The Pharma Innovation Journal 2022; 11(8): 1484-1488

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(8): 1484-1488

www.thepharmajournal.com
Received: 16-06-2022
Accepted: 23-07-2022

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Effect of farm yard manure, sulphur and zinc on growth, yield and quality of maize

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Abstract
A field experiment was conducted at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *rabi* seasons of 2019-20 and 2020-21 to evaluate influence of FYM, sulphur and zinc on growth, yield and quality of maize under middle Gujarat condition. The experiment was laid out in a randomized block design with factorial concept, comprising eighteen treatment combinations *i.e*. two levels of FYM (0 and10 t FYM /ha), three levels of sulphur (0, 20 and 40 kg S/ha) and three levels of zinc (0, 2.5 and 5 kg Zn/ha) with three replications. The results revealed that application of 10 t FYM/ha, 40 kg S/ha and 5 kg Zn/ha significantly increased plant population, plant height at harvest, grain yield, stover yields as well as protein content (%) in grain during individual year and in pooled results were significantly influenced by the various levels of, FYM, sulphur and zinc. FYM x sulphur interaction was found significant in case of grain yield and protein in grain. All the parameters were increased with increasing level of sulphur.

Keywords: *Zea mays* L., FYM, sulphur, zinc, growth, yield and quality

Introduction
Maize (*Zea mays* L.) is third most an important cereal crop of world as well as India after wheat and rice plays a pivotal role in agricultural economy both as staple food for larger section of population, raw material for industries and feed for animals. In India, maize occupies an area of 9.21 million ha with the production of 25.82 million tonnes having average productivity of about 2804.75 kg/ha (Anonymous, 2020) [2].
The application of organic manures induce improvement in physical, chemical and biological properties of soil and building up of secondary and micronutrients, counteracting deleterious effects of soil acidity, salinity and alkalinity and alkalinity and substances of soil health are the key beneficial effects associated with FYM application. The addition of organic manures improved the status of S, Zn, other micro and macronutrients in soil over time.
Role of sulphur in Indian agriculture is now gaining importance because of the recognition of its role in increasing crop production, not only for oilseeds, pulses, legumes and forages but also for many cereals (Singh *et al*. 2000) [12]. Removal of sulphur by crops in India is about 1.26 million tonnes, whereas its replenishment through fertilizers is only about 0.76 million tonnes (Tiwari and Gupta, 2006) [20]. Further, the recovery of added sulphur through external sources is only 8-10%. Maize yield loss to an extent of 10 to 30 per cent and up to 35 per cent due to sulphur deficiency according to Pal and Singh (1992) [6]. The sulphur requirement of cereals to produce one tone of cereals is low but uptake per unit area becomes almost equal to that of oilseeds mainly due to higher productivity of cereals (Sutar *et al*., 2017) [18].
Zinc is one of the most important micronutrients for many crop plants such as rice, maize and wheat, or soybean, which all are worldwide cultivated. Zinc also catalyses the biosynthesis of indole acetic acid, acting as metal activator of the enzyme, helps in synthesis of nucleic acids, proteins and stimulates seed formation there by ultimately increasing crop yield. Its deficiency retards photosynthesis and nitrogen metabolism. Therefore, an experiment planned to know the effect of FYM, sulphur and zinc on growth, yield and quality of maize.

Material and methods
The experiment was conducted at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *rabi* seasons of 2019-20 and 2020-21 to evaluate influence of FYM, sulphur and zinc on growth, yield and quality of maize under middle Gujarat condition. The climate of Anand region is semi-arid subtropical with hot summer and cool winter.

The mean annual rainfall of this region is 865 mm. During 2019-20 total 63.5 mm of rainfall was received during 43rd, 44th and 45th meteorological weeks during rabi season, whereas, total 26.8 mm of rainfall was recorded during 42nd and 50th meteorological weeks during rabi season and 16.4 mm of rainfall during 11th meteorological week summer season of 2020-21. The maximum temperature ranged between 22.5-41.5 ^{0}C and minimum temperature ranged between 9.7-22.8 ^{0}C during the crop season of the year 2019-2020, while in the year 2020-21 maximum temperature ranged between 15.4-39.5 ^{0}C and minimum temperature ranged between 5.30-26.3 ^{0}C were recorded. The sunshine hours during *rabi* crop season (October-January) of the years 2019-20 and 2020-21 ranged from 4.7-9.3 hr/day and 4.1-9.5 hr/day, respectively. The minimum and maximum of mean relative humidity during *rabi* crop season ranged from 54.0-78.0% and 55.0-78.0% during both years. The soil of the experimental plot was loamy sand in texture, alkaline in reaction [pH(1:2.5) 8.30], low in soluble salts [EC(1:2.5) 0.23 dS/m], organic carbon (0.30%) and available nitrogen (197 kg N/ha), medium in available phosphorus (44.5 kg P_2O_5/ha), high in potash (287 kg K_2O/ha) and deficient in available sulphur (7.56 mg/kg) and zinc (0.55 mg/kg). The experiment comprised of total eighteen treatment combinations in which two levels of FYM (0 and10 t FYM /ha), three levels of sulphur (0, 20 and 40 kg S/ha) and three levels of zinc (0, 2.5 and 5 kg Zn/ha) were laid out in Randomized Block Design having factorial concept with three replications. The recommended dose of fertilizer was applied to maize (150:60:00 kg NPK/ha) at the time of sowing. Recommended dose of nitrogen was applied through urea in four equal splits (basal and three fourth dose of nitrogen as top dressing at 30, 45 and 60 days after sowing), recommended dose of P_2O_5 was applied through Diammonium phosphate (DAP) as basal. The seed of maize variety GAYMH-3 (Gujarat Anand Yellow Maize Hybrid-3) was dibbled in third week of October with spacing of 60 cm x 15 cm and seed rate of 20 kg ha^{-1}. The crop was raised with all the standard package of practices and protection measures also timely carried out as they required. At the maturity of crop, randomly five plant were selected (previously tagged) from each plot and harvested first for recording necessary biometric observations. The experimental data recorded for growth parameters, yield attributes and yield parameters were statistically analysed for level of significance.

Results and discussion

Plant population

The data given in Table 1 indicated non-significant effect of different levels of FYM, sulphur and zinc application and their respective interactions on plant population at 20 DAS and at harvest. The data on plant population obtained in the present investigation were the outcome of treatments employed in the experiment and did not deviated owing to weather or other factors and crop seed emergence was not adversely affected by various treatments.

Table 1: Plant population and plant height of maize as influenced by different treatments

Treatments	No. of plants per meter row length						Plant height (cm)					
	20 DAS			At harvest			30 DAS			At harvest		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Levels of FYM (t /ha)												
FYM_0	5.55	5.60	5.57	5.49	5.54	5.52	66.64	66.79	66.72	192.33	196.77	194.55
FYM_{10}	5.57	5.65	5.61	5.55	5.67	5.61	65.91	67.00	66.46	207.94	213.13	210.54
S. Em ±	0.13	0.12	0.09	0.11	0.11	0.08	1.16	1.09	0.79	2.37	2.78	1.83
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	6.82	8.00	5.16
Levels of Sulphur (kg /ha)												
S_0	5.48	5.53	5.50	5.43	5.47	5.45	63.68	64.37	64.02	187.72	191.67	189.70
S_{20}	5.57	5.65	5.61	5.56	5.71	5.64	66.81	67.47	67.14	201.56	206.60	204.08
S_{40}	5.62	5.69	5.66	5.58	5.63	5.60	68.34	68.85	68.59	211.13	216.58	213.86
S. Em ±	0.15	0.15	0.11	0.13	0.14	0.10	1.42	1.33	0.97	2.90	3.41	2.24
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.35	9.80	6.32
Levels of Zinc (kg /ha)												
$Zn_{0.0}$	5.52	5.56	5.54	5.46	5.49	5.48	64.57	65.21	64.89	195.00	198.48	196.74
$Zn_{2.5}$	5.56	5.63	5.60	5.53	5.66	5.60	66.27	66.89	66.58	199.37	204.42	201.90
$Zn_{5.0}$	5.59	5.69	5.64	5.58	5.66	5.62	67.99	68.59	68.29	206.04	211.95	208.99
S. Em ±	0.15	0.15	0.11	0.13	0.14	0.10	1.42	1.33	0.97	2.90	3.41	2.24
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.35	9.80	6.32
Significant Interaction(s)	F X S											
Year effect	-	-	NS	-	-	NS	-	-	NS	-	-	NS
CV%	11.8	11.2	11.5	10.1	10.5	10.3	9.1	8.5	8.8	6.2	7.1	6.6

Plant height

Effect of FYM

The application of FYM did not produced significant difference on plant height of maize at 30 DAS. However, numerically the maximum plant height 65.91, 67.00, 66.46 cm was recorded during 2019-20, 2020-21 and pooled respectively are presented in Table 1. The corresponding significantly higher plant height due to application of 10 t FYM/ha at harvest was 207.94. 231.13, 201.54 cm during 2019-20, 2020-21 and in pooled results, respectively, which was 8.2 percent higher over control in pooled results. Application of FYM provide steady supply of various nutrients during decomposition process, which also provide 0.5% N, 0.3% P and 0.5% K and also increased microbial population that assimilates from atmospheric N uptake along with other nutrients. These finding are close agreement with those obtained by Shanwad *et al.* (2010) [9] in maize-bengalgram, Faujdar *et al.* (2014) [3] in maize -wheat cropping sequence, Sindhi *et al.* (2016) [11] in Mustard crop.

Effect of Sulphur

Application of sulphur did not produce any significant effect on plant height at 30 DAS during individual years as well as in pooled results. The higher plant height 213.86 cm at harvest was recorded under 40 kg S/ha in pooled results. Application of sulphur @ 40 kg/ha recorded maximum plant height was 68.34, 68.85 and 68.59 cm during 2019-20, 2020-21 and in pooled, respectively. Minimum plant height 63.68, 64.37 and 64.02 cm were noted over control at 30 DAS. The sulphur application with the recommended dose of FYM enhanced the oxidation process of elemental sulphur to sulphate sulphur (SO4-S) which can be easily available to crop. Further, oxidation of sulphur leads to formation of sulphuric acid, which can reduce the soil pH in rhizosphere and increased the availability of other nutrients also. The sulphur also helps to synthesis of chlorophyll which required for photosynthesis and formation of organic constituents in plant system. Sulphur is involved directly or indirectly in different metabolic pathways of plants and play important role in enzymatic process including photosynthesis and respiration activities. The involvement of sulphur is an important component of several enzymes and metabolic process in plants. Similar results also found by Thirupathi *et al*. (2016) [19] They reported that application of sulphur shows positive effect on growth and yield of maize.

Effect of zinc

The application of zinc did not exert significant effect on plant height in individual years and in pooled results at 30 DAS. However, numerically higher plant height of 67.99, 68.59 and 68.29 cm during 2019-20, 2020-21 and pooled basis was noticed under 5 kg Zn/ha. Application of 5 kg zinc /ha logged significantly the highest plant height 206.04, 211.95 and 208.99 cm than control during both the years and in pooled results but remained at par with 2.5 kg Zn/ha during 2019-20. The per cent increase in plant height due to 5.0 kg Zn/ha was to the tune of 6.2 and 3.5 per cent over control and 2.5 kg Zn/ha in case of Pooled results. Increased in plant height due to application of zinc might be due to zinc being work as an essential constituent of several enzymes and also involved in nitrogen metabolism, cellular proteins and nucleic acid synthesis and encouraged the meristematic activities of crop and increased uptake of all the nutrients which in turn helped in better plant growth and dry matter production reported by Abhiram *et al*. (2014) [1]. Singh *et al*. (2016) [13] reported that treatment receiving the application of 4 kg Zn /ha was recorded significantly maximum plant height, green forage yield and dry matter yield of fodder oat in comparison with other treatments.

Interaction effect

Interaction effect of different levels of FYM, sulphur and zinc did not exert any significant effect during individual years and in pooled results on plant height recorded at 30 DAS and at harvest.

Yield of maize

Grain and stover yield

The grain and stover yield of maize was significantly influenced by application of FYM, sulphur, zinc and FYM x S interaction during 2019-20 of experiment and in pooled basis are presented in Table 2. The interaction between FYM x Zn, S x Zn and FYM x S x Zn was found non-significant during both the years of experimentation and in pooled results.

Effect of FYM

The incorporation of 10 t FYM /ha to maize crop recorded significantly higher maize grain and stover yield during 2019-20, 2020-21 and in pooled results (5369, 5504 and 5437 kg /ha and 7494, 7689 and 7591 kg/ha, respectively) than no FYM addition (4527, 4601, 4564 kg/ha and 6650, 6756, 6703 kg/ha, respectively). Application of 10 t FYM/ha recorded 19.1 and 13.2 per cent higher grain and stover yield as compared to control on pooled basis. These phenomenon increased growth and development of maize crop and ultimately reflected in grain and stover yield reported by Singh *et al.* (2019) [16]. These results supported by the findings of Faujdar *et al.* (2014) [3] in maize crop.

Table 2: Grain yield, stover yield and grain protein of maize as influenced by different treatments

Treatments	Grain yield (kg /ha)			Stover yield (kg /ha)			Protein content in grain (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Levels of FYM (t /ha)									
FYM_0	4527	4601	4564	6650	6756	6703	9.97	10.02	9.99
FYM_{10}	5369	5504	5437	7494	7689	7591	10.63	10.80	10.71
S. Em ±	80	79	56	106	98	72	0.076	0.075	0.054
C. D. at 5%	231	226	159	305	281	204	0.220	0.216	0.151
Levels of Sulphur (kg /ha)									
S_0	4576	4651	4614	6296	6477	6387	9.43	9.48	9.46
S_{20}	5030	5150	5090	7108	7270	7189	10.55	10.71	10.63
S_{40}	5237	5357	5297	7811	7921	7866	10.91	11.03	10.97
S. Em ±	98	96	69	130	120	88	0.094	0.092	0.066
C. D. at 5%	283	277	194	374	344	249	0.269	0.265	0.185
Levels of Zinc (kg /ha)									
$Zn_{0.0}$	4733	4838	4786	6836	6933	6884	9.94	10.02	9.98
$Zn_{2.5}$	4933	5045	4989	7073	7255	7164	10.32	10.44	10.38
$Zn_{5.0}$	5178	5275	5227	7307	7480	7393	10.63	10.76	10.70
S. Em ±	98	96	69	130	120	88	0.094	0.092	0.066
C. D. at 5%	283	277	194	374	344	249	0.269	0.265	0.185
Significant Interaction(s)	F X S								
Year effect	-	-	NS	-	-	NS	-	-	NS
CV%	8.4	8.1	8.3	7.8	7.0	7.4	3.86	3.75	3.80

Effect of Sulphur

Significantly higher grain yield was recorded under application 40 kg S/ha as compared to control, being at par with that of 20 kg S/ha during individual year of experimentation. In case of pooled results, application of 40 kg S/ha recorded significantly higher yield (5297 kg/ha) of maize grain, which was 14.8 and 4.1 per cent higher as compared to control and 20 kg S/ha, respectively. Significantly the highest stover yield was recorded under the application 40 kg S/ha as compared to that of control and 20 kg S/ha during individual years and in pooled results. In case of pooled results, application of 40 kg S/ha recorded significantly the highest stover yield (7866 kg/ha) of maize, which was 23.2 and 9.4 per cent higher as compared to control and 20 kg S/ha, respectively.

The sulphur helps to synthesis of chlorophyll which required for photosynthesis and formation of organic constituents in plant also reported by Shivran *et al.* (2013) [10] in maize, Abhiram *et al.* (2014) [1] in maize, Sipai *et al.* (2015) [15] in mustard and Kuniya *et al.* (2018) [5] in clusterbean.

Effect of zinc

Significantly higher grain yield (5178, 5275 kg/ha) and stover yield (7307,7480 kg/ha) was recorded under application 5 kg Zn/ha application as compared to control, being at par with that of 2.5 kg Zn/ha during individual years. On pooled basis, application of 5 kg Zn/ha recorded significantly higher grain and stover yield of maize (5227 and 7393 kg/ha). The increased in grain yield under 5 kg Zn/ha was to the tune of 9.2 and 4.5 per cent in case of grain yield and 7.4 and 3.2 per cent over control and 2.5 kg Zn/ha, respectively in pooled basis. The similar results were also reported by Upadhyay (2013) [21] in lentil, Sipai *et al.* (2015) [15] in mustard and Kuniya *et al.* (2018) [5] in clusterbean, Praveena *et al.* (2018) [7] and Kumar *et al.* (2021) [4].

Interaction effect

At a given level of FYM, grain yield was increased with the increasing level of sulphur during 2019-20 and in pooled basis (Table 3). Significantly higher grain yield during 2019-20(5737 kg/ha) and in pooled results (5818 kg/ha) was recorded with combined application of 40 kg S/ha and 10 t FYM/ha, which was found statistically at with that of $F_{10}S_{20}$ during 2019-20 and also in pooled results. The significant interaction between FYM and sulphur might be because of combined application FYM and sulphur makes the sulphur availability by the oxidation of sulphur to sulphate easily and early growth stage of crop and more absorption of S and other nutrients in crop. The sulphur application in absence of any organic manure was not oxidized as sulphate easily which ultimately restrict the absorption by the crop plant. Similar results were also noticed by Srinivasarao *et al.* (2010) [17].

Table 3: Grain yield of maize as influenced by FYM x S interaction

Levels of Sulphur (kg /ha)	Grain yield of maize (kg /ha)			
	Levels of FYM (t /ha)			
	2019-20		Pooled	
	F_0	F_{10}	F_0	F_{10}
S_0	4361	4792	4379	4848
S_{20}	4483	5578	4537	5643
S_{40}	4738	5737	4776	5818
S. Em. ±	139		97	
C. D. at 5%	400		275	

Table 4: Protein content in maize grain as influenced by FYM x S interaction

Levels of Sulphur (kg /ha)	Protein content in grain (%)					
	Levels of FYM (t /ha)					
	2019-20		2020-21		Pooled	
	F_0	F_{10}	F_0	F_{10}	F_0	F_{10}
S_0	9.41	9.45	9.38	9.58	9.4	9.5
S_{20}	10.11	10.99	10.22	11.21	10.2	11.1
S_{40}	10.38	11.44	10.46	11.61	10.4	11.5
S. Em. ±	0.132		0.130		0.093	
C. D. at 5%	0.381		0.374		0.262	

Protein content

The protein content in maize grain was significantly influenced by application FYM, sulphur, zinc and FYM x S interaction during 2019-20, 2020-21 years of experimentation and in pooled basis (Table 2).

Effect of FYM

Significantly the highest value of protein content 10.63, 10.80 and 10.71% was recorded under 10 t FYM/ha during 2019-20, 2020-21 and pooled results, respectively. The per cent increase in protein content under 10 t FYM/ha was to the tune of 7.2 over no application of FYM in pooled basis. Results were harmony with Singh *et al.* (2017) [14] in wheat.

Effect of Sulphur

Significantly the highest protein content *i.e.* 10.91, 11.03 and 10.97% was recorded with 40 kg S/ha during 2019-20, 2020-21 and in pooled results as compared to control and 20 kg S/ha. On Pooled basis, the increased in protein content under 40 kg S/ha was to the tune of 16.0 and 3.2 per cent over control and 20 kg S/ha, respectively. Sulphur plays active role in precursor of nucleic acid. Finally, it is content of protein, reported by Singh *et al.* (2014) in pearl millet, Sipai *et al.* (2015) [15] in mustard and Thirupathi *et al.* (2016) [19] in maize.

Effect of Zinc

Significantly the highest (10.63, 10.76 and 10.7%) protein content was noted under Zn 5.0 kg/ha over that of control and 2.5 kg Zn/ha during 2019-20, 2020-212 and in pooled results, respectively. The increased in protein content under 5.0 kg Zn/ha was to the tune of 7.2 and 3.1 per cent over control and 2.5 kg Zn/ha on pooled basis. This might be due to fact that association of Zn with functions as co factor of many metabolic activities in plant system, reported by Rana *et al.* (2013) [8].

Interaction effect

Significantly the highest protein content during 2019-20 (11.44%), 2020-21(11.61%) and in pooled results (11.5%) was recorded with combined application of 40 kg S/ha and 10 t FYM/ha (Table 4). The significant interaction between FYM and sulphur might be because of combined application of FYM and sulphur makes the sulphur availability by the oxidation of sulphur to sulphate easily and early growth stage of crop and more absorption of S and other nutrients in crop. Similar results were also noticed by Srinivasarao *et al.* (2010) [17].

Conclusion

The results revealed that application of 10 t FYM/ha,40 kg S/ha and 5 Kg Zn /ha to the maize crop recorded significantly

the highest plant height at harvest, grain and stover yields of maize as well as protein content in grain during individual year and in pooled results. FYM x sulphur interaction was found significant in case of grain yield and protein content in grain.

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