Effect of integrated nutrient management and Agronomic Biofortification on growth and yield of Wheat (*Triticum aestivum*. L.)

Abstract

A field experiment was conducted at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.) to assess the effect of organic source with foliar application of micronutrients on growth and yield of wheat for two consecutive years (2021) and (2022).The experiment comprises three treatment under main plot *viz:* F_1- Control (100% RDF), F_2- 100 % RDF + Vermicompost @ 2.5t/ha, and F_3- 100 % RDF + FYM @ 5t/ha, and five treatments foliar spray of micronutrient in sub plot *viz:* M_1- control (No spray), M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage, M_3- Spray of Nano Zinc @ 0.5% spray at tillering and heading stage, M_4- Foliar application of $FeSO_4$ @ 0.25% at tillering and booting stage and M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage. Fifteen treatment combination were assigned under Split Plot Design (SPD) and replicated thrice. Wheat variety (K- 1006) was grown with the recommended agronomic practices. Results showed that maximum increase in growth parameters and yield and yield attribute of wheat *viz*: plant height (cm), number of tillers/m^2, leaf area index and spike length (cm), number of spikelets /spike and harvest index (%) and biological yield (ton ha^{-}) recorded significantly higher with F_2- 100 % RDF + Vermicompost @ 2.5t/ha treatments Among the sub-plot , M_5- Foliar application $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage, produced significant maximum highest harvest index (42.78 %) and biological yield (13.88 ton /ha) as compared to all other treatments.

Keywords: *FYM, Vermicompost, Nano-Zinc, Zinc sulphate, Iron sulphate and Wheat*

1. Introduction

Wheat (*Triticum aestivum* L.) one of the most important cereal crops in the world of family "Poaceae" and genus "Triticum" grown under different agro-climaticconditions and it occupies 220.29-million-hectare (mha) area with the production of 780.59 million tones and productivity of 3390 kg ha^{-1}. The largest producer of wheat in the world wide is the European Union followed by China and India. In India wheat cultivated in area of with the production 109.52 million tones and productivity of 3464 kg ha^{-1}. **(Anonymous, 2022-23a)**. Promising wheat producing states are Uttar Pradesh (30 million tons), Punjab (16.4 million tons) and Haryana (11.6 million tons), with an estimated area of 9.75, 3.59, 2.52, mha, respectively. Uttar Pradesh stands first in area and production of wheat in India. Productivity of wheat (2661 kg/ha) is still less than the national average **(Anonymous, 2022-23b)** which remains a serious thought on crop improvement and management process. Wheat is considered to be a major staple food in many countries of the world. Despite its lower zinc and iron content (20-40 mg/kg

(Welch and Graham, 2004) in grain, the consumption by the target groups is increasing at a higher rate, which further elevated nutritional related problems. Primarily both zinc (Zn) and iron (Fe) contributes to the human health and any deficient noticed leads to affect the immune system that has a major impact on health leading to many other diseases, even to the extent of mortality. Thus, agronomic biofortification at critical stages by using zinc and iron as foliar application will play a critical role in providing a complimentary effect in grains.

Almost 50% of the agricultural lands around the world are Zn deficient for cereal productivity **(Cakmak, 2008).** Biofortification is the process of increasing the content and bioavailability of essential nutrients in crops during plant growth through genetic and agronomic pathways **(Bouis *et al*. 2011).** Agronomic biofortification involves the practices of fertilization that increase the nutrient content in grains. Micronutrients such as Fe and Zn very essential for normal plant growth and development of wheat crops **(Fageria, 2007)** Agronomic biofortification is achieved through micronutrient fertilizer application to the foliar application directly to the leaves of the crop to improve the growth and yield in wheat crop. Biofortification is mainly focused on starchy staple crops wheat because they dominate diets worldwide especially among groups vulnerable to micronutrient deficiencies and provide a feasible means of reaching malnourished populations with limited access to diverse diets, supplements, and commercially fortified foods **(Saltzman *et al*., 2013)** Balanced nutrient application through organic and inorganic source plays an important role in improving the micronutrient level in grain and straw as well as increase in yield of wheat crop. The organic source of nutrients not only provides good soil health but also acts as a catalyst for other available soil chemical properties in the soil. Among integrated nutrient management (INM), Farm Yard Manure (FYM) is widely chosen because of its availability and ease in application which contributes for soil fertility and physical properties. It plays a major role towards build-up of organic matter in soil **(Das *et al.,*2008).** The improvement in grain and straw yield with the INM application proves beneficial, on nutrient uptake, crop growth rate and yield attributing components. **(Singh and Agarwal, 2004).**

Keeping these views in mind the research was conducted to optimize the use of nutrients by combined application of both organic and inorganic source along with the foliar application of micro nutrients for better improvement of Zn and Fe content in wheat grains.

2. Materials and Methods

2.1. Experimental site:

The experiment was conducted consecutively on two rabi seasons during 2021 and 2022 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, which is situated in the alluvial tract of Indo - Gangetic plains in central plain zone of Uttar Pradesh. The soil type and fertility status were determined by the mechanical and chemical analysis of the soil. In order to ascertain the physico-chemical properties of the experimental soil, primary soil samples were drawn randomly up to 15cm

depth from different spots of the entire experimental area. The soil of the experimental field was sandy loam in texture, well drained, slightly saline in nature having initial values of pH (8.00), EC (0.29 dsm^{-1}), low in organic carbon (0.35%), low in available nitrogen (192.50 kg ha^{-1}), medium in phosphorus (15.75 kg ha^{-1}), Potash (173.51 kg ha^{-1}). Iron (1.75 mg kg^{-1}) and Zinc (61.15 mg kg^{-1}). respectively,

2.2. Geography and climate:

This zone has semi-arid climatic condition having alluvial fertile soil. The average relative humidity during the experimental season fluctuated between 44.4 % to 85.8 % and 47 % to 96% During 2021 to 2022 respectively. During the crop growing period, the mean weekly highest and lowest total rainfall recorded ranging from 0.0 mm to 23.5 mm and 0.0 mm to 39.2 mm and evaporation ranged from 7.6 to 26.0 mm/day^{-1} and 8.8 to 25 mm/day^{-1} during 2021 to 2022, respectively. The mean weekly total evaporation mm/day^{-1} recorded ranging from 326.4 to 340.4 mm/day^{-1} during 2021 to 2022, respectively. The weekly mean wind velocity during the year 2021-22 and 2022-23 experimental season was between 1.2 to 6.2 km and 1.1 to 6.0 km respectively.

2.3. Experiment Details

The field experiment was laid out in Split Plot Design. There were fifteen treatments combinations consisting of three organic manure as a main treatment *viz*: F_1- Control (100% RDF), F_2- 100 % RDF + Vermicompost @ 2.5t/ha, and F_3- 100 % RDF + FYM @ 5t/ha, and five sub-treatments with Zn and Fe as foliar application *viz:* M_1- control (No spray), M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and heading stage, M_3- Spray of Nano Zinc @ 0.5% spray at tillering and heading stage, M_4- Foliar application of $FeSO_4$ @ 0.25% at tillering and heading stage and M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage the treatments were replicated three times.

2.4. Agronomic practices

The pre sowing irrigation was applied 7-10 days before sowing of wheat for optimum level of moisture for field preparation for good germination, The seed of wheat variety K- 1006 was selected for these studies. Clean and healthy seed @ 120 kg ha^{-1} were taken and sown at shallow furrows of 5 cm deep with 20 cm row spacing on both rabi seasons of 2021-22 and 2022-23.

Manure and Fertilizers application

The experimental crop was uniformly fertilized–according to treatments, Farm yard manure (FYM) 5 t ha^{-1}, and Vermicompost (VC) 2.5 t ha^{-1} applied Before 15 days of sowing. The basal application of fertilizers @ 40 kg N and full does P_2O_5, & K_2O was given and foliar application of micronutrients @ 0.25% $ZnSO_4$, Nano-Zinc @ 0.25%, @ 0.25% $FeSO_4$ and foliar application @ 0.25% $ZnSO_4$ + @ 0.25% $FeSO_4$ at tillering and heading stage were done according to treatments and remaining nitrogen was top dressed in two splits.

2.5. Observation Recorded:

The observations were recorded on plant height (cm), number of tillers/m^2 and leaf area index as well as growth characters Plant height of the longest tiller was measured from five tagged plants from the base of the plant to highest terminal point by a meter scale. Average of five plant height at harvest was taken for analysis of plant height. Number of tillers was recorded by using meter row from three places in each plot at harvest and average of three places was taken for analysis of number of tillers m^{-2} and Plants from 25 cm row length removed from two places from the second row on either side in each plot were used for recording leaf area. The leaves were separated from the base of lamina. Leaf area was measured at 30 days intervals till the senescence of crop with the help of leaf area meter and the spike length of wheat was measured by using meter scale of five spikes of each plot and mean of the spike length was used for analysis of data and expressed in cm. For grain yield (tha^{-1}), grains were separated with the help of mini plot thresher from biological yield obtained from net area of each plot. The grain yield obtained from net plot area was converted into tha^{-1}. After harvesting of the net plot area, the bundles of wheat crop were sun dried for two days and then weight recorded and converted into t ha^{-1} for calculating biological yield. and harvest index are which is the ratio of economic yield to biological yield expressed in percent respectively.

2.6 Statistical analysis

using the F-test as per the procedure given by Gomez and Gomez (1984). Critical difference values at P=0.05 were used to determine the significance of differences between treatment means.

3. Result and discussions

3.1 Growth characters

The data plant height and number of tillers/m^2 during both the years of experimentation and data were pooled and presented in Table. 1. it is clear from the data the maximum tallest plant height and number of tillers/m^2 was recorded with the treatments F_2- 100 % RDF + Vermicompost @ 2.5t/ha at harvest, followed by F_3- 100 % RDF + FYM @ 5t/ha. Both F_2 and F_3 treatments were significantly superior over the Control (100% RDF) during both the year as well as pooled basis data.

Table 1. Effect of organic manure + RDF and foliar spray of micronutrients on plant height (cm), No. of tillers and LAI of wheat at successive periods of crop growth.

Treatments	Plant height (cm)			Number of tiller/m^2			LAI		
	At harvest			At harvest			90 DAS		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (organic manure + RDF)									
F_1- Control (100% RDF)	70.73	71.72	71.13	273.40	276.40	274.90	2.81	2.90	2.85
F_2- 100 % RDF + Vermicompost @ 2.5t/ha	77.50	78.32	78.21	338.20	341.20	339.70	4.93	5.06	5.00
F_3- 100 % RDF + FYM @ 5t/ha	73.72	74.53	74.53	318.80	321.80	320.30	3.68	3.76	3.72
S.Em, ±	**0.156**	**0.190**	**0.491**	**0.761**	**0.390**	**0.756**	**0.008**	**0.007**	**0.011**
C.D. (P=0.05)	**0.629**	**0.767**	**1.978**	**3.067**	**1.572**	**3.048**	**0.031**	**0.029**	**0.044**
Sub plot (foliar spray of micronutrient)									
M_1- Control (No spray)	70.52	71.67	71.09	287.00	290.00	288.50	3.14	3.20	3.17
M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage.	74.53	75.17	74.85	313.00	316.00	314.50	3.99	4.07	4.03
M_3- Spray of Nano Zinc @ 0.5% spray at tillering and booting stage.	75.13	75.87	75.50	318.00	321.00	319.50	4.02	4.16	4.09
M_4- Foliar application of $FeSO_4$ @ 0.25% at tillering and booting stage.	73.67	74.52	74.09	308.33	311.33	309.83	3.71	3.77	3.74
M_5- Foliar application of $ZnSO_4$ @ 0.25% + @ 0.25% $FeSO_4$ at tillering and booting stage.	76.07	77.07	76.57	324.33	327.33	325.83	4.18	4.32	4.25
S.Em, ±	**0.423**	**0.723**	**0.641**	**2.593**	**1.789**	**1.970**	**0.023**	**0.036**	**0.030**
C.D. (P=0.05)	**1.243**	**2.123**	**1.882**	**7.614**	**5.253**	**5.785**	**0.066**	**0.106**	**0.089**
Interactions									
S.Em, ±	**0.674**	**1.136**	**1.011**	**4.089**	**2.799**	**3.145**	**0.036**	**0.057**	**0.048**
C.D. (P=0.05)	**NS**	**NS**	**NS**	**12.161**	**8.277**	**9.433**	**0.107**	**0.167**	**0.144**

Note: - RDF- (Recommended dose of fertilizers), FYM- (Farm yard manure), $ZnSO_4$ – (Zinc Sulphate) and $FeSO_4$ – (Ferrous Sulphate) and DAS (day after sowing)

Table 2. Effect of organic manure + RDF and foliar spray of micronutrient on Spike length, no of spikelet/spike, harvest index and biological yield in wheat.

Treatments	Spike length (cm)			No of spikelet/spike			Harvest Index			Biological yield (t/ha)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (Organic manure +RDF)												
F_1- Control (100% RDF)	8.87	9.16	9.01	17.83	18.68	18.25	40.99	41.65	41.32	10.83	11.16	11.00
F_2- 100 % RDF + Vermicompost @ 2.5t/ha.	11.99	12.81	12.40	20.90	21.83	21.37	43.50	44.49	44.00	13.34	13.97	13.65
F_3- 100 % RDF + FYM @ 5t/ha.	10.38	11.25	10.82	19.23	20.09	19.66	41.96	42.77	42.37	11.94	12.66	12.30
S.Em, ±	**0.054**	**0.039**	**0.044**	**0.035**	**0.055**	**0.088**	**0.140**	**0.087**	**0.173**	**0.029**	**0.048**	**0.046**
C.D. (P=0.05)	**0.219**	**0.159**	**0.179**	**0.141**	**0.220**	**0.355**	**0.564**	**0.349**	**0.697**	**0.118**	**0.195**	**0.185**
Sub plot (Foliar spray of micronutrient)												
M_1- Control (No spray)	9.54	9.71	9.63	18.56	18.70	18.63	41.90	42.55	42.22	10.08	10.47	10.28
M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage.	10.49	10.83	10.66	19.38	20.43	19.91	42.07	43.37	42.72	12.19	12.76	12.48
M_3- Spray of Nano Zinc @ 0.5% spray at tillering and booting stage.	10.71	11.73	11.22	19.61	20.67	20.14	42.15	43.02	42.58	12.72	13.30	13.01
M_4- Foliar application of $FeSO_4$ @ 0.25% at tillering and booting stage.	10.21	11.63	10.92	18.94	19.92	19.43	42.07	42.94	42.51	11.62	12.26	11.94
M_5- Foliar application of $ZnSO_4$ @ 0.25% + @ 0.25% $FeSO_4$ at tillering and booting stage.	11.10	11.45	11.28	20.11	21.28	20.70	42.56	42.99	42.77	13.57	14.20	13.88
S.Em, ±	**0.102**	**0.100**	**0.095**	**0.157**	**0.174**	**0.120**	**0.213**	**0.220**	**0.334**	**0.113**	**0.124**	**0.095**
C.D. (P=0.05)	**0.300**	**0.293**	**0.278**	**0.461**	**0.510**	**0.353**	**NS**	**NS**	**NS**	**0.333**	**0.364**	**0.280**
Interactions												
S.Em, ±	**0.157**	**0.159**	**0.153**	**0.246**	**0.275**	**0.206**	**0.358**	**0.352**	**0.546**	**0.178**	**0.198**	**0.155**
C.D. (P=0.05)	**0.469**	**0.479**	**0.464**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.562**	**0.626**	**0.490**

Note: - RDF- (Recommended dose of fertilizers), FYM- (Farm yard manure), $ZnSO_4$ – (Zinc Sulphate) and $FeSO_4$ – (Ferrous Sulphate) and DAS (day after sowing`

Similar type of experimental finding reported by **Patra (2017), Singh *et al.,* (2018) and Chaudhary *et al.,* and Kumawat *et al.,* (2022).** Among micronutrient foliar application M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage recorded tallest plant height which was at par with **M_3-** Nano Zinc @ 0.5% followed by, **M_2-** foliar application of $ZnSO_4$ @ 0.25% M_4- foliar application of $FeSO_4$ @ 0.25% at tillering and heading stage at harvest stages. Whereas minimum plant height was recorded in control (No spray) for both the years as well as on pooled basis. Highest growth characters under these treatments may be due to micronutrient spray which gave better environment for crop growth and development. It confirms the conclusion drawn by **Fatima *et al.,* (2021) and Noreen *et al.,* (2023).** However, the maximum number of tillers/m^2 recorded in M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% was significant at par with the treatment of M_3- Spray of Nano Zinc @ 0.5% spray, M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage. The minimum number of tiller/m^2 was recorded in control (No spray) at 30 DAS, 60 DAS, 90 DAS and at harvest stage of growth during both the years as well as pooled basis. These results corroborated with the findings of **Meena *et al.,* (2020) and Ramzen *et al.,* (2020).** Similarly, leaf area index at 90 DAS (Table. 1) revealed that organic manure F_2- 100 % RDF + Vermicompost @ 2.5t/ha was significantly higher than other treatments during both the year as well as pooled basis data. The result is close conformity with the finding of **Tiwari *et al.,* (2022).** Among micronutrient foliar spray, highest LAI was recorded under the M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% followed by M_3- Spray of Nano Zinc @ 0.5% spray at M_2- Foliar application of $ZnSO_4$ @ 0.25% and M_4- foliar application of $FeSO_4$ @ 0.25% at tillering and heading stage at harvest stages. Whereas, lowest LAI was recorded under the control (No spray) for both the years as well as pooled basis. Similar type of result was recorded **Nadim *et al*., (2011) and Dimkpa *et al.,* (2020).**

3.2 Yield attributes and yield

Data on spike length (cm), No of spikelet/spike, harvest index and biological yield (ton/ha) was presented in Table. 2.The spike length (cm), No of spikelet/spike, harvest index and biological yield was recorded higher in F_2- 100 % RDF + Vermicompost @ 2.5t/ha at harvest followed by F_3- 100 % RDF + FYM @ 5t/ha. Both were significantly superior over the Control (100% RDF) during both the year as well as pooled basis data. These results corroborated with the findings of **Davi *er al.,* (2011), Verma *et al*., (2016) Bairagya *et al*., (2019) and Kumari *et al*., (2022).** Among foliar application of micro nutrient, M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% recorded highest spike length (cm), no. of spikelet/spike, harvest index and biological yield which was at par with M_3- Spray of Nano Zinc @ 0.5% spray followed by, M_2- Foliar application of $ZnSO_4$ @ 0.25%, and M_4- foliar application of @ 0.25% $FeSO_4$ at tillering and booting stage respectively. It confirms the conclusion drawn by **Yadav *et al.,* (2023).** These results corroborated with the findings of **Sattar *et al*., (2022), Kandil and Marie (2017**) and **Noreen *et al.*, (2023).** However, there is non-significant difference found between harvest index in foliar spray of micronutrients.

CONCLUSION

Based on the foregoing discussion it can concluded that the combined application of 100 % RDF + Vermicompost @ 2.5t/ha are found to be superior with respect of growth, yield as well as yield attribute of wheat crop. Moreover, the combined foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and booting stage proved to be best for growth parameters, yield attribute as well as yield of wheat crop as compared to others treatment combinations.

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