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Shaik Wasim Akram
M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Rajesh Singh
Assistant Professor, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Pratyasha Tripathi
Assistant Professor, Department of Mathematics and Statistics, Faculty of Science, SHUATS, Prayagraj, Uttar Pradesh, India

Gera Roopa Lavanya
Associate Professor, Department of Genetics and plant Breeding, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Shaik Wasim Akram
M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of Phosphorus and Sulphur on yield and economics of Wheat (*Triticum aestivum* L.)

Shaik Wasim Akram, Rajesh Singh, Pratyasha Tripathi and Gera Roopa Lavanya

Abstract
A field experiment was conducted during *Rabi* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice on the basis of one year experimentation. The treatments which are T_1: Phosphorus 40 kg/ha + Sulphur 20 kg/ha, T_2: Phosphorus 40 kg/ha + Sulphur 30 kg/ha, T_3: Phosphorus 40 kg/ha + Sulphur 40 kg/ha, T_4: Phosphorus 60 kg/ha + Sulphur 20 kg/ha, T_5: Phosphorus 60 kg/ha + Sulphur 30 kg/ha, T_6: Phosphorus 60 kg/ha + Sulphur 40 kg/ha, T_7: Phosphorus 80 kg/ha + Sulphur 20 kg/ha, T_8: Phosphorus 80 kg/ha + Sulphur 30 kg/ha, T_9: Phosphorus 80 kg/ha + Sulphur 40 kg/ha are used. The results showed that application of Phosphorus 80 kg/ha + Sulphur 40 kg/ha was recorded significantly higher plant height (96.47 cm), No, of Tillers/hill (10.47), Plant dry weight (18.54 g/plant), Grains/spike (47.36), Test weight (38.59 g), Grain yield (6.25 t/ha), Straw yield (9.54 t/ha), and Harvest index (39.58 %), Higher gross returns (Rs.99,187.50/ha), net return (Rs.67,049.40/ha), and benefit cost ratio (2.08), was obtained in the treatment of Phosphorus 80 kg/ha + Sulphur 40 kg/ha as compared to other treatments.

Keywords: Wheat, Phosphorus, Sulphur, yield, Economics

Introduction
Wheat (*Triticum aestivum* L.), which triggered Green revolution in the Indian subcontinent, is an important food grain providing nourishment nearly to 35 per cent people of the world. On global scale, the crop is grown over an area of 211.06 million ha with a production of 566.8 million tonnes. India is the second largest producer of wheat in the world next only to China and the crop has provided the fastest pace of growth to Indian agriculture. Among cereals, wheat is next to rice in area (24.23 million ha) and production (75.6 million tonnes) (Jagshoran *et al*., 2004) [6]. Wheat contributes about 60 per cent of daily protein requirement and more calories to world diet than any other food crop (Mattern *et al*., 1970) [8]. As main staple food, wheat continues to assume greater significance in the years to come both from grain productivity as well as quality point of view. Wheat is one of the most important cereal crops of India with diverse uses. Intensive cultivation has resulted in depletion of soil nutrients to a great extent thus nutrients requirement of crops has increased considerably during the last few years.

Phosphorus is the second most essential plant nutrient which plays a major role for achieving the maximum crop production. It plays a vital role in several physiological processes *viz.* photosynthesis, respiration, energy storage and cell division/ enlargement. It is also an important structural component of many biochemicals *viz*. nucleic acid (DNA and RNA enzymes and co-enzymes) and also stimulates root growth and associated with early maturity of crops (Khan *et al*., 2007) [7].

Sulphur is another one of the essential nutrients in all plant nutrients and component of amino acids which are the building block of protein. In the cereal crops, sulphur contain in the ranges from 0.16-0.20%. Sulphur performs many physiological functions like synthesis of sulphur containing amino acids which have positive role in improving quality of grain (Chaudhary *et al*., 2003) [1]. Sulphur is a structural constituent of organic compounds, some of which are uniquely synthesized by plants, providing human and animals with essential amino acids (methionine cystine and cysteine). It is involved in chlorophyll formation, activation of enzymes and is a part of vitamins biotin and thiamine (B1) (Hegde and Sudhakara babu, 2007) [4]. Sulphur deficiency in crops is gradually becoming widespread due to continuous use of sulphur free fertilizers, high yielding crop varieties, intensive multiple cropping systems coupled with higher productivity.

Materials and Methods

The experiment was carried out during *Rabi* season of 2021 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (Allahabad) which is located at 25o 24' 42" N latitude, 81o50' 56" E longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of nine treatments with T_1: Phosphorus 40 kg/ha + Sulphur 20 kg/ha, T_2: Phosphorus 40 kg/ha + Sulphur 30 kg/ha, T_3: Phosphorus 40 kg/ha + Sulphur 40 kg/ha, T_4: Phosphorus 60 kg/ha + Sulphur 20 kg/ha, T_5: Phosphorus 60 kg/ha + Sulphur 30 kg/ha, T_6: Phosphorus 60 kg/ha + Sulphur 40 kg/ha, T_7: Phosphorus 80 kg/ha + Sulphur 20 kg/ha, T_8: Phosphorus 80 kg/ha + Sulphur 30 kg/ha, T_9: Phosphorus 80 kg/ha + Sulphur 40 kg/ha are used. The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg/ha), higher available P (19.50 kg/ha) and medium available K (213.7 kg/ha). In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were No. of grains/spike, grain yield, stover yield and harvest index were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984) [2].

Results and Discussion

Yield attributes and Yield

Number of grains/spikes

Significantly Maximum Number of Grain/spike (47.36) was recorded with the treatment of application of Phosphorus 80 kg/ha + Sulphur 40 kg/ha over all the treatments. However, the treatments Phosphorus 60 kg/ha + Sulphur 40 kg/ha (46.89) and Phosphorus 80 kg/ha + Sulphur 30 kg/ha (47.15) which were found to be statistically at par with Phosphorus 80 kg/ha + Sulphur 40 kg/ha.

Application of Phosphorus increased the number of grains/spikes might be due to the enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more tillers which consequently increased the number of grains bearing tillers significantly. Similar findings were observed by Islam *et al.* (2017) [5].

Test weight (g)

Significantly highest Test weight (38.59 g) was recorded with the treatment of application of Phosphorus 80 kg/ha + Sulphur 40 kg/ha over all the treatments. However, the treatments Phosphorus 60 kg/ha + Sulphur 40 kg/ha (38.15 g) and Phosphorus 80 kg/ha + Sulphur 30 kg/ha (38.40 g) which were found to be statistically at par with Phosphorus 80 kg/ha + Sulphur 40 kg/ha.

Higher vigour and growth attained by the plants due to sufficient absorption of nutrients might have resulted in higher test weight Noonari *et al*. (2016) [9].

Increase in value of yield contributing characters with higher doses of sulphur was due to the facts that the adequate sulphur was available during the entire period of crop growth for better vegetative growth and development of wheat. The results were found to be similar with Sharma *et al.* (2003) [11].

Grain yield (t/ha)

Significantly highest Grain yield (6.25 t/ha) was recorded with the treatment application of Phosphorus 80 kg/ha + Sulphur 40 kg/ha over all the treatments. However, the treatments with (6.02 t/ha) in Phosphorus 60 kg/ha + Sulphur 40 kg/ha and with (6.18 t/ha) in Phosphorus 80 kg/ha + Sulphur 30 kg/ha which were found to be statistically at par with Phosphorus 80 kg/ha + Sulphur 40 kg/ha.

The increase in grain yield due to phosphorus application is attributed to source and sink relationship. It appears that greater translocation of photosynthates from source to sink might have increased seed yield. Phosphorus increases yield due to its well-developed root system, increased N fixation and its availability to the plants and favourable environments in the rhizosphere. The results were in according with Sandana and Pinochet (2014) [10].

The increment in number of grains/spikes with increasing dose of sulphur application might be better for root growth, cell multiplication, elongation and cell expansion in the plant body by higher dose of sulphur application, which ultimately increased the grain yield. The results were found to be similar with Yadav *et al.* (2004) [13].

Stover yield (t/ha)

Significantly highest Straw yield (9.54 t/ha) was recorded with the treatment application of Phosphorus 80 kg/ha + Sulphur 40 kg/ha over all the treatments. However, the treatments with (9.22 t/ha) in Phosphorus 60 kg/ha + Sulphur 40 kg/ha and with (9.44 t/ha) in Phosphorus 80 kg/ha + Sulphur 30 kg/ha which were found to be statistically at par with Phosphorus 80 kg/ha + Sulphur 40 kg/ha.

Straw yield is dependent on vegetative growth as use of balanced and optimum use of fertilizer increased plant height, green leaves per hill, and dry matter production, which finally resulted in higher straw yield. The results were in accordance with Sharma *et al.* (2011) [12].

Harvest index (%)

Significantly highest Harvest index (39.58 %) was recorded with the treatment application of Phosphorus 80 kg/ha + Sulphur 40 kg/ha. However, the treatments Phosphorus 60 kg/ha + Sulphur 30 kg/ha (39.10 %), Phosphorus 60 kg/ha + Sulphur 40 kg/ha (39.49 %) and Phosphorus 80 kg/ha + Sulphur 30 kg/ha (39.56 %) which were found to be statistically at par with phosphorus 80 kg + Sulphur 40 kg/ha Highest harvest index was observed due to improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth and yield attributes of the crops probably due to more absorption and utilization of available nutrients leading to overall improvement of crop growth reflected to source-sink relationship, which in turn enhanced the yield attributes that ultimately more yield which was reported by Hadiya and Shah (2014) [3].

Economics

Gross returns, Net returns and Benefit cost ratio were significantly influenced due to different treatments.

Gross returns

Higher Gross returns have been recorded with the Phosphorus 80 kg/ha + Sulphur 40 kg/ha (Rs.99,187.50/ha) over rest of the treatments followed by Phosphorus 80 kg/ha + Sulphur 30 kg/ha (Rs.93,441.60/ha) whereas minimum gross return was recorded with Phosphorus 40 kg/ha + Sulphur 20 kg/ha (Rs.60,333.28/ha).

Net returns

Higher Net returns have been recorded with the treatment Phosphorus 80 kg/ha + Sulphur 40 kg/ha (Rs.67,049.40/ha) over rest of the treatments followed by Phosphorus 80 kg/ha + Sulphur 30 kg/ha (Rs.62,215.86/ha) whereas minimum Net returns was recorded with Phosphorus 40 kg/ha + Sulphur 20 kg/ha (Rs.32,209.89/ha).

Benefit cost ratio

Higher Benefit cost ratio have been recorded with the treatment Phosphorus 80 kg/ha + Sulphur 40 kg/ha (2.08) over rest of the treatments followed by Phosphorus 80 kg/ha + Sulphur 30 kg/ha (1.99) whereas lower Benefit cost ratio was recorded with Phosphorus 40 kg/ha + Sulphur 20 kg/ha (1.14).

Table 1: Effect of Phosphorus and Sulphur on Yield attributes and Yield of Wheat

Treatments	Grains/spike	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
Phosphorus 40 kg/ha + Sulphur 20 kg/ha	45.17	36.81	5.23	8.39	38.38
Phosphorus 40 kg/ha + Sulphur 30 kg/ha	45.43	37.05	5.35	8.54	38.50
Phosphorus 40 kg/ha + Sulphur 40 kg/ha	46.28	37.76	5.63	8.91	38.70
Phosphorus 60 kg/ha + Sulphur 20 kg/ha	45.60	37.37	5.47	8.65	38.71
Phosphorus 60 kg/ha + Sulphur 30 kg/ha	46.54	38.02	5.80	9.04	39.10
Phosphorus 60 kg/ha + Sulphur 40 kg/ha	46.89	38.15	6.02	9.22	39.49
Phosphorus 80 kg/ha + Sulphur 20 kg/ha	45.89	37.52	5.53	8.74	38.72
Phosphorus 80 kg/ha + Sulphur 30 kg/ha	47.15	38.40	6.18	9.44	39.56
Phosphorus 80 kg/ha + Sulphur 40 kg/ha	47.36	38.59	6.25	9.54	39.58
S. Em (±)	0.18	0.18	0.11	0.07	0.28
CD (P = 0.05)	0.53	0.54	0.32	0.21	0.85

Table 2: Effect of Phosphorus and Sulphur on Economics of Wheat

	Treatments	Cost of cultivation	Gross returns	Net returns	B:C Ratio
1.	Phosphorus 40 kg/ha + Sulphur 20 kg/ha	28,123.39	60,333.28	32,209.89	1.14
2.	Phosphorus 40 kg/ha + Sulphur 30 kg/ha	29,005.74	64,858.05	35,852.31	1.23
3.	Phosphorus 40 kg/ha + Sulphur 40 kg/ha	29,888.10	76,342.80	46,454.70	1.55
4.	Phosphorus 60 kg/ha + Sulphur 20 kg/ha	29,248.39	68,571.92	39,323.53	1.34
5.	Phosphorus 60 kg/ha + Sulphur 30 kg/ha	30,130.74	81,200.00	51,069.26	1.69
6.	Phosphorus 60 kg/ha + Sulphur 40 kg/ha	31,013.10	87,470.60	56,547.50	1.82
7.	Phosphorus 80 kg/ha + Sulphur 20 kg/ha	30,373.39	72,553.60	42,180.21	1.38
8.	Phosphorus 80 kg/ha + Sulphur 30 kg/ha	31,255.74	93,441.60	62,215.86	1.99
9.	Phosphorus 80 kg/ha + Sulphur 40 kg/ha	32,138.10	99,187.50	67,049.40	2.08

Conclusion

It is concluded that application of treatment Phosphorus 80 kg/ha + Sulphur 40 kg/ha was recorded significantly higher Grain yield (6.25t/ha) higher gross returns (Rs.99,187.50/ha), net returns (Rs.67,049.40/ha) and benefit cost ratio (2.08) as compared to other treatments. Since, the findings based on the research done in one season.

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