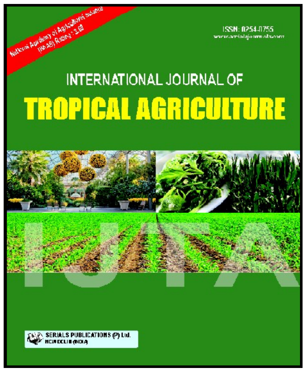

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Effect of Gypsum and Zinc Sulphate Application on Yield and Quality of Mustard (*Brassiccajuncea L.*) in Vertisols

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Abstract: A field experiment was conducted to study the "Effect of gypsum and zinc sulphate application on yield and quality of mustard (*Brassiccajuncea L.*) in Vertisols" at Research Farm of Agriculture College, Nagpur. Twelve treatment combinations were studied in FRBD design with three replications, which comprises four levels of gypsum (0, 18, 36 and 54 kg ha^{-1}) and three levels of zinc sulphate (0, 5 and 10 kg ha^{-1}). The experimental site was medium black, moderately alkaline in reaction, clayey in texture, medium in organic carbon, low in available N, medium in available P, high in available K, low in available S and Zn. The significant increase in seed and stover yield of mustard were recorded due to application of gypsum at 36 kg ha^{-1}and zinc sulphate at 5 kg ha^{-1}. The oil and protein content in seed was significantly influenced with the application of different levels of gypsum and zinc sulphate. The highest oil (40.65%) and protein (19.93%) content was observed with the application of 54 kg gypsum ha^{-1} and with application of 10 kg $ZnSO_4$ ha^{-1} the maximum oil content (40.62%) and protein content (19.54%) was observed.

Key words: Gypsum, zinc sulphate, yield, quality, mustard.

INTRODUCTION

Mustard is an important rabi oilseed crop of India, widely grown on large area. It occupies prominent place, next in importance to groundnut in area and production. It contains about 37 to 49 per cent oil in the seed. Low cost of production and high yield of potentials, hold promise for its large scale cultivation in the country (Chiddha Singh, 1998).

In Maharashtra, the productivity of mustard is very low. The declined soil fertility is the main cause of low productivity of the cultivated lands. So far the emphasis has been to supplement the soil with the major nutrients *viz*., N, P, K and the crop requirements for secondary (Ca, Mg and S) and micronutrients (Zn, Fe, Cu and Mn) could be met from the soil reserve. According to soil test findings use of high analysis fertilizers, limited recycling of plant residues and gap between the removal and supplementation of secondary and micro-nutrients have resulted in widespread multiple nutrient deficiencies, especially of N, P, K, S and Zn along with other nutrients (Fe and Cu).

In recent years, sulphur deficiency has been aggravated in the soil due to continuous crop removal and use of sulphur and zinc-free high analysis NPK fertilizers. Leaching and erosion losses also contribute to sulphur deficiencies (Jayalalitha and Narayanan, 1995). Saalbach (1973) reported that, sulphur deficiency tends to affect adversely the growth and yield of seed crop, which reduces the crop yield to an extent of 10-30%.For oilseeds, sulphur and zinc are most vital nutrients for the growth and development, sulphur is required for the synthesis of sulphur containing amino acids which are methionine (21% S), cysteine (26% S) and cystine (27% S), cystine is formed by the oxidation of two molecules of cysteine. Sulphur is also a constituent of S-glycoside (mustard oil), co-enzymes A, vitamins biotin and thiamine as also of iron-sulphur protein called ferrodozin-1. Sulphur application can increase oil production by increasing seed yield or oil content in seeds or both. Sulphur is needed for development of cell and increases cold resistance and drought hardiness of plant (Patel *et al*., 1992).

Zinc has role in activation of enzymes in biosynthesis of oil. Deficiency of zinc causes marked decrease in number of pods, size of pods and boldness of seed. (Tisdale and Nelson, 1985). Therefore, zinc is important micronutrient for the growth and development of mustard plant and increase in seed yield. Soils (Vertisols) of this region are categorized of having high fixation of applied zinc due to smectiterich character (Shinde and Deb, 1981) creating a deficiency of zinc, which is further widened because land use system remained mostly dominated by high yielding varieties of wheat, paddy, cotton etc. which are efficient fertilizer users (Yojana, 1993).

There are many causes of the low production of oilseeds but the main cause is that they are cultivated mostly under conditions of energy starvation. The oilseeds are energy rich crops and for production of oil and fat requires more energy than production of cereals. But they are mostly grown on residual soil moisture and on soils of poor fertility. Sulphur and zinc are identified as yield limiting factor particularly in oilseed production. However, no attention was paid to secondary and micronutrients in Vidarbha region. Thus , it was felt necessary to undertake research project on "Effect of gypsum and zinc sulphate application on yield and quality of mustard in Vertisols".

MATERIALS AND METHODS

A field experiment was conducted at Farm of Agriculture College, Nagpur which is situated at 21° 10′ North latitude and 79° 10′ East latitude at the elevation of 321.26 m above mean sea level and lies under sub tropical zone. Nagpur is characterized by hot and dry summer and fairly cold winter. This area shows wide duirnal fluctuation in temperature. The maximum and minimum temperature ranged from 29.6°C to 34.1°C and 9.9°C to 19.4°C, respectively, whereas the relative humidity varied from 20 to 72 per cent during the crop growth period, mean annual precipitation is about 938.4 mm. The soil of experimental field had pH 8.01, EC 0.32 dSm^{-1}, organic carbon 5.3 g kg^{-1}, available nitrogen 222.6 kg ha^{-1}, available phosphorus 14.58 kg ha^{-1}, available potassium 368.80 kg ha^{-1}, available sulphur 8.16 mg kg^{-1} and DTPA-extractable micronutrients Zn, Fe, Mn and Cu 0.59, 3.86, 2.53 and 1.36 mg kg^{-1}, respectively. The experiment was laid out in factorial randomized block design with twelve treatment combinations each replicated thrice. The treatments consisting of four levels of gypsum (0, 18, 36 and 54 kg ha^{-1}) and three levels of zinc sulphate (0, 5 and 10 kg ha^{-1}). The treatments were applied as basal dressing through gypsum and zinc sulphate as per treatments. Recommended dose of nitrogen and phosphorus was applied through urea and DAP, respectively. Nitrogen was applied in two split doses , 1st dose at the time of sowing and 2nd at 30 DAS. Full dose of phosphorus, gypsum and zinc sulphate was given at the time of sowing. The crop was harvested at maturity and yield data were recorded. The N content in mustard seed was determined by Kjeldahl method and protein content was obtained by multiplying with a factor of 6.25. Oil content in seed was determined by using Soxhlet apparatus (A.O.A.C., 1970).

RESULTS AND DISCUSSION

Seed Yield of Mustard

The results obtained in respect of seed and stover yield of mustard as influenced by gypsum and zinc sulphate application are presented in table 1. The yield (seed and stover) of mustard were significantly influenced due to different gypsum and zinc sulphate levels. From the data presented in table 1, revealed that the highest seed yield of mustard (8.13 q ha^{-1}) was obtained with application of 54 kg gypsum ha^{-1}, which was found to be at par with application of 36 kg gypsum ha^{-1}(8.02 q ha^{-1}).The significant increase in seed yield of mustard was recorded up to application of 36 kg gypsum ha^{-1}. With the increase in supply of sulphate the process of tissue differentiation from somatic reproduction, meristimatic activity and development of floral primordial might have increase resulting in more flowers and siliqua, longer siliqua and higher siliqua yield. Similar results were reported by Singh *et al.* (1998).

Application of zinc sulphate was significantly increased the seed yield up to application of 5 kg $ZnSO_4$ ha^{-1}. The response of zinc sulphate to seed yield of mustard was significant with increasing level of $ZnSO_4$. The highest seed yield of mustard (7.78 q ha^{-1}) was recorded with the application of 10 kg $ZnSO_4$ ha^{-1}, which was found to be at par

Table 1
Seed and stover yield (q ha^{-1}) of mustard as influenced by gypsum and zinc sulphate levels.

Treatments		*Seed yield*			*Stover yield*	
Levels of Gypsum (kg ha^{-1})						
G_0		6.74			19.19	
G_{18}		7.21			20.50	
G_{36}		8.02			22.74	
G_{54}		8.13			23.16	
'F' test		Sig.			Sig.	
SE (m) ±		0.18			0.38	
CD at 5%		0.56			1.16	
Levels of Zinc sulphate (kg ha^{-1})						
Zn_0		7.12			20.30	
Zn_5		7.67			21.76	
Zn_{10}		7.78			22.14	
'F' test		Sig.			Sig.	
SE (m) ±		0.14			0.29	
CD at 5%		0.45			0.90	
Interaction (Gypsum × Zinc sulphate)						
	Zn_0	*Zn_5*	*Zn_{10}*	*Zn_0*	*Zn_5*	*Zn_{10}*
G_0	6.52	6.82	6.88	18.48	19.36	19.73
G_{18}	6.94	7.27	7.41	19.84	20.62	21.06
G_{36}	7.47	8.24	8.36	21.23	23.30	23.68
G_{54}	7.53	8.38	8.49	21.64	23.77	24.09
'F' test		Sig.			Sig.	
SE (m) ±		0.30			0.62	
CD at 5%		0.91			1.92	

with application of 5 kg $ZnSO_4$ ha^{-1}(7.67 q ha^{-1}). Application of 5 kg $ZnSO_4$ ha^{-1} shows the significant increase in seed yield over control (7.12 q ha^{-1}). Increase in yield due to increase level of growth hormone such as auxin, promotes starch formation and seed maturation. Similar results were also reported by Balusamy*et al.* (1996).

The interaction effect between gypsum and zinc sulphate in respect to seed yield was found to be significant. The maximum seed yield (8.49 q ha^{-1}) was noticed with $G_{54}Zn_{10}$ treatment combination which was found to be at par with $G_{54}Zn_5$ (8.38 q ha^{-1}), $G_{36}Zn_{10}$ (8.36 q ha^{-1}) and $G_{36}Zn_5$ (8.24 q ha^{-1}) treatment combinations. The behaviour of interaction of gypsum and zinc sulphate at different levels showed that they add to the effect of each other in increasing seed and stover yields. They are complementary to each other. This type of behaviour of sulphur and zinc interactions in increasing seed and stover yield was reported by Sharma *et al.* (1990).

Stover Yield of Mustard

A perusal of data in table 1, revealed that during the experimentation there was significant increase in stover yield of mustard up to 36 kg gypsum ha^{-1}. The highest stover yield of mustard (23.16 q ha^{-1}) was observed with the application of 54 kg gypsum ha^{-1} which was found to be at par with 36 kg gypsum ha^{-1} (22.74 q ha^{-1}). Application of 36 kg gypsum ha^{-1} showed the significant increased in stover yield of mustard over 18 kg gypsum ha^{-1} (20.50 q ha^{-1}) and control (19.19 q ha^{-1}). Similar results were also recorded by Kumar and Singh (1980),Jat and Mehra (2007) reported an increase in straw yield of Indian mustard with increasing level of sulphur.

Application of zinc sulphate significantly influenced the stover yield up to 5 kg zinc sulphate ha^{-1}. The highest stover yield (22.14 q ha^{-1}) was recorded with 10 kg $ZnSO_4$ ha^{-1} which was found to be at par with 5 kg zinc sulphate ha^{-1} (21.76 q ha^{-1}). Application of 5 kg $ZnSO_4$ ha^{-1} showed the significant increased in stover yield over control (20.30 q ha^{-1}). The increased yield might be due to the role of zinc in biosynthesis of Indole acetic acid (IAA) and especially due to its role in initiation of primordial for productive parts and partition in photosynthates towards fruiting. The findings of present investigation are supported by Singh *et al.* (1996).

The data presented in table 1, indicated that, the interaction effect between gypsum and zinc sulphate in respect to stover yield was found to be significant. The highest stover yield (24.09 q ha^{-1}) was recorded with the treatment combination $G_{54}Zn_{10}$ followed by $G_{54}Zn_5$ (23.77 q ha^{-1}), $G_{36}Zn_{10}$ (23.68 q ha^{-1}), $G_{36}Zn_5$ (23.30 q ha^{-1}) and these treatment combinations were found at par with each other. Similar results were also reported by Sharma *et al.* (1990) he observed that interaction effect of sulphur and zinc with respect to seed and stover yield of mustard was significant.

Quality of Mustard Grain

The data on oil and protein content of mustard seed have been presented in table 2. The individual effect of gypsum and zinc sulphate recorded significant results on quality parameters with regarding to seed of mustard. But its interaction G × Zn effect recorded non-significant results in protein content of seed. The oil content of mustard seed was significantly and synergistically influenced by the application of gypsum and zinc sulphate. The oil content of mustard seed significantly increased from 40.35% in control to 40.65% at 54 kg gypsum ha^{-1}. Application of 54 kg gypsum ha^{-1} shows maximum oil content (40.65%) followed by 36 kg gypsum ha^{-1} (40.60%). The increase in oil content due to sulphur application might be because of S role in oil synthesis, as S is constituent of glutathione a compound that plays a vital role in oil synthesis. The results are in agreement with the findings of Piri and Sharma (2006).

It is evident from the data in the table 2 that, successive increasing zinc sulphate application from 0 to 10 kg $ZnSO_4$ ha^{-1} significantly increased the oil content in mustard seed. Application of 10 kg $ZnSO_4$ ha^{-1} recorded highest oil content (40.62%) followed by 5 kg $ZnSO_4$ ha^{-1} (40.56%), whereas lowest value of oil content was recorded in control (40.42%). Application of zinc sulphate, in general increased the oil content during the experimentation as shown in table 2. Zinc functions in plant largely as metal activator of enzymes like cysteine desulphydrase, dihydropetidase, glycyl-glycine dipeptidase, etc

(Tisdale and Nelson, 1970). Thus addition of zinc might have activated the enzymes responsible for the production of oil and proteins and caused higher oil and protein contents. Beneficial effects of zinc application were also reported by Mehrotra*et al.* (1977), Pathak *et al.* (1999).

The data regarding to interaction effect of gypsum and zinc sulphate on oil content in mustard seed are presented in table 3. From the data, it revealed that, the interaction effect between gypsum and $ZnSO_4$ on oil content was found significant. The highest oil content (40.72%) was recorded in $G_{54}Zn_{10}$ treatment combination which was found to be at par with $G_{54}Zn_5$ treatment combination (40.69%). Whereas, the lowest oil content (40.18%) was recorded in control treatment (G_0Zn_0). The improvement in oil content in rapeseed and mustard through sulphur application has also been reported by Golakiya and Dhuka (1991) and Joshi *et al.* (1991). Increase in oil content by S nutrition may be attributed to direct involvement of this element in oil synthesis, as it is constituent of mustard oil (glucosides and glucosinolates). Similar results were also reported by Patel *et al.* (2009).

Protein content of mustard seed was significantly influenced by application of gypsum and zinc sulphate. The protein content of mustard seeds increased from 18.29 to 19.93 per cent with the increasing levels of gypsum from 0 to 54 kg gypsum ha^{-1} and varied from 18.89 to 19.54 per cent with increasing levels of zinc sulphate from 0 to 10 kg $ZnSO_4$ ha^{-1}, which was 8.96 and 3.44 per cent increased, respectively over the control. Similar results were also reported by Tamak *et al.* (1997). This might be due to the fact that S is an integral part of sulphur - containing amino acids and rest is required for the S-containing compounds, hence improved protein as well as oil synthesis in oilseeds.

CONCLUSIONS

On the basis of results it is concluded that the application of gypsum up to 36 kg ha^{-1} and zinc

Table 2
Effect of gypsum and zinc sulphate on quality of mustard.

	Content in seed (%)	
Treatments	*Oil content (%)*	*Protein content (%)*
Levels of Gypsum (kg ha⁻¹)		
G_0	40.35	18.29
G_{18}	40.52	19.05
G_{36}	40.60	19.78
G_{54}	40.65	19.93
'F' test	Sig.	Sig.
SE (m) ±	0.006	0.09
CD at 5%	0.020	0.27
Levels of Zinc sulphate (kg ha⁻¹)		
Zn_0	40.42	18.89
Zn_5	40.56	19.36
Zn_{10}	40.62	19.54
'F' test	Sig.	Sig.
SE (m) ±	0.005	0.08
CD at 5%	0.017	0.24
Interaction (Gypsum × Zinc sulphate)		
'F' test	Sig.	N.S.
SE (m) ±	0.011	0.16
CD at 5%	0.034	–

Table 3
Interaction effect of gypsum and zinc sulphate on oil content (%) in mustard seed.

Treatments	Zn_0	Zn_5	Zn_{10}	*Mean*
G_0	40.18	40.37	40.49	40.35
G_{18}	40.41	40.55	40.59	40.52
G_{36}	40.52	40.61	40.67	40.60
G_{54}	40.55	40.69	40.72	40.65
Mean	40.42	40.56	40.62	
SE (m) ±		0.011		
CD at 5%		0.034		

sulphate up to 5 kg ha^{-1} significantly influence the seed and stover yield of mustard. Application of gypsum and zinc sulphate improve the quality of seed in mustard by increasing oil and protein content.

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