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RESEARCH PAPER

Response of yield and quality parameters of maize hybrid to single super phosphate and gypsum

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Abstract : Maize has the highest potential yield and responds greatly to applied fertilizers especially in the irrigated conditions in Tamil Nadu. Phosphorus and sulphur are the major yield limiting factor after nitrogen in the study area- Sivagangai district of Tamil Nadu. Therefore, this study was initiated with the aim of increasing the yield of hybrid maize by optimizing the phosphorus and sulphur fertilizers in the farmer's field. The experiment was laid out in a Factorial Randomized Block Design replicated thrice with five levels of phosphorus *viz.*, 0, 50, 75, 100, 125 kg P_2O_5 per ha and five levels of sulphur *viz.*, 0, 20, 40, 60, 80 kg S per ha. The results revealed that plant height, dry matter production, cob length, cob girth, the number of grains per cob and hundred grain weight were significantly increased with increased dose of P and S, and significantly higher at 125 kg P_2O_5 per ha and 80 kg S per ha. Similarly, the maize grain yield was higher at 125 kg P_2O_5 per ha (5964 kg per ha) and 80 kg S per ha (5035 kg per ha). Interaction of phosphorus and sulphur was additive with respect to growth and yield of maize.

Key Words : Maize, Phosphorus, Sulphur, Yield, Quality

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INTRODUCTION

Maize is the third most important cereal crop in India grown for food, feed and several industrial purposes. Maize cultivated both in irrigated and rainfed situations in India. In India, maize occupies 8.55 million ha producing 22 million tonnes with productivity of 2540 kg per ha (Agricultural Statistics at a glance, 2012). In Tamil Nadu, during 2011- 2012 it is cultivated over an area of 0.3 million ha with the production of 1.57 million tonnes and the average productivity of 5173 kg per ha. Soil fertility management is very important to ensure the supply of nutrients in sufficient amounts and desirable proportions to improve the crop productivity.

Farmers tended to practice unbalanced fertilization which has a negative effect on the quality of food, fodder and crop resistance to pests and diseases. Efficient fertilization means optimization of soil nutrient replenishment with the minimal nutrient losses to the environment (Maene, 2001). Among the major nutrients, phosphorus ranks next to nitrogen in importance on account of its vital role in major life processes. Its availability to the growing crop in required level is of prime importance in soil fertility. Phosphorus fertilization is imminent to all crops for maximizing crop yield. Application of fertilizer P in balanced proportion with other essential nutrients produces higher crop yields and

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ensures more profit to farmers (Kumaresan and Doraisamy, 2005). Phosphorus is the most critical element in highly weathered tropical and subtropical soils and per cent utilization of applied P by the crops is very low. Recovery rate rarely exceeds 20 per cent and rest is rendered unavailable due to chemical fixation in the soil (Singh and Sharma, 1994).

Sulphur is now recognized as the 4th major plant nutrient along with N, P, and K. In early 1990s, it was estimated in 130 districts of India where sulphur application was needed to obtain higher yields. But S deficient becomes prominent and has increased to more than 200 districts in 2001. This list is increasing as more results of research become available. Therefore, sulphur is now very much a part of a balanced fertilization and soils should be supplied with sulphur for increasing yield. This necessitates the study on the response of crop to different levels of fertilizer. Maize has high yield potential and responds greatly to applied fertilizers. Therefore, proper management of nutrients is essential to realize the maximum potential of the crop and to get higher economic benefit. Therefore, this study aimed at investigating the effect of varying doses of phosphorus and sulphur, their interaction effect on growth, yield and quality parameters of maize.

MATERIAL AND METHODS

Field experiments was conducted at farmer's field in Sivagangai district, Tamil Nadu during *Rabi* season in 2009 to study the influence of phosphorus and sulfur fertilizers on growth and yield of hybrid maize-30 OR 77. Sivagangai district is mostly plains with less mountains and hillocks. The district is brought under sub zone V of Southern zone, as per Agro climatic zone grouping. The Sivagangai district is located within North latitude $9^0 31^0$ to $10^0 27^0$ and East longitude $78^0 8^0$ to $79^0 2^0$. The mean annual rainfall in Sivagangai block is 912 mm, which has been distributed during southwest monsoon (348 mm), northeast monsoon (411 mm), winter rains (29 mm) and summer rains (124 mm). The soil moisture regime is Ustic, with mean temperature varying from 25.5 ^{0}C in January to 31.5 ^{0}C during April to July months.

The experiment was laid out in Factorial Randomized Block Design replicated thrice. The plot size was 5 × 4 m. A total of 25 treatments were experimented: five phosphorus levels *viz.*, control (0), 50, 75, 100, 125 P_2O_5 per ha constituted the first factor treatments and five sulphur levels *viz.*, control (0), 20, 40, 60, and 80 kg S per ha constituted the second factor treatments. Phosphorus was applied as di-ammonium phosphate while sulphur was applied as gypsum. The experimental field had pH of 7.3 and electrical conductivity of 0.37 dSm^{-1}. The cation exchange capacity (CEC) of the soil was 7.6 cmol (p+) kg^{-1}. The available N, P and K status of the soil were 182, 10.11 and 274 kg ha^{-1}, respectively. The available S status of the soil was 14.2 mg kg^{-1}.

The experimental field was ploughed thrice with the disc plough followed by breaking the clods. The field was then leveled after removing the stubbles. Ridges and furrows were formed with the size of 5m × 4m. Irrigation and drainage channels were provided according to the need and slope of the field. Seeds of maize hybrid (PIONEER 30 OR 77) were dibbled at the rate of single seeds per hill adopting a spacing of 60 cm between rows and 25 cm within the row. The treatment schedule, recommended dose of nitrogen 135 kg/ha was applied in three splits *viz.*, 25: 50: 25 per cent at basal, 25 and 45 DAS, respectively. The recommended dose of potassium 50 kg/ha was applied as two equal split doses *viz.*, basal and 45 DAS. The N and K fertilizers were applied in the form of urea (46 % N) and muriate of potash (60 % K_2O), respectively. The fertilizers were placed at 5 cm depth on nearby the plants by forming small furrows. First irrigation was given immediately after sowing. Life irrigation was given on the fourth day after sowing. Subsequent irrigations were given on need basis at an interval of 8-12 days. Pre - emergence application of atrazine @ 0.5 kg ha^{-1} was done on third day after sowing followed by one hand weeding on 30th days after sowing. Earthing up was done on 30thdays after sowing.

Five plants from each plot were selected at random, tagged and the following growth and yield parameters were recorded. Growth parameters such as plant height were recorded on 30th day and 60th days after sowing and at harvest stage. Similarly, five plants from sampling rows of each plot were uprooted for recording dry matter production at the same stages of biometric observations. Five tagged plants were used for measuring cob length, cob girth, and number of grains per cob. Five cobs were randomly selected from each plot and were shelled. A sample of one hundred grains were counted from each cob and weighed by using an electrical top pan balance and the mean weight was expressed in gram (g). Crude protein content in maize was estimated by the Micro kjeldhal method (Humpries, 1956) and starch content was estimated by Anthrone method (Clegg, 1956). The data

collected were statistically analyzed as suggested by Gomez and Gomez (1984). Wherever the treatment differences were found significant, the critical difference were worked out at five per cent probability level.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Plant height and dry matter production :

Phosphorus and sulphur applications significantly increased plant height and dry mater production. The effect of P and S levels and their interaction significantly increased the plant height at all stages of crop growth (Table 1). Maximum plant height was noticed at 125 kg ha^{-1} at 30, 60 and 90 days after sowing though rate of increase was slow during 60 to 90 days after sowing. The significantly higher mean (70.41 cm) value was observed with the application of 125 kg P_2O_5 ha^{-1} at 30 days after sowing. Similar to that of P levels, an increasing trend was observed in the plant height with increasing levels of sulphur application and significantly higher value of 63.35 cm was recorded with the application of 80 kg S ha^{-1} 30 at days after sowing. The per cent increase in plant height due to phosphorus and sulphur varied from 11 to 48 per cent and 0.074 to 5.71 per cent, respectively at 90 days.

Inclusion of P and S levels and their interaction had a significant effect on dry matter production at all stages of crop growth (Table 2). The dry matter production at 30 DAS was significantly influenced by the application of increasing levels of P and sulphur in maize crop. Application of 125 kg P_2O_5 ha^{-1} recorded maximum value of 843 kg ha^{-1} of dry matter production. The application of 80 kg S ha^{-1} recorded significantly higher value of MP (799 kg ha^{-1}). Similar trend was observed at 60 days after sowing and days after sowing. The significant higher value of plant height and dry matter production was observed with the application of 125 kg P_2O_5 ha^{-1}. Similar results were reported by Suresh (2000) in rice crop and Kumar *et al*. (2008) in groundnut crop. The improvement in biometric observations might be due to the fact that the increased supply of P and S which favored better nutritional environment. This finding corroborates with reports of Kumawat *et al*. (2004).

Yield attributing variables :

Application of phosphorus and sulphur significantly influenced yield attributing characters such as cob length, cob girth, number of grain per cob and hundred grain weights (Table 3 and 4). Application of 125 kg P_2O_5 ha^{-1} recorded significantly high cob length (15.19 cm), cob girth (8.11 cm), 301 numbers of grains per cob, hundred grain weights (29.94 g) over other levels (Table 3). Application of 80 kg S ha^{-1} recorded maximum cob length of 14.41 cm, cob girth of 7.73 cm, 268 numbers of grains per cob, hundred grain weights (31.68 g) over control and other levels of S.

Interaction of P and S was found to be significant in increasing the yield attributes. A similar trend of results was reported by Kumar *et al*. (2008) in groundnut crop. The P and S are both being anion; they have complemented each other in order to strike a proper balance between cation and anion in producing synergistic effect on yield characters. Increase in yield attributes due to P could be due to the role of P in formation and translocation of carbohydrates and other essential intermediate compounds. Roy and Jha (1987) noticed increase in yield characters due to P application in rice crop. The improved nutritional environment as a result of increased S supply might have favorably influenced the carbohydrate metabolism due to role of S in energy transformation and activation of enzymes. This favorable effect might have resulted in improved yield attributes. The similar effect of S on yield components was reported by Chowdhury and Majumder (1994) in rice crop.

Yield :

Maize grain and straw yield increased significantly with increasing levels of phosphorus and sulphur (Table 5). The per cent increase in grain yield due to phosphorus and sulphur varied from 40 to 119 per cent and 19 to 42 per cent, respectively. The maximum yield obtained with 125 kg P_2O_5 $ha^{-1}$and 80 kg S ha^{-1}. The magnitude of response was more in case of phosphorus than sulphur. Similar trend of result was reported by Sinha *et al*. (1995) in maize and Singh and Singh (2004) in black gram. Kumawat *et al*. (2004) reported that the seed and straw yield increased significantly with increasing levels of either phosphorus or sulphur. Synergistic effect of phosphorus and sulphur interaction on grain was highest at 125 kg P_2O_5 and 40 kg S per ha.

The synergistic effect of P and S may be due to utilization of high quantities of nutrients through their well-developed root system and nodules which might have

Table 1 : Effect of phosphorus and sulphur levels on plant height (cm) of hybrid maize at different stages of crop growth

Treatments	Plant height (cm)																	
	30 DAS						60 DAS						90 DAS					
Phosphorus levels	Sulphur levels						Sulphur levels						Sulphur levels					
	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean
P_0	39.9	43.2	44.3	45.0	46.8	43.8	97.3	95.2	98.0	94.3	99.6	96.8	113.5	103.8	118.4	107.5	116.3	111.9
P_1	53.2	57.3	59.2	59.8	62.3	58.3	110.6	112.4	114.5	108.4	111.2	111.4	121.5	123.6	127.9	118.7	131.8	124.7
P_2	63.9	60.6	62.4	64.2	66.4	63.5	117.6	116.4	119.4	122.6	127.7	120.7	137.0	137.7	129.0	131.3	135.6	134.1
P_3	61.6	63.7	67.6	68.6	70.4	66.4	121.0	127.9	132.8	138.0	126.1	129.1	138.7	141.9	147.1	151.6	154.1	146.6
P_4	66.7	68.9	71.7	73.8	70.8	70.4	137.5	144.1	147.3	152.2	150.1	146.2	157.6	161.5	168.1	169.5	170.7	165.5
Mean	57.0	58.7	61.0	62.2	63.3		116.8	119.2	122.4	123.1	122.95		133.6	133.7	138.1	135.7	141.7	
		P	S	P × S				P	S	P × S				P	S	P × S		
S.E. ±		0.21	0.21	0.47				0.27	0.27	0.61				0.24	0.24	0.54		
C.D. (P=0.05)		0.42	0.42	0.95				0.55	0.55	1.23				0.49	0.49	1.09		

Table 2 : Effect of phosphorus and sulphur levels on dry matter production (kg ha^{-1}) of hybrid maize at different stages of crop growth

Treatments	Dry matter production (kg ha^{-1})																	
	30 DAS						60 DAS						90 DAS					
Phosphorus levels	Sulphur levels						Sulphur levels						Sulphur levels					
	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean
P_0	546.6	723.3	623.3	593.3	643.3	626.0	6165.1	7168.0	7072.0	7704.1	7806.2	7183.0	8918.8	9030.1	9122.5	9511.6	9824.0	9281.0
P_1	763.2	715.3	746.4	776.3	784.3	757.1	7835.0	8326.2	8223.0	8411.0	8822.0	8333.4	10175.0	10279.2	10180.2	10182.1	10867.1	10336.0
P_2	735.0	782.0	810.0	848.0	864.0	807.8	8343.4	8568.0	8843.0	9052.2	9566.3	8874.4	10271.5	10431.0	10856.7	11218.0	11639.0	10883.0
P_3	773.1	783.0	794.5	814.0	834.8	799.6	8276.0	8479.5	9729.0	10281.0	10416.0	9436.2	10484.0	11238.8	11674.0	11723.0	11838.3	11391.7
P_4	808.3	822.3	844.3	875.3	869.3	843.9	8424.1	9365.0	10386.0	10816.4	11054.0	10009.0	11322.3	11479.3	11730.4	11837.7	11727.3	11619.3
Mean	725.2	765.2	763.6	781.4	799.0		7818.6	8381.2	8850.6	9252.8	9532.8		10234.0	10491.4	10712.4	10894.2	11179.1	
		P	S	P × S				P	S	P × S				P	S	P × S		
S.E. ±		0.54	0.54	1.22				1.80	1.80	4.04				1.24	1.24	2.77		
C.D. (P=0.05)		1.10	1.10	2.46				3.63	3.63	8.13				2.49	2.49	5.58		

Table 3 : Effect of phosphorus and sulphur levels on cob length and cob girth of hybrid maize

Treatments	Cob length (cm)						Cob girth (cm)					
Phosphorus levels	Sulphur levels						Sulphur levels					
	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean
P_0	14.43	14.37	14.13	14.73	14.53	14.44	7.33	7.27	7.33	6.93	6.83	7.14
P_1	14.33	14.73	14.53	14.83	13.73	14.43	7.43	7.73	7.53	6.83	7.63	7.43
P_2	13.93	14.53	14.63	14.83	13.83	14.35	7.33	7.73	6.97	7.27	7.57	7.37
P_3	14.53	14.73	14.43	14.93	14.83	14.69	7.67	7.77	7.97	8.17	7.77	7.87
P_4	15.13	15.43	14.93	15.33	15.13	15.19	7.47	7.80	8.10	8.37	8.83	8.11
Mean	14.47	14.76	14.53	14.93	14.41		7.45	7.66	7.58	7.51	7.73	
		P	S	P X S				P	S	P x S		
S.E. ±		0.05	0.05	0.12				0.06	0.06	0.15		
C.D. (P=0.05)		0.11	0.11	0.25				0.14	0.14	0.31		

Table 4 : Effect of phosphorus and sulphur levels on number of grain/cob and hundred grain weight of hybrid maize

Treatments	No. of grain/cob						Hundred grain weight					
Phosphorus levels	Sulphur levels						Sulphur levels					
	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean
P_0	211	217	247	213	217	221	26.94	28.13	29.08	31.53	33.61	29.86
P_1	232	237	244	248	265	245	24.73	26.26	27.58	28.56	30.55	27.54
P_2	233	245	276	270	280	261	25.15	26.16	27.43	28.41	30.24	27.48
P_3	254.67	284	262	286	279	273	25.13	26.53	28.13	27.03	30.58	27.48
P_4	285.00	314	296	312	301	301	26.57	28.39	29.82	31.48	33.41	29.94
Mean	243	259	265	266	268		25.71	27.10	28.41	29.41	31.68	
		P	S	P × S				P	S	P × S		
S.E. ±		1.01	1.01	2.25				0.05	0.05	0.12		
C.D. (P=0.05)		2.03	2.03	4.54				0.11	0.11	0.25		

Table 5 : Effect of phosphorus and sulphur levels on grain and stover yield of hybrid maize

Treatments	Grain yield (kg ha^{-1})						Stover yield (kg ha^{-1})					
Phosphorus levels	Sulphur levels						Sulphur levels					
	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean
P_0	2189	2580	2838	2930	3063	2720	2184	3435	2575	4036	3470	3140
P_1	2975	3603	4070	4140	4255	3808	3210	4462	3345	5243	4508	4154
P_2	3466	4170	4333	5420	5760	4630	4470	5952	6021	6208	6370	5804
P_3	4306	4745	5526	5732	5899	5242	4218	4590	6822	5916	6515	5613
P_4	4832	5995	6499	6295	6196	5964	6822	6410	7159	6722	7418	6907
Mean	3554	4219	4653	4903	5035		4181	4970	5185	5625	5656	
		P	S	P × S				P	S	P × S		
S.E. ±		168.38	168.38	376.51				20.06	20.06	44.85		
C.D. (P=0.05)		338.57	338.57	NS				40.33	40.33	90.19		

NS=Non-significant

Table 6 : Effect of phosphorus and sulphur levels on starch and crude protein of hybrid maize

Treatments	Starch (%)						Crude protein (%)					
Phosphorus levels	Sulphur levels						Sulphur levels					
	S_0	S_1	S_2	S_3	S_4	Mean	S_0	S_1	S_2	S_3	S_4	Mean
P_0	52.29	54.73	52.49	56.99	52.37	53.77	5.98	6.40	6.98	7.80	7.98	7.02
P_1	56.85	55.66	53.95	53.77	55.45	55.13	7.00	7.21	7.65	7.98	8.21	7.61
P_2	55.28	55.50	50.66	53.94	52.90	53.66	6.22	7.03	7.57	7.83	8.06	7.34
P_3	56.33	52.62	54.71	59.39	53.70	55.35	5.64	6.58	7.49	7.93	8.18	7.16
P_4	47.66	50.37	59.26	63.23	59.73	56.05	7.17	7.74	8.02	8.51	8.22	7.93
Mean	53.68	53.78	54.21	57.46	54.83		6.40	6.99	7.54	8.01	8.13	
		P	S	P × S				P	S	P × S		
S.E. ±		0.47	0.47	1.06				0.22	0.22	0.51		
C.D. (P=0.05)		0.95	0.95	2.14				0.46	0.46	1.03		

resulted in better growth and yield at medium. These results confirm the earlier findings of Sinha *et al.* (1995) in winter maize, Choudhary and Das (1996) in black gram, Randhawa and Arora (2000) in wheat, Teotia *et al*. (2000) in moong bean, and Islam *et al.* (2006) in rice. Balanced fertilization of P and S increased yield of soybean (Kumar and Singh, 1980) and cluster bean (Yadav, 2011).

Starch and protein content :

Starch and protein content were significantly increased with an increase in levels of P and S individually as well as in combination (Table 6). The maximum starch content of 56.05 and 57.46 per cent recorded with the application of 125 kg P_2O_5 ha^{-1} and 80 kg S ha^{-1}, respectively. The maximum increase in starch content (63.20%) was obtained with 125 kg P2O5 per ha and 60 kg S per ha in combination. Protein content was increased with increasing level of P and S individually as well as their combinations. The increased quality parameters in maize crop might be due to the reason that the phosphorus plays a vital role in crop nutrition for photosynthesis, respiration, better root growth and energy transfer in the living cells by high energy phosphate bond of ATP. Sulphur plays on outstanding role for the formation of amino acids, synthesis of proteins, chlorophyll and oil. Similar results have been reported by Faujdar *et al*. (2008). The synergistic effect of phosphorus and sulphur was reported on protein content of cluster bean (Yadav, 2011).

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