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Effect of Soil Test Crop Response Approach on Yield, Nutrient Content and Uptake by Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during *Rabi* season of 2018-19 under AICRP project on Soil Test Crop Response at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner to find out the effect of soil test crop response approach on yield, nutrient content and uptake of wheat. The experiment was laid out in randomized block design with five treatment combinations *viz.* general recommendation dose, soil test crop response recommendation for target yield 30 q ha^{-1}, soil test crop response recommendation for target yield 30 q ha^{-1} with integrated plant nutrient system, soil test crop response recommendation for target yield 40 q ha^{-1} and soil test crop response recommendation for target yield 40 q ha^{-1} with integrated plant nutrient system with four replications. Research finding of long term field experiment revealed that application of soil test crop response recommendation for target yield 40 q ha^{-1} with integrated plant nutrient system gave maximum number of effective tillers m^{-1} row length, spike length, number of grains $spike^{-1}$, weight of grains $spike^{-1}$, test weight, grain yield (4026 kg ha^{-1}) and straw yield (5629 kg ha^{-1}) of wheat which was found statistically at par with soil test crop response recommendation for target yield 30 q ha^{-1} with integrated plant nutrient system. Application of soil test crop response recommendation for target yield 40 q ha^{-1} with integrated plant nutrient system also improved the N, P and K content and their uptake by grain and straw of wheat. These study

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results proved that soil test crop response recommendation with integrated plant nutrient system gave better results of all parameters in the comparison of general recommendation dose and soil test crop response without integrated plant nutrient system.

Keywords: Growth; IPNS; nutrient; STCR; wheat; yield.

1. INTRODUCTION

Among the different food crops, role of cereals are highest towards transformation of Indian agriculture from deficit to sufficiency. Wheat (*Triticum aestivum* L.) is an important crop cultivated for food and feed under a wide range of agro-climatic conditions in India. India stands in second position next to china in the world with regard to area and production of wheat. In India, wheat is grown on 29.14 million hectares with total production of 102.19 million tonnes with average productivity of 3507 kg ha^{-1} [1]. Rajasthan contributed 10.49 million tonnes of wheat from 3.0 million hectares area with productivity of 3501 kg ha^{-1} [1] to the national pool. Wheat productivity is highly variable within different agro-ecologies of India, due to variable climatic conditions, genotypes, seeding time and practices and other management practices [2].

The wheat crop contributed significantly in food grain production for ensuring nations food security. There are reports of decreasing crop yields which raised questions on sustainability of the wheat crop. The reasons behind stability of crop yields are not exactly known, though it has been found that changes in quantity and quality of soil organic matter and a gradual decline in the supply of soil nutrients are major responsible factors [3]. Long-term studies indicated that soil fertility is decreased mostly due to excessive removal of nutrients and inadequate refill through manures and fertilizers. Appropriate application of fertilizers based on soil test nutrient availability and crop response to fertilizer applied for specific target yield seems to be a good option to achieve targeted food grain production as well as reducing environmental degradation. Soil test crop response approach of fertilizer application involved both soil and plant analysis in a scientific basis that proved to be a refined and unique technique for most efficient use of fertilizer and soil nutrients. Several studies have documented effects of soil test crop response-based fertilizer recommendation with integrated plant nutrient system on soil nutrient status, soil organic carbon pools and potassium dynamics in soils. Soil test crop response approach is aiming at obtaining a basis for precise quantitative adjustment of fertilizer doses under varying soil test values and response conditions of the farmers and for targeted levels of crop production. According to soil test crop response-based research experiment results shown very close correlation between targeted yield ad yield actually obtained and an evidence of the usefulness of soil testing within limit of variation under field conditions [4]. Keeping all this point in mind the present investigation was conducted to determine the effect of Soil Test Crop Response approach on yield, nutrient content and uptake by wheat (*Triticum aestivum* L.).

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was carried out during *Rabi* season of 2018-19 under AICRP project on Soil Test Crop Response (STCR) at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner. Geographically, the study area is located at 28° 10′ N latitude, 73° 18′ E longitude and 223.88 meters above mean sea level and this region falls under agro-climatic zone I C of Rajasthan. The climate of this tract is typically arid nature by aridity of the atmosphere and some salinity in the rhizosphere with extremes of temperature in summers and winters. There is wide range of temperature in summer (40 °C to 48 °C) and in winter (-1 °C to 10 °C) with annual rainfall of 250-270 mm. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction.

2.2 Experimentation and Crop Husbandry

The experiment was laid out in Randomized Block Design with five treatment combinations *viz.* general recommendation dose (T_1), STCR recommendation for target yield 30 q ha^{-1} (T_2), STCR recommendation for target yield 30 q ha^{-1} with IPNS (T_3), STCR recommendation for target yield 40 q ha^{-1} (T_4) and STCR recommendation for target yield 40 q ha^{-1} with IPNS (T_5) and replicated four times. Standard crop production practice and methods were followed for weeding, fertilizer application and crop protection management to grow the crop.

2.3 Data Collection

Five plants were selected from net plot and tagged for measurement of number of effective tillers m^{-1} row length, spike length, number of grains $spike^{-1}$, weight of grains $spike^{-1}$, test weight, grain yield, straw yield and biological yield of wheat Numbers of effective tillers were counted in five randomly selected per meter row lengths in each plot at physiological maturity of the crop. These were averaged to record and express effective tillers per meter row length. Five spikes were taken randomly from the observational plants in each plot and their length (cm) was measured with meter scale from neck node to tip and their average was computed. Randomly selected five productive spike heads $plot^{-1}$ was threshed separately and grains were counted and average number of grains $spikes^{-1}$ was worked out. The grains from five spikes of the plants tagged already were collected, weighed and average weight of grains $spike^{-1}$ (g) was worked out. A seed sample was select from the produce of each of the net plot harvested and 1000 seeds were counted and weighed to record as test weight in grams. The grain yield of each net plot (inclusive of tagged plants) was recorded in kg $plot^{-1}$ and the threshed produce was converted as q ha^{-1}. Straw yield in kg $plot^{-1}$ was calculated by deducting the grain yield from biological yield per plot recorded earlier and expressed in q ha^{-1}. Grain and straw sample of wheat from individual plot was taken at the time of threshing for estimation of nutrients content. The samples were dried in oven and grind separately using grinder and N, P and K contents were determined by using standard methods. Nitrogen content was determined by colorimetric method using Nessler's reagent [5]. Nitrogen content was expressed as percentage. Phosphorus content was estimated by Vanadomolybdete phosphoric yellow colour method [6] and was expressed as percentage. Potassium content was obtained by flame photometer [7] and expressed as percentage. The uptake of nitrogen, phosphorus and potassium by grain, straw and total plant of wheat was calculated by following formula.

> Nutrient uptake (kg ha^{-1}) = Per cent nutrient content in grain or straw x Seed or straw yield (kg ha^{-1})

2.4 Statistical Analysis

The experimental data were subjected to statistical analysis by adopting appropriate method of analysis of variance assuming homogeneity, analysis of the data was carried out to establish the trend of treatments applied as per Gomez and Gomez [8]. Wherever, the F values were found significant at 5% level of probability, the critical difference (CD) values were computed for making comparison among the treatment means.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes and Yield

Analysis of data stated that different treatments bring significant effect on yield attributes *viz*. effective tillers m^{-1} row length, spike length, number of grains $spike^{-1}$, weight of grains $spike^{-1}$ and yields *i.e.* (grain and straw) of wheat (Table 1). The maximum values of effective tillers m^{-1} row length, spike length, number of grains $spike^{-1}$, weight of grains $spike^{-1}$ and yields *i.e.* (grain and straw) was obtained by treatment T_5 (STCR recommended for target yield 40 q ha^{-1} with IPNS). The data related to correlation study between grain yield and yield attributes showed that relationship between grain yield and yield attributes of wheat was also found positive and significant (Table 2). The reason behind improvement in yield parameters and yield of wheat with application of STCR based fertilizer recommendation for yield of the crop along with IPNS treatments in the comparison of normal recommendation and soil test-based treatments because steady and justifiable use of the inorganic fertilizers with FYM. The beneficial impact of fertilizers and organic manure (STCR recommended for target yield with IPNS) on wheat might be the availability of sufficient amount of plant nutrients to crop which resulted better uptake of nutrients, plant vigour and improved yield. By virtue of increased availability of nutrients, there might have been increment in dry matter with increasing fertilizer application and increased growth components due to improved fertilizer levels gave stability in higher supply of photosynthates towards the sink (grains $spike^{-1}$). As a result, all yields attributes of wheat increased significantly. The improvement in yield (grain and straw) might be due to improved nutritional environment in low status of N and P_2O_5 soil through increased supply of major nutrients which increase their uptake by plants led to enhanced growth and yield attributes, which ultimately resulted in increased yield (grain and straw) of the crop. Tiwari et al. [9], Sellamuthu et al. [10] and Singh et al. [11] were also noted similar results which support the results of present experiment.

Table 1. Effect of STCR approach on yield attributes and yield of wheat

Treatments	Yield attributes						Yield (q ha^{-1})	
	No. of effective tiller m^{-1} row length	No. of non-effective tiller m^{-1} row length	Spike length (cm)	No. of grains spike^{-1}	Grain weight spike^{-1} (g)	Test weight (g)	Grain yield	Straw yield
T_1	72.1	13.0	7.96	30.8	2.71	31.26	27.11	38.52
T_2	73.4	12.7	8.13	31.1	2.76	32.10	33.14	46.68
T_3	85.8	11.2	9.63	37.7	3.44	37.83	39.80	55.80
T_4	75.1	11.4	8.27	31.4	2.84	32.80	33.97	47.70
T_5	87.2	11.0	9.77	38.7	3.50	38.44	40.26	56.29
SEm±	2.53	0.36	0.36	0.36	0.15	1.76	1.64	2.12
CD (P = 0.05)	7.8	1.11	1.12	1.1	0.45	5.4	5.05	6.52

Table 2. Relationship between grain yield and yield attributes of wheat

	Grain yield	No. of effective tiller	No. of non-effective tiller	Spike length	No. of grains spike^{-1}	Grain weight spike^{-1}	Test weight
Grain yield	1						
No. of effective tiller	0.927*	1					
No. of non-effective tiller	0.932*	0.999**	1				
Spike length	0.923*	1	0.999**	1			
No. of grains spike^{-1}	0.894*	0.995**	0.995**	0.997**	1		
Grain weight spike^{-1}	0.916*	0.999**	0.998**	1	0.997**	1	
Test weight	0.980**	0.982**	0.984**	0.981**	0.965**	0.977**	1

Table 3. Effect of STCR approach on N, P and K content in grain, straw and their uptake by grain, straw and total plant of wheat

Treatments	N content (%)		N uptake (kg ha^{-1})			P content (%)		P uptake (kg ha^{-1})			K content (%)		K uptake (kg ha^{-1})		
	In grain	In straw	By grain	By straw	Total	In grain	In straw	By grain	By straw	Total	In grain	In straw	By grain	By straw	Total
T_1	1.64	0.67	35.4	25.7	61.1	0.542	0.225	14.6	8.7	23.3	0.442	1.09	12.0	42.1	54.1
T_2	1.53	0.61	50.8	28.4	79.2	0.492	0.202	16.3	9.5	25.7	0.394	1.01	13.0	46.9	59.9
T_3	1.68	0.69	66.8	38.3	105.0	0.588	0.252	23.4	14.0	37.4	0.447	1.15	17.8	64.2	82.0
T_4	1.60	0.63	54.3	29.9	84.2	0.546	0.230	18.6	11.0	29.5	0.407	1.06	13.8	50.8	64.6
T_5	1.72	0.71	69.3	40.0	109.2	0.593	0.256	23.9	14.4	38.3	0.458	1.17	18.4	65.9	84.4
SEm+	0.05	0.02	4.2	1.7	4.8	0.013	0.006	0.9	0.7	1.4	0.012	0.03	0.7	2.7	3.0
CD (P = 0.05)	0.14	0.06	12.9	5.3	14.9	0.040	0.018	2.6	2.1	4.3	0.037	0.10	2.1	8.2	9.4

3.2 Nutrient Content and Uptake

The significantly highest nitrogen, phosphorus and potassium content in grain and straw and their uptake in grain, straw and total plant of wheat (Table 3) was obtained with STCR recommended for target yield 40 q ha^{-1} with IPNS (T_5) which was superior to T_2 (STCR recommended for target yield 30 q ha^{-1}), and T_4 (STCR recommended for target yield 40 q ha^{-1}) but found at par with T_1 (general recommended dose) and T_3 (application of STCR recommended for target yield 30 q ha^{-1} with IPNS). The significant increase in nitrogen, phosphorus and potassium content in grain, straw and root and their uptake in grain, straw, root and total plant of wheat with the application of STCR recommended for target yield (40 q ha^{-1}) with IPNS could be due to improved nutrient supplying capacity of nutrients and flush of available nutrients on autolysis of microbial cells besides, improvement in biochemical parameters of soil. When organic manure is added to soil, complex nitrogenous compounds slowly break-down and make steady nitrogen, phosphorus and potassium supply throughout growth period of crop which might be attributed to more nutrient availability. The increase in nitrogen, phosphorus and potassium content in grain, straw and root of wheat with the application of fertilizers might be due to improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of N, P and K in plant parts which ultimately enhance the uptake of nutrient in all parts of plant. Similar finding has also been reported by [12] who reported positive influence of fertilizers and FYM on nitrogen content in grain and straw of wheat. Sawarkar et al. [13], Jat et al. [14] and Sharma et al. [15] has also been reported similar positive influence of inorganic fertilizers alone or in combination with organic manure.

4. CONCLUSION

Results of a long-term experiment concluded that STCR recommendation with IPNS on wheat brought an additive effect in increasing yield attributes, yield, nutrient content and nutrient uptake by wheat crop. Application of STCR recommended for target yield 40 q ha^{-1} with IPNS (T_5) gave maximum yield attributes, grain yield (4026 kg ha^{-1}), straw yield (5629 kg ha^{-1}), N, P and K content in grain and straw and their uptake in by grain, straw and total plant which was statistically found at par with treatment T_3 (STCR recommended for target yield 30 q ha^{-1} with IPNS). These study results proved that STCR recommended with IPNS gave better results of all parameters in the comparison of general recommended dose and STCR without IPNS.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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