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Impact of Levels of Phosphorus and Sulphur on Yield and Economics of Wheat (*Triticum aestivum* L.) Crop

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ABSTRACT: During the *rabi* season of 2015-16, a field experiment was carried out in Junagadh, Gujarat, on calcareous clayey soil to investigate the impact of phosphorus and sulphur levels on yield and economics of wheat (*Triticum aestivum* L.). In terms of available nutrients, the soil had low levels of nitrogen (242 kg ha^{-1}), medium levels of phosphorus (39.20 kg ha^{-1}), high levels of potash (292 kg ha^{-1}), and medium levels of sulphur (19.05 ppm). Applying 90 kg P_2O_5 ha^{-1} (P_3) produced maximum spike length (8.7 cm), number of spikelets spike^{-1} (15.9), grain yield (4451 kg ha^{-1}), straw yield (6886 kg ha^{-1}) and B: C ratio (2.08), which was found to be comparable to P_2 (60 kg P_2O_5 ha^{-1}). These experimental results were reported in the results of the study. Applying 40 kg S ha^{-1} was found to be equivalent to applying 20 kg S ha^{-1} and resulted in a significant increase in the number of spikelets spike^{-1} (15.8), spike length (8.6 cm), grain yield (4354 kg ha^{-1}), straw yield (6809 kg ha^{-1}) and B:C ratio of 2.00. Grain yield was significantly higher (4937 kg ha^{-1}) with the combined application of 90 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} (P_3S_2) than with the control (P_0S_0).

Keywords: Economics, yield, phosphorus, sulphur and interaction effect.

INTRODUCTION

One of the most valuable cereal crops, wheat (*Triticum aestivum* L.), is a member of the Poaceae family of grasses and is consumed in large quantities in India. After rice and maize, it is the cereal that is produced the most. India has advanced significantly over the previous 40 years to become the second-largest wheat producer in the world. In temperate regions, wheat is the most common crop grown for human consumption and animal feed. All of the qualities and trails needs to make bread are present in flour derived from bread wheat.

The main factor behind bread wheat's supremacy in the baking sector is its unique viscoelastic gluten protein complex, which makes it the best cereal grain for leavened bread baking. The quality of bread is highly correlated with the fractions of gluten, gliadins, and glutenins (Hadzi *et al.*, 2013). Anon (2013) reports that wheat is planted on 10.24 lakh hectares in Gujarat, producing 29.44 lakh tonnes of total output and 2803 kg ha^{-1} productivity. Most of the soil in Gujarat's Saurashtra region is medium-black calcareous soil with low levels of sulphur and nitrogen. Strategic fertilizer application could increase wheat crop productivity and protein content. Gujarat's productivity is comparatively lower due to a number of issues, including inadequate irrigation systems, unbalanced fertilizer use, and a lack of understanding of contemporary agronomic practices like appropriate genotypes, appropriate sowing times, seed rates, spacing, weed control, fertilization, and plant protection measures, among others. The second-most important nutrient for plants is phosphorus, which is crucial for getting the most crop production. Numerous physiological processes, such as photosynthesis, respiration, energy storage, and cell division and enlargement, depend on it.

Phosphorus that plants need for healthy growth and yield. However, because soluble forms are not present in the soil, it is thought to be one of the most restricting factors in many crop production systems. According to Nisha *et al.* (2014), the formation of complexes with Al or Fe in acidic soils or Ca in calcareous soils immobilises about 80% of applied phosphorus fertilisers. In the soil of various land forms in southern Saurashtra, available phosphorus content ranged from 5.6-42.2 kg ha^{-1}, with an overall mean of 19.4 kg ha^{-1}, according to Savalia (2005). Improved uptake and utilisation efficiency are two factors contributing to plant phosphorus efficiency (Balemi and Negisho 2012). Another essential nutrient found in all plant nutrients is sulphur, which is also a component of amino acids, the building blocks of protein. The ranges of sulphur content in cereal crops are 0.16 to 0.20%. Plants have a critical sulphur content of 0.20–0.25%, below which crops exhibit deficiencies in sulphur and react negatively to sulphur fertiliser. Not only is sulphur essential for plant growth, but it also improves grain quality. One essential macronutrient is sulphur, which is mostly made during the synthesis of cysteine and methionine. It contributes to the synthesis of disulfide bonds in proteins as well. The amount of sulphur present also has a significant impact on the bread wheat's storage proteins' quality (Pompa *et al.,* 2009). Wheat production and quality are greatly impacted by sulphur deficiency. Because of the disulfide bonds that form from the sulphydryl groups of cysteine, a deficiency in sulphur reduces grain size and baking quality (Gyori, 2005). Consequently, this experiment was conducted with these factors in view.

MATERIALS AND METHODS

The current study examined the effects of phosphorus and sulphur levels on wheat (*Triticum aestivum* L.) yield and economics during the *rabi* season of 2015-16 at the College Farm, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) with a pH of 8.10 and an EC of 0.36 dS m^{-1}, the soil of the experimental plot had a silty loam texture and was slightly alkaline in reaction. In terms of available nutrients, the soil had low levels of nitrogen (242 kg ha^{-1}), medium levels of phosphorus (39.20 kg ha^{-1}), high levels of potash (292 kg ha^{-1}), and medium levels of sulphur (19.05 ppm). A total of 12 treatment combinations were used in the factorial randomized block design experiment. The phosphorus levels were 0.00 kg ha^{-1} (P_0), 30.00 kg ha^{-1} (P_1), 60.00 kg ha^{-1} (P_2), and 90.00 kg ha^{-1} (P_3), and the sulphur levels were 0.00, 20.00, and 40.00 kg ha^{-1} as S_0, S_1, and S_2, respectively. There were three replications of these treatments. In the form of urea (46% N), di-ammonium phosphate (46% P_2O_5 and 18% N), and muriate of potash (60% K_2O), the recommended dose of nitrogen, phosphorus, and potassium ($N:P_2O_5:K_2O$ @ 120:60:60 kg ha^{-1}) was applied as a basal application and the remaining amount as rest. 30 days after sowing, 60 kg ha^{-1} of nitrogen was applied. According to the treatments, sulphur was applied in the form of Cosavet (90% S).

RESULTS AND DISCUSSION

A. Effect of phosphorus on yield

The results revealed that different treatments of phosphorus manifested significant influence on yield attributes and yield of wheat (Table 1). Application of 90 kg P_2O_5 ha^{-1} (P_3) recorded significant maximum spike length (8.7 cm), number of spikelets $spike^{-1}$ (15.9), grain yield (4451 kg ha^{-1}) and straw yield (6886 kg ha^{-1}) which was found at par with P_2 (*i.e.* 60 kg P_2O_5 ha^{-1}). Yield attributes *viz*., maximum spike length by 11.53%, 6.41%, number of spikelets $spike^{-1}$ by 14.38%, 10.07% and ultimately increased grain yield by 26.41%, 13.44% and straw yield by 14.46%, 08.85%, respectively by 90 kg P_2O_5 ha^{-1} (P_3) and P_2 (*i.e.*60 kg P_2O_5 ha^{-1}) over the control (P_0). This could be because the plant used more phosphorus from its native source as a result of the higher amount of phosphorus applied mobilizing native phosphorus. It is also true that phosphorus plays a role in the metabolism of organic compounds and is necessary for higher nitrogen utilization. One of phosphorus's major functions is to increase the number of tillers in cereals, which explains the increase in yield attributes and yield with phosphorus levels. The metabolism and enzymatic reactions that lead to an increase in total and effective tillers are facilitated by phosphorus. One essential component and co-enzyme for photosynthesis and protein synthesis is phosphorus. This may have resulted in an increase in grain and straw yield, spike length, and spikelet $spike^{-1}$. The findings of Khan *et al.* (2007); Gaur and Singh (2010); Hussain *et al.* (2011); Arshad *et al.* (2016) are corroborated by these results.

B. Effect of sulphur on yield

Table 1 shows that varying sulphur levels significantly impact yield and attributes, with 40 kg S ha^{-1} fertilization resulting in higher spike length, spikelet number, grain yield, and straw yield. S_0 (control) showed the lowest recorded yield and yield attributes. The corresponding increases with 40 and 20 kg S ha^{-1} over control were in the length of the spike by 10.25%, 5.12%, number of spikelets $spike^{-1}$ by 15.32%, 10.21%, grain yield by 28.13%, 15.95%, and straw yield by 11.13%, 3.37%. The application of sulphur may have increased various yield attributes and yields because sulphur is an essential amino acid that aids in the formation of chlorophyll, the photosynthetic process, the activation of enzymes, and the formation of seeds. It appeared that fertilization increased chlorophyll synthesis and photosynthetic activity, which aided in the promotion of vegetative growth. In the case of wheat crops, the results are in close agreement with those reported by Ganeshamurty *et al.* (1994); Vyas *et al.* (1997); Orman and Ok (2012); Singh and Bhadoria (2013); Khan *et al.* (2015); Kharub and Dhillon (2007).

C. Interaction effect of phosphorus and sulphur on yield

Table 3 shows that there is a significant interaction effect between the levels of phosphorus and sulphur on grain yield. Notably, the wheat crop fertilized with 90 kg P_2O_5 ha-1 + 40 kg S ha^{-1} (P_3S_2) produced the maximum grain yield of 4937 kg ha^{-1}, which remained statistically equivalent to treatment combinations of P_3S_1, P_2S_1, P_1S_2, and P_0S_2. Significantly, the control treatment (i.e., P_0S_0) produced a lower grain yield of 2711 kg ha^{-1}. It could be because sulphur and phosphorus are absorbed as anions and work in concert with one another. The outcomes support the conclusions of the following studies on wheat crops: Marok and Dev (1980); Randhawa and Arora (2000); Islam *et al.* (2006); Abdallah *et al.* (2013).

D. Effect of phosphorus and sulphur on economics

The information presented in Table 3 made it abundantly evident that applying 90 kg of P_2O_5 ha^{-1}, which was closely followed by 60 kg of P_2O_5 ha^{-1}, secured the highest gross and net returns of ₹ 91,666 ha^{-1} and ₹ 47,637 ha^{-1}, respectively, as well as a B: C ratio of 2.08. In the case of sulphur, however, application of 40 kg S ha^{-1}, closely followed by 20 kg S ha^{-1}, secured maximum gross and net returns of ₹ 89,813 ha^{-1} and ₹ 44,795 ha^{-1}, respectively, along with a B: C ratio of 2.00, due to additional grain and straw yield obtained high under these treatments.

Table 1: Effect of phosphorus and sulphur levels on yield attributes and yield of wheat crop.

Treatments	Length of spike (cm)	No. of spikelet spike^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Phosphorus (P_2O_5 kg ha^{-1})				
P_0- 0	7.8	13.9	3521	6016
P_1- 30	8.0	14.3	3623	6242
P_2- 60	8.3	15.3	3994	6549
P_3- 90	8.7	15.9	4451	6886
S.Em.±	0.21	0.52	163	216
C.D. at 5 %	0.61	1.53	478	635
Sulphur (S kg ha^{-1})				
S_0- 0	7.8	13.7	3398	6127
S_1- 20	8.2	15.1	3940	6334
S_2- 40	8.6	15.8	4354	6809
S.Em.±	0.18	0.45	141	187
C.D. at 5 %	0.53	1.32	414	550
Interaction (P×S)				
S.Em.±	0.36	0.90	282	375
C.D. at 5 %	NS	NS	828	NS
C.V. %	7.58	10.50	12.55	10.11

Table 2: Economics of different treatments.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B: C ratio
Phosphorus (P_2O_5 kg ha^{-1})						
P_0- 0	3521	6016	73650	38418	35232	1.92
P_1- 30	3623	6242	75896	44289	35607	1.88
P_2- 60	3994	6549	82995	42159	40836	1.97
P_3- 90	4451	6886	91666	44029	47637	2.08
Sulphur (S kg ha^{-1})						
S_0- 0	3398	6127	71720	37429	34291	1.92
S_1- 20	3940	6334	81621	41224	40398	1.98
S_2- 40	4354	6809	89813	45018	44795	2.00

Table 3: Interaction effect of phosphorus and sulphur on grain yield.

Levels of phosphorus	Levels of sulphur		
	S_0	S_1	S_2
P_0	2711	3574	4276
P_1	3287	3160	4422
P_2	3881	4321	3779
P_3	3711	4703	4937
S.Em.±		282	
C.D. at 5 %		828	

Appendix- I: Economic of different treatment combinations

Treatments combination	Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B: C Ratio
P_0S_0	58618	34623	23995	1.69
P_0S_1	74254	38418	35836	1.93
P_0S_2	88077	42212	45865	2.09
P_1S_0	69769	36494	33275	1.91
P_1S_1	67516	40289	27227	1.68
P_1S_2	90404	44083	46321	2.05
P_2S_0	80153	38364	41789	2.09
P_2S_1	88726	42159	46567	2.10
P_2S_2	80108	45954	34154	1.74
P_3S_0	78336	40235	38101	1.95
P_3S_1	93325	44029	49296	2.12
P_3S_2	104244	47824	56420	2.18

Appendix-II: Cost of cultivation treatment wise.

Tr. combi.	Cost of cultivation (₹ ha^{-1})	Treatment cost (₹ ha^{-1})	Total cost of cultivation Cost A (₹ ha^{-1})	Interest on total cost @ 12 % for 3.5 months	Cost B	Cost C_1	Supervision charge @ 10 % of total cost	Cost C_2
	(a)	(b)	(a+b)	(c)	(a+b+c)	(d)	(e)	(d+e)
P_0S_0	30403	0	30403	1073	31476	31476	3147	34623
P_0S_1	30403	3333	33736	1190	34926	34926	3492	38418
P_0S_2	30403	6666	37069	1306	38375	38375	3837	42212
P_1S_0	30403	1643.29	32046.29	1131	33177	33177	3317	36494
P_1S_1	30403	4976.29	35379.29	1248	36627	36627	3662	40289
P_1S_2	30403	8309.29	38712.29	1364	40076	40076	4007	44083
P_2S_0	30403	3286.58	33689.58	1188	34877	34877	3487	38364
P_2S_1	30403	6619.58	37022.58	1305	38327	38327	3832	42159
P_2S_2	30403	9952.58	40355.58	1422	41777	41777	4177	45954
P_3S_0	30403	4929.87	35332.87	1246	36578	36578	3657	40235
P_3S_1	30403	8262.87	38665.87	1362	40027	40027	4002	44029
P_3S_2	30403	11595.87	41998.87	1479	43477	43477	4347	47824

CONCLUSIONS

Based on the findings of a year-long field study, it seems reasonable to conclude that irrigated wheat (GW 496) should be fertilized with 90 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} along with a nitrogen dose based on 120 kg N ha^{-1} in order to increase yield and net realization.

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