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Impact of Different Fertility Levels and Organic Nutrient Sources on Productivity, Quality and Economics of Wheat (*Triticum aestivum* L. Emend. Fiori & Paol)

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ABSTRACT

A field study was carried out at the Agricultural Research Farm, Vivekanand Global University, Jaipur, Rajasthan during *Rabi* season of 2018-19 with the objective to find out the impact of different fertility levels and organic nutrient sources on productivity, quality and economics of wheat. The field experiment was laid out with three fertility levels (75%, 100% and 125% recommended dose of fertilizers) randomly allocated to the main plots of split plot design and five treatments of organic sources (control, vermicompost @ 2.5 t ha^{-1}, vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + *PSB*, farmyard manures @ 5 t ha^{-1} and farmyard manures @ 5 t ha^{-1} + *Azotobacter* + *PSB*) assigning to sub-plots by replicating thrice. The experimental findings revealed that, among the fertility levels, the application of 125% recommended dose of fertilizers (120:60:60 N: P: K) being at par with 100% recommended dose of fertilizers, recorded significantly maximum yields (grain, straw and biological yield, respectively 40.19, 58.27 and 98.46 q ha^{-1}), nitrogen content and their uptake by grain and protein content in grain of wheat over 75% recommended dose of fertilizers. The same treatment also recorded significantly maximum net returns (₹33698 ha^{-1}) and B: C ratio (1.46) of wheat. Similarly, the application of farmyard manures @ 5 tha^{-1} + *Azotobacter* + *PSB* being at par with application of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + *PSB*, recorded significantly highest grain, straw and biological yield (42.13, 61.07 and 94.85 q ha^{-1}, respectively), nitrogen content and their uptake by grain and protein content in grain of wheat as compared to other treatments. The results further stated that significantly maximum net returns (32384 ha^{-1}) and B: C ratio (1.48) of wheat was obtained by application of farmyard manures @ 5 tha^{-1} + *Azotobacter* + *PSB*.

Key words: *Azotobacter, Farmyard manures, Vermicompost, Wheat and Yield*

Introduction

Wheat (*Triticum aestivum* L. Emend. Fiori & Paol) is the most important staple food crop of world. Role of wheat production in world economy is significant both in terms of cultivated land and food supply, feeding and commerce. In India, it is the second important food crop after rice and occupies a notable position among the food grains not only in area and production but also in its versatility in adaptation to a wide range of agro-climatic conditions. The economic importance of wheat and its contribution to the diets of humans and livestock cannot be disputed. It plays an important role in food and nutritional security as it is an excellent health building staple food consumed by nearly 65 per cent of the population in various forms and thus, emerged as the backbone of India's food security. Wheat 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}. Rajasthan contributed 10.49 million tonnes of wheat from 3.0 million hectares area with productivity of 3501 kg ha^{-1} to the national pool. Based on the several benefits and production statistics discussed, the need to promote the cultivation and consumption of wheat required by developing a multi-sector and multi-level strategy that prioritizes the economic and health interests of human-soil-environment.

Since the possibility of horizontal expansion or putting more area under wheat cultivation is less. Therefore, future augmentation in yield would have to be harnessed vertically through increase in productivity by judicious management of all input resources. But recently the soil fertility has been declined due to the intensive use of lands without proper replenishment of plant nutrients especially where high yielding varieties of cereals are being cultivated using unbalanced doses of mineral fertilizers with little or no organic recycling. The potential solution to facing these challenges and for enhancing productivity exist, such as integrated nutrient management, *i.e.* use of bulky organic manures along with reduced amount of chemical fertilizers. Nitrogen, phosphorus and potassium are the major nutrients for plant growth and these nutrients status in soils of this region is low. Nitrogen being a structural part of plant body which helps in synthesis of protein and important for photosynthetic activities in the plants. Likewise, phosphorus is the key element in the process of conservation of solar energy into chemical energy. The optimum supply of phosphorus to the plant stimulates root development and growth thereby helps to establish seedling quickly and also reduces the harmful effect of excess nitrogen in plants. Potassium is also one of the major elements essential for growth, yield and quality of plant and it is thought to be essential for the formation and translocation of carbohydrates which needed in large quantities by most of the crops. The utilization of organic fertilizers as a nutrient source has been in use since the beginning of established agriculture, but after the induction of prevalent utilization of inorganic fertilizers, the bulky organic manures were deemed as a second alternative of nutrients. In order to safeguard the environment and health of soil-plant-human from further degradation, again we should choose for less use of chemical fertilizers and shift from chemical to biological agriculture to nourish the crop. In this regard, for maintaining the higher production level, recourse has to be made to the application of synthetic fertilizers and organic manures in a judicious way. Bulky organic manures provide most of the essential plant nutrients (instead to one or two nutrients by chemical fertilizers) beside enhancing the soil carbon stock and improving soil physical and biological conditions. Use of organic manures *i.e.* farm-yard manure (FYM), vermicompost etc. as a part of nutrient management strategy helps in mitigating the multiple nutrient deficiencies. A judicious combination of organic and inorganic fertilizers can maintain long-term fertility and sustain higher productivity of crops. Therefore, keeping these points in view, a field investigation was conducted to determine theimpact of different fertility levels and organic nutrient sources on productivity, quality and economics of wheat.

Materials and Method

Experimental site: - The field experiment was carried out during *Rabi* season of 2018-19 at Research Farm, Vivekananda Global University, Jaipur. Geographically, the study area is located at 075°88′99″ E longitude and 26°81′17″ N latitude and this region falls under agro-climatic zone III A of Rajasthan (Semi-arid Eastern Plain Zone). The region's climate is classified as semi-arid with characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5 °C) and winter (4 °C) with annual rainfall of 500-700 mm. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction.

Experimentation and crop husbandry: The field experiment was laid out with three fertility levels (75%, 100% and 125% recommended dose of fertilizers) randomly allocated to the main plots of split plot design and five treatments of organic sources (control, vermicompost @ 2.5 t ha^{-1}, vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + *PSB*, farmyard manures @ 5 t ha^{-1} and farmyard manures @ 5 t ha^{-1} + *Azotobacter*

+ *PSB*) assigning to sub-plots by replicating thrice.The gross plot size was 5.0 m x 4.0 m (20.0 m^2) and total experimental area was 1732.64 m^2. The wheat variety 'Raj 4238' was sown on 2nd December 2018.The herbicide pendimethalin was applied as pre-emergence and 2,4-D as post-emergence at appropriate soil moisture to control the grassy and broad-leaved weeds. A pre-sowing irrigation was given for better seed germination, better seedling emergence and proper growth and development. After that total six irrigation was given at the critical stages of crop growth. Standard crop production practice and methods were followed for fertilizer application and crop protection management to grow the crop.

Data collection: -Five plants were selected randomly from net plot and tagged for measurement of grain yield, straw yield, biological yield and harvest index of wheat. The weight of crop biomass (biological yield) was recorded. The harvested plants in the net plot (excluding the border rows) were threshed, dried and cleaned to record the grain yield. The net plot yield was converted to kg per hectare. Straw yield was obtained by subtracting the grain yield (q ha^{-1}) from biological yield. The harvest index is the ratio of grain yield to biological yield and expressed in percentage. Grain sample of wheat from individual plot was taken at the time of threshing for estimation of nitrogen content. The samples were dried in oven and ground separately using grinder and nitrogen content were determined by colorimetric method using Nessler's reagent. The uptake of nitrogen by grain of wheat was calculated as per cent nitrogen content in grain multiplied by grain yield (kg ha^{-1}) and expressed as nitrogen uptake kg ha^{-1}. Economics of different treatments were worked out by considering the cost of inputs and income obtained from output based on the prevailing market price.

Statistical analysis

Comprehensive statistical analysis (treatment mean, standard error mean, critical difference and range of variation) and test of significance test (F-test) were carried out for each quantitative and qualitative trait. For this, entire biometric data recorded during the course of investigation were compiled in proper tables and statistically analyzed by using the standard procedures of statistical analysis for split plot design suggest by Gomez and Gomez (1984).

Results and Discussion

Effect of fertility levels

Data revealed that increase in fertility levels from 75% RDF to 125% RDF exhibited significant impact on yield of wheat. The data showed that the plants received 125% RDF recorded significantly maximum grain yield, straw yield and biological yield (40.19, 58.27 and 98.46 q ha^{-1}, respectively) of wheat as compared to 75% RDF and remained at par with 100% RDF level (Table 1). While, the harvest index of wheat was not influenced by different fertility levels and remained unchanged among all the treatments. The grain and straw yield significantly influenced with application of different fertility levels might be due to improvement in yield attributes and cumulative interaction between vegetative and reproductive growth of the crop. By virtue of increased supply of metabolites, there might have been significant improvement in dry matter production with increasing fertilizer application. The continuous availability of N, P and K in plant at all critical stages, which might have resulted in higher photosynthesis, better root development which increased the higher supply of photosynthates from source to sink which ultimately increased the grain yield of wheat. The significant increase in straw yield due to application of 125% RDF could be ascribed to the increased vegetative growth resulted effective utilization of nutrients absorbed through extensive root system developed due to phosphate fertilization. Biological yield is a function of grain and straw yields. Thus, significant increase in biological yield with the application of 125% RDF could be attributed due to increased grain and straw yield. Mohanta *et al*., 2020; Singh *et al*. (2019); Jakhar *et al.* (2021); Kumawat *et al.* (2021) and Patidar and Singh (2021) also reported improvement in yield with increasing fertilizer levels in wheat crop. The data (Table 1) revealed that the N content and their uptake by grain and protein content significantly influenced by different fertility levels. It was found that the N content and their uptake by grain and protein content was significantly higher with the application of 125% RDF than the 75% RDF. Although, 125% RDF was statistically at par with 100% RDF in terms of N content and their uptake by grain and protein content.The significant increase in nutrient contents due to greater availability of nutrients in soil applied through addition of fertilizers. The uptake of nutrients as a function of biomass production and nutrient content of that biomass increased with fertilizer application. These results are in line with the findings of Mohanta *et al*. (2020) and Kumari *et al*. (2021). The data further revealed that net returns and B: C ratio of wheat was significantly enhanced due to different fertility levels (Table 2). The significantly maximum net returns (33698 ha^{-1}) and B: C ratio (1.46) of wheat was obtained with the application of 125% RDF which was closely followed by 100% RDF and superior over 75% of RDF. The higher net return and B: C ratio was associated with higher grain and straw yield per unit of added cost in this treatment. The maximum net return and benefit: cost ratio with higher fertility levels were also reported in wheat.

Effect of organic nutrient sources

The data concerning to the yield of wheat showed significant variations due to different organic nutrient sources. Among different treatments, the highest yield, *i.e.* grain yield, straw yield and biological yield (42.13,61.07 and 94.85 q ha^{-1}, respectively) of wheat was recorded with combined application of FYM @ 5 t ha^{-1} + *Azotobacter* + *PSB* (Table 1). This was significantly superior to remaining treatments but statistically at par with the vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + *PSB*. This might be due to the fact that application of vermicompost/FYM + *Azotobacter* + *PSB* increased the nitrogen supply which resulted in the increased conversion of carbohydrates in to proteins which in turn are elaborated in to protoplasm. The favorable effect of nitrogen on the size of cell, which is expressed morphologically in terms of increased plant height, dry matter accumulation etc. The improvement in growth attributing parameters directly supports the development of yield attributing characters. Significant increase in grain and straw yield was recorded due to different organic nutrient sources and this might be due to their positive influence on maintaining balanced source - sink relationship which clearly evident from remarkable improvement in dry matter production, growth characters and yield attributes which eventually resulted in increased grain yield. The increase in straw yield with application of organic manure and biofertilizers could be partly attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth. Earlier Ahmad *et al.*, (2013); Patel *et al.*, (2017); Singh *et al.*, (2019); Dhiman and Dubey, (2017) and Jat *et al.*, (2018), also proved the significance of organic fertilizers towards improvement in the crop yield of wheat crop. The data (Table 1) revealed that the N content and their uptake by grain and protein content significantly influenced by different organic nutrient sources. It was found that the N content and their uptake by grain and protein content was significantly higher with

Table 1. Yield, N content and their uptake and protein content of wheat as influenced by different fertility levels and organic sources of nutrient

Treatment	Yield attributes			Harvest index (%)	N content (%)	N uptake (kg ha^{-1})	Protein content (%)
	Grain yield	Straw yield	Biological yield				
Fertility levels							
F_1 – 75% RDF	36.15	52.41	88.56	40.71	1.97	71.21	12.32
F_2 – 100% RDF	40.19	58.27	98.46	40.68	2.04	81.98	12.78
F_3 – 125% RDF	41.88	60.72	102.60	40.86	2.07	86.69	12.91
SEm±	0.765	1.094	1.85	0.112	0.016	1.96	0.10
CD at 5%	2.49	3.57	6.06	NS	0.05	6.38	0.33
Organic sources							
O_1 – Control	35.64	51.67	79.49	40.41	1.85	65.93	11.91
O_2 – Vermicompost @ 2.5 t ha^{-1}	38.82	56.27	86.76	40.73	1.95	75.70	12.54
O_3 – Vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB	41.97	60.84	94.55	40.64	2.05	86.04	13.14
O_4 – FYM @ 5 t ha^{-1}	38.49	55.80	87.16	40.65	1.95	75.05	12.56
O_5 – FYM @ 5 t ha^{-1}+*Azotobacter* + PSB	42.13	61.07	94.85	41.34	2.05	86.36	13.19
SEm±	0.959	1.371	2.32	0.433	0.025	2.70	0.15
CD at 5%	2.83	4.05	6.87	NS	0.07	7.96	0.45

Table 2. Economics of wheat as influenced by different fertility levels and organic sources of nutrient

Treatment	Cost of cultivation (ha^{-1})	Gross return (ha^{-1})	Net return (ha^{-1})	B:C ratio
Fertility levels				
F_1 – 75% RDF	69294	92729	23435	1.34
F_2 – 100% RDF	74661	103090	28430	1.39
F_3 – 125% RDF	73727	107425	33698	1.46
SEm±	-	1954	1954	0.03
CD at 5%	-	6373	6373	0.09
Organic sources				
O_1 – Control	67840	83233	22860	1.38
O_2 – Vermicompost @ 2.5 t ha^{-1}	78340	90845	14722	1.19
O_3 – Vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB	78592	99001	22626	1.30
O_4 – FYM @ 5 t ha^{-1}	68890	91255	24582	1.37
O_5 – FYM @ 5 t ha^{-1} + *Azotobacter* + PSB	69142	99309	32384	1.48
SEm±	-	2450	2450	0.03
CD at 5%	-	7227	7227	0.10

the application of FYM @ 5 t ha^{-1} + *Azotobacter* + PSB than the other treatments. The positive influence of this treatment could be appearing due to improved nutritional level both in the root zone and plant system. The increased availability of nutrients in root zone coupled with increased metabolic activity at cellular level might increase nutrient uptake and their accumulation in vegetative plant parts. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of these nutrients to reproductive organs of the crop and ultimately increased the contents in grain. Increased uptake of N seems to be due to the fact that uptake of nutrient is a product of biomass accumulated by particular part and its nutrient content. These results are in close conformity with the findings of Kumar *et al*., (2017) and Argal *et al.*, (2017). Now-a-days in agriculture, the feasibility of any treatment can be decided only on the basis of monetary returns and the results stated that significantly maximum net returns (32384 ha^{-1}) and B: C ratio (1.48) of wheat was obtained by application of farmyard manures @ 5 tha^{-1} + *Azotobacter* + *PSB*. The cost involved under these treatments was comparatively lower than additional income, which led to more returns under these treatments as compared to other treatments. Similar finding have also been reported by Kumar *et al.*, (2017) and Kaur *et al.*, (2018).

Conclusion

On the basis of results of present investigation, it may be concluded that integrated use of inorganic and organic fertilizers significantly influenced the yield attributes, yield and economics of wheat. The application of 125 % RDF+ farmyard manures @ 5 t ha^{-1} + *Azotobacter* + *PSB* gave significantly highest yield attributes, grain, straw and biological yield along with increased monetary returns and this treatment was found suitable for farmer practices on the basis of higher productivity and monetary returns of this treatment.

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