The Pharma Innovation Journal 2020; 9(10): 410-415

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(10): 410-415

www.thepharmajournal.com
Received: 09-08-2020
Accepted: 18-09-2020

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Effect of different levels of zinc and sulphur on seed quality of Indian mustard

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Abstract
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An experiment was designed to find out the influence of different doses of zinc and sulphur on seed quality of Indian mustard variety Urvashi. The field experiment and laboratory experiment was conducted in Split Plot Design with three replications during 2011-12 & 2012-13 at New Dairy Farm, Kalyanpur, Kanpur and Seed Testing Laboratory of Department of Seed Science and Technology, Respectively. Six doses of zinc and sulphur *viz*. 0.0, 2.5, 5.0, 7.5, 10.0, 12.5 Kg ha^{-1} and 0, 10, 20, 30, 40, 50 Kg ha^{-1}, respectively were applied as basal dose. Observations were recorded on seed quality parameters. Results showed that the application of zinc and sulphur affected significantly to all parameters. The dose 10 Kg Zn ha^{-1} & 50 Kg S ha^{-1} recorded highest seed germination (91.16 & 91.19%), seedling length (13.54 & 13.47 cm), seedling vigour index (1230.73 & 1225.46), oil content (39.92 & 39.67%), linolenic acid (15.51 & 15.06%), linoleic acid (21.15 & 22.79%), oleic acid (13.89 & 14.30%) and palmatic + stearic acid (2.96 & 3.06%) and lowest amout recorded in erucic acid and eicosenoic acid. The application of 10.0 kg Zn ha^{-1} and 40 Kg S ha^{-1} increased days to maturity (134.64 & 135.08) and 1000-seed weight (5.30 & 5.72 g) was recorded in 7.5 Kg Zn ha^{-1} and 50 Kg S ha^{-1}, respectively. However, rest of the characters was affected by the application of zinc and sulphur.

Keywords: Mustard, zinc, sulphur, effect, seed quality

Introduction
Mustard (*Brassica juncea*(L.) Czern and Coss) is important *Rabi* oilseed crop which belongs to family "Cruciferae. In India, first rank in area and third in production after China and Canada. On the world map, Indian rapeseed and mustard occupies about 6.18 million hectare area with a production of 7.36 mt and average productivity of 1190 kg/ha. In India Rajasthan ranks first both in area in production. Gujarat state has the highest productivity of rapessed and mustard, Whereas in UP repressed and mustard is grown on 6.58 lakh.ha area with production of 0.76 mt and productivity of 1155kg/ha (Anonymous 2015) [2].

In India consumption of oil and fats is continuously increasing due to increase in population at an annual growth rate of 2.1 per cent and improved standards of living due to accelerated economic development in the base scenario of per capita growing by 4.0 per cent annually, an average Indian's yearly edible oil requirement in fated to rise from 9. 81 kg in 1999-2000 to 16 kg by 2015 (Hegde, 2004) [7].

For oil seeds sulphur and zinc are vital nutrients for growth and development. Sulphur in considered to be the fourth important essential nutrient after nitrogen, phosphorus and potassium for the plant growth. Sulphur performs many physiological functions like synthesis of cysteine, methionine, chlorophyll and oil content of oil seed crops. It is also responsible for synthesis of certain vitamins (B, Biotin and Thiamine), metabolism of carbohydrates, proteins and oil formation of flavor compounds in crucifers.

Keeping this in view, the present investigation was carried out to study the effect of sulphur, zinc and FYM on growth, yield attributes, seed yield, gross income, net profit and B:C ratio in irrigated Indian mustard.

In recent years, sulphur deficiency has been aggravated in the due to continuous removal by crops and use of high analysis sulphur devoid fertilizers coupled with intensive cropping with high yielding varieties and reduction in use of organic manure and sulphur containing fungicides and insecticides resulted in sulphur deficiency in soils (Pasricha *et al.*, 1972)

Sulphur deficiency is as high as 81 per cent in the light textured soils of North and North West zone of Gujarat (Sadasania, 1992) [15]. They reported that sulphur deficiency tends to affect adversely on growth and which reduces the crop yield to the extent of 10-30 per cent.

Materials and Methods

The experiment was conducted at the New Dairy Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur, Kanpur UP during 2011-12 and 2012-13 Indian mustard variety Urvashi under Split Plot Design with three replications having plant distance 45 cm and 5 cm respectively. Five rows were sown in each plot of 4 × 2.25 $m^{2.}$ The recommended fertilizer was applied at the rate of 120 Kg N, 60 Kg P_2O_5 and 40 Kg K_2O ha^{-1} uniformly in all plots as feeder dose and plant protection measure were Spraying of Malathion 50 EC @ 1 liter dissolved in 1000 liters of water ha^{-1} for the control of hairy caterpillar. Spraying of Imidachloroprid 17.8 EC @ 375 ml in 1000 liters of water ha^{-1} was applied as per requirement for the control of aphids. The study was consisted of two factors *viz*. zinc and sulphur with Six doses of zinc and sulphur viz. 0.0, 2.5, 5.0, 7.5, 10.0, 12.5 Kg ha^{-1} and 0, 10, 20, 30, 40, 50 Kg ha^{-1}, respectively were applied as basal dose. The composition of soil of the experimental plot is alluvial in nature. The soil samples were drawn and analyzed in the Soil Testing Laboratory Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for different physical and chemical composition following the standard procedure.

Observations were Recorded 1000 Seed Weight, Standard Germination test was carried out by following the procedure out lined by ISTA rules (Anonymous, 1999). Seedling Length (cm), Seedling Vigour Index: (S. V. I. The seed vigour index was determined by using the formula suggested by Abdul Baki and Anderson (1973). S. V. I. = Germination Percentage x Seedling Length (cm), Oil Content (%) and Fatty Acid Component Fatty acid component was evaluated by electronic model Nucon Gaschromatograph-5765.

Results

Effect of Zinc and Sulphur 1000-Seed Weight

Data pertaining to 1000-seed weight (g) of Indian mustard as influenced by different levels of zinc and sulphur have been presented in Table 1.

It is clear the application of zinc significantly influenced the 1000-seed weight (g) of Indian mustard. The effect on 1000-seed weight between Zn_5 and Zn_4, Zn_4 and Zn_3 and Zn_2 and Zn_1 were non-significant to each other. Significantly highest 1000-seed weight (5.34 g) of Indian mustard was obtained with the application of Zn_5 followed by Zn_4 (5.31 g), Zn_3 (5.30 g), Zn_2 (5.24 g) and Zn_1 (5.20 g) while minimum 1000-seed weight (5.07 g) of Indian mustard was obtained with control plot.

It is evident that the application of different levels of sulphur significantly influenced the 1000-seed weight (g) of Indian mustard. It was observed that every increasing dose of sulphur significantly increased the 1000-seed weight of Indian mustard. Table 1 reveals that the treatment S_5 and S_4, S_4 and S_3, S_3 and S_2, S_2 and S_1 and S_1 and S_0 had exhibited significant difference to each other. Significantly highest 1000-seed weight (5.72 g) of Indian mustard was obtained with the application of $S_{5.}$ While lowest 1000-seed weight (4.86 g) of Indian mustard was obtained in control plot.

Effect of Zinc and Sulphur on Standard Germination (%)

A perusal of data on standard germination per cent as influenced by different levels of zinc and sulphur have been presented in Table 1.

It is showed Table 1 reveals that every increasing levels of zinc significantly increased standard germination per cent of Indian mustard. The treatment Zn_5 and Zn_4, Zn_4 and Zn_3, Zn_3 and Zn_2, Zn_2 and Zn_1 and Zn_1 and Zn_0 showed significant difference to each other. Maximum standard germination (91.16%) of mustard was recorded in the treatment Zn_5 while minimum (88.32%) was recorded in control plot.

Every increasing doses of sulphur exhibited significant differences on standard germination per cent (Table 1). The treatment S_5 and S_4, S_4 and S_3, S_3 and S_2, S_2 and S_1 and S_1 and S_0 exhibited significant differences to each other. The maximum standard germination (91.19%) of Indian mustard was recorded with the application of S_5 while minimum (89.25%) was recorded in control plot.

Effect of Zinc and Sulphur on Seedling Length

The data pertaining to seedling length (cm) of Indian mustard as influenced by different levels of zinc and sulphur have been presented in Table 1.

Every increasing dose of zinc significantly increased seedling length of Indian mustard (Table 1)**.** The treatment Zn_5 and Zn_4, Zn_4 and Zn_3, Zn_3 and Zn_2, Zn_2 and Zn_1 and Zn_1 and Zn_0 had shown significant effect to each other. Application of Zn_5 produced maximum seedling length (13.54 cm) of Indian mustard as compared to rest of the doses of zinc. The minimum seedling length (11.69 cm) of Indian mustard was observed in control.

It is showed Table 1 discloses that various levels of sulphur i.e. S_5 and S_4, S_4 and S_3, S_3 and S_2, S_2 and S_1 and S_1 and S_0 expressed significant difference among themselves on seedling length. Every increasing doses of sulphur significantly increased seedling length of Indian mustard. Treatment of S_5 produced maximum seedling length (13.47 cm) while minimum seedling length (11.99 cm) was obtained in without sulphur applied plot.

Effect of Zinc and Sulphur on Seedling Vigour Index

The data pertaining to seedling vigour index of Indian mustard as influenced by different levels of zinc and sulphur have been presented in Table1.

Every increasing dose of zinc significantly increased seedling vigour index of Indian mustard. The treatment Zn_5 and Zn_4, Zn_4 and Zn_3, Zn_3 and Zn_2, Zn_2 and Zn_1 and Zn_1 and Zn_0 exhibited significant difference to each other. Application of Zn_5 produced significantly highest seedling vigour index (1230.73) as compared to rest of the doses of zinc. The minimum seedling vigour index (1044.24) was recorded in control.

It is clear the application of sulphur significantly influenced to seedling vigour index of Indian mustard. Application of various doses of sulphur i.e. S_5 and S_4, S_4 and S_3, S_3 and S_2, S_2 and S_1 and S_1 and S_0 expressed significant differences to each other on seedling vigour index. Every increasing dose of sulphur significantly increased seedling vigour index of Indian mustard. Application of S_5 produced highest seedling vigour index (1225.46) while minimum seedling vigour index (1071.90) of Indian mustard was recorded in without sulphur applied plot.

Effect of Zinc and Sulphur on Oil Content

Data pertaining to oil content in Indian mustard as influenced by different levels of zinc and sulphur have been presented in Table 1.

It is evident from the Table 1 shows that the application of zinc at every increasing dose significantly increased oil content of Indian mustard during investigation. The treatment

Zn_5 and Zn_4, Zn_4 and Zn_3, Zn_3 and Zn_2, Zn_2 and Zn_1 and Zn_1 and Zn_0 exhibited significant difference to each other. The Application of Zn_5 produced significantly highest oil content (39.92%) followed by Zn_4 (39.63%). The application of Zn_0 was produced lowest oil content (38.78%) of Indian mustard.

Table 1reveals that every increasing dose of sulphur significantly increased oil content in Indian mustard during experimentation. Treatment S_5 and S_4, S_4 and S_3, S_3 and S_2, S_2 and S_1 and S_1 and S_0 exhibited significant differences to each other. Significantly highest oil content (39.67%) of Indian mustard was obtained with the application of S_5 followed by S_4 (39.57%). While minimum oil content (38.96%) of Indian mustard was recorded in control plot (Table1).

Effect of Zinc and Sulphur on Fatty Acid Component

Effect of Zinc and Sulphur on Erucic Acid Content

A perusal of data on erucic acid content of Indian mustard as influenced by different levels of zinc and sulphur have been presented in Table 2.

Table 2 reveals that all treatments were shown significant differences to each other. Every increasing dose of zinc significantly decreased erucic acid content of Indian mustard. Highest erucic acid (44.24%) content of Indian mustard was obtained in treatment of Zn_0, while lowest erucic acid (40.75%) content was obtained with the application of Zn_5.

It is clear from the Table 2 reveals that the every increasing dose of sulphur significantly decreased erucic acid content of Indian mustard. All treatments were exhibited significant effect to each other. Application of highest tested dose of S_5 produced significantly lowest erucic acid content (42.23%), while maximum (45.74%) was obtained in control plot.

Effect of Zinc and Sulphur Eicosenoic Acid Content

Data pertaining to eicosenoic acid content of Indian mustard as influenced by different levels of zinc and sulphur have been presented in Table 2.

It showed that the Table 2 discloses that various levels of zinc expressed significant difference among themselves on eicosenoic acid content of Indian mustard. It was found that the every increasing dose of zinc significantly decreased eicosenoic acid content of Indian mustard. The minimum eicosenoic acid (5.13%) content of Indian mustard was obtained with the application of Zn_5 followed by Zn_4 (5.26%). Highest ecosenoic acid (6.00%) content of Indian mustard was obtained in without zinc applied plot.

It was observed that every increasing dose of sulphur significantly decreased eicosenoic acid content. Various levels of sulphur expressed significant differences among themselves on eicosenoic acid content. Treatment S_5 was produced significantly lowest eicosenoic acid (5.31%) content of Indian mustard. While without sulphur applied plot recorded maximum eicosenoic acid (5.85%) content of Indian mustard (Table 2).

Effect of Zinc and Sulphur Linolenic Acid Content

Data on linolenic acid content of Indian mustard as influenced by different levels of zinc and sulphur have been presented is Table 2.

It is obvious from the Table 2 discloses that treatment Z_5 and Z_4, Z_4 and Z_3, Z_3 and Z_2, Z_2 and Z_1 and Z_1 and Z_0 were shown significant difference to each other. The application of highest tested dose of Zn_5 significantly increased linolenic acid (15.51%) content of Indian mustard followed by Zn_4 (15.21%). Without zinc applied plot (Zn_0) recorded minimum linolenic acid (13.51%) content of Indian mustard.

It showed significant Table 2 discloses that every increasing dose of sulphur significantly increased linolenic acid content of Indian mustard. Treatment S_5 and S_4, S_4 and S_3, S_3 and S_2, S_2 and S_1 and S_1 and S_0 were exhibited significant effect to each other. Treatment S_5 was produced significantly highest linolenic acid (15.06%) content of Indian mustard followed by S_4 (14.96%). The lowest linolenic acid (13.55%) content of Indian mustard was obtained in absolute control plot S_0.

Effect of Zinc and Sulphur Linoleic Acid Content

A perusal of data on linoleic acid content of Indian mustard as affected by different doses of zinc and sulphur have been presented in Table 2.

It is clear from the Table 2 exhibits that the every increasing dose of zinc significantly increased linoleic acid content of Indian mustard. All treatments were exhibited significant difference to each other. Significantly highest linoleic acid (21.15%) content of Indian mustard was produced with treatment of Zn_5 followed by Zn_4 (20.87%), Zn_3 (20.73%), Zn_2 (20.60%) and Zn_1 (20.44%). Lowest linoleic acid (20.33%) content of Indian mustard was obtained without zinc applied plot Zn_0.

Table 2 reveals that the linoleic acid content of Indian mustard was significantly increased with the increasing dose of sulphur. All treatments were exhibited significant difference to each other. Significantly highest linoleic acid (22.79%) content of Indian mustard was obtained with the application of S_5 followed by S_4 (21.70%), S_3 (20.80%), S_2 (20.19 %) and S_1 (19.67%). Lowest linoleic acid (18.96%) content of Indian mustard was recorded with control (S_0).

Effect of Zinc and Sulphur Oleic Acid Content

The data pertaining to oleic acid content of Indian mustard as influenced by various levels of zinc and sulphur have been presented in Table 3.

It is obvious from the Table 3 shows that treatment Zn_0 and Zn_1, Zn_1 and Zn_2, Zn_2 and Zn_3, Zn_3 and Zn_4 and Zn_4 and Zn_5 significant differences to each other. Every increasing dose of zinc was significantly increased oleic acid content of Indian mustard. Significantly highest oleic acid (13.89%) content of Indian mustard was obtained with the application of Zn_5 followed by Zn_4 (13.75%), Zn_3 (13.56%), Zn_2 (13.43%) and Zn_1 (13.27%). While minimum oleic acid (13.17%) content of Indian mustard was obtained in control plot.

It is evident from the Table 3 reveals that every increasing dose of sulphur significantly increased oleic acid content of Indian mustard. Treatment S_0 and S_1, S_1 and S_2, S_2 and S_3, S_3 and S_4 and S_4 and S_5 were exhibited significant effect to each other. Application of highest dose of S_5 produced significantly highest oleic acid (14.30%) content of Indian mustard as compared to rest of the doses of sulphur during experimentation. It was also observed that the application of S_4 recorded more oleic acid (13.83%) content of Indian mustard followed by S_3 (13.49%), S_2 (13.38%) and S_1 (13.18%). The minimum oleic acid (12.90%) content of Indian mustard was recorded in without sulphur applied plot (Table 3).

Effect of Zinc and Sulphur Palmatic + Stearic Acid Content

Data on palmatic + stearic acid content of Indian mustard as affected by different levels of zinc and sulphur have been presented in Table 3.

It is obvious from the Table 3 shows that every increasing dose of zinc significantly increased palmatic + stearic acid content of Indian mustard. Treatment Zn_0 and Zn_1, Zn_1 and Zn_2, Zn_2 and Zn_3, Zn_3 and Zn_4 and Zn_4 and Zn_5 were shown significant differences to each other. Treatment Zn_5 was produced significantly highest palmatic + stearic acid (2.96%) content of Indian mustard followed by Zn_4 (2.89%), Zn_3 (2.80%), Zn_2 (2.70%) and Zn_1 (2.62%). Minimum palmatic + stearic acid (2.55%) content of Indian mustard was obtained in control.

It is clear from the Table 3 reveals that every increasing dose of sulphur significantly increased palmatic + stearic acid content. Treatment S_0 and S_1, S_1 and S_2, S_2 and S_3, S_3 and S_4 and S_4 and S_5 were exhibited significant effect to each other. Highest tested dose of S_5 was recorded significantly more palmatic + stearic acid (3.06%) content of Indian mustard followed by S_4 (2.98%), S_3 (2.89%), S_2 (2.76%) and S_1 (2.52%). The minimum palmatic + stearic acid (2.31%) content was recorded in control.

Discussion

Effect of Zinc, Sulphur and their Interaction on Seed Quality of Indian Mustard:

The application of zinc and sulphur showed significant effect on 1000-seed weight. The statistically maximum 1000-seed weight has been registered under the regime of zinc and sulphur i.e. 7.5 Kg Zn ha^{-1} and 50 Kg S ha^{-1} ($Zn_3 \times S_5$). The minimum 1000-seed weight was recorded in absolute control plot. The present study revealed that 1000-seed weight exhibited positive correlation with the increasing levels of zinc (upto 7.5 Kg Zn ha^{-1}) and sulphur. The increase in 1000-seed weight due to sulphur application have also been reported by several workers (Jat *et al.* 2008, Verma *et al.* 2012, Sharifi 2012, and Dubey *et al.* 2013) [9, 12, 17]. The increase in 1000-seed weight of mustard due to application of zinc have also been reported by Baudh and Prasad (2012), Verma *et al.* (2012) [19] and Dubey *et al.* (2013).

The application of zinc and sulphur affected significantly to seed quality in mustard viz., standard germination, seedling length and seedling vigour index. Enhancement in standard germination, seedling length and seedling vigour index was accompanied by increasing doses of zinc and sulphur. Statistically highest standard germination, seedling length & SVI were recorded under the regime of 12.5 Kg Zn ha^{-1} and 50 Kg S ha^{-1}. The combined application of zinc and sulphur did not influence the standard germination & seedling length. However, seedling vigour index was significantly affected by the combined application of zinc and sulphur. Similar results were reported by Maurya (2012) in wheat and Trivedi *et al.* (2011) [13] in mustard.

Significant increase in oil content (39.67%) with the application of highest tested dose of sulphur might be due to sulphur participation in the formation of acetyl Co-A, a precursor compound for synthesis of long chain fatty acids. Sulphur as a constituent of multi enzyme complex 'fatty acid synthetase' is also known to play an important role in oil synthesis. These results are in close conformity with the findings of Kumar and Trivedi (2011) [13], Singh *et al.* (2012) [18], Verma *et al.* (2012) [19] and Dubey *et al.* (2013). The increase in oil content with the application of zinc have also been reported by Deo and Khandelwal (2009) [5], Verma *et al.* (2012) [19] and Dubey *et al*. (2013), Sahito *et al*. (2014) [6].

Application of zinc and sulphur significantly influenced on fatty acid composition viz. erucic acid and eicosenoic acid content. Every increasing doses of zinc and sulphur upto highest tested dose significantly decreased erucic acid and eicosenoic acid content. Application of 12.5 Kg Zn ha^{-1} and 50 Kg S ha^{-1} either singly or in combination recorded significantly minimum erucic acid and eicosenoic acid content as compared to rest of the doses of zinc and sulphur. Without zinc and sulphur applied plots recorded highest erucic acid and eicosenoic acid content.

Every increasing doses of zinc and sulphur significantly increased linolenic, linoleic, oleic and palmatic+stearic acid content in mustard. Significantly highest linolenic, linoleic, oleic and palmatic acid content was recorded with the application of 12.5 Kg Zn ha^{-1} and 50 Kg S ha^{-1} as compared to other doses of zinc and sulphur. Without zinc and sulphur applied plot recorded minimum linolenic, linoleic, oleic and palmatic acid content of Indian mustard. The interaction effect of different levels of zinc and sulphur were found to be significant on linolenic, linoleic, oleic acid content while palmatic acid content was non-significant. The maximum linolenic, linoleic, oleic content was produced with combined application of zinc (12.5 Kg ha^{-1}) and sulphur (50 Kg ha^{-1}) while it was minimum was recorded in absolute control plots.

Sulphur improves the quality of mustard by increasing the oil content, protein content and several fatty acids (Aulakh and Pasricha, 1988) [3]. Sulphur promotes oil synthesis. It is an important constituent of seed protein, amino acid, enzymes, glucosinolate and is needed for chlorophyll formation (Holmes, 1980) [8]. Krauze and Bobrzecka (1983) [12] reported that sulphur application to winter rapeseed, the contents of oleic, linoleic and linolenic acids increased with increasing levels of sulphur. Ahmed and Abdin (2000) [1] reported that the application of 60 Kg S ha^{-1} enhanced oil content and increased in the oleic acid and linolenic acid contents and decreases in the eicosenoic acid and erucic acid content in mustard. Jat *et al.* (2005) [10] reported that significant improvement in palmatic, stearic, linoleic and linolenic acids concentration of mustard oil up to 60 Kg S ha^{-1}. The application of sulphur at increasing levels (0-90 Kg ha^{-1}) gradually decreased the oleic acid concentration in mustard oil. Similar results have also been reported by Joghee *et al.* (2011) [11] and Parmar and Parmar (2012) [14].

Table 1: Effect of Zinc and Sulphur on 1000-Seed Weight (g), Seed Germination (%), Seedling Length (cm), Seedling Vigour Seedling Vigour and Oil Content (%) in Indian Mustard Variety Urvashi.

Treatment	1000-Seed Weight (g)			Seed Germination (%)			Seedling Length (cm)			Seedling Vigour			Oil Content (%)		
Zinc levels (kg ha^{-1})	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled
0.0 (Zn_0)	5.21	4.94	5.07	68.01 (86.02)	74.29 (92.67)	71.15 (88.32)	11.68	11.70	11.69	1004.29	1084.19	1044.24	38.76	38.80	38.78
2.5 (Zn_1)	5.33	5.07	5.20	68.49 (86.55)	74.54 (92.92)	71.52 (89.90)	12.47	12.22	12.35	1079.46	1136.56	1108.01	38.01	39.04	39.02
5.0 (Zn_2)	5.36	5.13	5.24	68.98	74.75	71.86	12.79	12.37	12.58	1114.28	1151.29	1132.79	39.09	39.12	39.11

				(87.13)	(92.98)	(90.07)									
7.5 (Zn_3)	5.43	5.17	5.30	69.27 (87.46)	75.00 (93.49)	72.14 (90.47)	13.10	12.72	12.91	1145.70	1186.48	1166.09	39.27	39.25	39.26
10.0 (Zn_4)	5.46	5.20	5.31	69.57 (87.81)	75.24 (93.79)	72.40 (90.80)	13.31	12.99	13.15	1172.96	1214.87	1193.92	39.51	39.65	39.63
12.5 (Zn_5)	5.44	5.24	5.34	70.04 (88.33)	75.31 (93.99)	72.68 (91.16)	14.01	13.07	13.54	1238.22	1222.53	1230.73	39.91	39.93	39.92
SE(d)	0.04	0.02	0.02	0.16	0.18	0.12	0.20	0.03	0.10	17.72	2.56	8.95	0.06	0.006	0.006
CD (p=0.05)	0.08	0.05	0.05	0.32	0.36	0.23	0.41	0.05	0.20	35.45	5.12	17.63	0.13	0.012	0.011
Sulphur levels (kg ha^{-1})															
0 (S_0)	4.95	4.77	4.86	62.20 (86.21)	73.89 (92.26)	71.05 (89.25)	12.12	11.86	11.99	1047.74	1096.08	1071.90	38.95	38.97	38.96
10 (S_1)	5.11	4.89	4.99	68.72 (86.82)	74.47 (92.84)	71.59 (89.81)	12.38	12.20	12.29	1075.87	1132.31	1104.09	39.04	39.08	39.06
20 (S_2)	5.22	4.92	5.07	68.90 (87.09)	74.72 (93.10)	71.81 (90.06)	12.56	12.46	12.51	1093.34	1159.84	1126.59	39.05	39.20	39.18
30 (S_3)	5.40	5.15	5.27	69.05 (87.20)	75.04 (93.46)	72.04 (90.33)	12.94	12.70	12.82	1129.15	1185.30	1157.22	39.28	39.31	39.30
40 (S_4)	5.68	5.45	5.56	69.54 (87.76)	75.39 (94.02)	72.46 (90.89)	13.40	12.86	13.13	1176.37	1203.91	1190.14	39.57	39.56	39.57
50 (S_5)	5.86	5.57	5.72	69.95 (88.23)	75.62 (94.16)	72.79 (91.19)	13.96	12.99	13.47	1232.44	1218.48	1225.46	39.67	39.67	39.67
SE (d)	0.04	0.03	0.03	0.12	0.14	0.09	0.20	0.03	0.10	15.88	2.86	8.07	0.06	0.006	0.03
CD (p=0.05)	0.09	0.07	0.05	0.26	0.32	0.19	0.45	0.06	0.21	35.36	6.37	16.83	0.14	0.012	0.05

Table 2: Effect of Zinc and Sulphur on Fatty Acid (Erucic acid), Fatty Acid (Eicosenoic acid), Fatty Acid (Linolenic acid), Fatty Acid (Linoleic acid) Fatty Acid (Linoleic acid) in Indian Mustard Variety Urvashi.

Treatment	Fatty Acid (Erucic acid)			Fatty Acid (Eicosenoic acid)			Fatty Acid (Linolenic acid)			Fatty Acid (Linoleic acid)		
Zinc levels (kg ha^{-1})	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled
0.0 (Zn_0)	43.89	44.60	44.24	5.99	6.01	6.00	13.65	13.36	13.51	20.32	20.33	20.33
2.5 (Zn_1)	43.66	44.51	44.12	5.88	5.90	5.89	14.03	13.52	13.77	20.43	20.45	20.44
5.0 (Zn_2)	43.20	43.55	43.37	5.62	5.64	5.63	14.89	13.94	14.21	20.58	20.61	20.60
7.5 (Zn_3)	42.34	42.69	42.51	5.48	5.50	5.49	15.45	14.33	14.89	20.77	20.70	20.73
10.0 (Zn_4)	41.50	41.86	41.68	5.26	5.28	5.26	15.64	14.78	15.21	20.78	21.02	20.87
12.5 (Zn_5)	40.67	40.83	40.75	5.17	5.13	5.13	15.92	15.10	15.51	21.08	21.10	21.15
SE(d)	0.10	0.03	0.05	0.04	0.03	0.02	0.03	0.01	0.02	0.05	0.03	0.02
CD (p=0.05)	0.20	0.06	0.10	0.08	0.05	0.04	0.06	0.03	0.03	0.10	0.05	0.03
Sulphur levels (kg ha^{-1})												
0 (S_0)	45.88	45.60	45.74	5.84	5.87	5.85	13.87	13.22	13.55	18.95	18.97	18.96
10 (S_1)	44.11	44.08	44.09	5.71	5.73	5.72	14.70	13.71	14.21	19.61	19.64	19.67
20 (S_2)	42.77	43.10	42.94	5.60	5.62	5.61	14.93	14.14	14.54	20.18	20.21	20.19
30 (S_3)	41.87	42.59	42.27	5.45	5.52	5.51	15.07	14.50	14.79	20.79	20.81	20.80
40 (S_4)	40.94	41.89	41.41	5.45	5.41	5.40	15.23	14.69	14.96	21.66	21.79	21.70
50 (S_5)	39.69	40.78	40.23	5.29	5.31	5.31	15.36	14.75	15.06	22.78	22.70	22.79
SE (d)	0.11	0.02	0.06	0.04	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.03
CD (p=0.05)	0.25	0.05	0.13	0.08	0.02	0.01	0.03	0.02	0.03	0.12	0.04	0.06

Table 3: Effect of Zinc and Sulphur on Fatty Acid (Oleic acid) and Fatty Acid (Palmatic + Stearic acid) in Indian Mustard Variety Urvashi.

Treatment	Fatty Acid (Oleic acid)			Fatty Acid (Palmatic + Stearic acid)		
Zinc levels (kg ha^{-1})	2011-2012	2012-2013	Pooled	2011-2012	2012-2013	Pooled
0.0 (Zn_0)	13.16	13.18	13.17	2.54	2.55	2.55
2.5 (Zn_1)	13.25	13.27	13.27	2.61	2.63	2.62
5.0 (Zn_2)	13.45	13.45	13.43	2.69	2.71	2.70
7.5 (Zn_3)	13.55	13.57	13.56	2.79	2.81	2.80
10.0 (Zn_4)	13.74	13.76	13.75	2.88	2.90	2.89
12.5 (Zn_5)	13.88	13.90	13.89	2.96	2.97	2.96
SE(d)	0.05	0.02	0.02	0.02	0.03	0.02
CD (p=0.05)	0.09	0.05	0.04	0.05	0.05	0.03
Sulphur levels (kg ha^{-1})						
0 (S_0)		12.91	12.90	2.30	2.32	2.31
10 (S_1)	13.17	13.18	13.18	2.52	2.53	2.52
20 (S_2)	13.36	13.39	13.38	2.75	2.76	2.76
30 (S_3)	13.48	13.49	13.49	2.88	2.90	2.89
40 (S_4)	13.87	13.83	13.83	2.97	2.99	2.98
50 (S_5)	14.29	14.31	14.30	3.05	3.07	3.06

SE (d)	0.04	0.01	0.01	0.01	0.01	0.01
CD (p=0.05)	0.08	0.03	0.01	0.01	0.02	0.01

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