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Effect of Sulphur and zinc with combination of FYM on yield and uptake of nutrients in Mustard (*Brassica Juncea* (L.) under Alfisols of Odisha

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Abstract
A pot culture experiment was conducted in Alfisols to study the effect of sulphur and zinc fertilization, separately and their combination with Farm Yard manure on the yield and nutrient uptake by rabi mustard (Var. Andhra Keveri) with a design of CRD. The treatments were four levels of sulphur (0, 20,40 and 60 kgha^{-1}), two levels of Zinc (0 and 2.5 kgha^{-1}) and two levels of FYM (0 and 10 tha^{-1}) with three replications and recommended doses of Nitrogen, Phosphorus and Potash. The results revealed that highest seed yield (1.71 g/pot) of mustard was found in the treatment of sulphur @60kg ha^{-1} + zinc @ 2.5kg ha^{-1} along with FYM @ 10t ha^{-1}. The application of only sulphur @ 60 kgha^{-1} yielded 1.03g/pot over control whereas application of only Zinc @2.5 kgha^{-1} yielded 59.7% over control. Similar trend were observed in case of stover also. Higher uptake of Nitrogen, Phosphorus, Potassium, Sulphur and zinc were found by the application of Sulphur @60 kgha^{-1} + Zinc @2.5 kgha^{-1} and FYM @10 tha^{-1}. The positive interaction effect of Zinc with Nitrogen, Potash and sulphur were found whereas antagonistic effect with Phosphorous was observed.

Keywords: Mustard, Sulphur, Zinc, NPK, FYM

Introduction
Mustard (*Brassica juncea* (L.) belongs to family Cruciferae is important oilseed crop and ranked third oilseed crops in India in terms of area and production. It contributes 28.6% towards total oilseed production and being second most important edible oilseed after Groundnut. The share of oilseed is 14.1% in the total cropped area of India and Mustard occupy 3% of it. The Global production of Mustard and its oil is around 38-42 and 12-14mt., respectively. India contributes 28.3 and 19.8% in world acreage and production. India produce around 6.9mt of rapeseed-mustard next to China (11-12 mt) and EU (10 – 13 mt) with significant contribution in world mustard industry (Anonymous, 2014) [1]. In Odisha, total oilseed area is 752.40,000 ha, Yield is 928 kg ha^{-1} and productivity is 698.57, 000 MT. Out of these, 19% area is covered and yield contribution is 45.6% per ha (Odisha Agricultural Statistics (2013 -14). Sulphur and Zinc are most vital nutrients for growth and development. Sulphur is considered to be the fourth important essential nutrient after Nitrogen, Phosphorus and Potassium for plant growth. Sulphur performs many physiological functions like synthesis of Cystein, methionine, chlorophyll and oil content of oilseed crops. It also responsible for synthesis of certain vitamins (B, Biotin and Thiomine) metabolism of carbohydrate, protein and its oil formation of flavor compounds in crucifers. Sulphur increase the seed yield of mustard by 12-48% under irrigated and 17 to 124% under rainfed condition (Rathore *et al*., 2015) [12]. The Zinc application in mustard may be attributed to various enzymatic reactions, merit. Similarly length at 95 DAS, number of nodes at 95 DAS, number of branches at 45 DAS were the good general combiners.
growth processes, hormone production and protein synthesis and also the translocation of photosynthate to seed leading to higher yield (Bhadauria *et al*, 2012) [2]. Continuous use of high analysis fertilizers leads to deficiency of secondary and micronutrients. FYM application leads to increase soil health and nutrient supplying capacity of soils. Keeping these in view, the present investigation was carried out to study the effect of sulphur, zinc and FYM on yield and uptake of nutrients in Mustard (*Brassica Juncea* (L).

Material and Methods
The soils of the experiment was Alfisols, sandy loam texture with pH 5.54, EC 0.011dSm-1, Organic carbon 4 gkg-1, CEC 6.10 Cmol (p+) kg-1, BD 1.60 g/cc, PD 2.64g/cc, Clay 8.0%,

Available N 69.7 kg ha- 1, available P2O5 5.2 kg ha-1, available K2O 69.7 kg ha-1, available S 19 kg ha-1, Fe 10.23 mg kg-1 and Zn
0.308 mg kg-1. A pot culture experiment was conducted with Mustard (Var. Andhra kaveri) as a test crop
at Department of Soil Science, Institue of Agriculture, SOA University, Bhubaneswar. The earthen pots were prepared by taking 10 kg. soil with recommended dose of 20 kg N, 40 kg P2O5 and 40 kg K2O in the form of urea, single super phosphate and muriate of Potash. A calculated quantities of Sulphur @ (0,20 40 and 60 kgha-1), Zinc @ (0 and 2.5 kgha-1) and FYM @ (0 and 10 tha-1) were mixed thoroughly with the soil. The experiment was laid out in Completely Randomized Design (CRD) with sixteen treatments combination replicated thrice. Seeds were grown up to maturity with proper management practices. At harvest, randomly collected siliqua, then separated and recorded yield of seed and. stover. Total nutrient uptake was computed by adding seed and stover determined separately taking into account their respective yield and nutrient content determined by using following methods: Nitrogen content of mustard seed and stover was determined by modified Micro Kjeldal's Method (Jackson, 1973) [4], Phosphorus content was determined by Vandomolybdophosphoric yellow color method (Jackson, 1973) [4], Potassium was estimated by Flame Photometry method (Jackson, 1973) [4], For sulphur and zinc determination, samples were digested in diacid (HNO3: HClO4:2:1) mixture. Plant sulphur was determined by Colorimetric method (Jackson, 1973) [4] and Zinc by Atomic Absorption Spectrophotometer Lindsay and Novel, 1978) method and the data was analysed statistically.

Result and Discussion

Effect of S, Zn and FYM on yield of Mustard

Effect of Sulphur: Among the different levels of sulphur, application of sulphur @ 60 kg ha-1 resulted significant higher seed and stover yield of mustard which was at par Sulphur @ 40kg ha-1 (Table 1).The application of sulphur @60kg ha-1 increased seed yield of mustard by 66, 14.0 and 10 percent over control, 20 and 40 kgS ha-1, respectively. Similarly, stover yield (2.67g/pot) with the application of suphur @ 60 kgha-1 which was 39.7, 15.7 and 9.4 percent over 20 and 40 kg ha-1, respectively. The increase in seed and stover yield of mustard may be due to role of sulphur for plant growth through its enzymatic activity for biochemical functioning. It also enhanced cell multiplication, better chlorophyll synthesis, increase area for photosynthesis resulting accumulation of drymatter in comparison to S deficient plant. Similar results was reported by Mehriya and Khangarot (2000) [8]. Significant yield increase of mustard was influenced by sulphur was the findings of Malik *et al*. (2004) [7], Subhas and Yadav (2007) [14] and Sipai *et al*. (2017) [15].

Effect of zinc

The maximum seed yield was recorded by the application of zinc @ 2.5 kg ha-1 Which was 59.7 percent increased over control. Similar observation was found in case of stover (Table 1). Significant increased in seed and stover yield may be due to zinc application, various enzymatic reaction, growth processes, hormone production and protein synthesis and also the translocation of photosyntheta to seed leading to higher yield of mustard (Bhadauria *et al*, 2012) [2].

Effect of FYM

The results indicated that the application of FYM @ 10t ha-1 increased seed and stover Yield of mustard over control (Table 1) which may be due to consequence of vegetative growth and dry matter accumulation. FYM may stimulate the enzymatic activity resulting nutrient recycling in the ecosystem. The findings are corroborated with Desmukh *et al*. (2005) and Patil *et al*.(2007). Combined effect of S, Zn and FYM: Application of S alongwith Zn had significant yield increased with the incremental dose of S (Table 1). The highest seed yield was obtained 1.53 g/pot under 60 kgSha-1 in combination of Zn @ 2.5 kg ha-1 ie. In addition Zn resulted 48.5 percent yield increased over S @ 60kgha-1. Similarly, 37 and 32 percent yield increased over S@40 and 20kgha-1, respectively. Similar trend was also observed in stover yield. Subhas and Yadav (2007) [14]; Singh *et al*. (2007) [13]; Sipai *et al*.(2017) [15] and Rana *et al*. (2018) [11] observed that the combined application of S and Zn had synergistic effect in increasing seed and stover yield. Further application of FYM @10tha-1 over S and Zn increased seed yield of mustard marginally(Table 1). The increase over only Zn was 29 percent whereas 13.6,13.5 and 11.7 percent increase over Zn @ 2.5kgha-1 along with 20, 40and 60 kgSha-1, respectively.

Effect of S,Zn and FYM on nutrient uptake

The results showed that the uptake of N,P,K,S and Zn by seed and stover were significantly increased due to application of 60kg S ha-1 (Table 2 & 3). The uptake may be due to profused vegetative and increase nutrient concentration. It seemed that the seed and stover yield maybe deciding factor for uptake of nutrients. Patel *et al*. (2007) [10] and Kumar and Yadav (2007) [14] also found positive and significant effect of added S on nutrients content and their uptake. The single effect of Zn application on N,P and Zn uptake by seed were significant and K and S were non significant. However, S, Zn, K and N uptake by stover were significant (Table 2 & 3). The combined effect of S and Zn, the uptake of all the nutrients in seed and stover were increased significantly. The maximum uptake of N,P,K,S and Zn were found significantly when combined application of S and Zn alongwith FYM. The uptake of S were 23.94 and 32.63 mg/pot in seed and stover, respectively whereas in Zn it was 16.99 and 45.41 mg/pot in respect seed and stover of mustard. Similar findings were observed by Meena *et al*. (2006) [6] and Sipai *et al*. (2017) [15].

Soil physical properties after harvest of crop

The effect of S and Zn along with FYM had no influence on pH, EC and total N but marginal effect on organic carbon, available P, K, S and Zn was found when FYM was added to the treatments (Table 4).

Table 1: Effect of sulphur and zinc and FYM on seed and stover yield (g/pot) of mustard

Treatments	Seed	Stover	Total
T0 – Control	0.62	1.91	2.54
T1 – S @ 20 kg-1	0.94	2.37	3.30
T2 – S @ 40 kg-1	0.97	2.49	3.46
T3 – S @ 60 kg-1	1.03	2.67	3.70

T4 – FYM @ 10 tha-1	0.77	2.20	2.96
T5 – S @ 20 kg-1 + FYM @ 10 tha-1	1.09	2.48	3.57
T6 – S @ 40 kg-1+ FYM @ 10 tha-1	1.30	2.65	3.95
T7 – S @ 60 kg-1+ FYM @ 10 tha-1	1.37	2.90	4.26
T8 – Zinc @ 2.5 kg-1	0.99	2.39	3.38
T9 – S @ 20 kg-1+ Zinc @ 2.5 kg-1	1.25	2.71	3.96
T10 – S @ 40 kg-1+ Zinc @ 2.5 kg-1	1.33	2.79	4.12
T11 – S @ 60 kg-1+ Zinc @ 2.5 kg-1	1.53	2.98	4.50
T12 – FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	1.28	2.77	4.04
T13 - S @ 20 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	1.42	2.98	4.39
T14 - S @ 40 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	1.51	3.13	4.64
T15 - S @ 60 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	1.71	3.26	4.97
CD (P=0.05)	4.21	6.10	

Table 2: Effect of Sulphur, Zinc and FYM on N, P and K uptake (gm/pot) in mustard

Treatments	Nitrogen			Phosphorus			Potassium		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
T0 – Control	14.45	15.31	29.77	3.24	3.45	6.68	1.56	17.80	19.36
T1 – S @ 20 kg-1	30.64	24.38	55.02	7.12	6.63	13.75	3.00	29.11	32.11
T2 – S @ 40 kg-1	33.85	27.67	61.52	7.83	7.48	15.31	3.77	34.40	38.17
T3 – S @ 60 kg-1	40.17	33.41	73.58	8.65	8.02	16.67	4.02	37.42	41.44
T4 – FYM @ 10 tha-1	29.61	27.89	57.49	6.04	6.15	12.19	2.75	29.21	31.96
T5 – S @ 20 kg-1 + FYM @ 10 tha-1	44.57	32.98	77.55	9.24	7.44	16.68	4.46	35.96	40.42
T6 – S @ 40 kg-1+ FYM @ 10 tha-1	53.22	36.88	90.09	11.55	8.49	20.04	5.84	40.33	46.17
T7 – S @ 60 kg-1+ FYM @ 10 tha-1	57.82	40.54	98.37	12.44	9.56	22.00	6.70	44.89	51.59
T8 – Zinc @ 2.5 kg-1	29.91	23.21	53.12	7.70	4.31	12.01	3.45	32.54	36.00
T9 – S @ 20 kg-1+ Zinc @ 2.5 kg-1	45.19	29.30	74.49	10.33	9.77	20.10	4.86	38.25	43.11
T10 – S @ 40 kg-1+ Zinc @ 2.5 kg-1	51.83	34.29	86.12	11.56	10.32	21.88	5.71	40.98	46.70
T11 – S @ 60 kg-1+ Zinc @ 2.5 kg-1	63.68	35.72	99.40	13.59	11.91	25.50	7.33	45.85	53.18
T12 – FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	46.87	31.54	78.41	10.47	10.51	20.99	5.75	39.01	44.76
T13 - S @ 20 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	55.26	37.21	92.48	12.33	12.50	24.83	6.94	45.55	52.49
T14 - S @ 40 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	64.61	41.06	105.66	13.77	12.51	26.28	8.02	49.41	57.43
T15 - S @ 60 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	78.15	44.70	122.85	16.25	18.27	34.52	9.92	52.86	62.78
CD (P=0.05)	6.14	4.54		3.78	2.45		3.74	3.91	

Table 3: Effect of treatment on uptake of Sulphur and Zinc (mg/pot) in mustard

Treatments	Sulphur			Zinc		
	Seed	Stover	Total	Seed	Stover	Total
T0 – Control	4.98	7.66	12.64	2.63	13.24	15.87
T1 – S @ 20 kg-1	9.37	14.20	23.57	4.72	18.60	23.32
T2 – S @ 40 kg-1	10.64	17.45	28.09	5.55	22.00	27.54
T3 – S @ 60 kg-1	12.36	18.71	31.07	6.37	25.18	31.55
T4 – FYM @ 10 tha-1	7.65	15.37	23.02	4.52	18.98	23.50
T5 – S @ 20 kg-1 + FYM @ 10 tha-1	11.96	19.84	31.80	7.44	23.63	31.07
T6 – S @ 40 kg-1+ FYM @ 10 tha-1	15.58	21.22	36.80	9.37	26.59	35.96
T7 – S @ 60 kg-1+ FYM @ 10 tha-1	17.77	26.06	43.84	10.85	30.63	41.48
T8 – Zinc @ 2.5 kg-1	10.86	16.75	27.61	8.00	25.75	33.75
T9 – S @ 20 kg-1+ Zinc @ 2.5 kg-1	13.70	18.99	32.69	11.14	32.06	43.20
T10 – S @ 40 kg-1+ Zinc @ 2.5 kg-1	15.95	22.30	38.25	12.26	34.98	47.24
T11 – S @ 60 kg-1+ Zinc @ 2.5 kg-1	19.85	23.82	43.67	15.09	38.52	53.61
T12 – FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	15.32	22.14	37.46	10.71	32.60	43.31
T13 - S @ 20 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	18.42	26.79	45.21	12.76	38.28	51.04
T14 - S @ 40 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	19.67	28.14	47.81	14.16	41.38	55.54
T15 - S @ 60 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	23.94	32.63	56.57	16.99	45.41	62.40
CD (P=0.05)	5.94	3.92		3.57	5.96	

Table 4: Soil physical properties after harvest of crop

Treatments	pH	EC (dSm- 1)	OC (gkg- 1)	Total N (%)	Available p (kg/ha-1)	Available K (kgha- 1)	Available S (kgha-1)	Available Zinc (ppm)
T0 – Control	5.28	0.010	7.2	0.07	2.3	165.5	42.0	0.49
T1 – S @ 20 kg-1	5.28	0.011	7.4	0.05	4.1	241.6	72.0	0.63
T2 – S @ 40 kg-1	5.48	0.010	7.6	0.06	3.5	149.1	76.0	0.54
T3 – S @ 60 kg-1	5.17	0.015	7.9	0.1	4.5	248.9	81.0	0.49
T4 – FYM @ 10 tha-1	5.7	0.012	8.3	0.06	18.7	168.2	44.0	0.69
T5 – S @ 20 kg-1 + FYM @ 10 tha-1	6.0	0.013	8.4	0.08	21.8	274.2	75.0	0.85
T6 – S @ 40 kg-1+ FYM @ 10 tha-1	5.59	0.016	8.7	0.07	19.8	162.9	80.0	0.62
T7 – S @ 60 kg-1+ FYM @ 10 tha-1	6.26	0.014	8.8	0.06	17.6	280.0	87.0	0.77

T8 – Zinc @ 2.5 kg-1	4.97	0.010	7.2	0.05	3.6	168.3	38.0	1.02
T9 – S @ 20 kg-1+ Zinc @ 2.5 kg-1	5.54	0.008	7.4	0.06	3.5	239.6	55.0	1.38
T10 – S @ 40 kg-1+ Zinc @ 2.5 kg-1	5.51	0.012	7.6	0.05	4.3	135.2	79.0	1.43
T11 – S @ 60 kg-1+ Zinc @ 2.5 kg-1	5.24	0.012	7.9	0.05	4.2	228.4	94.0	1.48
T12 – FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	5.67	0.013	8.7	0.1	19.8	164.8	47.0	1.32
T13 - S @ 20 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	6.18	0.013	8.9	0.06	24.4	245.5	79.0	1.85
T14 - S @ 40 kg-1+ FYM @ 10 tha-1+ Zinc @ 2.5 kg-1	6.20	0.013	9.3	0.08	25.8	158.2	88.0	1.75
T15 – S @ 60 kg-1+ FYM @ 10 tha- 1+ Zinc @ 2.5 kg-1	5.94	0.015	9.5	0.04	14.1	228.5	90.0	1.33
Initial	5.54	0.011	4.0	0.2	5.2	69.7	19.0	0.31

Conclusion

The study on use of secondary and micronutrient like Sulphur and zinc with manure Indicated the usefulness of integrated nutrient management by application of S @ 60 kgha-1 +Zn @ 2.5 kgha-1 along with FYM @ 10 tha-1 gave highest yield as well as nutrient uptake by mustard and also the physical properties of soil after harvest of mustard which maintained soil health.

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