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Research Paper

Assessment of wheat (*Triticum aestivum*) growth, yield and economics under varying nutrient and weed management options

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ABSTRACT

A field experiment was carried out during *rabi* seasons of 2020–21 and 2021–22 at research farm of ICAR-Indian Agricultural Research Institute, New Delhi, to study the effect of nutrient and weed management on crop growth, yield and economics of wheat. Experiment was carried out in factorial randomized complete block design and replicated thrice. First factor, nutrient management comprised of three levels *viz.,* control, 100% recommended dose of fertilizer (RDF) and 75% RDF + biofertilizer (BF) consortia and second factor weed management comprised of five levels viz. weedy check, Sulfosulfuron 75% + Metsulfuron 5% WG @40 g/ha (ready mix) at 28-30 DAS of wheat, hand weeding at 45 DAS + Sulfosulfuron 75% + Metsulfuron 5% WG) @40 g/ha (ready mix) at 28-30 DAS, mulch + hand weeding at 45 DAS and weed free check. Crop growth, yield attributes and grain yield (4.63 and 4.48 t/ha) of wheat were recorded higher under 100% RDF and these were at par with 75% RDF + BF and the lowest growth and yield was reported under control. The plant growth, yield attributes, grain and straw yield were highest under weed free check and those were at par with hand weeding + sulfosulfuron + metsulfuron and sulfosulfuron + metsulfuron. Gross returns were significantly higher with 100% RDF over 75% RDF + BF and control but net returns and B: C with 100% RDF were at par with 75% RDF + BF over control. Significantly higher net returns and B:C was obtained with Sulf + Mets and HW + Sulf + Mets. It was concluded that 75 % RDF + biofertilizer consortia application in along with Sulfosulfuron + metsulfuron ready mix use met the nutrition and weed management requirement in wheat and gave higher growth, productivity and profitability of the crop.

***Key words*:** Biofertilizer consortia, Integrated Nutrient Management, Returns, Weed Management, Yield

Wheat (*Triticum aestivum* L.) is the most important staple food crop of the world and thus named as king of cereals. In India, wheat is 2nd important food crop after rice covering an area of 31.40 mha with production and productivity of 110.55 mt and 3.5 t/ha, respectively. Wheat is mainly cultivated in Uttar Pradesh, Madhya Pradesh, Punjab, Haryana and Rajasthan (https://ipad.fas.usda.gov/countrysummary/?id=IN&crop=Wheat).

Nutrient mining by high yielding varieties of exhaustive cereal crops particularly rice and wheat is more than the amount of fertilizer nutrients made available to these crops (Sanyal *et al*., 2014). It has been realized that overdependence on fossil fuel derived fertilizers cause environmental pollution and thus sustainable crop production demands establishment of integrated nutrient management (INM) strategies. Biofertilizers or microbial consortia has emerged as one of the integral components of INM and can supplement chemical fertilizers for enhancing growth and yield of cereal crops (Behera *et al*., 2021). Biotic factor, weed infestation is a major hurdle in achieving handsome yield and productivity of irrigated wheat (Bhalse *et al*., 2023). Hand weeding and other cultural methods are labour intensive and thus costly, whereas sole dependence on herbicides in recent years has caused weed flora shift and herbicide resistance development in weeds. Information regarding the interaction effect of nutrient management and weed management is scanty in aerobic rice wheat cropping system in Indo-Gangetic Plains thus, needs to be explored more. Hence to ensure

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higher growth, productivity and profitability integrated nutrient and weed management is required in wheat and keeping these facts in mind this field experiment was undertaken.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season of 2020–21 and 2021–22 at research farm of ICAR-Indian Agricultural Research Institute, New Delhi. The site falls under Trans-Gangetic plains agro climatic zone and climate is sub-tropical, semi-arid with prominent hot dry summers. Rainfall recorded in *Rabi* season of 2020–21 and 2021–22 were 78.5 mm and 181.5 mm, respectively. Mean temperature minimum recorded in second fortnight of March to first week of April was 14-17 ºC in 2021 and 16–18 ºC in 2022 whereas mean maximum temperature recorded in II fortnight of March to I week of April was 30–36 ºC in 2021 and 32–39 ºC in 2022. The soil of the field was alluvial having sandy clay loam texture with moderate water holding capacity. The pH of the soil was 8.2 and electrical conductivity was 0.22dS/m. The soil was low in organic carbon (0.46%) and available nitrogen (218 kg/ha) and medium in available phosphorous (16.12 kg/ha) and available potassium (260 kg/ha). The experiment was laid out in factorial randomized complete block design with three replications and 15 treatment combinations. First factor, nutrient management comprised of three levels viz., N_1, Control (No fertilizer), N_2, 100% RDF (100% mineral fertilization) and N_3, 75% RDF + BF (75% mineral fertilization along with biofertilizer consortia) and second factor weed management comprised of five levels viz. W_1, Weedy check (No weed control measure applied); W_2, Sulf + Mets (Sulfosulfuron + Metsulfuron (post –em) ready mix); W_3, HW + Sulf + Mets (Hand weeding at 45 DAS+ Sulfosulfuron + Metsulfuron (post–em) ready mix); W_4, mulch (Paddy straw mulch (3.0 t/ha) + one hand weeding at 45 DAS) and W_5, Weed free check (Regular hand weeded to keep the plot weed free). Biofertilizer consortia used included liquid formulation of *Azotobacter chroococcum,* Phosphorus Solubilizing Bacteria (PSB), Potassium Solubilizing Bacteria (KSB) and Zinc Solubilizing Bacteria (ZnSB) biofertilizers specific to wheat. Seeds were treated with biofertilizers using jaggery solution, dried in shade and then were used for sowing. Recommended dose of fertilizer used for wheat was 120 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2O/ha. Phosphorus in form of DAP and potassium in form of MOP (complete dose) was supplied at the time of sowing and nitrogen in form of urea was applied in three equal splits viz., at basal, active tillering and panicle initiation stages. Wheat variety 'HD-2967' was used in the experiment. Seed rate of 100 kg/ ha was used. Seeds were drilled at a depth of 4 cm with the row spacing of 22.5 cm by using seed cum fertilizer drill. Other agronomic practices were followed as per package of practices for the region. Herbicide commercial product and dose used was Total (Sulfosulfuron 75% + Metsulfuron 5% WG) @ 40 g/ha (ready mix) at 28–30 DAS of wheat. Observations on plant growth, grain and biological yield were taken at physiological maturity stage of crop as per standard procedures. Economics was calculated as per the current market prices of inputs, labour and yield with respect to the crop season. Experimental data was statistically analyzed by the standard technique of analysis of variance (ANOVA) and significance was tested by F-test at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Crop growth

Biometric observations and crop growth, viz. plant height, no. of tillers/m^2 and dry matter accumulation of wheat were found higher under 100% RDF (99.52cm and 95.80 cm, 485 and 464.7, 938.70 g/ m^2 and 901.15 g/m^2) which were at par with 75% RDF + BF (96.87 cm and 93.05 cm, 475.2 and 459.5, 917.01g/ m^2 and 880.33 g/ m^2) and lowest growth was reported under control during 2020–21 and 2021–22, respectively (Table 1). Beneficial effect of biofertilizers and their contribution by near about remaining 25% nutrients dose supply could have enhanced growth of the crop. Kandil *et al.* (2011) also reported that biofertilizer inoculated wheat plants have higher plant height. Biometric observations and crop growth of wheat were recorded highest with weed free check and lowest with weedy check. However, the plant growth with weed free check was at par with HW + Sulf + Mets and Sulf + Mets. This might be due to weed control under these treatments and under controlled weed condition, the weed-crop competition for the monetary and non-monetary inputs might have reduced and crop has grown profusely. Similarly, the higher growth of wheat under weed control with herbicidal treatments has been reported by Chaudhari *et al.* (2017) and Singh *et al.* (2018). Interaction effect of nutrient and weed management on no. of tillers of wheat 80 DAS and at harvest during both the years of experimentation was recorded to be significant. The effect of weed management was more prominent and clearer under 100% RDF and 75% RDF + BF.

Yield attributes and yield

Yield attributes, viz. no. of spikes/m^2, weight of spike, length of spike and no. of grains/ spike (Table 1) were significantly higher with 100% RDF which were at par with 75% RDF + BF and significantly superior over control. The results might be due to balanced and optimum supply

Table 1. Effect of nutrient and weed management practices on growth parameters of wheat at harvest

Treatment	Plant height (cm)		No. of tillers		Dry matter accumulation (g/m^2)		No. of spikes/m^2		Weight of spike (g)		Length of spike (cm)		No. of grains/ spike	
	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
Nutrient management (NM)														
Control	91.21	87.67	439.3	424.8	825.72	792.69	345.5	330.0	3.00	2.87	7.99	7.67	49.73	46.34
100% RDF	99.52	95.80	485.0	464.7	938.70	901.15	381.5	364.3	3.82	3.64	10.29	9.88	64.97	62.37
75% RDF+BF	96.87	93.05	475.2	459.5	917.01	880.33	371.0	357.0	3.72	3.54	10.14	9.74	61.94	59.46
SEm±	1.81	1.75	5.4	5.2	17.25	16.56	4.2	4.0	0.07	0.07	0.19	0.18	1.17	1.12
CD (P=0.05)	5.25	5.08	15.6	15.0	49.98	47.98	12.2	11.7	0.20	0.19	0.54	0.51	3.38	3.23
Weed management (WM)														
Weedy check	90.07	86.88	398.8	384.4	835.16	801.75	313.0	299.6	3.27	3.11	8.94	8.59	50.42	47.74
Sulf + Mets	97.05	93.17	482.5	465.1	911.66	875.19	378.5	362.4	3.55	3.40	9.53	9.14	60.96	57.85
HW + Sulf + Mets	98.13	94.20	492.9	475.1	917.14	880.45	386.7	370.3	3.61	3.47	9.74	9.35	62.44	59.61
Mulch + HW	93.51	89.62	460.8	444.2	870.05	835.25	361.5	346.2	3.43	3.26	9.22	8.86	55.79	53.23
Weed free check	100.56	97.00	497.4	479.4	935.05	897.65	390.2	373.6	3.70	3.52	9.94	9.54	64.79	61.86
SEm±	2.34	2.26	6.9	6.7	22.28	21.38	5.4	5.2	0.09	0.08	0.24	0.23	1.51	1.44
CD (P=0.05)	6.77	6.56	20.1	19.4	64.53	61.95	15.8	15.1	0.26	0.24	0.70	0.66	4.37	4.17
Interaction (NM x WM)	NS	NS	S	S	NS	NS	S	S	NS	NS	NS	NS	NS	NS

Table 2. Effect of nutrient and weed management practices on yield and economics of wheat

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Harvest index (%)		Cost of cultivation (₹ /ha)		Gross returns (₹/ha)		Net returns (₹/ha)		Benefit: cost ratio	
	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
Nutrient management (NM)														
Control	3.39	3.17	5.20	4.80	39.27	39.54	26,362	25,944	79,909	7,5822	53,547	49,878	2.04	1.93
100% RDF	4.63	4.48	6.21	5.98	42.67	42.81	33,008	32,590	107,069	1,05330	74,061	72,740	2.25	2.24
75% RDF+BF	4.35	4.18	6.03	5.87	41.67	41.36	31,756	31,338	100,965	9,8867	692,09	67,528	2.19	2.16
SEm±	0.10	0.10	0.12	0.12	0.69	0.72	-	-	2,072	2,109	2,072	2,109	0.07	0.07
CD (P=0.05)	0.30	0.30	0.34	0.34	1.99	2.08	-	-	6,003	6,111	6,003	6,111	NS	0.20
Weed management (WM)														
Weedy check	3.43	3.25	5.01	4.72	40.37	40.42	27,111	26,694	80,176	77,209	53,065	50,516	1.95	1.88
Sulf + Mets	4.31	4.13	6.05	5.72	41.10	41.41	28,921	28,504	100,287	97,545	71,366	69,041	2.44	2.39
HW + Sulf + Mets	4.38	4.20	6.00	5.79	42.05	41.92	30,321	29,904	101,518	99,110	71,197	69,206	2.34	2.30
Mulch + HW	4.05	3.87	5.77	5.55	41.06	40.88	30,011	29,594	94,376	91,835	64,365	62,241	2.15	2.11
Weed free check	4.45	4.27	6.25	5.97	41.44	41.56	35,511	35,094	103,546	10,0999	68,035	65,906	1.91	1.87
SEm±	0.13	0.13	0.15	0.15	0.89	0.93	-	-	2,675	2,723	2,675	2,723	0.08	0.09
CD (P=0.05)	0.38	0.38	0.44	0.44	NS	NS	-	-	7,750	7,889	7,750	7,889	0.25	0.25
Interaction (NM x WM)	S	S	NS	NS	NS	NS	-	-	-	-	-	-	-	-

Table 3. Interaction effect between nutrient and weed-management practices on grain yield in wheat during 2020–21 and 2021–22

Treatment	Weedy check	Sulf + Mets	HW + Sulf + Mets	Mulch + HW	Weed free check	Mean
Control	2.71	3.11	3.58	3.76	3.78	3.39
100% RDF	3.93	4.77	4.87	4.64	4.97	4.63
75% RDF + BF	3.64	5.05	4.69	3.75	4.61	4.35
Mean	3.426	4.312	4.380	4.048	4.451	
SEm±	0.23					
CD (P=0.05)	0.66					
Control	2.49	2.89	3.36	3.54	3.56	3.17
100% RDF	3.78	4.62	4.72	4.49	4.82	4.48
75%RDF + BF	3.47	4.88	4.52	3.58	4.44	4.18
Mean	3.25	4.13	4.20	3.87	4.27	
SEm±	0.23					
CD (P=0.05)	0.66					

of nutrients and beneficial effect of biofertilizer inoculation on wheat. 1000-grain weight of wheat was however not significantly influenced by nutrient management treatments. Notable impact of INM including biofertilizers as component on yield attributing characters of wheat was reported by Desai *et al.* (2015), Shah *et al.* (2017) and Gangmei *et al.* (2024). Lowest grain and straw yield as well as harvest index were recorded with control and highest with 100% RDF (4.63 t/ha and 4.48 t/ha, 6.21 t/ha and 5.98 t/ha, 42.67% and 42.81%) which was at par with 75% RDF + BF (4.35 t/ha and 4.18 t/ha, 6.03 t/ha and 5.87 t/ha, 41.67% and 41.36%) during 2020–21 and 2021–22, respectively. Proper and well distributed timely rainfall led to higher growth of the wheat crop in 2021–22 but the temperature rises in month of march let down the yield attributing characters and thus yield as a result of terminal heat stress. Due to this reason the growth of wheat crop was higher in 2021–22 in comparison to 2020–21 wheat crop but the yield was lower. This temperature rise declined the wheat yield in whole wheat belt of north west India. Cereal crops are heavy nutrient feeders and thus higher yields are obtained with higher nutrient supply. The experimental findings corroborate with Rana *et al.* (2015) and Shah *et al.* (2017). Yield attributes were recorded highest under weed free check and lowest under weedy check (Table 1). Higher growth of crop under weed free check in absence of weeds might have higher photosynthates accumulation and their transfer from source to sink. Also, the yield attributes under weed free check were statistically at par with HW + Sulf + Mets and Sulf + Mets treatment of weed management. Grain yield and straw yield of wheat was also reported significantly higher with weed free check (4.45 t/ha and 4.27 t/ha, 6.25 t/ha and 5.97 t/ha), which was at par with HW + Sulf + Mets and Sulf + Mets and superior over mulch + HW and weedy check (Table 2). Significant interaction effect between nutrient management and weed management was observed on grain yield during both the years of experimentation (Table 3). 100% RDF + weed free check treatment combination recorded highest grain yield during both the years of experimentation. Harvest index was however not influenced significantly by weed management treatments. Weed interference and the crop weed competition reduced under the herbicidal treatments and crop received proper supply of light, space, nutrients and water and thus yielded more. Researchers like Chaudhari *et al.* (2017), Kaur and Singh (2019) and Prasanna and Sharma (2023) also reported similar findings under weed management in wheat.

Economics

Cost of wheat cultivation was recorded highest with 100% RDF which was followed by 75% RDF + BF and lowest with control (Table 2). Higher cost of fertilizers is the reason behind this. Gross returns were significantly higher with 100% RDF over 75% RDF + BF and control but net returns and B: C with 100% RDF were at par with 75% RDF + BF over control. This might be due to higher yield under these treatments which fetched higher returns. Similar findings were reported by Upasani *et al.* (2013).

Highest cost of wheat cultivation was recorded under weed free check and lowest under weedy check (Table 2). Weedy check was a plot of no disturbance hence incurred lowest cost whereas weed free check was a plot of regular hand weeding hence incurred higher labour cost. After weedy check lower cost was incurred under Sulf + Mets. Other two weed management treatments, viz. HW + Sulf + Mets and mulch + HW also costed higher be-

cause of HW labour cost. Gross returns were recorded significantly higher under weed free check which was at par with HW + Sulf + Mets and Sulf + Mets. However, due to higher cost of cultivation under weed free check, the net returns reduced. Net returns were recorded higher under other three weed management treatments. Benefit cost ratio was highest with Sulf + Mets and statistically at par with HW + Sulf + Mets. Similar results were reported by Kumar *et al*. (2013) and Meena *et al*. (2016) with weed management in wheat.

Based on the experiment, it was concluded that for wheat crop nutrition 75% RDF + Biofertilizer consortia application along with Sulfosulfuron + Metsulfuron ready mix for weed management can be suggested for higher crop growth, yield and profitability.

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