Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 19(3), September-December, 2021]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

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PANTNAGAR JOURNAL OF RESEARCH

Vol. 19(3) September-December, 2021

CONTENTS

Assessment of different nutrient management approaches for grain yield, gluten content and net income of common bread wheat (*Triticum aestivum* l.) in Western Himalayan region of Uttarakhand

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ABSTRACT: The field experiment was carried out during *Rabi* season of 2020-2021 at experimental block of School of Agricultural Sciences of the Shri Guru Ram Rai University (SAS-SGRRU), Pathribagh, Dehradun, Uttarakhand to study the effect of various nutrient management approaches on growth, yield, quality and net profit of the wheat crop. The experiment was laid out in Randomized Complete Block Design (RCBD) with eight treatments *viz.*,Control (T_1), 100 % RDF (T_2), 0 % RDF + FYM @ 3 t ha^{-1} (T_3), 0 % RDF + FYM @ 3 t ha^{-1} + PSB (T_4), 50 % RDF + FYM @ 3 t ha^{-1} (T_5), 50 % RDF + FYM @ 3 t ha^{-1} + PSB (T_6), 75 % RDF + FYM @ 3 t ha^{-1} (T_7) and 75 % RDF + FYM @ 3 t ha^{-1} + PSB (T_8) which were replicated three times. The soil of the experimental field was sandy loam with low available nitrogen & organic carbon, medium available phosphorous and available potassium. Application of 50 % RDF + FYM @ 3 t ha^{-1} recorded 74.3 % more wheat grain yield; 34.2 and 79.7 % more wet and dry gluten per cent respectively, compared to 100 % RDF, which is significantly higher than other nutrient management approaches. Substitution of 50 % inorganic fertilizers with FYM can be adopted for economical viable and sustainable wheat production with improved yield and quality in Western Himalayan region of Uttarakhand.

Key words: FYM, gluten content,nutrient management, PSB, Western Himalayan zone, wheat

Wheat has been described as "Staff of life and king of cereals" and is one of most important staple food crop which has its own importance as a human food due to presence of rich carbohydrates and protein content. Wheat is grown in at least 43 nations throughout the world with China, India, Thailand, Indonesia and the United States of America being the top producers. India ranks second among wheat producing country in the world meeting 61 % of the protein requirement (Majumdar *et al.*, 2013). In India, the wheat is grown over an area of 31.4 million hectares (m ha) which is about 24.65 % of the total food grains with a production of 107.9 million tonnes (m t) and productivity of 3.44 t ha^{-1} (Indiastat, 2021).

Continuous use of synthetic fertilizers create issues *viz.*, nutrient deficiency in plants, heavy metal accumulation, which further leads to the food contamination besides deterioration of soil health, reduced productivity and sustainability. The deteriorating soil health, declining soil organic matter and increase of micronutrient deficiencies has put a big question mark on the sustainability of wheat production (Verma, 2021; Verma *et al.*, 2021b). For this, use of indigenous sources like farm yard manure (FYM) should be encouraged as it supplies plant nutrient, improve the physical, chemical and biological properties of the soil and thereby increase the fertility and productivity of the soil while maintaining the ecological balance. To address these, inclusion of inexpensive organic fertilizers either sole or with other organic resources in combination with inorganic fertilizers enhance the soil health, soil fertility and bring about sustainable crop yields without any negative impact on the environment (Verma, 2019a).

The use of organic and inorganic fertilizers offers many advantages, including minimizing the dependency on inorganic sources, reducing potential environmental risks, and utilizing favorable impacts on soil characteristics to improve the efficiency of applied inorganic sources. This is seen as a key practice in the eco-friendly system to ensure sustainable and safe production. Yield attributing parameters like dry matter accumulation, no. of effective tillers, grains spike^{-1} and the test weight were shown to be influenced by the integrated use of inorganic and organic fertilizer (Mary *et al.,* 2018). Therefore, an integrated approach to plant nutrient management gained momentum and importance in recent years. The objective of this approach is efficient, judicious and economic use of all major sources of plant nutrients in an integrated manner so as to maximize/ optimize yield of a crop or a cropping system without any adverse effect on the agro- ecosystem.

Quality for bread wheat is mainly determined based on gluten proteins, the concentration and composition of which is found to affect the quality of baked products (Johansson, 2001). Unfortunately, organic farmers find it difficult to meet the quality standards for wheat (especially protein and gluten content), although they are paid a much higher price for organically produced grain. The supplementary and complementary use of organic nutrients and inorganic chemical fertilizers maintain a high level of quality of wheat grains in terms of gluten content. An integrated use of organic manure with inorganic fertilizer resulted in build-up of available nutrients in soil much more effectively than that of chemical fertilizer alone as reported by Bhatt *et al*. (2017). Therefore; the primary purpose of this field experiment was to find out the economical viable and sustainable nutrient management practices for achieving higher yield of wheat crop with appreciable chapatti making quality parameters under assured irrigated conditions of Western Himalayan region of Uttarakhand, India.

MATERIALS AND METHODS

The field experiment was conducted during *Rabi* season of 2020-2021 in the Experiment block of the School of Agricultural Sciences of the Shri Guru Ram Rai University (SAS-SGRRU), Pathribagh Dehradun, Uttarakhand which is located in the north western region of Uttarakhand at an altitude of 450m above mean sea level (MSL) and in between 29^0 58' and 31^0 2' 30 North latitude and 77^0 34´45´ and 78^0 18´30´´ east longitudes. During summer of the experimental year, maximum & minimum temperature was ranged between 36^0 C and 16^0 C while winter temperature varied between 23.4^0 Cand 5.2^0 C. The average annual precipitation was of 1440 mm. The month withthe lowest relative humidity was April (39.28%) while lowest number of rainy days was being November (1.17 days). Lowest number of average daily sunshine hours was confined in the month of January with 8.86 hours per day making total of 274.81 hours.

The soil of experimental site was sandy loam in texture, low in available nitrogen (225.3 kg ha^{-1}) and organic carbon (0.42 %), medium in available phosphorous (16.1 kg ha^{-1}), available potassium (236.3 kg ha^{-1}) with slightly neutral pH of 7.26. The experiment was laid out in Randomized complete block design (RCBD) with three replications and eight treatments. The allocated treatmentswereT_1- Control, T_2- 100 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}, T_3- 0 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}+ FYM @ 3 t ha^{-1}, T_4- 0 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}+ FYM @ 3 t ha^{-1} + PSB, T_5- 50 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}+ FYM @ 3 t ha^{-1}, T_6- 50 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}+ FYM @ 3 t ha^{-1} + PSB, T_7- 75 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}+ FYM @ 3 t ha^{-1} and T_8- 75 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}+ FYM @ 3 t ha^{-1} + PSB. At optimum moisture condition, the land of the experimental site was ploughed thoroughly cross wise for two times with tractor drawn harrow and final land preparation was done with mould board plough followed by proper leveling with the help of tractor drawn leveler. The wheat variety PBW- 75 was sown during first fortnight of November 2020 by line sowing method in the open furrows at a row-to-row distance of 22.5 cm by throwing the seeds in continuous fashion maintaining 5 cm plant to plant distance with the seed rate of 100 kg ha^{-1}. Fertilizers and farm yard manure were applied as per the treatments given in different blocks of the design at the time of field preparation by incorporating and mixing it in the soil. Half of the total nitrogen and full P_2O_5 and K_2O were applied as basal and the remaining half nitrogen was top dressed in two splits at 21 DAS and 50 DAS. Inoculants of phosphorus solubilizing bacteria (PSB) @ 100 g per kg of the well rotten FYM were applied at the time of ploughing. First irrigation was given at crown root initiation (CRI) stage usually 21-25 days after sowing. The crop was harvested when the grain became hard with a moisture content of 19-20 %. Harvesting was done manually by the sickle and harvested produce was allowed to sundry for 3-4 days and threshed to separate grain and straw.

The observation of growth and yield attributes were taken on the basis of randomly selected 5 plants from each plot. Plants from the randomly selected places using a one- meter row length in each plot was cut close to the ground to record dry weight at 30, 60, 90 DAS and at harvest. Samples were first dried in sun and then oven dried at 65± 2^0 C till constant weight was achieved. After drying, the samples were weighed for recording dry weight. CGR, RGR and NAR were analyzed by using following formula:

$$\mathbf{CGR} = \frac{w_2 - w_1}{t_2 - t_1} \quad \mathbf{RGR} = \frac{\log_e w_2 - \log_e w_1}{t_2 - t_1}$$

Where,

W_1= dry weight per unit area at t_1, W_2= dry weight per unit area at t_2.

t_1= first sampling, t_2= second sampling

$$\mathbf{NAR} = \frac{(W_2 - W_1)(\log_e LA_2 - \log_e LA_1)}{(t_2 - t_1)(LA_2 - LA_1)}$$

Where,

W_1= dry weight per unit area at t_1, W_2 = dry weight per unit area at t_2

LA_1= leaf area at t_1, LA_2 = leaf area at t_2

t_1= first sampling, t_2= second sampling

For estimation of gluten content, 25 g of wheat flour of the harvested grains from each treatment was taken in a plastic bowl followed by adding 15 ml of water so as to make dough and then immersing it in water for one hour. Starch was washed out by kneading gently over a fine sieve. Washed water was squeezed into clean water, andthen cohesive mass was obtained so called wet gluten. After pressing the content to make it dry, it was placed in petri dish containing small piece of aluminum foil, the wet gluten obtained was dried in a hot air oven at 100p C for 24 hrs (Imran *et al*., 2013). The dried gluten obtained during this process is called as dry gluten. Following formulas were used to calculate the wet and dry per cent gluten as describe under:

$$\textbf{Wet gluten (\%)} = \frac{W_2 - W_1}{25} \times (100 - A)$$

$$\textbf{Dry gluten (\%)} = \frac{W_3 - W_1}{25} \times (100 - B)$$

Where,

Weight of flour taken = 25 g

Weight of empty petri dish wash =W_1

Weight of petri dish+wet gluten (before drying)=W_2

Weight of petri dish+dry gluten (After drying) = W_3

Wet gluten content = A; Dry gluten content = B

Net return was calculated by subtracting respective values of cost of cultivation from gross return.

RESULTS AND DISCUSSION

Crop growth rate (CGR) and relative growth rate (RGR) of wheat crop was significantly influenced by various nutrient management approaches being maximum in T_5 and lowest found from the T_2. Various nutrient management sources had significantly influenced growth of the wheat crop during all the stages (Table 1). The maximum net assimilation rate at 30 DAS was recorded from T_3 which was at par with T_7 while lowest value from treatment T_2 among the fertilizer treatment. At 60 DAS, the maximum value of NAR was observed in treatment T_6 which was at par with T_5 and the lowest value from the treatment T_2. Laghari *et al.* (2010) also observed the similar findings and conceptualized that nitrogen, phosphorus and potassium had an important role in various physiological and metabolical processes which increase the net assimilation rate of wheat. However, application of organic manure to the soils is well known to increase microbial populations and their activities for nutrient cycling and production of plant growth influencing materials resulting in enhanced growth of the crop (Arancon *et al*., 2006; Verma, 2019c; Verma, 2019d; Verma, 2019e; Verma, 2019f) Yield attributing characteristics of the wheat crop *viz*. spike length, spikelet per spike, number of grains per spike and grain yield were also influenced significantly by various nutrient management approaches (Table 2). The highest values of these parameters were recorded from treatment T_5 which was on a par with T_6 while the lowest was obtained in the control treatment where no nutrient sources were applied (T_1). Plots treated with 100 % RDF

Table 1: Crop growth rate, relative growth rate and net assimilation rate of wheat at different stages as influenced by different nutrient management approaches

Treatments	CGR (g m^{-2} day^{-1})			RGR (mg g^{-1} day^{-1})			NAR (g m^{-2} day^{-1})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	0.235	0.306	0.798	0.037	0.041	0.056	0.442	0.570	1.373
T_2	0.256	0.276	0.611	0.039	0.046	0.061	0.440	0.568	1.077
T_3	0.312	0.329	0.691	0.043	0.049	0.066	0.540	0.676	1.185
T_4	0.313	0.341	0.758	0.047	0.055	0.071	0.517	0.711	1.249
T_5	0.320	0.343	0.859	0.059	0.061	0.075	0.465	0.734	1.156
T_6	0.316	0.360	0.804	0.044	0.051	0.063	0.492	0.753	1.246
T_7	0.317	0.336	0.850	0.046	0.042	0.066	0.518	0.634	1.345
T_8	0.318	0.366	0.835	0.038	0.045	0.067	0.490	0.684	1.217
SEm±	0.010	0.014	0.036	0.001	0.001	0.001	0.019	0.039	0.057
CD at 5 %	0.029	0.044	0.111	0.003	0.004	0.006	0.058	0.119	0.174

T_1- Control, T_2- 100 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}, T_3- 0 % RDF + FYM @ 3 t ha^{-1}, T_4- 0 % RDF + FYM @ 3 t ha^{-1} + PSB, T_5- 50 % RDF + FYM @ 3 t ha^{-1}, T_6- 50 % RDF + FYM @ 3 t ha^{-1} + PSB, T_7- 75 % RDF + FYM @ 3 t ha^{-1} and T_8- 75 % RDF + FYM @ 3 t ha^{-1} + PSB

Table 2: Yield attributes, yield, gluten content and net return of wheat as influenced by different nutrient management approaches

Treatments	Spike length (cm)	No. of Spikelets per spike	No. of grains per spike	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)	Wet gluten (%)	Dry gluten (%)	Net Return (Rs. ha^{-1})
T_1	7.91	63.00	27.90	1.83	2.63	4.53	41.1	25.8	6.1	23,766
T_2	8.25	69.24	28.69	3.04	3.32	6.01	43.3	27.8	7.9	38,663
T_3	8.63	75.23	31.45	4.09	4.09	7.71	46.3	32.1	11.2	53,833
T_4	9.40	66.31	32.20	4.29	4.32	8.12	46.0	35.1	12.2	56,343
T_5	10.26	87.23	36.57	5.30	4.89	9.20	46.6	37.3	14.2	73,515
T_6	9.77	82.59	35.21	5.07	4.81	9.06	46.2	36.0	12.7	67,291
T_7	8.85	79.61	34.20	4.15	3.60	6.47	44.1	34.1	12.1	48,189
T_8	8.39	79.60	29.76	4.05	3.35	6.07	43.7	33.0	9.1	44,633
SEm±	0.46	3.99	1.92	0.05	0.01	0.15	0.73	0.4	0.3	939.2
CD at 5 %	1.36	12.08	5.69	0.144	0.30	0.48	2.28	1.1	0.8	2,876.4

T_1- Control, T_2- 100 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}, T_3- 0 % RDF + FYM @ 3 t ha^{-1}, T_4- 0 % RDF + FYM @ 3 t ha^{-1} + PSB, T_5- 50 % RDF + FYM @ 3 t ha^{-1}, T_6- 50 % RDF + FYM @ 3 t ha^{-1} + PSB, T_7- 75 % RDF + FYM @ 3 t ha^{-1} and T_8- 75 % RDF + FYM @ 3 t ha^{-1} + PSB

alone (T_2) showed significantly lesser values of yield attributing characteristics as compared to plots treated with 50 % RDF along with FYM (T_5). Abebe and Abede (2016) also reported that fertilizer application showed increment in length of spike as compare to control treatment. Similar trends were also observed by Siavoshi *et al.* (2011) who reported that application of inorganic fertilizers along with manure increase the panicle length (Arif *et al.*, 2017 and Narkhede *et al.,*2015). In a study it is well documented that numbers of grains per spike is generally increased if farm yard manure or other organic fertilizers are added with NPK (Arif *et al.*, 2017). Kumar *et al.*(2017) also observed similar findings and reported that the maximum no. of grains increased by integrating FYM with NPK.

The maximum grain yield of 5.30 t ha^{-1} was recorded from the treatment T_5 which was followed by T_6 (4.26 t ha^{-1}) and the lowest grain yield was recorded from the treatment T_2 (2.60 t ha^{-1}) and the lowest value of grain yield followed by T_2 (2.60 t ha^{-1}) among the fertilizer treatments. The maximum grain yield in T_5 and T_6 is due the 50% RDF of N, P_2O_5 and K_2O application along with incorporation of FYM. Ayoub (1994) also reported the similar findings that grain yield may be increased with application of nitrogen fertilizer or the application of organic matter along with chemical fertilizers (Bandyopadhyay *et al.* 2010; Bharati *et al.* 2017; Khan *et al.*, 2007;

Mahapatra *et al*., 2017; Siavoshi *et al*., 2011; Verma, 2019b; Verma *et al*., 2018a; Verma *et al*., 2018b; Verma *et al*., 2018c; Verma *et al*., 2019a; Verma *et al*., 2019b and Verma *et al*., 2021a).

The maximum straw yield of 4.89 t ha^{-1} was recorded from the treatment T_5 which was at par with T_6 (4.81t ha^{-1}) might be due to the effect of FYM and PSB in combination with inorganic fertilizer which led in higher straw yield of the crop. These findings were in close conformity with the findings of Khanna *et al.* (2019); Roy *et al*. (2017); Dubey *et al. (*2017). For improvement in growth and yield attributes of wheat, the combination of FYM and other nutrient sources seems to be better than FYM alone (Davari *et al.,* 2012). Addition of FYM and N fertilizer increase the biological yield, harvest index of the crop (Singh *et al*., 2018; Arif *et al*., 2016)

The wet gluten content of wheat was found maximum from the treatment T_5, lower value was observed from the treatment T_2 followed by control (Table 2). A maximum dry gluten content of wheat was observed from T_5 and lower value found from the T_2. Singh *et al*. (2002) observed that the protein content of wheat grain increase with the application of FYM over absolute control. Blecharczyk and Malecka (2004) also reported that the application of FYM along with NPK on the protein and gluten content of grain. However, Dwivedi *et al*. (2002) foundthat the protein content may be increased by zinc and sulphur which might have been supplied by farm yard manure.

Highest net returns of Rs. 73,515 was recorded in T_5 where 50 % of recommended dose of fertilizers along with 3 tone per hectare of farm yard manure (T_5) were applied followed by T_6 (Rs. 67,291) where PSB was added with 50 % RDF + FYM (T_6). Saving of Rs. 30,230were found in T_5 over T_1 control.

CONCLUSION

On the basis of one season study, it can be concluded that the growth, yield, quality and net benefit of the wheat crop was influenced greatly by various nutrient management approaches. Application of FYM @ 3 t ha^{-1} along with 50 % RDF (120: 60: 40) N: P_2O_5:K_2O kg ha^{-1}may be suggested for enhancing grain yield and net returns with appreciable amount of gluten under irrigated conditions of Western Himalayan region of Uttarakhand.

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Received: October 24, 2021
Accepted: December 30, 2021