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Effect of nutrient management on growth and yield of wheat (*Triticum aestivum* L.) under rice-wheat cropping system of central U.P.

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Abstract
This experiment was carried out during *Rabi* season of 2021-22 at Agricultural Research Farm of faculty of Agricultural Sciences and Allied Industries, Rama University, Mandhana, Kanpur Nagar (U.P). The present experiment was laid out in randomized block design, the experiment consists of 9 treatments *viz;* 100 % RDF, 100 % RDF + Zn (@ 5 kg ha^{-1}), 100 % RDF + S (@ 25 kg ha^{-1}), 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}), 100% RDF+ Azotobacter (seed treatment), 100% RDF+ FYM + 10 t ha^{-1}, 75 % RDF + FYM 10 t ha^{-1}, FYM 20 t ha^{-1} and control with three replications in wheat crop. Among growth parameter *viz*; plant height, number of tillers and yield attributing character *viz*; length of ear, number of spikelet's /ears, number of grains per ear and test weight and grain and straw yield of wheat crop was recorded maximum from (100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}). Among the treatment (100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}), growth parameter, yield attributing character and yield of grain and straw was recorded maximum from (75 % RDF + FYM 10 t ha^{-1}), (FYM 20 t ha^{-1}) and (control) at maximum at all stage of wheat crop. The maximum gross return, net return and B:C ratio was recorded from (100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}), which were statistically highest when (75 % RDF + FYM 10 t ha^{-1}) stage which were statistically at par with (FYM 20 t ha^{-1}) at all stage of wheat crop.

Keywords: Nutrient management, growth, yield and quality

Introduction
Wheat (*Triticum aestivum* L.) is the world's most extensively planted food crop. It is the principal food crop in the temperate zone. It also encompasses tropical lowlands and warm temperate and subtropical regions. It is one of the world's oldest crops. It was first grown during the Neolithic era. Wheat was an important factor in the development of city-based societies at the dawn of civilization because it was one of the first crops that could be easily mass-produced and yielded a harvest that could be stored for long periods of time. Bread wheat was known to have been produced in the Nile valley by 5000 B.C., and its apparent subsequent cultivation in other regions (e.g., the Indus and Euphrates valleys by 4000 B.C., China by 2500 B.C., and England by 2000 B.C.) implies that it spread from Mediterranean domestication centres. Wheat has long been a staple of West Asian and European cultures, whereas rice has long held a stronger position in East Asia. Since the dawn of agriculture, wheat has been the main ingredient in bread throughout Europe and the Middle East. India is perhaps one of the few countries on the planet that grows three types of wheat. The majority of the land is planted with bread wheat (*Triticum aestivum* L.), around 12% with durum wheat (*Triticum turgidum* L.), and the balance is planted with *dicoccum* wheat (*Triticum dicoccum* L.) (*Triticum monococcum* L.). After rice, wheat is the second most significant food crop in terms of both area and production. India, behind China, is the world's second-largest wheat producer, and the grain has aided India's agricultural development at the fastest rate. Wheat is farmed on 224.66 million hectares around the world, with 793.04 million tonnes produced and 3.53 tonnes ha-1 productivity (USDA 2021) [1].

Result and Discussion
Growth parameters
Plant height
Data pertaining on plant height significantly influenced due to different nutrient

management practices at harvest the plant height were significantly influenced due to different nutrient management practices. The significantly maximum plant height at harvest 98.65 cm respectively were measured under the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}) (T4). However, the minimum plant height was measured with under the control treatment (I_9).

Table 1: Effect of nutrient management on Plant height of wheat under rice-wheat cropping system.

Symbol	Treatment	Plant Height (cm)
		At harvest
T_1	100 % RDF	88.75
T_2	100 % RDF + Zn (@ 5 kg ha-1)	91.1
T_3	100 % RDF + S (@ 25 kg ha -1)	92.15
T_4	100 % RDF + Zn (@ 5 kg ha-1) +S (@ 25 kg ha -1)	98.65
T_5	100% RDF+ Azotobacter (seed treatment)	97.3
T_6	100% RDF+ FYM + 10 t ha-1	95.25
T_7	75 % RDF + FYM 10 t ha -1	87.45
T_8	FYM 20 t ha -1	86.68
T_9	Control	74.75
	S.E(m)	2.071
	S.E(d)	2.929
	CD	6.211

Effective tillers at harvesting

Data obtained on number of tillers (m^{-2}) has been presented in Table 2. The number of tillers (m^{-2}) was calculated significantly due to different nutrient management practices at 90 DAS of crop growth stages. The significantly maximum number of tillers (456.49m^{-2}) was noticed under the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}) (T_4) however, minimum number of tillers (366.6m^{-2}) were counted under the control treatment (I_9) at 90 DAS respectively.

Table 2: Effect of nutrient management on effective tillers at harvesting of wheat under rice-wheat cropping system

Symbol	Treatment	No. of Tillers
		90 DAS
T_1	100 % RDF	415.15
T_2	100 % RDF + Zn (@ 5 kg ha-1)	420.2
T_3	100 % RDF + S (@ 25 kg ha -1)	451.35
T_4	100 % RDF + Zn (@ 5 kg ha-1) +S (@ 25 kg ha -1)	456.49
T_5	100% RDF+ Azotobacter (seed treatment)	442.85
T_6	100% RDF+ FYM + 10 t ha-1	434.8
T_7	75 % RDF + FYM 10 t ha -1	398.65
T_8	FYM 20 t ha -1	424.91
T_9	Control	366.6
	S.E(m)	6.685
	S.E(d)	9.453
	CD	20.046

Yield attributing parameters

Data pertaining on yield attributing parameters, which determined the yield of experimental crop, is the resultant of the vegetative development of the crop. The yield attributing parameters *viz*., number of effective tillers (m^{-2}), length of spike (cm), number of spikes (m^{-2}) and number of grains $spike^{-1}$ were affected significantly due to different nutrient management practices except test weight presented in Table 3. Number of effective tillers (m^{-2}), length of spike (cm), number of spikes (m^{-2}) and number of grains $spike^{-1}$were recorded significantly higher under the treatment of T_4 (100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}).

Table 3: Effect of nutrient management on Yield attributing parameters of wheat under rice-wheat cropping system.

Symbol	Treatment	No. of effective Tillers (m^{-2})	Length of spike (cm)	Number of spikesm-2	Number of seeds $spike^{-1}$	Test weight (g)
T_1	100 % RDF	394.40	9.75	394.40	50.51	39.75
T_2	100 % RDF + Zn (@ 5 kg ha-1)	399.20	9.87	399.20	51.33	39.87
T_3	100 % RDF + S (@ 25 kg ha -1)	428.78	10.60	428.78	55.12	39.95
T_4	100 % RDF + Zn (@ 5 kg ha-1) +S (@ 25 kg ha-1)	433.64	10.72	433.64	55.75	40.25
T_5	100% RDF+ Azotobacter (seed treatment)	420.70	10.40	420.70	54.08	40.12
T_6	100% RDF+ FYM + 10 t ha-1	413.06	10.21	413.06	53.10	39.98
T_7	75 % RDF + FYM 10 t ha -1	378.75	9.36	378.75	48.68	39.5
T_8	FYM 20 t ha -1	403.66	9.98	403.66	51.90	39.65
T_9	Control	349.25	8.64	349.25	44.93	38.75
	SE(m)	6.304	0.233	6.304	1.098	0.146
	SE(d)	8.91	0.3296	8.91	1.553	0.206
	CD	18.903	0.6981	18.903	3.295	NS

The higher values of yield attributing parameters under the T_4 (100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha $^{-1}$) treatment was mainly due to favorable vegetative growth and development occurred over to adequate nutritional supply. The higher growth like plant height and leaf area index were highest, which contributed to higher yield attributes due to increased photosynthesis activity of leaves, besides, translocation of photosynthates accumulate from source to sink. However, lowest yield attributing parameters were recorded under the control treatment (I_9) was unable to extract more nutrient and poor nutritional supply resulted in poor growth and yield attributing characters. This result is in close proximity to those obtained by Khan Naqvi (2011) and Baloch *et al.* (2014).

Yield parameters

The perusal of data pertaining to grain yield presented in Table 4. Experimental data revealed that the all yield parameters *viz.* grain, straw, biological yield and harvest index were significantly affected due to different nutrient management practices except harvest index.

The significantly highest grain yield (55.35 q ha^{-1}), straw yield (88.90 q ha^{-1}) and biological yield (144.25 q ha^{-1}) were recorded under the treatment of T_4 (100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha $^{-1}$) presented in Table 4.7. This was might be due to adequate nutrient supply which contributed to better growth parameter and finally yield attributing parameters and grain yield. Similar research finding were also reported by Nayak *et al.* (2015) and Sharma and Pannu (2008).

Table 4: Effect of nutrient management on Grain Yield and Straw Yield (q ha^{-1}) of wheat under rice-wheat cropping system.

Symbol	Treatment	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Biological Yield (q ha^{-1})
T_1	100 % RDF	49.75	83.66	133.41
T_2	100 % RDF + Zn (@ 5 kg ha-1)	50.95	84.95	135.9
T_3	100 % RDF + S (@ 25 kg ha -1)	51.55	85.48	137.03
T_4	100 % RDF + Zn (@ 5 kg ha-1) +S (@ 25 kg ha -1)	55.35	88.90	144.25
T_5	100% RDF+ Azotobacter (seed treatment)	54.55	88.06	142.61
T_6	100% RDF+ FYM + 10 t ha-1	53.35	87.30	140.65
T_7	75 % RDF + FYM 10 t ha -1	48.95	82.00	130.95
T_8	FYM 20 t ha -1	52.15	86.00	138.15
T_9	Control	42.1	72.24	114.34

Biological Yield

Data pertaining on Biological Yield under rice-wheat cropping system is very obvious and consistent. There was significant difference among the application of the different treatment on Biological Yield and among the treatment applied the maximum Biological Yield was found in T_4(100 % RDF + Zn (@ 5 kg ha-1) +S (@ 25 kg ha^{-1}) with (144.25q ha^{-1}) followed by T_5(100% RDF+ Azotobacter (seed treatment)) with (142.61 q ha^{-1}) which were significantly superior over T_0 (Control) with (114.34 qha^{-1}).

Harvest Index

Harvest index of experimental crop did not influenced significantly due to irrigation schedules. However maximum value of harvest index 38.70 % was noticed under the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha $^{-1}$). While, the minimum value of harvest index 36.82 % was noticed under the control treatment.

Economics

Total cost of cultivation

The experimental data of cost of cultivation is presented in Table 6 under different treatments indicated that the maximum cost of cultivation (78561.00 Rs. ha^{-1}) was recorded with the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha $^{-1}$) (T_4). While, the minimum cost of cultivation (70702.00 Rs. ha^{-1}) was recorded under the control treatment (I_9).

Table 5: Effect of nutrient management on Cost of cultivation, Gross Income, Net Income and B: C Ratio of wheat under rice-wheat cropping system

Treatment	Cost of cultivation	Gross Income	Net Income	B:C Ratio
T1	109450	75483	33967	1.450
T2	112090	76252	35838	1.470
T3	113410	76628	36782	1.480
T4	121770	78561	43208	1.550
T5	120010	77928	42082	1.540
T6	117370	77217	40153	1.520
T7	107690	75308	32382	1.430
T8	114730	77000	37730	1.490
T9	92620	70702	21918	1.310

Gross return

The experimental data of gross return is presented in Table 5 under different treatments indicated that the maximum gross return (121770.00Rs. ha^{-1}) was recorded with the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha $^{-1}$) (T_4) while, minimum gross return (92620.00 Rs. ha^{-1}) was recorded under the control treatment (I_9).

Net return

The experimental data of net return is presented in Table 5. Under different treatments indicated that the maximum gross return (43209.00 Rs. ha^{-1}) was recorded with the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha $^{-1}$) (T_4) while, minimum net return (21918.0 Rs. ha^{-1}) was recorded under the control treatment (I_9).

B:C ratio

It is evident from the data presented in Table 5 illustrated that the value of B:C ratio was found highest (Rs. 1.55) under the treatment of 100 % RDF + Zn (@ 5 kg ha^{-1}) +S (@ 25 kg ha^{-1}) (T_4) followed by (Rs. 1.54) under the treatment of 100% RDF+ Azotobacter (seed treatment) (T_5). While, the lowest B:C ratio (Rs. 1.31) was computed under the control treatment (I_9).

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