AN AJSS An Asian Journal of Soil Science
Volume 12 | Issue 1 | June, 2017 | 10-17 | e ISSN–0976–7231 ■ Visit us : www.researchjournal.co.in

Research Article

DOI : 10.15740/HAS/AJSS/12.1/10-17

Effect of sulphur and zinc with and without FYM on yield and soil physical property after harvest of mustard [*Brassica juncea* (L.) Czern & Coss] grown on light textured soil of Kachchh

■ A.H. SIPAI, KULDEEP SEVAK, K.U. KHORAJIYA AND D.B. MODI

Received : 21.02.2017; **Revised :** 02.04.2017; **Accepted :** 16.04.2017

MEMBERS OF RESEARCH FORUM:

Corresponding author :
A.H. SIPAI, Regional Research Station (S.D.A.U.) Bhachau, KACHCHH (GUJARAT) INDIA
Email: Sipaisoil@gmail.com

Co-authors :
KULDEEP SEVAK, K.U. KHORAJIYA AND D.B. MODI, Regional Research Station (S.D.A.U.) Bhachau, KACHCHH (GUJARAT) INDIA

Summary

A field experiment consisting of 24 treatment combinations of four levels of sulphur (0,20,40,60 kg/ha) and three levels of zinc (0,2.5 and 5.0 kg Zn/ha) and two level of FYM (0 and 10 t FYM/ha) was conducted for two consecutive years from 2007-08 and 2008-09 were tested with three replications under factorial Randomized Block Design at Bhachau-Kachchh to study the effect of S and Zn with and without FYM on yield and property of soil after harvest of mustard. The soil of the experimental field was loamy sand with alkaline in reaction, low in nitrogen, sulphur and zinc, medium in phosphorus and potassium. Application of 40kg S/ha and 5.0 kg Zn/ha along with 10 t FYM/ha produced significantly higher yield and affected the physical properties of soil at harvest of crop over the control but it was at par with the application 40kg S/ha and 5.0kg Zn/ha along with 10t FYM/ha. Maximum economic benefits of gross realization, net realization along with highest BCR of 4.44:1was obtained with F_1S_2 Zn_2 treatment.

Key words : FYM, Mustard, Physical property of soil, Sulphur, Yield, Zinc

How to cite this article : Sipai, A.H., Sevak, Kuldeep, Khorajiya, K.U. and Modi, D.B. (2017). Effect of sulphur and zinc with and without FYM on yield and soil physical property after harvest of mustard [*Brassica juncea* (L.) Czern & Coss] grown on light textured soil of Kachchh. *Asian J. Soil Sci.*, **12** (1) : 10-17 : **DOI : 10.15740/HAS/AJSS/12.1/10-17.**

Introduction

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 is fated to rise from 9.81 kg in 1999-2000 to 16 kg by 2015

In recent years, sulphur deficiency has been aggravated in the soil 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. Sulphur deficiency is as high as 81 per cent in the light textured soils of North and North West zone of Gujarat They reported that sulphur deficiency tends to

Table A : Physico-chemical properties of the experimental soil

Properties	2007-08	2008-09	Method of analysis	References
Physical	0-30 cm	0-30 cm		
Sand (%)	83.2	83.5	International pipette method	Piper (1950)
Silt (%)	8.12	7.89		
Clay (%)	8.68	8.61		
Textural class	Loamy sand	Loamy sand	Triangular diagram	Brady (1983)
Maximum water holding capacity(%)	23.19	22.75	Gravimetric method	Piper (1950)
Bulk density (Mg /m^3)	1.66	1.67	Core method	Piper (1950)
Soil moisture(%)	1.822	1.811	Gravimetric method	Piper (1950)
Infiltration rate (cm hr^{-1})	14.05	14.34	Double ring infiltrometer method	Piper (1950)
Chemical				
Soil pH (1:2.5)	8.03	8.15	Potentiometric method	Jackson (1967)
EC (dSm^{-1})(1:2.5) at 25 ^{0}C	0.72	0.76	Conductometric method	Jackson (1967)

affect adversely on growth and which reduces the crop yield to the extent of 10-30 per cent.

Zinc being one of the essential micronutrient, plays significant role in various enzymatic and physiological activities of the plant system. It is also essential for photosynthesis and N-metabolism. It is important for stability of cytoplasmic ribosomes, cell division, dehydrogenase, proteinase and peptidase enzymes and also helps in the synthesis of protein and carotene. The available zinc in Gujarat soils ranges between 0.25 to 2.58mg kg^{-1}. As nearly half of the Indian soil are Zn deficient and 24 per cent soils of Gujarat state are Zn deficient and 58 per cent soils of North and North Gujarat found deficient to medium in available zinc status (Micronutrient report, 1994). Soils of India had multiple nutrient deficiencies, mainly of N, P, K, S and Zn and their use have become essential to obtain optimum crop yield.

FYM helps in maintaining soil sustainability in terms of nutrients supply capacity of soil. The increase in productivity of the crops might be attributed due to its essential role of all nutrients present in FYM for plant growth through its effect as a good source of soil organic matter which improves the physico-chemical and biological properties of soil. Application of FYM also increases cation exchange capacity and helps in keeping soil micro nutrients in available form through its chelating action as well as microbial activity in soil besides supplying macro and micro plant nutrients.

Resource and Research Methods

A field experiment was conducted during *Rabi* season of two consecutive years 2007-08 and 2008-09 at Agricultural Research Station, Sardarkrushinagar Dantiwada Agricultural University, Bhachau, Kachchh. It is located in the North- West Gujarat Agro-climatic zone and characterized by sub-tropical monsoon type arid climate with extreme cold winter, hot and dry windy summer. The soil was loamy sand in texture and alkaline in reaction (pH 8.03 and 8.15). The soil samples were analyzed for EC, pH and various physical properties like bulk density and maximum water holding capacity after harvest as per method given in Table A.

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of sulphur, zinc and FYM on yield :

Effect of sulphur :

The results of the experiment indicated that among the different levels of sulphur, application of sulphur @ 60 kg ha^{-1} (S_3) resulted in significantly higher seed and stover yield, but found at par with 40 kg ha^{-1} (S_2) during 2007-08, 2008-09 and in pooled results (Table 1). Application of 60 kg S ha^{-1} increased seed yield by 41.86, 13.25 and 3.24 per cent in 2007-08, 35.66, 7.16 and 4.60 per cent in 2008-09 and 38.76, 10.20 and 3.83 per cent in their pooled data over control, 20 and 40 kg S ha^{-1}, respectively. Similarly application of 40 kg S ha^{-1} increased the seed yield by 37.41 and 9.69 per cent in 2007-08 and 29.69 and 2.45 per cent in 2008-09 as well as 33.64 and 6.13 in their pooled data over control and 20 kg S ha^{-1},

respectively. 23.35, 9.08 and 1.79 per cent in 2007-08, 22.65, 8.89 and 3.08 per cent in 2008-09 and 23.02, 8.99 and 2.40 per cent in the pooled results over control, 20 and 40 kg S ha^{-1}, respectively, whereas, application of 40 kg S ha^{-1} increased the stover yield by 21.18 and 7.16 per cent in 2007-08, 18.99 and 5.64 per cent in 2008-09 and 20.14 and 6.44 per cent in pooled results over control and 20 kg S ha^{-1}, respectively. Similarly, application of 20 kg S ha^{-1} increased the stover yield by 13.08 per cent in 2007-08, 12.64 per cent in 2008-09 and 12.87 in pooled over control. The increase in seed and stover yield of mustard might be attributed due to its essential role of S for plant growth and yield through its effect on biochemical functioning related enzyme. Sulphur nutrition also enhances cell multiplication, elongation, expansion and imparts a deep green colour to leaves due to better chlorophyll synthesis, which in turn increases the effective area for photosynthesis, resulting in relatively greater amount of dry matter accumulation in comparison to sulphur deficient plants. These results are in agreement with the findings of Mehriya and Khangarot (2000). Yield of crop is sum of seed and stover yield representing vegetative and reproductive growth. The marked increase in both of these with increasing rates of sulphur fertilization ultimately led to realization of higher biomass of mustard crop. Higher nutrient uptake and better use of radiant energy led to increase vegetative and reproductive growth, thus, enhancing biological yield in presence of sulphur. Positive significant influence of sulphur on seed and stover yield of mustard also supported with the findings of Mir *et al*. (2004); Malik *et al*. (2004); Sahu *et al*. (2004); Singh *et al*. (2004); Kumar *et al*. (2006); Patel *et al*. (2007); Hassan *et al*. (2007) and Kumar and Yadav (2007).

Effect of zinc :

Seed and stover yields were also affected significantly due to application of zinc during 2007-08, 2008-09 and pooled (Table 1). The maximum seed yield was recorded with the application of Zn @ 5.0 kg ha^{-1} which was 14.87, 12.89 and 13.88 per cent higher than zinc @ 2.5 kg ha^{-1} level and 29.87, 38.68 and 34.13 per cent higher than no zinc application during 2007-08, 2008-09 and in pooled results, respectively. The highest stover yield was observed with the application of Zn @ 5.0 kg ha^{-1} which was 8.04, 5.90 and 7.03 per cent higher than

Table 1 : Effect of sulphur, zinc and FYM on yield of mustard

Treatments	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled
Sulphur						
0 kg S ha^{-1} (S_0)	1326	1290	1308	3409	3055	3232
20 kg S ha^{-1} (S_1)	1661	1633	1647	3855	3441	3648
40 kg S ha^{-1} (S_2)	1822	1673	1748	4131	3635	3883
60 kg S ha^{-1} (S_3)	1881	1750	1815	4205	3747	3976
S.E.±	33.4	37.9	28.7	98.5	97.1	78.7
C.D. (P=0.05)	95.0	107.8	83.1	279.9	276.2	223.8
Zinc						
0 kg Zn ha^{-1}(Zn_0)	1463	1316	1389	3725	3185	3455
2.5 kg Zn ha^{-1} (Zn_1)	1654	1618	1636	3833	3508	3670
5.0 kg Zn ha^{-1} (Zn_2)	1900	1825	1863	4141	3715	3928
S.E.±	33.4	37.9	28.7	98.5	97.1	78.7
C.D. (P=0.05)	95.0	107.8	81.6	279.9	276.2	223.8
FYM						
No FYM (F0)	1547	1466	1507	3724	3298	3511
10 t FYM ha^{-1} (F1)	1798	1707	1752	4076	3640	3858
S.E.±	27.3	31.0	23.4	80.4	79.3	64.3
C.D. (P=0.05)	77.6	88.0	66.6	228.5	225.5	182.7
Significant interactions	S x Zn	S x Zn	S x Zn	-	-	-
C.V. (%)	9.79	11.71	10.75	12.37	13.72	13.04

Zn_1 level and 11.17, 16.64 and 13.69 per cent over no zinc application during 2007-08, 2008-09 and in pooled results, respectively. The findings are in accordance with those reported by Husain and Kumar (2006).The significant increase in seed and stover yield of mustard due to application of Zn fertilization @5.0 kg Zn ha^{-1} could be attributed to its great importance in growth and development as it involves in various enzyme systems as prosthetic group and metallic constituents, in photosynthetic pigment biosynthesis and biosynthesis of auxin which in turn enabled the plant to grow taller and produce more dry matter (Sharma *et al*., 1994). Better zinc nutrition of crop helped it in branching both primary and secondary branches in present investigation resulting in higher stover yield at harvest, which in turn has affected the seed yield, which has direct bearings on the dependent characters. Results of various workers have also noted similar findings with zinc fertilization in alluvial soil of Pusa in Bihar and in sandy loam of Kalyani in West Bengal. The findings of present investigations are supported by Malewar *et al*. (2001) and Kumawat and Pathan (2002) who observed increase in seed and stover yield of mustard due to zinc application.

Effect of FYM :

The results further indicated that there was significant increase in seed and stover yield due to application of FYM (Table 1). The significantly higher seed yield of 1798, 1707 and 1752 kg ha^{-1} was registered with the application of FYM @ 10 t ha^{-1} which was 16.22, 16.44 and 16.26 per cent higher over no FYM during 2007-08, 2008-09 and pooled results, respectively. Similarly, application of FYM @ 10 t ha^{-1} also significantly increased the stover yield of mustard (Table 1). The significantly higher stover yield of 4076, 3640 and 3858 kg ha^{-1} was registered with the application of FYM @ 10 t ha^{-1} which was 9.45, 10.37 and 9.88 per cent higher as compared to no FYM during 2007-08, 2008-09 and pooled results, respectively. Positive effect of FYM on plant height, number of primary and secondary branches in mustard was observed by Patel *et al*. (1996). Nagdive *et al*. (2007) got better response on branching, flowering and siliquae development which resulted in maximum seed yield with FYM @ 5t ha^{-1}. Mir (1994) also observed significant increase in the yield attributes of sarson due to FYM @ 10 t ha^{-1}. Thus, increase in seed and stover yield might be due to the consequence of increased vegetative growth and dry matter accumulation as addition of FYM in the soil stimulates the enzyme activity which promotes the recycling of the nutrients in the soil ecosystem. Consequently, FYM has been reported to improve the soil fertility and productivity. Thus, there is a possibility to minimize the demand for chemical fertilizers and reduce pollution hazards (Mehriya and Khangarot, 2000). The increase in seed and stover yield of mustard might be attributed due to its essential role of all nutrients present in FYM for plant growth attributes and yield through its effect as a good source of soil organic matter which improves the physico-chemical and biological properties of soil. Application of FYM also increases cation exchange capacity and microbial activity in soil besides supplying macro and micro plant nutrients. It helps in minimizing leaching losses, improving buffering capacity and influencing the redox conditions in the soil. Results of the present investigation are in line with earlier findings Kumar *et al*. (2007); Patel and Shelke (2000); Deshmukh *et al*. (2005) and Patel *et al*. (2007).

Combined effect of sulphur and zinc on yield :

Application of sulphur along with zinc had significant

Table 2a : Combined effect of sulphur and zinc on seed yield of mustard

Treatments	Seed yield (kg ha^{-1})							
	2007-08				2008-09			
	Zn_0	Zn_1	Zn_2	Mean	Zn_0	Zn_1	Zn_2	Mean
S_0	951	1370	1656	1326	831	1435	1603	1290
S_1	1555	1651	1778	1661	1425	1527	1946	1633
S_2	1642	1751	2074	1822	1480	1738	1802	1673
S_3	1705	1844	2093	1881	1528	1774	1948	1750
Mean	1463	1654	1900		1316	1618	1825	
S.E.±		57.9				65.7		
C.D. (P=0.05)		164.5				186.7		
C.V. (%)		9.8				11.7		

Table 2b: Combined effect of sulphur and zinc on seed yield of mustard (Pooled)

Treatments	Seed yield (kg ha^{-1})			
	Zn_0	Zn_1	Zn_2	Mean
S_0	891	1403	1630	1308
S_1	1490	1589	1862	1647
S_2	1561	1744	1938	1748
S_3	1616	1809	2021	1815
Mean	1389	1636	1863	
S.E.±		49.7		
C.D. (P=0.05)		141.4		
C.V. (%)		10.7		

effect on seed yield (Table 2a and b). The highest seed yield of 2093, 1948 and 2021 kg ha^{-1} was recorded under 60 kg S ha^{-1} in combination with 5.0 kg Zn ha^{-1}, but it was found at par with $S_2 Zn_2$ during 2007-08 and pooled and $S_2 Zn_2$, $S_2 Zn_1$, $S_1 Zn_2$ and $S_3 Zn_1$ in 2008-09. Combined application of 40 kg S ha^{-1} and 5.0 kg Zn ha^{-1} resulted in increase in seed yield to the extent of 118.09, 116.85 and 117.51 per cent where neither sulphur nor zinc was applied during 2007-08, 2008-09 and in pooled results, respectively.

There was synergistic effect of combined application of sulphur and zinc upto certain levels. Positive significant interaction on growth parameters and seed yield of safflower was observed due to application of both sulphur and zinc @ 20 kg ha^{-1}. Similarly, synergistic interaction was noted by Babhulkar *et al*. (2000). These results are in accordance with those reported by earlier workers (Prasad *et al*., 2003; Akbari

Table 3 : Effect of sulphur, zinc and FYM on physical properties of soil after harvest of mustard (mean of two year data)

Treatments	EC (dSm^{-1})	pH	Soil physical properties		
			Soil moisture(%)	Max. water holding cap. (%)	Bulk density (g/cc)
			Pooled	Pooled	Pooled
Sulphur					
0 kg S ha^{-1} (S_0)	0.81	8.24	1.868	22.23	1.661
20 kg S ha^{-1} (S_1)	0.80	8.22	1.822	21.69	1.666
40 kg S ha^{-1} (S_2)	0.81	8.21	1.819	21.65	1.668
60 kg S ha^{-1} (S_3)	0.81	8.20	1.814	21.60	1.670
S.E.±	0.01	0.07	0.015	0.23	0.014
C.D. (P=0.05)	NS	NS	NS	NS	NS
Zinc					
0 kg Zn ha^{-1}(Zn_0)	0.81	8.22	1.834	21.83	1.663
2.5 kg Zn ha^{-1} (Zn_1)	0.81	8.22	1.831	21.80	1.666
5.0 kg Zn ha^{-1} (Zn_2)	0.80	8.21	1.827	21.75	1.670
S.E.±	0.01	0.07	0.015	0.23	0.014
C.D. (P=0.05)	NS	NS	NS	NS	NS
FYM					
No FYM (F0)	0.81	8.28	1.792	21.01	1.674
10 t FYM ha^{-1} (F1)	0.80	8.15	1.870	22.57	1.658
S.E.±	0.01	0.05	0.012	0.19	0.011
C.D. (P=0.05)	NS	NS	0.034	0.54	NS
Significant interactions	-	-	-	-	-
C.V. (%)	6.20	4.89	4.90	6.43	5.07

NS= Non-significant

et al., 2003; Meena *et al*., 2006a and b; Subhash and Yadav, 2007 and Singh *et al*., 2007) who observed combined application of sulphur and zinc had synergistic effect in increasing seed and stover yield of mustard.

Effect of soil physical properties after harvest :

Effect of sulphur :

The results presented in Table 3 revealed that application of sulphur fertilization did not influence significantly on pH, EC and physical properties like bulk density, soil moisture per cent and maximum water holding. Increasing rates of sulphur fertilization there was decrease in pH continuously during both the years of experimentation and pooled. The gradual decrease in pH with increasing levels of sulphur might be due to formation of H_2SO_4 by the application of sulphur which reduce pH of soil. Application of sulphur has been reported to help in lowering the soil pH. Roop Chand *et al*. (2007) observed non-significant effect of added gypsum @ 5 t ha^{-1} on soil pH and bulk density. Similarly, Hamza and Anderson (2007) also observed that gypsum applied @ 2.5 t ha^{-1} had non-significant effect on bulk density.

Effect of zinc :

The results presented in Table 3 revealed that application of zinc had not significant influence on pH, EC and physical properties like bulk density, soil moisture per cent and maximum water holding. The increase in rates of zinc resulted in decrease in pH continuously

Table 4 : Economical evaluation of sulphur, zinc and FYM

Treatment combinations	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Total expenditure (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net return (Rs. ha^{-1})	BCR
$F_0S_0Zn_0$	931	2912	8575	24327	15752	1.84
$F_0S_0Zn_1$	1153	3352	8668	29868	21200	3.45
$F_0S_0Zn_2$	1476	3352	8760	37296	28536	4.26
$F_0S_1Zn_0$	1456	3411	9019	36908	27889	4.09
$F_0S_1Zn_1$	1576	3451	9112	39695	30583	4.36
$F_0S_1Zn_2$	1725	3535	9204	43214	34010	4.70
$F_0S_2Zn_0$	1310	3433	9463	33567	24104	3.55
$F_0S_2Zn_1$	1532	3553	9556	38777	29222	4.06
$F_0S_2Zn_2$	1865	3853	9648	46744	37096	4.84
$F_0S_3Zn_0$	1465	3670	9907	37357	27450	3.77
$F_0S_3Zn_1$	1668	3552	10000	41906	31907	4.19
$F_0S_3Zn_2$	1924	4061	10092	48315	38223	4.79
$F_1S_0Zn_0$	850	2119	11075	21678	10603	1.96
$F_1S_0Zn_1$	1652	3714	11168	41715	30547	3.74
$F_1S_0Zn_2$	1784	3941	11260	44963	33703	3.99
$F_1S_1Zn_0$	1579	3845	11519	40151	28632	3.49
$F_1S_1Zn_1$	1813	3847	11612	45534	33923	3.92
$F_1S_1Zn_2$	1855	3800	11704	46453	34749	3.97
$F_1S_2Zn_0$	1757	4164	11963	44563	32600	3.73
$F_1S_2Zn_1$	1746	3884	12056	44050	31994	3.65
$F_1S_2Zn_2$	2155	4409	12148	53979	41831	4.44
$F_1S_3Zn_0$	1768	4086	12407	44754	32347	3.61
$F_1S_3Zn_1$	1950	4011	12500	48871	36372	3.91
$F_1S_3Zn_2$	2118	4476	12592	53181	40589	4.22

Inputs cost		**Selling price**	
Urea	256 Rs. 50 kg^{-1}	Seed	Rs. 23 kg^{-1}
DAP	467 Rs. 50 kg^{-1}	Stover	Rs. 1 kg^{-1}
Gypsum	350 Rs. t^{-1}		
Zinc chloride	17 Rs. kg^{-1}		

during both the years of experimentation but the effect was found non-significant. Application of zinc has been reported to help in lowering the soil pH, which is the principal reason for greater availability and mobility of nutrients.

Effect of FYM :

The results presented in Table 3 revealed that application of FYM did not influence significantly on pH, EC and bulk density, but soil moisture per cent and maximum water holding capacity were significantly increased due to FYM application @ 10 t ha^{-1} over no FYM during 2007-08, 2008-09 and pooled results (Table 3). Results further showed that pH and bulk density of soil was numerically decreased due to addition of FYM @ 10 tha^{-1} during 2007-08, 2008-09 and pooled. Results of the present investigation are in accordance with those of reported by Akbari *et al*. (2005) who observed addition of FYM @ 12 t ha^{-1} resulted in increase in maximum water holding capacity as well as decrease in bulk density of soil. Similar results were also reported by Babu and Sharma (2005) who observed incorporation of FYM reduced pH, electrical conductivity and bulk density, whereas improved the organic carbon and water holding capacity of the soil.

Economics :

The maximum gross realization of Rs.53,979 and net return of Rs.41,831 ha^{-1} was obtained with integrated application of FYM @ 10 t ha^{-1}, sulphur @ 40 kg ha^{-1} along with zinc @ 5.0 kg ha^{-1} ($F_1S_2Zn_2$) followed by gross realization of Rs.53181 ha^{-1} and net return of Rs.40589 ha^{-1} was recorded under $F_1S_3Zn_2$ treatment combination (Table 4). The lowest gross realization of Rs.21678 ha^{-1} and net return of Rs.10603 ha^{-1} was recorded under control. The highest BCR of 4.84 was registered under combination of $F_0S_2Zn_2$ which closely followed by $F_0S_3Zn_2$ (BCR, 4.79) and $F_1S_2Zn_2$ (BCR, 4.44). The maximum gross realization and net return was obtained due to integration of sulphur @ 40 kg ha^{-1} along with zinc @ 5.0 kg ha^{-1} in the presence of 10 t FYM ha^{-1} ($F_1S_3Zn_2$). This could be attributed to higher seed and stover yield coupled with lower cost of production resulted in higher net return and BCR value. These results are in agreement with the earlier findings of Patel (1992) in mustard.

Conclusion :

Form the present study it can be concluded that increased application of zinc and sulphur can reduce the soil PH and application of FYM @ rate of 10 t/ha recorded the maximum soil moisture per cent and water holding capacity. Alkalinity and poor water holding capacity problems of the soil can be effectively managed by the application of FYM (10t/ha) along with sulphur or zinc. Higher yield can be attained by great availability of moisture and mobility of the nutrient.

Literature Cited

Akbari, K.N., Karan, F., Qureshi, F.M. and Patel, V.N. (2003). Effect of micronutrients, sulphur and gypsum on soil fertility and yield of mustard in red loam soils of mewar (Raj.). *Indian J. Agric. Res.,* **37**(2) : 94-99.

Babhulkar, P.S., Wandile, R.M., Bandole ,W.P. and Balpande, S.S. (2000). Residual effect of long term application of farmyard manure and fertilizer on soil properties (Vertisols) yield of soybean. *J. Indian Soc. Soil Sci.,* **48**(1) : 89-92.

Babu, N. and Sharma, A. (2005). Effect of integrated nutrient management on productivity of 'Jahajee' banana and soil properties under Nagaland foot ills condition. *Orissa J. Hort.,* **33** (2) : 31 - 35.

Brady, M. (1983). *Criteria for representations of shape*. In: Beck, J., Hope, B. and Kosenfeld, A.(Ed) IIuman and Machine Vision New York: Academic Press, 39-84.

Deshmukh, K.K., Saraiya, A.B. and Dubey, D.P. (2005). Effect of integrated nutrient management on productivity trends, economics and soil fertility in soybean chickpea cropping system. *JNKVV Res. J.*, **39**(2) : 29-32.

Hamza, A. and Anderson, W.K. (2007). Combination of ripping depth and tine spacing for compacted sandy and clayey soils. *Soil & Tillage Res.*, **99**(2) : 213-220.

Hassan, F.U., Manaf, A., Qadir, G. and Basra, S.M.A. (2007). Effects of sulphur on seed yield, oil, protein and glucosinolates of canola cultivars. *Internat. J. Agric.& Biol.,* **9** : 504-508.

Husain, M.F. and Kumar, R. (2006). Influence of sowing dates and application of zinc on the performance of mustard in South-West semi arid zone of Uttar Pradesh. *Internat. J. Agric. Sci.*, **2**(2) : 601-604.

Jackson, M.L. (1967). *Soil chemical analysis*, Prentice Hall of India Private Limited, New Delhi, India. pp. 38-82.

Kumar, H. and Yadav, D.S. (2007). Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. *Indian J. Agron.*, **52** (3): 154–157.

Kumar, N., Singh, S. and Singh, V. (2006). Effect of iron and sulphur levels on yield, oil content and their uptake by Indian mustard (*Brassica juncea*). *Indian J. Agron.,* **51**(1): 63-64.

Kumar, S., Sharma, R. and Dwivedi, V.K. (2007). Response of Indian mustard (*Brassica juncea* L.) to organic based on distillery compost, farm yard manure and inorganic fertilizer. *J. Living World*, **14**(2) : 20-23.

Kumawat, B.L. and Pathan, A.R.K. (2002). Effect of sulphur and zinc on growth of mustard under Typicpsamment. *Acta. Ecologica*., **24** : 128-131.

Malewar, G.V., Kate, S.D., Walker, S.L. and Saiyed, I.. (2001). Interaction effects of zinc and boron on yield, nutrient uptake and quality of mustard (*Brassica juncea* L.) on *Typic haplustert*. *J. Indian Soc. Soil Sci.*, **45** : 306-310.

Malik, M.A., Aziz, I., Khan, H.Z. and Wahid, M.A. (2004). Growth, seed yield and oil content response of canola (*Brassica napus* L.) to varying levels of sulphur. *Internat. J. Agric. & Biol.*, **6** : 1153–1155.

Meena, M.C., Patel, K.P. and Rathod, D.D. (2006a). Effect of zinc, iron and sulphur on mustard in loamy sand soil. *Indian J. Ferti.*, **2**(5) : 55-58.

Meena, M.C., Patel, K.P. and Rathod, D.D. (2006b). Effect of Zn and Fe enriched FYM on mustard yield and micronutrient availability in loamy sand soil (*Typic haplustept*) of Anand. *J. Indian Soc. Soil Sci.*, **54**(4) : 495-499.

Mehriya, M.L. and Khangarot, S.S. (2000). Response of mustard [*Brassica juncea* (L.) Czern and Coss] to sulphur and growth regulators. *Annal. Arid Zone*, **39** (1) : 81-82.

Mir, H., Hafiz, M., Salroo, M.Y. and Bhat, G.N. (2004). Effect of sulphur and naphthalene acetic acid on growth, yield and bio-chemical parameters of Indian mustard (*Brassica juncea*) *Plant Archiv.*, **4**(2) : 423-425.

Mir, M.R. (1994). Effect of organic-inorganic fertilization on mustard (*Brassica campestris* L.). M.Sc. (Ag.) Thesis. Sher-e-Kashmir University of Agriculture and Technology, Srinagar, J&K (INDIA).

Nagdive, S.J., Bhalerao, P.D., Dongarwar, U.R. and Goud, V.V. (2007). Effect of irrigation and nutrient management on yield, quality and uptake of nutrients by mustard (*Brassica juncea* L.). *J. Soils & Crops*, **17**(1) : 128-132.

Patel, B.A. (1992). Studies on sulphur and Zn fertilization with respect to yield, nutrient uptake and quality of mustard (*Brassica juncea* L.) in loamy sand. Doctoral Thesis, Rajasthan Agricultural University, Bikaner, RAJASTHAN (INDIA).

Patel, B.T., Patel, J.J. and Patel, M.M. (2007). Response of groundnut (*Arachis hypogaea*) to FYM, sulphur and micronutrients and their residual effect on wheat (*Triticum aestivum*). *J. Soils & Crops*, **17**(1) : 18-23.

Patel, J.R. and Shelke, V.B. (2000). Effect of organic and inorganic fertilizers on yield of mustard. *J. Maharastra Agric. Univ.*, **25**(1): 70-71.

Patel, K.C., Ramani, V.P., Patel, K.P. and George, V. (1996). Available S status in soil of Gujarat. *GAU Res. J.*, **22**(1) : 127-130.

Piper, C. S. (1950). *Soil and plant analysis*. Academic Press, NEW YORK, U.S.A.

Prasad, K., Chaudhary, H.P. and Uttam, S.K. (2003). Effect of fertility treatments on moisture use efficiency, yeidl and root development of rainfed mustard. *Indian J. Soil .Conserv.*, **31**: 2007-2009.

Roop-Chand, Mann, J.S., Sharma, S.C. and Meena, L.R. (2007). Effect of soil amendments to improve the soil health and food-fodder production in problematic soil under semi-arid region. *Range Mgmt. & Agro Forest.*, **28**(2B) : 366-367.

Sahu, B., Kwatara, V. and Nema, M.L. (2004). Response of mustard, *Brassica juncea* (L.) Czern and Coss. to phosphorus and sulphur levels in rice low lands. *J. Oilseeds Res.*, **21**(1):181-182.

Sharma, D.K., Khaddar, V.K. and Singh, O.S. (1994). Effect of different doses and sources of S on quality and yield of mustard. *J. Indian Soc. Soil Sci.*, **46**(1) : 132-135.

Singh, D., Jain, K.K. and Sharma, S.K. (2004). Quality and nutrient uptake in mustard as influenced by levels of nitrogen and sulphur. *J. Maharashtra Agric. Univ.*, **29**(1) : 87-88.

Singh, P., Kumar, M., Maurya, C.L. and Swarnkar, S.K. (2007). Effect of S and Zn nutrients on growth, seed yield and quality of Indian mustard [*Brassica juncea* (L.) Czern and Coss.] varieties. *Prog. Agric.*,**7**(1/2) : 124-127.

Subhash, A. and Yadav, K.K. (2007). Effect of sulphur and zinc on growth, yield, quality and net returns of mustard [*Brassica juncea* (L.) Czern and Coss]. *Curr. Agric.*, **31**(1/2) : 127-129.