 m
Row to row spacing	30 cm
Plant to plant spacing	15 cm
No. of rows per plot	14
No. of rows harvested per plot	10

The experiment consisted of fifteen treatments viz., T1- Control, T2 -100 % RDF + FYM 10 t/ha, T3 – 100 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha, T4 – 100 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha+ zinc @25 kg $ZnSO_4$/ha, T5- 100 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha+ zinc @25 kg $ZnSO_4$/ha+ boron@1kg/ B/ha, T6 - 75% of Recommended fertility, T7-75% of Recommended fertility++ FYM 10 t/ha, T8-75 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha, T9-75 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha+ zinc @25 kg $ZnSO_4$/ha, T10-75 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha+ zinc @25 kg $ZnSO_4$/ha+ boron@1kg/ B/ha, T11-50% of Recommended fertility, T12-50% of Recommended fertility++ FYM 10 t/ha, T13-50 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha, T14- 50 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha+ zinc @25 kg $ZnSO_4$/ha and T15- 50 % RDF + FYM 10 t/ ha + sulphur @ 40 kg S/ha+ zinc @25 kg $ZnSO_4$/ha+ boron@1kg/ B/ha laid out in randomized block design with three replications.

The urea, diammonium phosphate and muriate of potash were the sources of nitrogen, phosphorus and potassium. The gypsum and zinc sulphate were the sources of sulphur and zinc were while borax was used as a source of boron. Full doses of FYM, phosphorus, potassium, sulphur, zinc, boron and half dose of nitrogen was applied at the time of sowing. Rest half dose of nitrogen was top dressed in two splits, one after first irrigation and second at square leaf stage.

The uniform representative seed samples of *Brassica juncea* were taken, dried and processed separately. These samples were used for different chemical studies. Pooled seed samples of whole plant over the replication were used for the analysis of fatty acid composition. Different components of fatty acid viz., palmitic acid, oleic acid, linoleic acid, lonolenic acid, eicosenoic acid and erucic acid etc. were expressed in percent of the oil content in the seed.

For the estimation of glucosinolates content in the seed, defatted seed samples after extraction of oil in Soxhlet apparatus were used. The total glucosinolates content was estimated by determining the glucose released by myrosinase hydrolysis. The total glucosinolates content was expressed in µmoles/ g seed.

Seed samples from all branches were collected and analyzed for crude fibre and protein content. Protein content in seeds was by analyzed by multiplying N content with a constant factor of 6.25 and expressed in percent. The crude protein yield was calculated by multiplying the seed yield with protein content in seeds.

The percent of total carbohydrates was calculated by subtracting the sum of percentage of total ash, crude protein and oil content from 100.

% total carobyhydrates = 100-(% of total ash+ % crude protein+ % total lipids)

The experiment data obtained during the course of study were subjected to statistical analysis by applying the technique of analysis of variance (ANOVA) prescribed for the randomized block design (RBD) to test the significance of the overall differences among treatments by the ‘F’ test and conclusion were drawn at 5 percent probability level. When the ‘F’ value from analysis of variance tables was found to be significant, the critical difference (C.D.) was computed to test the significance of the difference between the two treatments.

Results

Fatty acid composition

The seed fatty acid composition was significantly influenced by the different integrated plant nutrient management practices. In general, successive decrease in fertility (100, 75 and 50 % R.F.) significantly deceased the most undesired erucic acid content (43.32, 42.78 and 42.23%) and increased palmitic (saturated fatty acid), oleic and linoleic acid (Table 2).

Table 1: Fatty acid composition (%) in oil of seeds of *Brassica juncea* seed as influenced by integrated plant nutrient management

Symbol	Treatment	Palmitic 16:0	Oleic 18:1	Linoleic 18:2	Linolenic 18:3	Eicosenoic 20:1	Erucic 22:1
T1	Recommended fertility (RF)	5.35	15.88	15.10	10.15	9.35	42.80
T2	T1+FYM 10 t/ha	5.10	16.90	15.40	10.45	9.50	41.78
T3	T2+ Sulphur @ 40 kg S/ha	4.65	15.70	14.70	10.13	9.00	45.16
T4	T3+Zinc @25 kg $ZnSO_4$/ha	4.60	16.70	14.85	9.85	9.50	43.61
T5	T4+Boron@1kg/ B/ha	4.53	15.80	14.87	10.40	10.35	43.25
T6	75% of Recommended fertility	4.75	17.65	16.50	10.90	9.75	39.81
T7	T6+ FYM 10 t/ha	5.15	17.50	15.10	9.95	9.50	41.80
T8	T7+ Sulphur @ 40 kg S/ha	4.80	16.03	14.70	9.80	9.40	44.40
T9	T8+ Zinc @25 kg $ZnSO_4$/ha	5.00	16.55	15.20	9.85	8.95	43.55
T10	T9+ Boron@1kg/ B/ha	4.71	16.75	14.75	9.70	8.90	44.35
T11	50% of Recommended fertility	4.42	17.00	14.85	10.65	10.50	41.60
T12	T11+ FYM 10 t/ha	4.80	20.50	15.10	10.00	9.55	39.15
T13	T12+ Sulphur @ 40 kg S/ha	4.55	15.40	15.30	10.82	10.50	42.60
T14	T13+ Zinc @25 kg $ZnSO_4$/ha	5.15	17.61	15.10	9.85	9.16	42.20
T15	T14+ Boron@1kg/ B/ha	4.45	14.85	14.45	10.00	9.75	45.60
	SEM±	0.02	0.02	0.02	0.02	0.09	0.02
	CD at 5%	0.06	0.06	0.06	0.06	0.26	0.07

Table 2: Protein content (%), protein yield (kg/ha), glucosinolate content (µmole/ g seed) and crude fibre content (%) in the seed of *Brassica juncea* seed as influenced by integrated plant nutrient management

Symbol	Treatment	Protein content	Protein yield	Glucosinolate	Crude fibre
T1	Recommended fertility (RF)	20.00	312.00	92.1	16.70
T2	T1+FYM 10 t/ha	21.12	343.41	97.6	13.95
T3	T2+ Sulphur @ 40 kg S/ha	21.25	393.12	106.7	14.10
T4	T3+Zinc @25 kg $ZnSO_4$/ha	21.31	419.81	102.5	11.62
T5	T4+Boron@1kg/ B/ha	21.37	442.36	95.8	11.73
T6	75% of Recommended fertility	20.00	275.00	103.7	18.05
T7	T6+ FYM 10 t/ha	20.62	293.83	103.0	14.10
T8	T7+ Sulphur @ 40 kg S/ha	20.94	304.68	117.7	13.45
T9	T8+ Zinc @25 kg $ZnSO_4$/ha	20.94	305.72	106.6	13.55
T10	T9+ Boron@1kg/ B/ha	21.00	327.18	93.5	12.80
T11	50% of Recommended fertility	19.37	188.86	111.2	18.25
T12	T11+ FYM 10 t/ha	20.00	200.00	114.2	15.04
T13	T12+ Sulphur @ 40 kg S/ha	20.06	201.80	114.7	15.23
T14	T13+ Zinc @25 kg $ZnSO_4$/ha	20.19	218.86	97.5	14.50
T15	T14+ Boron@1kg/ B/ha	20.31	235.60	97.2	14.60
	SEM±	0.05	1.02	0.21	0.02
	CD at 5%	0.16	2.95	0.60	0.06

The application of supplementary ingredient significantly influenced the fatty acid composition especially erucic acid. In general, the sulphur application (T3 to T5, T8 to T10 and T3 to T15) increased the erucic acid composition. Treatment T11, T6, T14 and T7 resulted in comparatively lower erucic acid composition in the oil. The saturated fatty acid (palmitic acid) content decreased with sulphur application. Increase in availability of sulphur attribute to increased conversion of fatty acid metabolites to the end products of fatty acids as supported by Tripathi *et al*. (2010) and Singh and Pal (2011) [11, 12].

Protein content

Differences in integrated plant nutrient management practices significantly influenced the protein content in seeds. Treatment 100% recommended fertilizer resulted in higher protein content than other fertilizer levels. Successive addition of different supplementary ingredients increased the protein content over no application and the highest protein content (21.37%) was recorded with treatment T5 (Table 3). The highest protein content was significantly higher than rest of the treatments.

Table 3: Total ash content (% on dry weight basis) of *Brassica juncea* seed as influenced by plant nutrient management

Symbol	Treatment	Total ash content (% on dry weight basis)
T1	Recommended fertility (RF)	4.60
T2	T1+FYM 10 t/ha	4.71
T3	T2+ Sulphur @ 40 kg S/ha	4.80
T4	T3+Zinc @25 kg $ZnSO_4$/ha	4.88
T5	T4+Boron@1kg/ B/ha	4.90
T6	75% of Recommended fertility	4.50
T7	T6+ FYM 10 t/ha	4.55
T8	T7+ Sulphur @ 40 kg S/ha	4.60
T9	T8+ Zinc @25 kg $ZnSO_4$/ha	4.63
T10	T9+ Boron@1kg/ B/ha	4.70
T11	50% of Recommended fertility	4.00
T12	T11+ FYM 10 t/ha	4.10
T13	T12+ Sulphur @ 40 kg S/ha	4.21
T14	T13+ Zinc @25 kg $ZnSO_4$/ha	4.32
T15	T14+ Boron@1kg/ B/ha	4.40
SEM±		0.02
CD at 5%		0.07

Protein yield

The mean protein yield was 492.38 kg/ha. The protein yield was significantly influenced by different integrated plant nutrient management practices. The successive increase in fertility levels as well as addition of supplementary ingredients increased the protein yield (442.36 kg/ha) was obtained with treatment T5 (Table 3). The highest protein yield was significantly higher than rest of the treatments. Addition of FYM +S resulted in significant increase in protein yield over respective no supplementation treatment in respective fertility levels.

Glucosinolate content in seed

The mean glucosinolate content in seed was 103.60 µmole/ g seed. The different integrated plant nutrient management practices significantly influenced the seed glucosinolate content. In general, successive increase in fertility levels decreased the seed glucosinolate content. The lowest seed glucosinolate content was observed with treatment T5 (Table 3). Addition of supplementary nutrient up to the sulphur resulted increase in glucosinolate content and further addition of supplementary nutrient reduced the glucosinolate content in seed. The application of sulphur to respective fertility level increased the seed glucosinolate content over no sulphur application. Application of supplementary ingredient zinc reduced the glucosinolate content. Successive addition of element boron further reduced the seed glucosinolate content.

Application of sulphur was reported to increase yield attributes and yield of Indian mustard (Patel *et al*. 2009, Kumar *et al*. 2011) [13, 14], which also has a significant effect on oil, fatty acid (Ahmad and Abdin 2000) and glucosinolates content in mustard seed (Falk *et al*. 2007) [15]. A decrease in glucosinolate content might be accorded to an increase in N: S ratio and increased vegetative growth probably outpaces the glucosinolate biosynthesis thereby, diluting their content (Rosen *et al*. 2005) [16].

Seed crude fibre content

The seed crude fibre content was recorded 16.05%. The integrated plant nutrient management practices significantly influenced the seed crude fibre content. It reduced with successive increase in fertility levels and successive addition of supplementary ingredients and the lowest seed fibre content (11.73%) was obtained with treatment T5.

Ash content

Mean total ash content (% on dry weight basis) was 4.53%. The maximum total ash content in seeds (4.90%) was recorded in treatment T5 (Table 4) which was significantly higher than rest of the treatments. Successive addition of supplementary ingredients increased the total ash accumulation in seeds and attained maximum at T5, T10 and T15, respectively over their respective fertility levels. The total ash content recorded in seeds had significant difference due to supplementation of nutrients had different levels of recommended fertility as compared to no supplementary nutrients.

Table 4: Total carbohydrates and others (%) of *Brassica juncea* seed as affected by integrated plant nutrient management

Symbol	Treatment	Total carbohydrates and others (%)
T1	Recommended fertility (RF)	36.50
T2	T1+FYM 10 t/ha	35.02
T3	T2+ Sulphur @ 40 kg S/ha	34.25
T4	T3+Zinc @25 kg $ZnSO_4$/ha	33.91
T5	T4+Boron@1kg/ B/ha	33.33
T6	75% of Recommended fertility	36.35
T7	T6+ FYM 10 t/ha	34.93
T8	T7+ Sulphur @ 40 kg S/ha	33.86
T9	T8+ Zinc @25 kg $ZnSO_4$/ha	33.53
T10	T9+ Boron@1kg/ B/ha	32.85
T11	50% of Recommended fertility	36.83
T12	T11+ FYM 10 t/ha	35.58
T13	T12+ Sulphur @ 40 kg S/ha	34.83
T14	T13+ Zinc @25 kg $ZnSO_4$/ha	34.09
T15	T14+ Boron@1kg/ B/ha	33.54
	SEM±	0.05
	CD at 5%	0.15

Total carbohydrate content (%)

Mean total carbohydrate content was 34.63%. The integrated plant nutrient management practices significantly influenced the total carbohydrate content in the seed. The minimum total carbohydrate content in seed was recorded in treatment T10 (32.85%) which was significantly lower than rest of the treatments (Table 5).

Successive addition of supplementary ingredients decreases the total carbohydrate accumulation in seed and minimum at T5, T10 and T15, respectively over their respective fertility levels. Average minimum total carbohydrate content was recorded in 75 % recommended fertility than in 50% and 100%. The total carbohydrate content recorded in seed had significant difference due to supplementation of nutrients had different levels of recommended fertility as compared to no supplementary nutrients. It can be concluded that the percent of total carbohydrates decreases as the total ash, percent crude protein as well as percent lipid content increases.

Conclusion

From the present study, it was concluded that the seed fatty acid composition was significantly influenced by the different integrated plant nutrient management practices. The highest protein content (21.37%) was recorded with treatment T5. The mean protein yield was 492.38kg/ha. The mean glucosinolate content in seed was 103.60 µmole/ g seed. The lowest seed fibre content (11.73%) was obtained with treatment T5. The maximum total ash content in seeds (4.90% on dry weight basis) was recorded in treatment T5. Average minimum total carbohydrate content was recorded in 75 % recommended fertility than in 50% and 100%. In the present study, it was found that the application of recommended dose of sulphur, zinc, boron along with farm yard manure increased the maximum nutrients and reduced anti-nutritional properties.

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