# Effect of integrated nutrient management and Agronomic Biofortification ~~of Iron and Zinc~~ on growth and yieldof 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 ~~organic manure~~with ~~and~~foliar application of micronutrients~~and their interaction effect~~ on growth and yield of wheat for two consecutive years (2021) and (2022).The experiment comprisesthree 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 treatmentsfoliar spray of micronutrient in sub plot*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. Fifteen treatmentcombinationwereassignedunder Split Plot Design (SPD) and replicated thrice.Wheat variety (K- 1006) was grown with therecommended agronomic practices. Results showed that maximum increase in growth parametersand 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 (tonha$^{-}$) recorded significantly higher ~~maximum~~ with $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha treatments~~,followed by $F_3$- 100 % RDF + FYM @ 5t/ha respectively.significantly highest harvest index (44.01 %) andbiological yield (13.65 t/ha) was recorded in $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha as compared to other organic manure + RDF applied.~~ Among ~~foliar spray of~~the sub-plot ~~micronutrient~~, $M_5$- Foliar application $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage, produced significant maximum highest harvest index (42.78 %) andbiological yield (13.88ton/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 offamily"Poaceae"andgenus"Triticum"~~it's~~grown under different agro-climaticconditions andit occupies 220.29 million h~~a~~ectare (mha)~~.~~ area with the production of 780.59 milliontones and productivity of 3390 kg $ha^{-1}$. The largest producer of wheat in the world wide is theEuropean Union followed by China and India. In India wheat cultivated in area of with the production 109.52million tones and productivity of 3464 kg $ha^{-1}$.**(Anonymous, 2022-23a)**. ~~Important~~Promisingwheat producing states are



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UttarPradesh(30milliontons),Punjab(16.4milliontons) andHaryana(11.6milliontons),withan estimated area of 9.75,3.59, 2.52,mha,respectively.Uttar Pradeshstands firstpositioninareaandproduction of wheat in India. AlthoughpProductivity of wheat (2661 kg/ha) is still less thanthe national average **(Anonymous, 2022-23b)**which remains a serious thought on crop improvement and management process. However,wWheat is considered to be a the major stabple food in many countries of theworld.Despite its lower and its zinc and iron contentcontentis very low (20-40 mg/kg**(Welch and Graham, 2004) in grain, the consumption by the target groups are increasing at a higher rate, which further elevated nutritional related problems.** that further elevate the nutritional problem.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.

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Duetozincdeficiency, reported that around 800,000 deaths occur annually out of which 450, 000 deaths are ofchildren under the age of five years. Thus, tThere is aurgent need to increase the productivity of wheat crop with improved micronutrient content in the grains. .Iron deficiency ??..Aneamic

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Balanced nutrient application through organic and inorganic source play on important role in improvedof micronutrient level in grain and straw as well as increase in yield of wheat crop. The organic source of nutrientis important for nutrient as well as for soil health, among organic source, FYMisagoodsourceofnutrientsandcontributed towards build up oforganic matter in soil **(Das *et al.*,2008).** The improvement in grain and straw yield with the application of FYM was owing tothe beneficialeffectofFYMonnutrientuptake,cropgrowthrate andyieldattributingcomponents. **(Singh and Agarwal, 2004).** However, vermi-compost that is a bio-oxidation and stabilization of FYM involving the joint action of earthworm andmicroorganisms. Almost 50% of the agricultural lands around the worldare 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). Write 2-3 sentences about agronomic biofortification???**

Although, nano fertilizersSsize below 100 nm nano particlescan be used as a fertilizer for efficient nutrient management which are eco-friendly and reduceenvironment pollution. This maybe a effective effectivelytoolinagricultureforbetterpestandnutrientmanagement because, these nano-materials havinghas more penetration capacity,surface areaand better use efficiency which avoid residues in environment. Hence, these agricultural usable nano particle developed with the helpof nanotechnology can be exploited in the value chain of entire agriculture production system**(Morales-Díaz *et al.*, 2017).**

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Write few lines about zinc on agronomicbiofortification??

Similarly, iron is also considered to be one of the most important elementsnext to zinc in nutritional status among grains. ~~Iron is mostimportant for the respiration and photosynthesis processes.~~~~Iron plays a greatest role in manyplant functions. These functions include chlorophyll development, energy transfer, ingredientofenzymesandproteins,andinvolvedinnitrogenfixation~~**(Pervaiz *et al.*, 2003).**

Write 2-3 sentences about iron on (Agronomic) biofortification?

Balanced nutrient application through organic and inorganic source play animportant role in improving themicronutrient level in grain and straw as well as increase in yield of wheat crop. The organic source of nutrients not only provides good soil healthbut also acts as a catalyst for otheravailable 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 oforganic matter in soil **(Das *et al.*,2008).** The improvement in grain and straw yield with the INM application proves beneficial,onnutrientuptake,cropgrowthrate andyieldattributingcomponents. **(Singh and Agarwal, 2004).**

~~Inintegratednutrientmanagementtheapplicationof FYMinthesoilhelpsinincreasing the fertility of the soil as well as physical condition of soil. Organic manures, which were perhaps the main sources of plant nutrients intraditionalagriculture,receivelessemphasiswiththeadventofhighanalysischemical fertilizers~~**~~(Kumar *et al.*, 2015).~~**Keeping these views in mind the research was conducted to ~~optimum~~optimize the use of nutrients by combined application of ~~appropriate combination of~~ both organic and ~~as well as~~ inorganic source along with the foliar application of micro nutrients for better improvement ~~in~~of Zn and Fe content in wheat grains.

## 2. MaterialsandMethods

### 2.1. Experimental site:

The experiment was conducted consecutivelyon two rabi seasonsduring2021 and 2022 at Students' Instructional FarmofChandraShekharAzadUniversityofAgricultureandTechnology, Kanpur, which is situated in the alluvial tract ofIndo - Gangetic plains in central plain zone of Uttar Pradesh.Thesoiltypeandfertilitystatusweredeterminedbythemechanicalandchemicalanalysisofthesoil.Inordertoascertainthe physico-chemicalpropertiesoftheexperimentalsoil, primary soil samples were drawn randomly up to 15cmdepth from different spots of the entire experimental area. The~~S~~Soil of the experimental field was sandy loam in texture, welldrained,slightly

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salinein naturehavinginitial values of pH (8.00), EC (0.29 $dsm^{-1}$), low in organiccarbon (0.35%), low in available nitrogen (192.50 kg $ha^{-1}$),medium in phosphorus (15.75 kg $ha^{-1}$), Potash (173.51 $kgha^{-1}$). 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 ~~fluctuated~~ between 1.2 to 6.2 km and 1.1 to 6.0 km ~~during 2021-22 to 2022-23,~~ respectively.

### 2.3. Experiment Details

The field experiment was laid out in Split Plot Design. Therewerefifteen treatmentscombinationsconsisting ofthreeorganic manure asa 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 ~~Foliar application of~~ sub-treatments with Zn and Fe as ~~micronutrient~~foliar application~~practices were appliedas sub treatments~~*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 varietyK- 1006 was selected forthese studies.~~The seed and sowing of~~Clean and healthy seed @ 120 kg $ha^{-1}$~~were~~taken and sown at shallow furrows of ~~(~~5~~)~~ cm deep with 20 cm rowspacing on both rabi seasons of 2021-22 and 2022-23. ~~were opened with the help of Desi plough and120kg /ha Seed wassownon21th,Nov,2021-22and22th,November-2022-23~~.

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### 2.5. Manure and Fertilizers application

The experimental crop was uniformly fertilized ~~with~~accordingtotreatments, Farm yard manure (FYM) 5 t $ha^{-1}$, and Vermicompost (VC) 2.5 t $ha^{-1}$ applied Before 15 days of sowing.Thebasalapplicationoffertilizers~~(~~@ 40kg N and full does $P_2O_5$& $K_2O$ was given ~~)~~ and ~~offersowing f~~Foliar application of Micronutrients @ 0.25% $ZnSO_4$~~at tillering and heading stage~~, Nano-Zinc @ 0.25%~~ at tillering and heading stage~~, @ 0.25% $FeSO_4$ ~~at tillering and heading stage~~ and ~~f~~Foliar application ~~of~~ @ 0.25% $ZnSO_4$ + @ 0.25% $FeSO_4$ at tillering and heading stage~~,~~were~~also~~doneaccordingtotreatmentsand

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remainingnitrogenwastopdressedintwosplits.

### 2.6. Observation Recorded:

Theobservationswererecordedon 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 thebase 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 ($t ha^{-1}$), 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 $t ha^{-1}$. 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 percentrespectively.

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Land area}}$$

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological Yield}} \times 100$$

### 2.7. Statistical analysis

The data collected from the experiments were subjected tostatistical 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, by applying the procedure for Split PlotDesign. Overall differences were tested by 'F' test at 5% levelof significance as suggested by **(Gomez and Gomez, 1984).** Incase of significant result, critical difference at 5% level ofprobabilitywasalsocalculatedfortestingthesignificancebetweentwotreatmentmeans.

## 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 data presented in (Table. 1.) it is clear from the data the maximum tallest

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plant heightand number of tillers/$m^2$ was recorded with thetreatments $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha at harvest~~.~~, followed by $F_3$- 100 % RDF + FYM @ 5t/ha.B~~b~~oth $F_2$ and $F_3$ treatments were significantly superior over the Control (100% RDF) during both the year as well as pooled basis data.~~$F_2$ 100 % RDF + Vermicompost @ 2.5t/ha,recordedsignificantly the highest Plant height, followed by $F_3$- 100 % RDF + FYM @ 5t/ha~~ Theseresultsindicatedthatincreaseingrowth characters resulted into more

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**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 | 281.60 | 285.00 | 283.30 | 2.81 | 2.90 | 2.85 |
| **$F_2$**- 100 % RDF + Vermicompost @ 2.5t/ha | 77.50 | 78.32 | 78.21 | 351.40 | 355.20 | 353.30 | 4.93 | 5.06 | 5.00 |
| **$F_3$**- 100 % RDF + FYM @ 5t/ha | 73.72 | 74.53 | 74.53 | 331.00 | 333.80 | 332.40 | 3.68 | 3.76 | 3.72 |
| **S.Em, ±** | **0.156** | **0.190** | **0.491** | **0.421** | **0.516** | **1.652** | **0.008** | **0.007** | **0.011** |
| **C.D. (P=0.05)** | **0.629** | **0.767** | **1.978** | **1.697** | **2.080** | **6.659** | **0.031** | **0.029** | **0.044** |
| **Sub plot (foliar spray of micronutrient)** | | | | | | | | | |
| **$M_1$**- Control (No spray) | 70.52 | 71.67 | 71.09 | 300.67 | 303.67 | 302.17 | 3.14 | 3.20 | 3.17 |
| **$M_2$**- Foliar application of $ZnSO_4$ @ 0.25% at tillering and heading stage. | 74.53 | 75.17 | 74.85 | 325.00 | 328.67 | 326.83 | 3.99 | 4.07 | 4.03 |
| **$M_3$**- Spray of Nano Zinc @ 0.5% spray at tillering and heading stage. | 75.13 | 75.87 | 75.50 | 329.33 | 332.67 | 331.00 | 4.02 | 4.16 | 4.09 |
| **$M_4$**- Foliar application of $FeSO_4$ @ 0.25% at tillering and heading stage. | 73.67 | 74.52 | 74.09 | 317.67 | 321.00 | 319.33 | 3.71 | 3.77 | 3.74 |
| **$M_5$**- Foliar application of $ZnSO_4$ @ 0.25% + @ 0.25% $FeSO_4$ at tillering and heading stage. | 76.07 | 77.07 | 76.57 | 334.00 | 337.33 | 335.67 | 4.18 | 4.32 | 4.25 |
| **S.Em, ±** | **0.423** | **0.723** | **0.641** | **1.792** | **1.895** | **2.398** | **0.023** | **0.036** | **0.030** |
| **C.D. (P=0.05)** | **1.243** | **2.123** | **1.882** | **5.262** | **5.565** | **7.040** | **0.066** | **0.106** | **0.089** |
| **Interactions** | | | | | | | | | |
| **S.Em, ±** | **0.674** | **1.136** | **1.011** | **2.808** | **2.981** | **4.065** | **0.036** | **0.057** | **0.048** |
| **C.D. (P=0.05)** | **NS** | **NS** | **NS** | **8.315** | **8.851** | **12.672** | **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 heading 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 heading 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 heading 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 heading 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`

vigorous crop growthdue to favorable growing environment. Any other? Pls include ?~~The development ofgrowthcharactersisanumerically maximum value of plant height, number of tillers and leaf area index was recorded under the $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha an over $F_3$- 100 % RDF + FYM @ 5t/ha~~ Similar, results reported by~~Chaudhary *et al.*, (2022),and Kumawat *et al.*, (2022).~~

~~the result of number of tillers in organic manure showedsignificantinfluence on growth of crop. $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha recorded the highest number of tillers than other organic manure applied. That is to higher growth characters than, $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha and $F_3$- 100 % RDF + FYM @ 5t/harespectively.~~Theseresultsfurtherindicatedthatincreased in growth characters and number of tillers $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha was due to better growingenvironmentthan otherorganic manureTheseresults are corroborated by the findings of **Singh and Patra (2017)**~~, and Singh *et al.*, (2018)~~ and Chaudhary *et al.*, (2022),and Kumawat *et al.*, (2022)~~.~~Among micronutrientfoliar application ~~of~~$M_5$- 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~~$F_3$~~-~~ ~~Spray of~~Nano Zinc @ 0.5% ~~spray at tillering and heading stage~~ followed by,$M_2$~~-~~ foliar application of $ZnSO_4$ @ 0.25% ~~at tillering and heading stage which was at par with~~$M_4$- foliar application of $FeSO_4$@ 0.25% at tillering and heading stageat harvest stages. ~~of growth duringWw~~hereas minimum plant height was recorded in ~~treatment~~ control (No spray) for both the years as well as on pooled basis.~~Among the foliar spray of micronutrient treatment, the maximum tallest plant height, recordedwiththeapplicationof $M_5$- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage.~~Highest growth characters under these treatmentsmaybeduetomicronutrient spray whichgavebetterenvironmentforcropgrowthanddevelopment.~~Because in these treatments~~ Itconfirmstheconclusion 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%~~at tillering and heading stagewhichwas~~ significant~~ly~~ at par with the treatment of $M_3$- Spray of Nano Zinc @ 0.5% spray ~~at tillering and heading stage~~, $M_2$- Foliar application of $ZnSO_4$@ 0.25% at tillering and heading stage. The minimum number of tiller/$m^2$~~recorded~~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 ~~are~~ corroborated with the findings of ~~research results~~**Meena *et al.*, (2020) andRamzen*et al.*, (2020).**Similarly, leaf area index at 90 DAS ~~highest LAI~~ (Table. 1)~~at polled basis~~ revealed that~~in~~ organic manure $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha ~~at harvest~~ was significantly higher than other treatments~~, 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. The result is close conformity with the finding of~~the result is close conformity with the finding of~~**Tiwari *et al.*, (2022).** **Among** ~~In~~ micronutrient foliar spray,highest LAI was recorded under the$M_5$- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% ~~at tillering and heading stage~~ followed by $M_3$- Spray of Nano Zinc @ 0.5% spray at ~~tillering and heading~~

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stage which was statistically at par with $M_2$- Foliar application of $ZnSO_4$ @ 0.25% at tillering and heading stage followed by 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 found by **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 given in (Table. 2). Revealed that all the parameters followed the same sequence which was highest The spike length (cm), No of spikelet/spike, harvest index and biological yield (t/ha) was recorded higher in under $F_2$- 100 % RDF + Vermicompost @ 2.5t/ha at harvest. followed by $F_3$- 100 % RDF + FYM @ 5t/ha. Bboth were significantly superior over the Control (100% RDF) during both the year as well as pooled basis data. These results are corroborated with the findings of research results **Davi *er al*., (2011), Verma *et al*., (2016) Bairagya *et al*., (2019) and Kumari *et al*., (2022).** Whereas, Aamong foliar application of micro nutrient, highest spike length (cm) foliar application of $M_5$- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage 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 at tillering and heading stage followed by, $M_2$- Foliar application of $ZnSO_4$ @ 0.25% at tillering and heading stage followed with and $M_4$- foliar application of@ 0.25% $FeSO_4$ at tillering and heading stage respectively. followed by control (No spray) harvest stages of growth during both the year as well as pooled basis data. Itconfirmstheconclusion drawn by **Yadav *et al.,* (2023).** However, during both the growing season as well as polled basis number of spikelet/spike recorded highest under foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage followed by $F_3$- Nano Zinc @ 0.5% spray at tillering and heading stage, $M_2$- Foliar application of $ZnSO_4$ @ 0.25% at tillering and heading stage, followed by $M_4$- foliar application of $FeSO_4$ @ 0.25% followed by control (No spray). These results are corroborated with the findings of research results **Sattar *et al*., (2022), Kandil and Marie (2017)** and **Noreen *et al*., (2023).** Data pertaining to biological yield indicate that the highest biological yield was recorded under the $M_5$- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and heading stage (13.88 t/ha) followed by $F_3$- Nano Zinc @ 0.5% spray at tillering and heading stage (13.01 ton/ha), $M_2$- Foliar application of $ZnSO_4$ @ 0.25% at tillering and heading stage(12.48 t/ha) followed by $M_4$- foliar application of $FeSO_4$ @ 0.25% (11.93 t/ha) followed bycontrol (No spray). **Sattar *et al*., (2022), Kandil and Marie (2017).** 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 heading stage proved to be best for growth parameters,

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yield attribute as well as yield of wheat crop as compared to others treatment combinations.

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