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Research Paper

Preceding *kharif* crops and fertilizer influence on growth, yield and nutrient requirement of succeeding wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted during 2 consecutive rainy (*kharif*) and winter (*rabi*) season each of 2020–21 and 2021–22 at C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to study the effect of preceding *kharif* crops and fertilizer on growth, yield, economics and nutrient requirement of succeeding wheat (*Triticum aestivum* L.) crop. The experiment was laid out in split plot design comprising of 4 *kharif* crops, viz. greengram [*Vigna radiata* (L.) R. Wilczek], sesame (*Sesamum indicum* L.), pearl millet [*Pennisetum glaucum* (L.) R.Br.] and fodder sorghum [*Sorghum bicolor* (L.) Moench] as main plots and 5 fertilizer treatments, viz. 100% RDF (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha); 75% RDF; 50% RDF; 75% RDF + *Azotobacter* + PSB (phosphate solubilizing bacteria); and 50% RDF + *Azotobacter* + PSB as sub plots with four replications. Wheat grown after *kharif* greengram had better growth parameters and yield attributes which was reflected in an increase in grain (4.78 t/ha) and straw (6.41 t/ha) yield of wheat. Among different fertilizer treatments, wheat fertilized with 100% RDF recorded significantly higher grain (4.60 t/ha) and straw yield (6.20 t/ha). Nutrient uptakes by grain and straw increased under wheat grown after greengram and fertilized with 100% RDF. Greengram-wheat crop sequence and wheat fertilized with either 100% RDF or 75% RDF along with *Azotobacter* + PSB seed inoculation earned higher net realization and B:C ratio.

Key words: *Azotoacter*, Fertilizer, Preceding crops, Succeeding wheat, Yield

Wheat (*Triticum aestivum* L.) is the second most important crop after rice in country, which contributes nearly one third of the total food grain production. The nutritive value of wheat is fairly high as compared to other cereals. Wheat contains more protein than other cereals and providing the characteristics substance "Gluten" which is very essential for bakers. Now it is increasingly realized that when crops are grown in system, the fertilizer needs of an individual crop cannot be precisely determined without taking into account the nature of preceding crop, it's yield level and residual effect of fertilizer application. Wheat generally follows rainy season crops, viz. pulses, paddy, maize, sorghum and pearl millet. Cereal-cereal is the most important cropping system which meets the feed pool of the nation. However, the cultivation of cereals in a year on the same piece of land leads to imbalance in the soil fertility, resulting in decline in yield of both the crops. Cultivation of nutrient exhaustive crops in the sequence without adequate nutrient management led to deterioration in soil health as well as productivity. Several studies have shown that crop yield and product quality are usually improved when legumes are grown as a preceding crop. Legume and crop residues play a unique role in preserving soil fertility. Maintaining soil fertility and use of plant nu-trients in sufficient and balanced amount is one of the key factors to increasing crop yield. Nitrogen, phosphorus and potassium are primary nutrients in crop nutrition. Biofertilizers are microorganisms which have the ability to mobilize plant nutrients in the soil and are cost effective, eco-friendly source to boost productivity. Under such condition, proper selection of suitable crops in the cropping system and supply of balanced nutrients through appropriate sources can not only meet the nutrient requirement of the crops but also aid in sustaining the soil fertility. Keeping these points in view, the present experiment was conducted to study the effect of preceding *kharif* crops on growth, yield and nutrient requirement of succeeding wheat.

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MATERIALS AND METHODS

An experiment was conducted during 2 consecutive rainy (*kharif*) and winter (*rabi*) season each of 2020–21 and 2021–22 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (24°-19' North and 72°-19' East with an elevation of 154.52 metre amsl), Gujarat. The climate of Sardarkrushinagar is subtropical monsoon type and comes under semi-arid region. The soil of experimental field was loamy sand having *p*H 7.56 and slightly alkaline in reaction. The soil was low in organic carbon (0.16%) and available nitrogen (159.2 kg/ha) estimated by Alkaline permanganate method; medium in available phosphorus (34.0 kg/ha by Olsen's method); and high in potassium (240.0 kg/ha, by Flame photometer method).

The experiment was laid out in a split plot design comprising of 4 preceding *kharif* crops, viz. C_1, Greengram [*Vigna radiata* (L.) R. Wilczek]; C_2, Sesame (*Sesamum indicum* L.); C_3, Pearl millet [*Pennisetum glaucum* (L.) R.Br.]; and C_4, Fodder sorghum [*Sorghum bicolor* (L.) Moench] allocated to the main plots; and 5 fertilizer treatment for succeeding wheat, viz. F_1, 100% RDF (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha); F_2, 75% RDF; F_3, 50% RDF; F_4, 75% RDF + *Azotobacter* + PSB (phosphate solubilizing bacteria); and F_5, 50% RDF + *Azotobacter* + PSB in subplots, replicated four times in a gross plot size of 5.0 m × 4.5 m. The *kharif* crops were sown in July with recommended package of practices and succeeding wheat crop variety 'GW 451' was sown in November during both the years. After harvesting of preceding *kharif* crops, sowing of wheat was done with recommended seed rate of 120 kg/ha by maintaining 22.5 cm distance between the rows. The recommended dose of fertilizer for wheat (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha) was applied basal in the form of urea, diammonium phosphate and muriate of potash as per fertilizer treatment. For wheat, nitrogen was applied 50% as basal and 50% as top-dressing at 21–25 days after sowing (DAS). Seeds of wheat were treated with *Azotobacter* and PSB in specific treatments at the time of sowing. The 1st irrigation was given immediately after sowing and 2nd at 21 DAS at crown root initiation stage for ensuring proper germination and establishment of the seed. Remaining irrigations were given as per requirement of the crop. During the entire crop season experimental area was kept weed free and clean. Wheat was harvested in the 3rd week of March during both the years.

Growth and yield attributes were recorded from randomly selected and previously tagged 5 plants in each net plot at different stages of wheat. The grain yield was calculated from each net plot after threshing, winnowing and cleaning, and expressed in tonnes per ha. Straw yield was calculated by subtracting the grain yield from total dry matter of each net plot. The uptake of nutrient was computed by multiplying the yield of grain and straw by their respective nutrient percentages. The gross and net realization were calculated based on the prevailing market prices of all the inputs and grain, and straw yield of wheat during the years of investigation. The benefit cost (B:C) ratio was calculated by using gross realization (₹/ha) divided by cost of cultivation (₹/ha). The pooled analysis of the 2-years data was carried out as per procedure suggested by Cochran and Cox (1967). The data recorded for various parameters were statistically analyzed using Analysis of Variance Test (ANOVA) as applicable to split plot design and the comparison of treatment means was made by least significant difference (LSD) at P=0.05.

RESULTS AND DISCUSSION

Growth, yield attributes and yield

Preceding *kharif* crops and fertilizer treatment exhibited significant effect on plant height at harvest of wheat during pooled results (Table 1). Among different *kharif* crops, greengram grown as preceding crop recorded significantly maximum plant height (65.55 cm) of wheat at harvest, being at par with sesame. The minimum plant height (58.42 cm) at harvest of wheat was noted with fodder sorghum. Kumar and Sharma (2000) also observed that blackgram grown as preceding crop produced higher plant height, number of tillers and dry matter per plant of wheat as compared to other *kharif* crops, viz. rice, maize, sesame, sorghum (fodder) and even groundnut. Among fertilizer treatment, significantly higher plant height (63.98 cm) of wheat was recorded with 100% RDF (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha) at harvest which was at par with treatment 75% RDF and 75% RDF + *Azotobacter* + PSB. Jat *et al.,* (2013) also fiund that the application of 120 kg N + 60 kg P_2O_5 + 60 kg K_2O/ha registered higher plant height and dry matter of wheat as compared to 80 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha. The enhancement in growth parameters with increase in fertilizer doses was owing to the rapid conversion of synthesized carbohydrates into protein and thus increases in the number and size of cell, which might cause increase in plant height and thereby ultimately increase in dry-matter accumulation. An application of 50% RDF to wheat crop recorded significantly lower plant height at harvest.

Wheat grown after greengram recorded significantly higher number of effective tillers per meter row length (82.76), spike length (7.94 cm), number of spikelets/spike (13.77) and numbers of grains per spike (31.31). While in case of spike length and numbers of grains per spike, greengram was stastically at par with sesame. Whereas, lowest number of effective tillers per meter row length (71.13), spike length (7.66), number of spikelets per spike

Table 1. Effect of preceding *kharif* crops and fertilizer treatments on growth and yield attributes of wheat (Pooled data of 2 years)

Treatment	Plant height (cm)	No. of effective tillers/ meter row	Spike length (cm)	No. of Spikelets/ spike	No. of grains/ spike	Yield (t/ha)	
						Grain	Straw
Kharif crop (C)							
C_1, Greengram	65.55	82.76	7.94	13.77	31.31	4.78	6.41
C_2, Sesame	63.23	76.57	7.84	13.21	29.94	4.22	5.72
C_3, Pearl millet	60.06	74.52	7.70	12.64	28.53	3.90	5.40
C_4, Fodder sorghum	58.42	71.13	7.66	12.20	27.46	3.38	4.78
SEm±	1.01	1.28	0.07	0.18	0.52	0.76	0.32
CD (P=0.05)	3.00	3.80	0.20	0.55	1.55	1.18	1.24
Fertilizer to wheat (F)							
F_1, 100% RDF	63.98	83.63	8.11	13.67	31.08	4.60	6.20
F_2, 75% RDF	62.98	75.04	7.74	13.06	29.56	3.98	5.50
F_3, 50% RDF	57.47	69.24	7.41	11.97	26.89	3.47	4.81
F_4, 75% RDF + *Azotobacter* + PSB	63.53	82.53	7.96	13.38	30.37	4.42	6.05
F_5, 50% RDF + *Azotobacter* + PSB	61.12	70.77	7.69	12.69	28.65	3.89	5.36
SEm±	0.66	0.85	0.07	0.11	0.35	0.44	0.67
CD (P=0.05)	1.84	2.40	0.18	0.31	0.97	1.23	1.88

(12.20) and numbers of grains per spike (27.46) of wheat were recorded with fodder sorghum. Significantly higher grain (4.78 t/ha) and straw yield (6.41 t/ha) of wheat were observed under preceded greengram as compared to other crops on pooled mean (Table 1). As compared to *kharif* crops, greengram increased the wheat yield by 13.20% over sesame, 22.60% over pearl millet and 41.38% over fodder sorghum. Singh *et al*., (2008) also found that growing of greengram and clusterbean as the preceding crop resulted in significantly higher grain yield of wheat than that of preceding pearl millet. Similarly, Maadi *et al*., (2012) also reported that preceding mungbean crop followed by wheat increased number of spikes, test weight and grain yield of wheat than rice-wheat cropping system. The higher value of grain yield of wheat sown after greengram crop might be owing to crop sequence involving legumes played an important role in restoring soil fertility because leguminous crops enriched soil through fixation of atmospheric nitrogen into their roots nodules, which in turn supply residual food nutrients into succeeding crops than the non leguminous crops. While lowest grain (3.38 t/ha) and straw yield (4.78 t/ha) of wheat were recorded when wheat was sown after fodder sorghum. Kumar *et al.,* (2013) also reported that growing of greengram as the preceding crop resulted in significantly higher straw yield of the wheat than the preceding fodder sorghum.

Wheat crop fertilized with 100% RDF produced significantly higher number of effective tillers/meter row length (83.63), spike length (8.11), number of spikelets/spike (13.67) and numbers of grains/spike (31.08), grain yield (4.60 t/ha) and straw yield (6.20 t/ha) (Table 1). In case of all yield attributes characters, 100% RDF was statistically at par with treatment 75% RDF + *Azotobacter* + PSB. The magnitude of increased in grain yield by 32.66% and straw yield by 28.80% over 50% RDF in pooled mean. Residual effect of 75% and 100% recommended level of fertilizer in sorghum significantly increased plant height and number of tillers/plant of succeeding wheat (Patidar and Mali, 2002). Thakur *et al.,* (2020) found that the application of 100% RDF (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha) recorded higher spike length, test weight, grain and straw yield of wheat as compared to 75% RDF + FYM @5 t/ha + *Azotobacter* + PSB.

Interaction effect

The interaction effect of preceding *kharif* crops and fertilizer treatment was found significant in case of grain and straw yield of wheat (Table 2). Wheat crop grown after *kharif* greengram and applied 100% RDF (C_1F_1) produced significantly higher grain (5.25 t/ha) and straw yield (7.00 t/ha) in 2 year pooled mean which was at par with greengram × 75% RDF + *Azotobacter* + PSB (C_1F_4). Significantly the lowest grain (2.63 t/ha) and straw yield (4.02 t/ha) were obtained with interaction C_4F_3 (wheat grown after fodder sorghum and applied 50% RDF) in pooled analysis.

Nutrients uptake

The higher values of nitrogen, phosphorus and potassium uptakes by grain and straw of wheat were observed

Table 2. Interaction effect of preceding *kharif* crops and fertilizer treatments on grain and straw yield of wheat (Pooled data of 2 years)

	C_1, Greengram	C_2, Sesame	C_3, Pearl millet	C_4, Fodder sorghum
Grain yield (t/ha)				
F_1, 100% RDF	5.25	4.90	4.40	3.86
F_2, 75% RDF	4.75	4.13	3.68	3.34
F_3, 50% RDF	4.12	3.83	3.28	2.63
F_4, 75% RDF + *Azotobacter* + PSB	5.19	4.34	4.23	3.92
F_5, 50% RDF + *Azotobacter* + PSB	4.59	3.91	3.91	3.15
SEm±		0.09		
CD (P=0.05)		0.24		
Straw yield (t/ha)				
	C_1, Greengram	C_2, Sesame	C_3, Pearl millet	C_4, Fodder sorghum
F_1, 100% RDF	7.00	6.35	5.92	5.55
F_2, 75% RDF	6.45	5.62	5.49	4.47
F_3, 50% RDF	5.61	5.27	4.36	4.02
F_4, 75% RDF + *Azotobacter* + PSB	6.97	5.95	5.78	5.32
F_5, 50% RDF + *Azotobacter* + PSB	6.05	5.44	5.43	4.52
SEm±		0.13		
CD (P=0.05)		0.37		

with preceding greengram than rest of the preceded *kharif* crops (Table 3). Significantly lower nitrogen, phosphorus and potassium uptakes by grain and straw were registered under fodder sorghum. Chaman and Singh (2007) also reported that wheat grown after legumes remove higher nitrogen as compared to crop preceded by cereals. Growing of greengram and clusterbean as the preceding crop resulted in significantly higher uptake of nitrogen and phosphorus by wheat than the preceding pearl millet (Singh *et al*., 2008).

Among fertilizer treatment, application of 100% RDF registered higher uptakes of nitrogen, phosphorus and potassium in both grain and straw of wheat. However, in case of potassium uptake by straw, it remained statistically at par with treatment 75% RDF + *Azotobacter* + PSB on pooled mean (Table 3). Higher uptake of nutrients by grain and straw under 100% RDF was attributed to more availability of nutrient which increased crop growth and finally grain and straw yield. Increased yield ultimately resulted in higher uptake of nutrients by wheat crop. Khandare *et al.,*

Table 3. Effect of preceding *kharif* crops and fertilizer treatments on nutrients uptake by grain and straw of wheat (Pooled data of 2 years)

Treatment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
Kharif crops (C)						
C_1, Greengram	86.27	32.41	20.29	13.87	23.10	82.00
C_2, Sesame	74.97	28.41	17.72	12.26	20.22	71.68
C_3, Pearlmillet	69.78	26.92	16.16	11.40	18.54	67.32
C_4, Fodder sorghum	59.37	23.49	13.81	9.95	15.84	58.13
SEm±	1.63	0.69	0.37	0.29	0.41	1.72
CD (P=0.05)	4.85	2.05	1.09	0.85	1.23	5.11
Fertilizer to wheat (F)						
F_1, 100% RDF	85.94	32.49	20.13	13.84	22.42	78.75
F_2, 75% RDF	70.71	27.43	16.57	11.71	18.85	69.52
F_3, 50% RDF	57.93	22.44	13.57	9.61	16.17	58.60
F_4, 75% RDF + *Azotobacter* + PSB	80.28	30.46	18.76	12.97	21.27	75.95
F_5, 50% RDF + *Azotobacter* + PSB	68.13	26.21	15.96	11.21	18.41	66.10
SEm±	1.13	0.48	0.29	0.20	0.27	1.25
CD (P=0.05)	3.18	1.35	0.82	0.55	0.75	3.50

(2015) found that the application of 100% RDF (120 kg N + 60 kg P_2O_5/ha) recorded higher uptake of NPK by wheat. An application of 50% RDF recorded significantly lower nitrogen, phosphorus and potassium uptakes by grain and straw of wheat.

Soil fertility status

Data (Table 4) showed that the effect of different *kharif* crops on available nitrogen after harvest of wheat crop was found significant, while available phosphorus and potash in soil after harvest of wheat did not differ significantly due

Table 4. Effect of preceding *kharif* crops and fertilizer treatments on available nutrients status in soil after harvest of wheat (Pooled data of 2 years)

Treatment	Available nutrients status (kg/ha)		
	N	P_2O_5	K_2O
Kharif crops (C)			
C_1, Greengram	180.94	38.47	282.60
C_2, Sesame	175.23	37.44	275.10
C_3, Pearlmillet	170.05	37.15	273.08
C_4, Fodder sorghum	167.71	36.82	270.62
SEm±	1.96	0.41	3.35
CD (P=0.05)	5.83	NS	NS
Fertilizer to wheat (F)			
F_1, 100% RDF	178.33	38.32	279.89
F_2, 75% RDF	173.66	37.57	274.46
F_3, 50% RDF	167.86	36.28	269.19
F_4, 75% RDF + *Azotobacter* + PSB	175.26	37.91	278.90
F_5, 50% RDF + *Azotobacter* + PSB	172.29	37.27	274.31
SEm±	1.57	0.36	2.90
CD (P=0.05)	4.41	1.01	NS

Table 5. Economics of preceding *kharif* crops-wheat sequence (Pooled data of 2 years)

Treatment	Gross realization (×10³ ₹/ha)			Cost of cultivation (×10³ ₹/ha)			Net realization (×10³ ₹/ha)	Benefit: cost ratio
	Kharif crops	Wheat	Total	*Kharif* crops	Wheat	Total		
C_1F_1	60.31	136.45	196.76	30.46	48.87	79.33	117.44	2.48
C_1F_2	60.31	123.96	184.28	30.46	47.48	77.94	106.34	2.36
C_1F_3	60.31	107.56	167.88	30.46	46.09	76.55	91.33	2.19
C_1F_4	60.31	135.17	195.48	30.46	48.27	78.73	116.76	2.48
C_1F_5	60.31	119.17	179.48	30.46	46.88	77.34	102.14	2.32
C_2F_1	36.32	126.93	163.25	28.07	48.87	76.94	86.31	2.12
C_2F_2	36.32	115.89	152.21	28.07	47.48	75.55	77.66	2.04
C_2F_3	36.32	100.16	136.48	28.07	46.09	74.16	62.32	1.84
C_2F_4	36.32	113.43	149.75	28.07	48.27	76.34	73.41	1.96
C_2F_5	36.32	102.48	138.80	28.07	46.88	74.95	63.85	1.85
C_3F_1	45.36	114.48	159.84	31.28	48.87	80.15	79.69	1.99
C_3F_2	45.36	97.51	142.86	31.28	47.48	78.76	64.11	1.81
C_3F_3	45.36	85.35	130.71	31.28	46.09	77.37	53.34	1.69
C_3F_4	45.36	110.30	155.66	31.28	48.27	77.55	76.11	1.96
C_3F_5	45.36	102.39	147.75	31.28	46.88	78.16	69.59	1.89
C_4F_1	66.00	101.61	167.61	30.25	48.87	79.12	88.49	2.12
C_4F_2	66.00	86.87	152.87	30.25	47.48	77.73	75.15	1.97
C_4F_3	66.00	69.99	135.99	30.25	46.09	76.34	59.65	1.78
C_4F_4	66.00	102.28	168.28	30.25	48.27	78.52	89.76	2.14
C_4F_5	66.00	83.05	149.05	30.25	46.88	77.13	71.93	1.93

C_1, greengram; C_2, sesame; C_3, pearl millet; C_4, fodder sorghum; F_1, 100% RDF (120:60:40 N-P_2O_5-K_2O kg/ha); F_2, 75% RDF; F_3, 50% RDF; F_4, 75% RDF + *Azotobacter* + PSB; F_5, 50% RDF + *Azotobacter* + PSB).

to *kharif* crops on pooled mean. Significantly maximum available nitrogen (180.94 kg N/ha) in soil after harvest of wheat was recorded in greengram-wheat crop sequence, whereas, minimum available nitrogen (167.71 kg N/ha) was under fodder sorghum-wheat crop sequence. This might owing to sorghum depletes and immobilized soil nitrogen, while legume crops improved the available soil nitrogen status.

In case of fertilizer treatments, application of 100% RDF (120 kg N + 60 kg P_2O_5/ha) registered higher available nitrogen (178.33 kg N/ha) and phosphorus (38.32 kgP_2O_5/ha) in soil after harvest of wheat crop. No any significant effect was found on available potash in soil due to different fertilizers treatment. The status of available nutrients in soil increased significantly with each successive increase in fertilizer levels. This might be owing to amount of added fertilizer, determine the availability of nutrient to the wheat crop and its content in post harvest soil.

Economics

Data (Table 5) revealed that the highest gross realization (₹196.76 × 10^3/ha) and net realization (₹117.44 × 10^3/ha) along with the benefit: cost ratio (BCR) of 2.48 was secured under interaction between greengram × 100% RDF (C_1F_1), followed by greengram × 75% RDF + *Azotobacter* + PSB (C_1F_4). While the interaction between pearl millet × 50% RDF (C_3F_3) recorded the lowest value of gross realization (₹130.71 × 10^3/ha) and net realization (₹53.34 × 10^3/ha) with benefit: cost ratio of 1.69. Singh *et al*., (2008) reported that the growing of greengram as the preceding crop resulted in significantly higher net return and BCR than the preceding pearl millet.

It is concluded that, for obtaining higher yield and net realization, wheat should be grown after *kharif* greengram and fertilized with either 100% RDF (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha) or 75% RDF + *Azotobacter* + PSB.

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