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EFFECT OF DIFFERENT LEVELS OF MICRONUTRIENTS MIXTURE AND VERMICOMPOST ON GROWTH, YIELD, HARVEST INDEX AND ECONOMICS OF WHEAT

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ABSTRACT

The experiment was conducted during rabi season (November – April, 2022-23) at research farm, Shri Ram College Muzaffarnagar (Uttar Pradesh.) to study the effect of different levels of micronutrients mixture and vermicompost on growth, yield, harvest index and economics of wheat. The experiment was conducted on high yielding dwarf variety of wheat HD 2967 sowing date 7 November 2022 in factorial randomized block design with 3 replications and 24 plots. The experiment comprised of eight treatments *viz.;* T_1 control, T_2 (nitrogen, phosphorus and potassium @ 120:60:60 kg ha^{-1}), and the treatments from T_3- T_7 received nitrogen, phosphorus and potassium @ 120:60:60 kg ha^{-1} with the level of micronutrients mixture @ 5,10, 15, 20 and 25 kg ha^{-1} respectively and T_8 was applied with the dose of nitrogen, phosphorus and potassium @ 120:60:60 kg ha^{-1}+ vermicompost @ 3 tones ha^{-1}. The experimental soil was low in organic carbon and available nitrogen and medium in phosphorus and higher in potassium with slightly alkaline in pH. The results revealed that the application of recommended nitrogen, phosphorus and potassium with vermicompost @ 3tones ha^{-1} gave the maximum plant height, number of tillers m^{-2}, dry matter accumulation, yield attributing characters, grain, straw, biological yield, harvest index and gross return among all the other treatments. Whereas application of recommended dose of fertilizers with micro-nutrients mixture @ 25 kg ha^{-1} resulted in highest net return and B: C ratio as compared to recommended dose of fertilizers with vermicompost @ 3tones ha^{-1} and similar other treatments.

***Key word*:** Wheat, micronutrients mixture, vermicompost, grain yield, Harvest index, net return, B: C ratio.

Introduction

The Poaceae family contains wheat (*Triticum aestivum* L.) (Singh and Singh, 2024). Amongst the most prominent families of flowering plants is this one. Reaching to a height of between two and four feet, the wheat plant is a perennial grass. The country's food and nutritional security depend heavily on wheat that is the second-most essential grain crop in India. Wheat contributes nearly twenty percent of the calories ingested by around 55% of the world's population. It is one of the major food grains of the country and a staple food of the people of North India, where people have a preference for chapati. The diverse environmental conditions and food habits of people in India support the cultivation of three types of wheat (*bread, durum, and dicoccum*) (Saha *et al.*, 2023). The quantity and nutritional value of plant products are undoubtedly among the factors affecting both human and animal welfare (Singh *et al.*, 2023). Numerous billion people, or 25% of the world's population, currently suffer from micronutrient deficiency, which is a major cause of illness and mortality. Numerous soil macro- and micronutrients play a crucial role in crop nutrition, increasing yield and overall plant growth ((Dhillon and Ram, 2023; Kumar *et al.*, 2023). But micronutrient deficiencies may exist in both soil and crops (Aziz *et al.*, 2019). In order to increase crop yield, micronutrients must be applied (Pati and Mahapatra, 2015; Karthika *et al.*, 2020; Dhaliwal *et al.*, 2021) especially when the traditional

NPK fertilizer application is ineffective numerous studies on wheat have helped to clarify the requirements and nutritional demands (Ks *et al.*, 2018). The Wheat production in India during 2023-24 is estimated at record 1132.92 Lakh metric tons. It is higher by 27.38 Lakh metric tons than previous year's wheat production of 1105.54 Lakh metric tons and production of Shree Anna is estimated at 175.72 Lakh metric tons as compared to 173.21 LMT during previous year (Press Information Bureau Delhi 2024). In India, main wheat growing states are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan and Bihar (Kumar *et al.*, 2021; Yadav *et al.*, 2024). The state Uttar Pradesh contributes more than 25% of India's total wheat production. Wheat can be grown in a variety of soil types. However, peaty soils with high mineral content (Na, Fe, and Mn) should be avoided whereas medium-textured soils are thought to be the best (Rawashdeh and Sala., 2015; Delsouz *et al.*, 2017). The optimum soil type for growing wheat is loam (Zulfiqar *et al.*, 2020; John *et al.*, 2022;). Because wheat is vulnerable to water logging, heavy soils with good drainage are ideal for growing it. The different levels of Micronutrients mixture and NPK in the soil have an important role in crop nutrition, (Ghasal *et al.*, 2017) leading to improved overall growth and development of crop plant that results into higher yield and overall plant development however, micronutrients are often deficient in both soil and crops (Sharma *et al.*, 2019; Ghasal *et al* (2015). Therefore, the application of micronutrients mixtures is necessary to enhance crop productivity particularly when conventional NPK fertilizer application is not efficient (Mathpal *et al.*, 2015; Groote *et al.*, 2021). Numerous experiments are being done in wheat to understand the requirements and needs of nutrients (KV Anitha and GG Kadalli 2019; Reddy *et al.*, 2023). The balance use of macronutrients and micronutrients is vital role in crop nutrition for improved yield and quality (Ramanjineyulu *et al.*, 2018; Singh *et al.*, 2024). High fertilizer responsive cultivars having potential to more crop yield, when applied micronutrients with NPK fertilizers (Faizan *et al.*, 2021).

Materials and Methods

The experiment was conducted at the Research Farm, Shri Ram College Muzaffarnagar (U.P.) during rabi season (November – April, 2022-23). The area receives 862 mm of rain annually on an average, of which 90% is confined to rainy season (July - September). The soil of experimental site was sandy loam in texture having 54.74, 28.36, and 16.90% sand, silt and clay, respectively; pH 7.65, Electrical conductivity (EC) 0.289 dSm^{-1}, Organic Carbon (4.8 g Kg^{-1}) low, alkaline $KMnO_4$ N 236.30 Kg ha^{-1}, Olson –P 20.60 Kg ha^{-1} ammonium acetate extractable K 268.70 Kg ha^{-1} and DTPA extractable Zn 1.16 mg Kg^{-1}, Fe 12.65 mg Kg^{-1}, Cu 2.16 mg Kg^{-1}, Mn 9.86 mg Kg^{-1}. The treatments comprised of 5 level of micronutrients mixture (5, 10, 15, 20 and 25 Kg ha^{-1}) and vermicompost with the combination of RDF (NPK @ 120:60:60) in the mode of soil application. There were 8 treatments combinations replicated thrice in a randomized block design. The vermicompost @ 3 t ha^{-1} were applied at time of sowing with the combination of RDF. While the graded level of micronutrients mixture was also applied at the time of sowing. A uniform dose of Urea, Diammonium Phosphate (DAP), Muriate of Potash (MOP), micronutrients mixture and vermicompost were used to provide N, P, K, Zn, Cu, Fe, Mn, and B as per treatments in T_2-T_8 Whereas in T_1 no fertilizers were used. A basal dose of 60 Kg N, full dose of P, K, micronutrients mixture and vermicompost were applied at the time of sowing while remaining half dose of N were applied in three equal splits at the Crown root initiation, Tillering and Late jointing stages of wheat. Growth observations were recorded at 30 and 60 days after sowing (DAS) and at the harvesting of the wheat crop. Yield attributes were recorded at harvest and grain and straw yield was recorded plot wise after threshing of produce. After cleaning and drying the to 14 per cent moisture. The yield of net plot, thus converted to t ha^{-1}. Dry weight of straw collected from net plot was recorded after sun grains; the grain yield was recorded in kg per plot. The gross returns in rupees /ha were calculated using the grain and straw yields from each treatment as well as local market prices. Each treatment's net return was calculated by subtracting the total cost of cultivation from the gross returns. The benefit: cost ratio (B: C) was calculated by dividing the net return by the cultivation cost. The entire data was analyzed statistically by using ANOVA. Chemical analysis of soil sample was done by using standard methods in the Department of Agriculture, Shri Ram College Muzaffarnagar (U.P.), India.

Results and Discussion

A study was undertaken during a rabi season in 2022-23 to study the "Effect of different levels of micronutrient mixture and vermicompost on growth, yield and economics of wheat" The study area was Research Farm, Shri Ram College Muzaffarnagar. Observation on different growth parameters at different growth stages, yield attributing characters, gross return, net return and B: C ratios of wheat were recorded.

Effect of different levels of micronutrients mixture and vermicompost on growth parameters of wheat

Table 1. Effect of different levels of micronutrients mixture and vermicompost on growth parameters of wheat.

Treatment	Plant height (cm)			Dry matter accumulation (g m^{-2})			Number of tillers (m^{-2})
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	At harvest
T1	19.38	55.38	69.27	47.65	118.54	226.85	322.00
T2	22.46	59.25	83.75	51.96	148.75	309.67	358.00
T3	24.75	62.32	77.04	60.86	171.93	330.83	367.00
T4	26.59	62.93	88.43	62.34	180.83	355.47	388.00
T5	27.35	65.67	89.53	64.25	183.45	363.85	414.00
T6	28.53	67.35	89.00	65.56	188.75	383.39	422.00
T7	29.45	69.65	93.63	70.68	190.76	387.57	448.00
T8	32.67	71.74	95.28	78.43	203.42	407.45	451.00
CD(p=0.05)	7.58	6.67	11.54	10.35	5.63	7.66	6.43
SE(m).	2.48	2.18	3.77	3.38	1.84	2.50	2.10

Plant height (cm)

Data present in the Table 1 Indicated that the measured plant height was affected significantly by different treatments at all the observation interval during experimental year. Plant height at 30 DAS ranges from 19.38 to 32.67 cm was recorded in the different treatments. Maximum plant height 32.67 cm was recorded in the treatment T_8 which was significantly superior among the all treatments while minimum plant height 19.38 cm was observed in the treatment T_1 (Control). Treatments T_7 (29.45 cm), T_6 (28.53) and T_5 (27.35) also received higher plant height which was statistically at par with treatment T8. The minimum plant height (19.38 cm) was recorded in the treatment T_1 (control) where any type of fertilizers was not applied. The similar trends in plant height were also observed at the 60 DAS and at harvest stages of wheat crop. The plant height at 60 DAS was achieved by treatment T_8 (71.74 cm) where vermicompost was applied @ 3tones $ha^{-1}$with NPK while the shortest plant height 55.38 cm was obtaining from the treatment T_1 (Control). Treatment T_7, T_6, and T_5 also achieved tallest plant height 69.65, 67.35 and 65.67 cm respectively which was significantly at par with the treatment T8 and superior among all the other treatments. The maximum plant height (98.28cm) at harvest was recorded in the treatment combination T8 where vermicompost was applied @ 3tones ha^{-1} with recommended dose of NPK while the minimum plant height (69.27 cm) was recorded in the treatment T_1 (control) where any types of fertilizers and manures was not applied.

This might be due to the mineralization of vermicompost and application of micronutrient mixture in different doses provide the nitrogen and Zn, Cu, fe, Mn, and other micronutrients throughout the life cycle of wheat crop. Similar results have been observed by. Higher leaf area index and crop growth rate was obtained with the application of zinc @ 10 kg ha^{-1}. Also, different micronutrients had significant interaction with application methods for physiological and agronomic traits including number of tillers, leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and grain yield. Nadim *et al.*, (2012). Growth, yield attributes, grain and straw yields of wheat were more in case of time of nitrogen was in 50% N as basal through VC+FYM (1:1), 25% at tillering and 20% at booting stage and 5% N as foliar spray at pre flowering stage through urea(S4).

Number of tillers at harvest (m^{-2})

The data present in the Table 1 exhibited that the number of tillers was also recorded highest (451) in the treatment combination of T_8 (Recommended NPK + Vermicompost @ 3 t ha^{-1}) was significantly superior among all the treatments and statistically at par with the treatments T_7 (448) where micronutrient mixture was used @ 25 kg ha^{-1} with recommended NPK. The lowest number of tillers 322 per m^{-2} was observed in the treatment T_1 (control). The number of tillers increased significantly with increase in Zn level over control. Similar finding have been reported by Sharma *et al.*, (2008).

Dry matter accumulation (g m^{-2})

Dry matter accumulation of wheat crop at 30,60 and at harvest are shown on the Table 1 It is clear from the Table 1 that measured dry matter accumulation was affected significantly by different treatments. The maximum dry matter accumulation at 30, 60 and at harvest 78.43, 203.42 and 407.45 g m^{-2} respectively was recorded in the treatment T_8 (Recommended NPK + Vermicompost @ 3 t ha^{-1}) which was statistically at par with the treatment T_7 (Recommended NPK +micronutrient mixture@ 25kg ha^{-1}). The minimum dry matter accumulation with values 47.65, 118.54 and 226.85 g m^{-2} respectively at different growth stages of wheat crop was recorded in the treatment T_1 (control). The significant increase in straw yield due to zinc fertilization could be attributed to the increased plant growth and

Table 2. Effect of different levels of micronutrients mixture and vermicompost on yield attributing characters, yields and harvest index of wheat.

Treatment	Yield attributing characters			Yields tha^{-1}			Harvest Index (%)
	Length of spike (cm)	No. of grains per spike	Test weight (g)	Grain yield	Straw yield	Biological yield	
T1	19.38	55.38	69.27	47.65	118.54	226.85	322.00
T2	22.46	59.25	83.75	51.96	148.75	309.67	358.00
T3	24.75	62.32	77.04	60.86	171.93	330.83	367.00
T4	26.59	62.93	88.43	62.34	180.83	355.47	388.00
T5	27.35	65.67	89.53	64.25	183.45	363.85	414.00
T6	28.53	67.35	89.00	65.56	188.75	383.39	422.00
T7	29.45	69.65	93.63	70.68	190.76	387.57	448.00
T8	32.67	71.74	95.28	78.43	203.42	407.45	451.00
CD(p=0.05)	7.58	6.67	11.54	10.35	5.63	7.66	6.43
SE(m).	2.48	2.18	3.77	3.38	1.84	2.50	2.10

biomass production, possibly as a result of the uptake of nutrients. Similar results were reported by (Singh *et al.*, 2015).

Effect of different levels of micronutrients mixture and vermicompost on yield attributing characters and yields and harvest index of wheat

Length of spike (cm)

Data present in the Table 2 exhibited that the highest spike length 13.86 cm was observed in the treatment T_8 which was significantly superior among the all treatments and followed by the treatment T7 (13.35 cm). The lowest spike length 10.53 cm was also observed in the treatment T_1 (control) where any fertilizers or manures was not applied. Highest length of panicle was recorded in the treatment T_8 (RDF +20 kg Zn/ha +0.5 kg B/ha). Higher value of panicle length might be due to increased transportation of photosynthates from source to sink due the application of zinc (Varshney, 1988; Jena *et al.*, 2006).

Number of grain $spike^{-1}$

Data present in the Table 2 indicated that maximum number of grain (60) per spike was recorded in the treatment T_8 where the recommended NPK was applied with vermicompost @ 3tones ha^{-1} which was statistically at par with the treatment T_7 and T_6 where micronutrient mixture was applied @ 25 and 20 kg ha^{-1} with recommended NPK respectively with the values of 13.35 and 12.98. The lowest number of grains (43) among the all treatments was observed in the treatment T_1 (control). Since boron is responsible for the translocation of food materials in plants therefore it played vital role in grain setting as well as higher number of grains in wheat. Present results are in line with Uddin *et al.*, (2008) who obtained higher number of grains by the application of boron @ 2 kg ha^{-1} while Tahir *et al.*, (2009) recorded significant increase in number of grains with the foliar application of boron.

Test weight (g)

Data present in the Table 2 indicated that the highest test weight (44.50 g) of wheat was observed in the treatment T8 (Recommended NPK + Vermicompost @ 3 t ha^{-1}) which was significantly at par with treatment T7 (42.33 g), T6 (41.67g) and T5 (41.17g) which received micronutrient mixture @ 25, 20 and 15 kg $ha^{-1}$with recommended NPK respectively. The lowest test weight (36.67 g) of wheat crop was also observed in the treatment T1 (control) (Gueins *et al.*, 2003) reported that significant increase in number of grains/spike and 1000-grain weight of wheat due to foliar application of boron and zinc.

Grain yield (t ha^{-1})

Data present in the Table 2 indicated that the grain yield of wheat significantly influenced by the application of different combination of micronutrients mixture along with Recommended NPK. The maximum grain yield (4.66 t ha^{-1}) was recorded in the treatment T_8 (Recommended NPK +Vermicompost @ 3tones ha^{-1}) while the minimum grain yield (3.18 t ha^{-1}) was also recorded in the treatment T_1 (control) where any fertilizers or manures was not applied. The treatment T_7 (4.49 t ha^{-1}), T_6 (4.38 t ha^{-1}) and T_5 (4.32 t ha^{-1}) also received higher grain yield and statistically at par with the treatment T_8. The treatment received micronutrients mixture with recommended NPK obtained higher grain yield percentage from 28.01 to 41.31 over the control. Application of boron exhibited significant effect with respect to leaf area index at 30 DAS, plant height, number of tillers per m^{-2} , raw and graded seed yield, seed length, 1000 seed weight, standard germination per cent, seedling length and seedling vigour index. The 7.5 kg Zn and 1.5 kg B ha^{-1} have been found to be most appropriate for increasing seed yield and seed quality of wheat crop Shukla *et al.*, (2018).

Table 3: Effect of different levels of micronutrients mixture and vermicompost on economic feasibility of wheat.

Treatments	Cost of cultivation (Rs/ha)	Gross Returns (Rs/ha)	Net Returns (Rs/ha)	B:C Ratio
T_1 Control (without fertilizer)	34147.98	90933.75	56785.77	1.66
T_2 (NPK @ 120:60:60 kg ha^{-1})	41181.98	110900.5	69719.52	1.69
T_3 NPK @ 120:60:60 kg ha^{-1} + Micro-nutrients Mixture @ 5 kg ha^{-1}	41806.98	116587.5	74780.52	1.79
T_4 NPK @ 120:60:60 kg ha^{-1} + Micro-nutrients Mixture @ 10 kg ha^{-1}	42431.98	120437.8	78005.82	1.84
T_5 NPK @ 120:60:60 kg ha^{-1} + Micro-nutrients Mixture @ 15 kg ha^{-1}	43056.98	122907.5	79850.52	1.85
T_6 NPK @ 120:60:60 kg ha^{-1} + Micro-nutrients Mixture @ 20 kg ha^{-1}	43681.98	124372.5	80690.52	1.85
T7 NPK @ 120:60:60 kg ha^{-1} + Micro-nutrients Mixture @ 25 kg ha^{-1}	44306.98	127325.3	83018.32	1.87
T_8 NPK @ 120:60:60 kg ha^{-1} + Vermicompost @ 3tones ha^{-1}	56181.98	131982	75800.02	1.35

Among the sources of nitrogen, FYM + Vermicompost + Urea resulted significantly higher yield (4.12 tha^{-1}) then FYM + Vermicompost (3.91 t ha^{-1}). Similar results were obtained by Akhter *et al*., (2017). This might be due to the reason that, urea contains more nitrogen concentration and improved the grain yield.

Straw yield (t ha^{-1})

Data present in the Table 2 exhibited that the straw yield of wheat was influenced significantly with the application of different doses of micronutrients mixture and vermicompost with recommended NPK respectively. The maximum straw yield (5.96 t ha^{-1}) was observed in the treatment T_8 (Recommended NPK + Vermicompost @ 3 t ha^{-1}) which was statistically at par with the treatments T_7 (5.78 t ha^{-1}), T_6 (5.67 t ha^{-1}) and T_5 (5.62 t ha^{-1}) where micronutrient mixture was applied @ 25, 20 and 15 kg ha^{-1} with recommended NPK respectively. The minimum straw yield (4.42 t ha^{-1}) of wheat crop was recorded in the treatment T_1 (control) which was significantly inferior among the all treatments. Significant increase in grain and straw yield due to iron application has also been reported by Shukla *et al*., (2018).

Biological yield and Harvest index

The data presented in Table 2 indicate the highest biological yield (10.63 t ha^{-1}) and harvest index (43.87%) was noticed in the treatment T_8 (Recommended NPK +Vermicompost @ 3 t ha^{-1}) which was statistically at par with T_7 (Recommended NPK +micronutrient mixture @ 25 kg ha^{-1}) have received biological yield 10.27 t ha^{-1} and harvest index 43.73%. However, the lowest biological yield (7.60 t ha^{-1}) and harvest index 41.80 % was recorded in the treatment T_1 (control). The biological yield is a function of grain and straw yields. Thus, increase in biological yield with the application of iron could be ascribed to increase grain and straw yields. These results are in line conformity of findings of Gill and Walia (2014). The highest mean values of all yield and its components *i.e*., spike length, number of spikelets /spike, number of spike/m2 , number of tillers/m2 , number of grains/spike, 1000-grain weight, grain, straw and biological yields (tons)/ ha.,, as well as, harvest index were produced by soil application treatment than foliar application treatment. These increases may be taken place due to the efficient utilization of nutrients in the soil which restricted the production number of tillers/m^2, number of spike /m2 and number of grains/spikes. Similar results, more or less, were obtained by Nadim *et al*., (2012). Application of micro-elements prominently improve grains $spike^{-1}$, 1000 grains weight, tillers $meters^{-2}$, grain yield, biological yields and harvest index of the wheat recorded by Zain *et al*., (2015).

Effect of different levels of micronutrients mixture and vermicompost on economic feasibility of wheat

Gross return, Net return and B: C ratio

The perusal of the data presented in Table 3 Indicated that higher gross return (Rs.131982) was recorded in the treatment T_8 (Recommended NPK+ Vermicompost @ 3 t ha^{-1}) while the maximum net return (Rs. 83018.32) and B:C ratio (1.87) was recorded in the treatment T_7. Whereas lowest gross return (Rs. 90933.75), net return (Rs. 56785.77) and B:C ratio (1.66) was recorded in the treatment T_1 (control) where any fertilizers and manures were not applied. Amongst all levels of micronutrients mixture, the application of micronutrients mixture @ 25 kg ha^{-1} with recommended NPK (T_7) recorded significantly higher net return and B:C ratio followed by application of micronutrient mixture @ 20 kg $ha^{-1}$with recommended NPK in T_6 with the net return (Rs. 80690.52) and B:C ratio (1.85) respectively. Shivay *et al*., (2015) reported that higher net return might be owing to greater increment in grain yield due to application of zinc Higher net return due to increasing levels of zinc may have been obtained since zinc is an essential plant nutrient and its involvement in the physiological process is well pronounced, therefore increase in both grain and straw yield may be expected. Oahiduzzaman *et al*., (2016) revealed that Zn applied recorded higher grain and straw yield so farmers should prefer zinc as it is economically profitable.

Conclusion

Based on the data gathered throughout the trial year, it can be said that adding vermicompost to wheat give highest yield. Although using vermicompost in cultivation may be more expensive, but it will help preserve the health of the soil and can supplement the micronutrients nutrition. While the soil application of micronutrients mixture at a rate of 25 kg ha^{-1} is generally advised for wheat, it was shown to be just as good and successful as the treatment that received vermicompost @ 3 t ha^{-1} along with required NPK.

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