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Effect of different doses of phosphorus and sulphur application on growth and yield of dwarf wheat (*Triticum aestivum* L.)

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Abstract
The present investigation entitled "Effect of Different Doses of Phosphorus and Sulphur application on growth and yield of Dwarf Wheat (*Triticum aestivum* L.)." was conducted at Crop Research Form of National Post Graduate college, Barhalganj, Gorakhpur, U. P. during Rabi season of 2020-21 and 2021-22 with an objective to study the effect of Phosphorous and Sulphur on growth, yield and economics of wheat (*Triticum aestivum L.*). The soil of the experimental filled 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 Randomized 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*-plant height, number of tillers, leaf area index and dry matter acumulation and yield parameters *viz*-length of spike, number of grains spike^{-1} and test weight and grain yield, straw yield, harvest index, gross return (Rs ha $^{-1}$), net return (Rs ha $^{-1}$) and B:C ratio. respectively, while Sulphur-45 kg ha^{-1} gave significantly highest value in terms of plant height, number of tillers, leaf area index and dry matter acumulation and yield parameters *viz*-length of spike, number of grains spike^{-1} and test weight and grain yield, straw yield, harvest index, gross return (Rs ha $^{-1}$), net return (Rs ha $^{-1}$) and B:C ratio over rest of the treatment during both the years, respectively. Phosphorous (90 kg ha^{-1}) and Sulphur (45 kg ha^{-1}) increased significantly the growth parameters, yield attributes and yield of wheat crop during both the years of experiment.

Keywords: Wheat, phosphorous, sulphur, fertilizer, growth parameters, yield attributing parameters, yield, protein content.

Introduction
The way India increase the wheat production and help the food security system through "Wheat Revolution" is worth to be remembered. It was felt that wheat revolution and green revolution have made it self-sufficient in food grains and that there will be no going back to old import days, when the food economy was either "Ship to mouth" or "Field to mouth". Wheat (*Triticum aestivum* L.) is the world's most largest cultivated crops and a vital strategic crop for the word belongs to the family Poaceae. In India, Wheat is grown approximately 31.4 million hectares, yielding about 113.29 millian tonnes with a production of 35.20 q ha^{-1} (USDA, 2023-24). Specifically, in Uttar Pradesh, wheat was calculated over an area of 32.76 million hectare, producing 117.59 million tonnes with a productivity of 35.87 q ha^{-1} during 2023-24 (UP Ag, 2023-24).Soil is an indispensable factor for plant growth which provide nutrients as well as moisture to crop beside this, gives mechanical anchorage to stand crop. Among the different important resources of crop-production, requirement of nutrients is well established fact for increasing crop growth, development and yields. Phosphorus plays a diversified role in crop development such as photosynthesis, respiration, development of reproductive part, root growth, increases the number of tillers in cereals, increase the ratio of grain to straw and stimulating the flowering, fruit setting and seed formation etc. (Sharma and Prasad, 2003) [5].

Sulphur (S) is one of the seventeenth nutrient elements and now recognised as a fourth major nutrient in addition to N,P, and K, which are essential for the growth and development of plants. Sulphur is essential for protein production and involved in the formation of chlorophyll, activation of enzyme and in the formation of glucosides. Sulphur improves crop yield, oil percentage in oil seed, plant protein, cereal quality for miling and baking. (Mengal and Kirby 1987) [3]. Among the various ingredients of crop production, Phosphorous and Sulphur are of immense importance and therefore need special attention to exploit full yield potential of wheat. However, scientific data on these aspects are very meagre. Keeping these facts in view, the present field trial was conducted.

Materials and Methods

The field experiment was carried out at the Crop Research Farm of National Post Graduate College, Barhalganj, Gorakhpur, U.P. during rabii 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 loam 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 07-04-2021.

Results and Discussion

Effect of Phosphorous

An experiment was conducted to observe the influence of Phosphorous on growth and yield of wheat. The data pertaining to growth, yield and economics along with statistical interpretations are presented and discussed. The data (Table 1) revealed that Phosphorous had a significant effect on wheat growth parameters *viz*-plant height, number of tillers, leaf area index and dry matter acumulation and yield parameters (Table-2) *viz*-length of spike, number of grains $spike^{-1}$ and test weight and grain yield, straw yield, harvest index and protein content. Results clearly indicates that maximum crop growth parameter *viz*-plant height (97.04 cm and 97.33 cm), number of tillers (297.90 and 307.41), leaf area index (4.78 and 4.93) and dry matter acumulation (856.46 and 818.23 g) and yield attributing characters *viz*-length of spike (10.61 and 11.19 cm), number of grains $spike^{-1}$ (39.67 and 39.76) and test weight (40.20 and 40.90 g) and grain yield (38.27 and 40.48 q ha^{-1}), straw yield (49.11 and 50.60 q ha^{-1}), harvest index (43.73 and 44.40) and protein content (12.73 and 12.86%) were recorded with the Phosphorous-90 kg per ha, which were significantly superior over 0, 30 kg P ha^{-1} but at par with 60 kg P ha^{-1} during both the years, respectively. It is due to fact that Phosphorus is essential for root development and translocation of photosynthates and being the constitution of nucleic acid, python and phospholipids, its application increase different growth parameters (Dewal and Prateek 2004) [1] and (Singh, *et al*. 2025) [6]. Phosphorus significantly increases yield attributing characters and yield by improving root development, nutrient uptake and photosynthetic activity, all of which are essential for biomass production and growth of crop (Madhavadia, *et al*., 2023) [4]. (Table 1).

Effect of Sulphur

An experiment was conducted to observe the influence of Sulphur on growth and yield of wheat. The data pertaining to growth parameter and yield and yield attributing parameters along with statistical interpretation are presented and discussed. The data (Table 1) revealed that Sulphur had a significant effect on wheat growth parameters *viz*-plant height, number of tillers, leaf area index and dry matter acumulation and yield parameters (Table-2) *viz*-length of spike, number of grains $spike^{-1}$ and test weight and grain yield, straw yield, harvest index and protein content. Results clearly indicates that maximum crop growth parameter *viz*-plant height (97.99 and 98.62 cm number of tillers (313.73 and 313.88), leaf area index (4.97 and 5.01) and dry matter acumulation (830.12 and 840.31 g) and yield attributing characters *viz*-length of spike (10.41 and 10.99 cm), number of grains $spike^{-1}$ (39.96 and 40.97) and test weight (40.27 and 41.00) and grain yield (38.93 and 40.80 q ha^{-1}), straw yield (50.11 and 50.70 q ha^{-1}) harvest index (43.60 and 44.44) and protein content (12.81 and 12.94) were recorded with the Sulphur-45 kg ha^{-1}, which were significantly superior over 0, 15 kg S ha^{-1} but at par with 30 kg ha^{-1} during both the years, respectively. It is due to fat that sulphur is a component of amino acid and plays a prominent role in the synthesis of proteins and other vital molecules. Sulphurs availability is essential for photosynthesis and metabolic process that drive plant growth and biomass production. The results are in closed agreement with the findings of Ghanshai S, (2022) [2].

Table 1: Effect of different phosphorus and sulphur levels on plant height, number of tillers, leaf area index, and dry matter accumulation during 2020-21 and 2021-22.

Treatment	Plant height (cm)		Number of tillers (m^2)		Leaf area index		Dry matter acumulation	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Phosphorus level (Kg ha^{-1})								
0	83.29	86.18	196.56	203.18	3.24	3.59	637.93	587.78
30	89.08	89.03	241.37	244.25	3.86	4.10	731.77	682.15
60	94.78	94.85	277.28	280.14	4.49	4.58	812.90	802.89
90	97.04	97.33	297.90	307.41	4.78	4.93	856.46	818.23
S.Em±	1.94	1.93	8.77	8.97	0.21	0.16	17.22	19.26
C.D. at 5%	5.59	5.58	25.34	25.89	0.62	0.47	49.73	55.62
Sulphur level (Kg ha^{-1})								
0	84.15	85.51	186.13	194.89	3.21	3.66	649.63	603.26
15	89.75	89.93	244.68	250.93	3.94	4.10	761.86	711.32
30	92.30	93.32	268.57	275.28	4.26	4.43	797.44	736.16
45	97.99	98.62	313.73	313.88	4.97	5.01	830.12	840.31
S.Em±	1.94	1.93	8.77	8.97	0.21	0.16	17.22	19.26
C.D at 5%	5.59	5.58	25.34	25.89	0.62	0.47	49.73	55.62

Table 2: Effect of phosphorus and sulphur levels on yield attributes, yield, harvest index, and protein content during 2020-21 and 2021-22.

Treatment	Length of spike		Number of grains spike^{-1}		Test weight (g)		Grain yield (qha^{-1})		Straw yield (qha^{-1})		Harvest index (%)		Protein content (%)	
	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
Phosphorus level (Kg ha^{-1})														
0	8.99	9.49	28.63	30.33	35.73	36.30	30.43	31.96	41.20	41.85	42.59	43.37	11.57	11.81
30	9.84	10.37	32.78	34.12	37.03	37.73	33.65	35.98	44.53	45.70	42.93	44.05	12.07	12.29
60	10.47	11.06	36.87	38.75	39.50	40.20	35.73	38.13	48.84	50.03	43.11	44.07	12.23	12.44
90	10.61	11.19	39.67	39.76	40.20	40.90	38.27	40.48	49.11	50.60	43.73	44.40	12.73	12.86
S.Em±	0.13	0.14	1.07	1.10	1.01	1.02	0.95	0.85	1.12	1.11	0.76	0.67	0.18	0.10
C.D. at 5%	0.39	0.40	3.08	3.18	3.03	3.05	2.74	2.45	3.22	3.21	**NS**	**NS**	0.52	0.42
Sulphur level (Kg ha^{-1})														
0	9.51	10.04	28.12	29.86	35.45	36.00	30.70	32.89	41.86	43.36	42.36	43.25	11.58	11.81
15	9.96	10.50	33.62	34.84	37.05	37.10	31.75	36.31	45.11	46.64	42.82	43.83	11.99	12.21
30	10.02	10.58	36.25	37.29	39.30	40.00	36.20	38.43	46.60	47.49	43.58	44.37	12.23	12.44
45	10.41	10.99	39.96	40.97	40.27	41.00	38.93	40.80	50.11	50.70	43.60	44.44	12.81	12.94
S.Em±	0.13	0.14	1.07	1.10	1.03	1.05	0.95	0.85	1.12	1.11	0.76	0.67	0.18	0.14
C.D at 5%	0.39	0.40	3.08	3.18	3.08	3.13	2.74	2.45	3.22	3.21	**NS**	**NS**	0.52	0.41

Economics feasibility

To examine the economic feasibility and viability of different treatments under investigation, economics of wheat crop in terms of gross return (Rs ha^{-1}), net return (Rs ha^{-1}) and B : C ratio were calculated for different treatment combination and the outcome is presented in Table-3. It is obvious from the above table that the treatment P_3 S_3 i. e. 90 kg P_2 O_5 ha + 45 kg S ha registered highest gross return (Rs 1,08102.15 and 1,16274.92 ha^{-1}), net return (Rs 63797.99 and 69008.69 ha^{-1}),) and B : C ratio (1.44 and 1.46). This might be due to higher yield with the treatment compared to other treatments.

Table 3: Effect of treatments on gross return, net return, and benefit-cost ratio during 2020-21 and 2021-22.

Grass return (₹)		Net return (₹)		Benefit cost ratio B:C Re^{-1} invested	
2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
66094.17	71767.59	28962.61	31673.96	0.78	0.79
68929.33	73911.94	31056.07	33076.61	0.82	0.81
71438.50	76502.56	32823.09	34925.08	0.85	0.84
73654.73	79617.30	34267.17	37267.67	0.87	0.88
73682.55	79727.90	34902.26	37985.54	0.90	0.91
82600.95	89216.52	43078.96	46732.46	1.09	1.10
84957.33	91635.56	44693.19	48413.35	1.11	1.12
90623.90	98049.44	49617.61	54081.08	1.21	1.23
92987.22	100233.90	52557.99	56842.60	1.30	1.31
95104.84	102830.66	53933.91	58697.90	1.31	1.33
98914.86	104110.30	57001.78	59235.15	1.36	1.32
98961.75	106290.63	56305.82	60672.33	1.32	1.33
96779.76	104042.93	54701.60	59002.70	1.30	1.31
100530.89	105298.46	57011.02	59516.52	1.31	1.30
101499.48	108866.34	57937.47	62342.26	1.33	1.34
108102.15	116274.92	63797.99	69008.69	1.44	1.46

Conclusion

Based on the experimental findings, it is explained that Phosphorous-90 kg P_2O_5 ha and Sulphur-45 kg P_2O_5 ha has been proved significantly best treatment among the different treatments of experiment to exploit the maximum yield. Hence, it is calculated that 90 kg P_2O_5 ha^{-1} + 45 kg S per ha can be used as remunerative strategy and can be practiced in a eastern Uttar Pradesh.

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