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PRODUCTIVITY AND PROFITABILITY OF WHEAT (*TRITICUM AESTIVUM* L.) UNDER DIVERSE NUTRIENT REGIMES

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ABSTRACT

A field experiment was conducted during *Rabi* season of the year 2022-23 at Agricultural Research Farm of Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala to assess the effect of integrated nutrient management on yield attributes, yield and relative economics of wheat. The experiment was laid out in randomized block design with three replications consisting of eight treatments *viz.* T_1-Control, T_2 - 50% RDF + Sulphur @ 40 kg/ha, T_3 - 50% RDF + $ZnSO_4$ @ 25 kg/ha, T_4 - 75% RDF, T_5 - 75% RDF + $ZnSO_4$ @ 25 kg/ha, T_6-100% RDF, T_7 - 75% RDF + 25% nitrogen through FYM + *Azotobacter* and T_8 - 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha. Among all the treatments, application of 100% RDF + 25% nitrogen number through vermicompost + $ZnSO_4$ @ 25 kg/ha (T8) produced significantly higher number of spikes/m^2 (367.09), number of grains/spike (37.10), 1000 grain weight (38.34 g), spike length (9.57 cm), grain yield (48.83 q/ha), straw yield (64.96 q/ha) and biological yield (113.79 q/ha). Additionally, this treatment also recorded numerically highest gross returns (Rs. 125995/ha) but along with highest cost of cultivation (Rs. 48914/ha) as well which greatly reduced its net returns (Rs. 77081/ha) and B:C ratio (1.57). Further scrutiny of relative economics revealed that T6 (100% RDF) recorded highest net returns (Rs. 83173/ha) and B:C ratio (2.60) owing to its lower cost of cultivation (Rs. 31414/ha). Superior net returns and B:C ratio in this treatment make it most desirable treatment even if its yields are marginally lower that T_8.

***Keywords*:** Wheat, Integrated Nutrient Management, Yield, Relative Economics, Organic Manures.

Introduction

Wheat is second most consumed crop in India after rice. It contains about 63-71% starch, 10-12% protein, 1.5-2.0% fat and 2-3% sugars (Kumar *et al.*, 2011). In India wheat covered an area of 31.83 million hectares with production of 113.29 million tonns and 35.59 q/ha yield (Anonymous, 2024). Higher demand and assured MSP on wheat encourage farmers to grow it on wider scale which eventually results in around 25% share of wheat in annual food grain production. Specifically, in Haryana, wheat was cultivated across 2.32 million hectares, resulting in an area of 10.93 million tons and an average yield of 47.04 q/ha in 2022-23 (Anonymous, 2024). Wheat productivity in major Northwestern states such as Punjab, Haryana, and western Uttar Pradesh have experienced minimal advancement lately (Khan *et al.*, 2023 and Sahu *et al.*, 2021). In order to increase wheat productivity, optimum nutrient management can be a great tool which can ensure sustainable food security in the country.

Nitrogen plays a critical role in plants by being a fundamental building block of proteins which, in turn, form the very foundation of protoplasm within each plant cell (Bhatta *et al.*, 2020). Being a vital component of building block of proteins, Nitrogen is significantly involved in all these processes (Singh *et al.*, 2019). Strong vegetative growth in any crop requires sufficient quantity of nutrients for chlorophyll synthesis and effective glucose utilization. For higher crop productivity, adequate amount of Phosphorus is essential. It is an essential building block of DNA and RNA which carry genetic instructions crucial for protein synthesis (Zhou *et al.*, 2024). It serves diverse functions in plant metabolism, including energy transfer, cellular respiration, glycolysis, metabolism of carbohydrates, oxidation-reduction reactions, enzyme activation and deactivation. Potassium is also essential for plants and many times its uptake eclipses even that of nitrogen. Not only did plant tissues have more potassium than other cations, but potassium also effectively controls a variety of physiological and biochemical processes (Kubar *et al*., 2019).

Zinc is a vital micronutrient which is significantly involved in numerous biological functions and the production of chlorophyll. Additionally, zinc contributes to nitrogen metabolism and is involved in the synthesis of key biomolecules like lipids, proteins, and auxin co-factors, thus playing a critical role in plant nucleic acid metabolism. Application of zinc has been demonstrated to effectively enhance both crop health and productivity (Hassan *et al*., 2019). Sulphur, another vital nutrient, is critical for the synthesis of nucleic acids and the establishment of protein structures through disulphide bonds. Several essential amino acids contain sulphur, including cysteine, methionine, cystine along with coenzymes, thioredoxine, sulpholipids *etc*. It contributes to increased chlorophyll production and helps in photosynthesis. Sulphur nutrition has a significant impact on wheat crop development and output (Singh, 2021).

Proper and optimal fertilizer application not only increases yield but also enhances food quality. To counter declining yields, implementing integrated nutrient management (INM) is essential. Additionally, farm yard manure and vermicompost provide micronutrients which are absent in most of chemical fertilizers (Kumar *et al*., 2024). Utilizing organic manures such as FYM and vermicompost enhances soil physicochemical and biological properties. These manures, rich in essential nutrients, increase soil organic matter and humus, fostering beneficial bacteria and improving nutrient availability to crops (Amanullah *et al*., 2019) Vermicompost is rich in both macro and micronutrients that support the growth of crops. It increases macropore, hence improving the air-water connection (Rana *et al.,*2018). Biofertilizers efficiently enhance agricultural production. Among these, *Azotobacter* is one of the most important biofertilizers that is responsible for conversion of atmospheric nitrogen into ammonium ions accessible to cereals, fixing an average of 20 kg N/ha annually (Aasfar *et al*., 2021) and ultimately increases crop yields by approximately 10-12 % across various agricultural crops (Noreen and Noreen, 2014). Current study aims to optimize wheat nutrition in an integrated way for obtaining substantial yield in a manner which is economically feasible for farmers as well.

Material and Methods

The present study was carried out during *Rabi* season of the year 2022-23 at Agricultural Research Farm, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala which is situated at 30^0 17´ N latitude, 77^0 3´ E longitude and at an altitude of 264 meter over mean sea level. The soil of experimental field was sandy loam in texture having 55% sand, 32% silt and 13% clay and was slightly alkaline in reaction (7.98), safer in electrical conductivity (0.98 dSm^{-1}) and low I organic carbon (0.30%). Soil of the field was also found to be low in available N (165.43 kg/ha), on the other hand it was medium in available P_2O_5 (14.40 kg/ha) and available K_2O (210.51 kg/ha). The experiment was carried out in randomized block design consisting of eight treatments that were replicated thrice *viz*. T_1 - Control, T_2 - 50% RDF + Sulphur @ 40 kg/ha, T_3 -50% RDF + $ZnSO_4$ @ 25 kg/ha, T_4 - 75% RDF, T_5 - 75% RDF + $ZnSO_4$ @ 25 kg/ha, T_6 - 100% RDF, T_7 - 75% RDF +25% nitrogen through FYM + *Azotobacter* and T_8 - 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha. Wheat variety HD 3086 was sown on 3rd December 2022 using seed rate of 100 kg/ha. The value of the RDF has been taken as per general recommendation (120:60:60 NPK kg/ha). Prior to sowing, FYM and vermicompost were applied to the experimental plots as per treatment requirements and were manually incorporated in soil with the help of a spade. Before sowing,1/3rd of the recommended nitrogen dose was applied along with full recommended dose of phosphorous and potassium. After first irrigation, additional one third dose of nitrogen was applied as top dressing. Prior to sowing *Azotobacter* was added to wheat seeds @ 20g/kg along with jaggery as per required treatment. The cost of cultivation and gross returns of each treatment was computed using current market prices and benefit cost ratio was determined as ratio of gross returns to cost of cultivation.

$$B:C = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

The statistical analysis for randomized block design was conducted using ANOVA (Analysis of variance) as outlined by Cocharan and Cox (1957). Critical difference values among treatments were worked out at a 5 % probability level.

Resutl and Discussion

Yield attributes

The data presented in Table 1 showed that application of treatment T8 (100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha) resulted in significantly higher number of spikes/m^2 (367.09), number of grains/spikes (37.10), 1000 grain weight (38.34 g) and spike length (9.57 cm). Also, treatments T5 (75% RDF + $ZnSO_4$ @ 25 kg/ha), T_6 (100% RDF) and T_7 (75% RDF +25% nitrogen through FYM + *Azotobacter*) were statistically at par with T_8. On the other hand, significantly lower values were observed in control (T_1) in terms of number of spikes /m^2 (286.70), grains/spike (27.22), 1000 grain weight (31.77 g) and spike length (5.67 cm). These enhanced values of the yield attributes might be due to the consistent supply of essential plant nutrients from the organic manures and as well as through chemical fertilizers which helped the plants to boost up their metabolic activity and hence resulted in superior early vegetative growth in terms of higher dry matter accumulation. Moreover, development of vigorous root system resulted in more number of tillers/m^2 which increased the number of spikes/m^2 significantly. It was also observed that due to the application of organic manures and chemical fertilizers in conjunction, all the essential plant nutrients were readily available to the plant roots for uptake and hence enhancing photosynthesis in plants. All of this eventually resulted in higher photosynthate accumulation and their translocation in reproductive organs resulting in superior yield attributes in these treatments. Similar results were also observed by the Singh *et al.* (2015), Pandey *et al.* (2009) and Devi *et al.* (2011).

Table 1: Effect of nutrient management on yield attributes of wheat

Treatments	No of spikes/m^2	Grains /spike	1000 grain weight (g)	Length of spike (cm)
T_1: Control	286.70	27.22	31.77	5.67
T_2: 50% RDF + Sulphur @ 40 kg/ha	311.67	31.72	35.48	8.04
T_3: 50% RDF + $ZnSO_4$ @ 25 kg/ha	321.74	31.79	35.79	8.21
T_4: 75% RDF	334.83	33.07	36.37	8.31
T_5: 75% RDF + $ZnSO_4$ @ 25 kg/ha	341.51	35.02	36.09	8.89
T_6: 100% RDF	355.30	35.20	37.86	9.20
T_7: 75% RDF + 25% nitrogen through FYM	354.64	35.00	37.09	9.06
T_8: 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha	367.09	37.10	38.34	9.57
SEm±	19.43	1.66	1.06	0.41
CD at 5%	31.90	3.56	2.27	0.87

Yield

Data pertaining to grain yield is presented in Table 2. It was observed that with the application of 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha (T8) recorded significantly higher grain yield (48.83 q/ha), straw yield (64.96 q/ha) and biological yield (113.79 q/ha). Which was closely followed by T_6 (100% RDF) which was statistically at par with T_7 (75% RDF +25% nitrogen through FYM + *Azotobacter*). On the other hand, significantly lower values were recorded in the control (T_1). It was also observed that harvest yield was not affected significantly in all the treatments. Superior yield in this treatment might be due to use of organic manures and synthetic fertilizers which provided sufficient quantity of essential nutrients which might have resulted in their superior nutrient uptake by the plants thus resulting in higher growth parameters and yield attributes under these treatments. Further, proper growth in these treatments might have promoted translocation of the photosynthates from source to sink resulting in increased grain yield. Superior growth parameters in these treatments suggest higher vegetative growth which eventually resulted in higher straw yield thus eventually enhancing biological yield of these treatments. These results were found in accordance with the studies conducted by Sarma *et al.* (2007) and Devi *et al.* (2011). But data also revealed that the treatments had no significant impact on the harvest index of wheat crop.

Table 2: Effect of nutrient management on yield and harvest index of wheat

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T_1: Control	20.85	27.75	48.60	42.73
T_2: 50% RDF + Sulphur @ 40 kg/ha	33.13	47.58	80.71	41.11
T_3: 50% RDF + $ZnSO_4$ @ 25 kg/ha	33.54	48.52	82.06	40.81
T_4: 75% RDF	39.53	53.35	92.89	42.35
T_5: 75% RDF + $ZnSO_4$ @ 25 kg/ha	40.01	53.59	93.60	42.21
T_6: 100% RDF	44.53	58.51	103.03	43.21
T_7: 75% RDF + 25% nitrogen through FYM	44.13	57.64	101.77	43.35
T_8: 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha	48.83	64.96	113.79	42.92
SEm±	1.94	2.13	3.13	1.50
CD at 5%	4.16	4.56	6.72	NS

Table 3: Effect of nutrient management on relative economics of wheat

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C Ratio
T_1: Control	22658	53807	31149	1.57
T_2: 50% RDF + Sulphur @ 40 kg/ha	28341	86978	58637	2.02
T_3: 50% RDF + $ZnSO_4$ @ 25 kg/ha	29536	88197	58662	1.99
T_4: 75% RDF	29225	102335	73110	2.48
T_5: 75% RDF + $ZnSO_4$ @ 25 kg/ha	33030	103391	70360	2.17
T_6: 100% RDF	31414	114587	83173	2.60
T_7: 75% RDF + 25% nitrogen through FYM	36825	113412	76587	2.08
T_8: 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha	48914	125995	77081	1.57

Relative economics

Data pertaining to relative economics is presented in Table 3, it was recorded that with the application of 100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 Kg/ha (T_8) resulted in numerically highest cost of cultivation (Rs. 48914/ha) and gross returns (Rs. 25995/ha) while application of 100% RDF recorded numerically highest net returns (Rs. 83173/ha) and benefit cost ratio (2.60). This might be attributed to remarkably higher cost of organic manures such as vermicompost and FYM which drastically increased cost of cultivation compared to the sole use of synthetic fertilizers. Similar findings were also observed by the Maurya *et al.* (2019) and Devi *et al.* (2011).

Conclusion

Based on the current study it can be concluded that treatment T8 (100% RDF + 25% nitrogen through vermicompost + $ZnSO_4$ @ 25 kg/ha) resulted in significantly higher growth parameters, yield attributing characters and yield but its cost of cultivation is also highest owing to high cost of vermicompost used in this treatment. So, considering economic returns, T6 (100% RDF) performed best among all the treatments with prominent yield, lower cost of cultivation hence superior net returns and B:C ratio.

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