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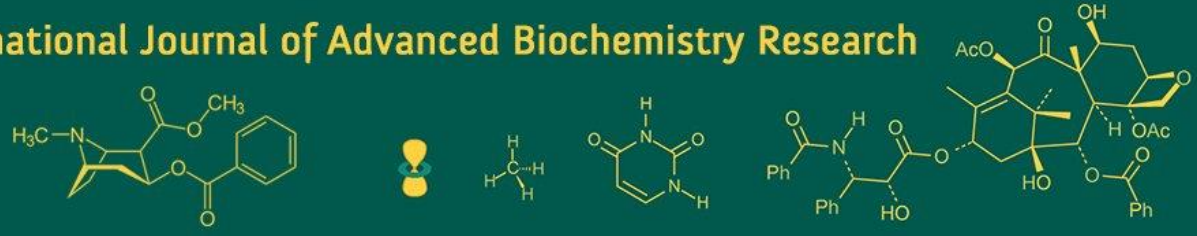

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Effect of phosphorus and sulphur on wheat quality and nutrient uptake by wheat (*Triticum aestivum* L)

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Abstract
A field experiment was conducted at Crop Research Farm of National Post Graduate College, Barhalganj Gorakhpur, U. P. during the rabi season of 2020-21 and 2021-22 with an objective to study the effect of Phosphorous and Sulphur on quality and nutrient uptake of wheat (*Triticum aestivum* L.). The soil of the experimental field was silty loom in texture with low, medium and high in N. P. and K., respectively. The experimental site is situated in sub-tropical zone in Indo-gangetic plains. The experiment was laid out in Randomise Black Design (Factorial) and sown dated on 16-11-2020 and 18-11-2021 with two factors viz-A-Phosphorus i.e. 0, 30, 60 and 90 kg ha^{-1} and B-Sulphur i.e. 0, 15, 30 and 45 kg S ha^{-1} with three replication and harvested dated on 05-04-2021 and 07-04-2022, respectively. The result indicated that the Phosphorus-90 kg ha^{-1} proved significantly superior over other Phosphorus level in terms of viz-protein content, nitrogen content in grains and straw, phosphorous content in grain and straw, potassium content in grain and straw and sulphur content in grain and straw and Uptake of nutrients viz-phosphorous uptake and sulphur uptake, except 60 kg ha^{-1}, during both the year, respectively, while Sulphur-45 kg ha $^{-1}$ gave significantly highest value in terms of protein content, nitrogen content in grain and straw, Phosphorous content in grain and straw, potassium content in grain and straw and sulphur content in grain and straw and uptake of nutrients viz-phosphorous uptake and sulphur uptake over other S level, except 30 kg S ha $^{-1}$ during both the year of experiment, respectively. Phosphorous-90 kg ha^{-1} + Sulphur-45 kg ha^{-1} increased significantly the quality content end uptake of nutrients in wheat.

Keywords: Wheat, phosphorus, sulphur, protein content, N content in wheat and straw, P content in wheat and straw, K content in wheat and straw, S content in wheat and straw, P uptake, S uptake

Introduction
The practice of intensive cropping with high yielding varieties for boosting food production caused nutrient depletions in soil, consequently macro and micronutrients deficiencies are reported in soils. Wheat (*Triticum aestivum* L.) is the most important staple food crop of the world and emerged as the backbone of India's food security. The possibility of expanding the area under wheat in the near future is limited. Therefore, this extra wheat production has to come by increase in productivity. Productivity of wheat become reduced in India due to various reasons like improper tillage methods, delayed sowing due to unpredictable monsoon seasons, water scarcity, weed intensification, poor quality seeds and soil becomes less fertile due to imbalanced fertilizer use (Kantwa, *et al*., 2015) [3]. To increase or to sustain the productivity of wheat, there is a need for application of secondary and micronutrients, as the addition of these nutrients is not common with the introduction of high analysis fertilizers.
The soils are poor in organic matter and deficient in secondary (Singh, 2015) [5] and micronutrients. Sulphur plays an important role in the formation of sulphur containing amino acids which act as building blocks in the synthesis of proteins. It has a role to play in increasing chlorophyll formation and aiding photosynthesis. Sulphur also plays a significant role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine.
Since not much work has been done on wheat in relation to phosphorus and sulphur to exploit it's quality and uptake potential. It becomes imperative to identify suitable integration of above practices. Keeping the above facts in view the present investigation have been made.

Materials and Methods

The field experiment was carried out at the Crop Research Farm of National Post Graduate college, Barhalganj, Gorakhpur, U.P. during rabi season of 2020-21 and 2021-22. The experimental site is situated in subtropical zone in indo-gangetic plains and lies between 260 471 North latitude, 820101 East longitude and 1130 m above sea level. The soil of the experimental field was silty loom in texture and slightly alkaline in reaction with PH 7.7, E. C. 0.20 dSm^{-1}, organic carbon 0.41% and available Nitrogen 195 kg ha^{-1} Phosphorus 18.3 kg ha $^{-1}$ and Potassium 262 kg ha^{-1} at 0-15 cm soil depth. The experiment was laid out in Randomized Block Design (Factorial) and sown on 16-11-2021 and 18-11-2022, respectively with two factors viz-A-Phosphorous i.e. 0, 30, 60 and 90 kg ha^{-1} and B-Sulphur i.e. 0, 15, 30 and 45 kg ha^{-1} with three replication. The crop was sown by using seed rate of 120 kg ha^{-1}, while Phosphorous and Sulphur were applied to the wheat as per treatment of the experimental crop. The other agronomical cultural practices such as Nitrogen, Potassium, irrigation, weeding and plant protection measures have been performed as per requisite and recommendation of the crop. The wheat was harvested dated on 05-04-2021 and 07-04-2022.

The representative dry plant samples (seed and stover) were wet digested using di-acid mixture of HNO_3 and $HClO_4$ in 3:1 ratio. The acid extract prepared after digestion was used for estimation of P, K and S content and uptake. The N, P, K and S contents were analyzed by micro-Kjeldahl method (KELPLUS model), vandomolybdo phosphoric acid, flame photometric method and turbidimetric method, respectively. The collected data for various parameters were statistically analyzed using Fishers' analysis of variance (ANOVA) technique and the treatments were compared at 5% level of significance.

Results and Discussion

Wheat Quality

It is evident from Table-1 that the protein content increased from 11.57 to 12.73 percent in first' year and 11.81 to 12.86 percent in wheat grain as the dose of phosphorus was increased from 0 to 90 kg P_2O_5 ha^{-1}. It is due to fact that, P is essential for protein synthesis, its main effect on grain protein content is often indirect. By enhancing yield, P can lead to more total protein being produced. The increase in protein content may be owing to higher nitrogen utilization by the crop Tiwari, *et al*., 2025 [6]. Nitrogen, phosphorus, potassium and sulphur content (%) in seed and straw were recorded with 90 kg P_2O_5 ha^{-1}., which was significantly superior over 30 and 0 kg P_2O_5 ha^{-1}, but at par with 60 kg P_2O_5 ha^{-1}. Table-1 described that the protein content increased from 11.58 to 12.81 percent in first' year and 11.81 to 12.94 percent in wheat grain as the dose of sulphur was increased from 0 to 45 kg S ha^{-1}. It is due to fact that, S is essential for synthesizing sulfur-containing amino acids that form vital gluten proteins, which give dough its elasticity and strength. Adequate sulphur boosts grain protein content, leading to better bread-making quality,

Nitrogen, phosphorus, potassium and sulphur content (%) in seed and straw were recorded with 45 kg S ha^{-1}., which was significantly superior over 15 and 0 kg Sha^{-1}, but at par with 30 kg S ha^{-1} Mishra, *et al*. (2018) [4].

Table 1: Protein content, N content, P content K content and S content as affected by phosphorus and sulphur

Treatment	Protein content		Nitrogen content in grain Kg ha^{-1}		Nitrogen content in straw Kg ha^{-1}		Phosphorus content in grain Kg ha^{-1}		Phosphorus content in straw Kg ha^{-1}		Potash content in grain Kg ha^{-1}		Potash content in straw Kg ha^{-1}	
Phosphorus level Kg ha^{-1}	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
0	11.57	11.81	1.79	1.82	0.63	0.65	0.32	0.33	0.14	0.17	0.31	0.32	0.45	0.47
30	12.07	12.29	1.95	1.97	0.66	0.68	0.34	0.35	0.15	0.17	0.33	0.34	0.47	0.49
60	12.23	12.44	2.02	2.04	0.67	0.69	0.35	0.36	0.15	0.18	0.33	0.34	0.48	0.50
90	12.73	12.86	2.05	2.07	0.69	0.71	0.36	0.37	0.16	0.18	0.34	0.35	0.49	0.51
S.Em±	0.18	0.10	0.07	0.07	0.009	0.009	0.006	0.006	0.002	0.002	0.004	0.004	0.006	0.007
CD.at 5%	0.52	0.42	NS	NS	0.02	0.02	0.001	0.01	0.006	0.005	0.01	0.01	0.01	0.01
Sulphur level Kg ha^{-1}														
0	11.58	11.81	1.85	1.87	0.63	0.65	0.32	0.33	0.14	0.17	0.32	0.32	0.45	0.47
15	11.99	12.21	1.92	1.94	0.66	0.68	0.34	0.35	0.15	0.17	0.33	0.34	0.47	0.49
30	12.23	12.44	2.01	2.04	0.67	0.69	0.34	0.36	0.15	0.18	0.33	0.34	0.48	0.50
45	12.81	12.94	2.03	2.05	0.70	0.72	0.36	0.38	0.16	0.18	0.35	0.36	0.50	0.52
S.Em±	0.18	0.14	0.07	0.07	0.009	0.009	0.006	0.006	0.002	0.002	0.004	0.004	0.006	0.007
CD.at 5%	0.52	0.41	NS	NS	0.02	0.02	0.01	0.01	0.006	0.005	0.01	0.01	0.01	0.01

Table 2: Phosphorus and sulphur uptake as affected by phosphorus and sulphur

Treatment	Phosphorus uptake in grain kg ha^{-1}		Phosphorus uptake in straw kg ha^{-1}		Sulphur uptake in grain kg ha^{-1}		Sulphur uptake in straw kg ha^{-1}	
Phosphorus level Kg ha^{-1}	**2020-21**	**2021-22**	**2020-21**	**2021-22**	**2020-21**	**2021-22**	**2020-21**	**2021-22**
0	9.77	10.64	6.15	7.30	9.02	9.13	9.21	9.28
30	11.57	12.81	6.89	8.16	10.77	10.84	10.83	10.88
60	13.03	14.32	7.64	9.02	12.90	12.97	12.98	13.10
90	14.11	15.37	7.94	9.39	13.97	13.99	13.98	14.07
S.Em±	0.40	0.39	0.19	0.21	0.55	0.57	0.44	0.46
CD.at 5%	1.16	1.13	0.54	0.63	1.63	1.81	1.33	1.39
Sulphur level Kg ha^{-1}								
0	9.84	10.96	6.24	7.56	9.01	9.16	9.25	9.32
15	12.64	12.83	6.95	8.30	10.69	10.74	10.98	11.03
30	11.54	13.71	7.28	8.56	12.88	12.93	12.94	13.01
45	14.46	15.63	8.14	9.45	13.90	13.97	13.96	14.11
S.Em±	0.40	0.39	0.19	0.21	0.49	0.50	0.51	0.53
CD.at 5%	1.16	1.13	0.56	0.63	1.48	1.51	1.55	1.60

Nutrient uptake

The highest phosphorus uptake (Table-2) by grain (14.11 and 15.37 kg ha^{-1}) and by straw (7.94 and 9.39 kg ha^{-1}) were recorded with application of 90 kg P_2O_5 ha^{-1}., which was found at par with 60 kg P_2O_5 ha^{-1} and significantly higher over 30 and 0 kg P_2O_5 ha^{-1}. These results were confirmed by the findings of Assefa, *et al*. (2021) [2] The highest phosphorus uptake (Table-2) by grain (14.46 and 15.63 kg ha^{-1}) and by straw (8.14 and 9.45 kg ha^{-1}) were recorded with application of 45 kg S ha^{-1}., which was found at par with 30 kg S ha^{-1} and significantly higher over 30 and 0 kg S ha^{-1}. These results were confirmed by the findings of Akram, *et al*. (2022) [1].

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