



Performance of Integrated Nutrient Management and Foliar Spray of Micronutrients on Growth, Yield Attribute and Yield of Wheat (*Triticum aestivum* L.)

**Reenu Kumar^{a++*}, M. Z. Siddiqui^{a#}, Vikash Teotia^{a++},
Anurag Dhanker^{b++}, Ram Naresh^{a++}, Naushad Khan^{a#}
and Suryabhan^{a++}**

^a *Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India.*

^b *Department of Soil Science and Agricultural, Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during two *rabi* seasons of 2021-2022 and 2022-23 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.) The experiment was carried out in SPD (Split Plot Design) with fifteen treatment combination

⁺⁺ *Ph.D. Scholar;*

[#] *Professor;*

^{*}*Corresponding author: E-mail: reenukumar660@gmail.com;*

were replication thrice. fifteen treatment treatments combination consisted of three organic manure + RDF nutrient source (Control (100% RDF), 100 % RDF + Vermicompost @ 2.5t/ha, and 100 % RDF + FYM @ 5t/ha) put under main plot and five foliar spray of micronutrient control (No spray),Foliar spray of ZnSO₄ @ 0.25% at tillering and booting stages, Foliar spray of Nano Zinc @ 0.5% at tillering and booting stages, Foliar spray of FeSO₄ @ 0.25% at tillering and booting stages and M₅- Foliar spray of ZnSO₄ @ 0.25% + FeSO₄ @ 0.25% at tillering and booting stages) allotted under sub plot. The study on yield attribute and yield of wheat. The result showed that the maximum increase growth parameters, yield attribute and yield of wheat viz plant height (cm), number of tillers/m², and leaf area index and number of grain/spike, number spike/m², total grain weight spike (g) and test weight (1000 grain weight) (g) and grain yield (t/ha) and straw yield (t/ha) recorded significantly higher with F₂- 100 % RDF + Vermicompost @ 2.5t/ha treatments. Among the sub plot, M₅- foliar spray of ZnSO₄ @ 0.25% + FeSO₄ @ 0.25% at tillering and booting stages produced significantly maximum highest grain yield (5.95 t/ha) and straw yield (7.94 t/ha)

Keywords: FYM; iron sulphate; nano-zinc; vermicompost; wheat and zinc sulphate.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) one of the most important cereal crops in the world. comes under the family "Poaceae" and genus "Triticum" It is a crop of temperate climate with winter season crop and hot summer being very favorable for its growth and maturity. Among the cereal wheat is the one of the most important sources of energy, carbohydrate and protein for the world population and wheat production is considerably important for food security. It's grown under different agro climate conditions. It occupies 220.29 million ha. area with would the production of 780.59 million tones and productivity is 3390 kg ha⁻¹. rank second in production of wheat in the world after China. Important wheat producing state are Uttar Pradesh (30 million tons), Punjab (16.4 million tons), Haryana (11.6 million tons), with area 9.75 m/ha, 3.59 mha, 2.52 mha, respectively. Uttar Pradesh has first position in area and production of wheat in India. Although productivity of wheat (2661 kg ha⁻¹) is still less than the national average [1]. "Due to continuous use of high doses of synthetic chemical fertilizer without use of organic source and intensive system of cultivation practices, there is change in soil physico-chemical condition and nutritional deficiencies are common in general and specifically with micronutrients, which are very essential for plants. In this endeavor proper blend of organic and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health" Weber et al. [2]; Pullicino et al. [3]. "Judicious use of FYM improves soil physical, chemical and biological properties and improves crop productivity. It also helped in arresting the emerging deficiencies of macro and micro nutrients favorable and achieving economy and efficiency in fertilizers use. In view of

shrinkage of land resources for cultivation, short supply and escalating cost of chemical fertilizers, environmental pollution and ill effects on soils, animals and human health, there is need to use farm yard manure with nano fertilizers for achieving the objective of environmentally and ecologically sustainable agriculture The present investigation was, therefore, carried out to study the effect of FYM on yield attribute and yield, nutrient uptake and quality of wheat". Kumar et al. [4].

"The vermin-compost is the excreta of the earth worms, and farm yard manure is the product of decomposition of the liquid and solid excreta of the livestock. As the source of nutrients, these materials may also reduce the cost of fertilizer input and improve the soil physico-chemical properties. It is imperative to develop strategy to use organic manures up to their maximum potential with proper technology to meet the shortage of fertilizers and for sustaining soil fertility on long term basis. Since organic manures are known to improve the soil health increase water retention and supply of most of the nutrients to the plants, hence the use of these in the form of farm yard manure and vermin composting will certainly boost up crop production from the soil. The organic material such as vermin compost and farm yard manure available in abundance at nominal cost in eastern Uttar Pradesh may be the alternative for the organic manures which has worsened the quality of cereal staple in terms of Zn". Singh et al. [5] "Similar is the situation for Fe deficiency in cereals. In modern cultivated wheat, the seed concentration of Zn and Fe were found less than in the wild wheat" Cakmak et al. [6]. "Zinc and Fe are important minerals required for various metabolic functions. It is obvious for both animals

and plants. Zinc is responsible for protein synthesis, gene expression, proper growth and immune system. Physically Zn deficiency is manifested as stunting, common health problem in children like diarrhea, low birth weight, high rate of infection, skin lesions and impaired wound healing” [7].

“Fertilizers are necessary for enhancing productivity in crops especially in wheat, maximum use of macro nutrients and low use of micronutrients leading to an imbalance in soil fertility. A balance fertilization program with macro nutrients and micronutrients in plant nutrition is very essential in the high production of crops with good quality products, so there is a need balance use of fertilizers and agronomic procedures are needed to increase yield of this crop. The function of micronutrients is vital role in crop nutrition for improved yield attribute, growth and development and quality of wheat crop”. Saeed et al. [8].

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted during the rabi season 2021-2022 and 2022-23 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. A field experiment was conducted consecutive two season of 2021-2022 and 2022-2023 at Students' Instructional Farm Department of agronomy. College of agriculture, Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.). “The soil type and fertility status were determined by the mechanical and chemical analysis of the soil. In order to ascertain physico-chemical properties of the experimental soil, primary soil samples were drawn randomly up to 15 cm depth from different spots of the entire experimental area. The soil of the experimental field was sandy loam in texture, well drained, plane topography, slightly saline in nature having initial values of pH (8.00), EC (0.36 dsm^{-1}), low in organic carbon (0.37%), low in available nitrogen ($195.50 \text{ kg ha}^{-1}$), medium in phosphorus (19.75 kg ha^{-1}), Potash ($178.51 \text{ kg ha}^{-1}$). Iron (1.85 mg kg^{-1}) and Zinc (15.50 mg kg^{-1}). Respectively” [9].

2.2 Experiment Details

A field experiment was laid out in Split Plot Design. There were fifteen treatments

combinations consisting of three organic manure as a main treatment viz: F₁- Control (100% RDF), F₂- 100 % RDF + Vermicompost @ 2.5t/ha, and F₃- 100 % RDF + FYM @ 5t/ha, and five Foliar spray of micronutrient practices were applied as sub treatments viz: M₁- control (100% RDF), M₂- Foliar spray @ 0.25% ZnSO₄ at tillering and booting stage, M₃- Nano Zinc @ 0.5% spray at tillering and booting stage, M₄- Foliar spray @ 0.25% FeSO₄ at tillering and booting stage and M₅- Foliar spray @ 0.25% ZnSO₄ + 0.25% FeSO₄ at tillering and booting stage The treatments were replicated three times.

2.3 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 2021-2022 and 2022-2023 experimental season was between 1.2 to 6.2 km and 1.1 to 6.0 km respectively.

2.4 Agronomic Practices

The pre sowing irrigation was applied 8-10 days before sowing of wheat for optimum level of moisture for field preparation for good germination, The seed of wheat crop variety K-1006 was selected for these studies. Clean and healthy seed @ 120 kg/ha were taken and sown at shallow furrows of 5 cm deep with 22.5 cm row spacing on both rabi seasons of 2021-2022 and 2022-2023.

2.4.1 Manure and Fertilizers spray

The experimental crop was uniformly fertilized according to treatments, Farm yard manure (FYM) 5 t/ha, and Vermicompost (VC) 2.5 t/ha applied Before 15-20 days of sowing. The basal spray of fertilizers @ 120 kg N and full does P₂O₅, & K₂O was given and foliar spray of micronutrients @ 0.25% ZnSO₄, Nano-Zinc @ 0.25%, @ 0.25% FeSO₄ and foliar spray @ 0.25% ZnSO₄ + @ 0.25% FeSO₄ at tillering and

booting stage were done according to treatments and remaining nitrogen was top dressed in two splits.

2.4.2 Irrigation

Frist irrigation (pre -sowing) was applied in experiment field to prepare the field and sow the crop at optimum soil moisture before the seed sowing. Irrigation in standing crop at different stage of crop were not applied due to abundant rainfall which provide water requirement of the crop. Irrigation was needed in the both years during the crop period. and after sowing of the crop, all five-six irrigations were given as per need of the crops coincide with critical stages of the crop during both the years.

2.5 Observation Recorded

The observations were recorded on plant height (cm), number of tillers/m² 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 22.5 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 total number of grains per spike was counted from the spikes selected for measuring spike length; the grain was separated from spikelet's and the total numbers of grain/spike counted, A composite sample of grains was taken from the produce of each plot and thousand no of grains was counted with the help of automatic seed counter and the weight of 1000 grains expressed in gram, The grain yield per net plot and direction wise was weighed in kilograms. The yield in ton per hectare was calculated by multiplying the plot yield. The yield was used for statistical analysis and Straw yield was worked out by subtracting the grain yield from total biological yield of net plot area and expressed in t/ha

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. RESULTS AND DISCUSSION

3.1 Growth Characters

The data plant height, number of tillers/m², leaf area index 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, number of tillers/m² and leaf area index was recorded under the treatments F2- 100 % RDF + Vermicompost @ 2.5t/ha at 60 DAS, followed by F3- 100 % RDF + FYM @ 5t/ha. Both F2 and F3 treatments were significantly superior over the Control (100% RDF) during both the year as well as pooled basis data. Similar type of experimental finding reported by Mohan et al. [10]; Bairagya et al. [11]; Tiwari et al. [12], Among micronutrient foliar spray M5- Foliar spray of ZnSO₄ @ 0.25% + FeSO₄ @ 0.25% at tillering and booting stages recorded tallest plant height (cm), number of tillers/m² which was at par with M3- Foliar spray of Nano Zinc @ 0.5% at tillering and booting stages followed by, M2- foliar spray of ZnSO₄ @ 0.25% M4- foliar spray of FeSO₄ @ 0.25% at tillering and booting stages 60 DAS. Whereas minimum plant height (cm) and number of tillers/m² 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 Solanki et al. [13]; Akhtar et al. [14] However, the maximum leaf area index recorded in M5- Foliar spray of ZnSO₄ @ 0.25% + FeSO₄ @ 0.25% followed by M3- Foliar spray of Nano Zinc @ 0.5% at tillering and booting stages followed by M2- Foliar spray of ZnSO₄ @ 0.25% at tillering and booting stages and M4- foliar spray of FeSO₄ @ 0.25% at tillering and booting stages at harvest stages. The minimum leaf area index was recorded in control (No spray) 60 DAS, during both the years as well as pooled basis. These results corroborated with the findings of Dimkpa et al. [15].

3.2 Yield Attribute and Yield

Data on Number of grains/spikes, Test weight (1000 grain wt.) (g) grain yield (ton/ha) and straw

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

| Treatments | Plant height (cm) 60 DAS | | | Number of tiller/m ² 60 DAS | | | LAI 60 DAS | | |
|--|--------------------------|---------|--------|--|---------|--------|------------|---------|--------|
| | 2021-22 | 2022-23 | Pooled | 2021-22 | 2022-23 | Pooled | 2021-22 | 2022-23 | Pooled |
| Main plot (organic manure + RDF) | | | | | | | | | |
| F1- Control (100% RDF) | 43.83 | 44.41 | 44.12 | 313.60 | 315.40 | 314.50 | 2.10 | 2.17 | 2.14 |
| F2- 100 % RDF + Vermicompost @ 2.5t/ha | 51.44 | 51.71 | 51.58 | 399.80 | 401.40 | 400.60 | 3.94 | 4.03 | 3.99 |
| F3- 100 % RDF + FYM @ 5t/ha | 47.24 | 48.13 | 47.69 | 360.00 | 362.00 | 361.00 | 2.84 | 2.89 | 2.87 |
| S.Em, ± | 0.065 | 0.128 | 0.150 | 1.500 | 0.919 | 1.187 | 0.005 | 0.005 | 0.014 |
| C.D. (P=0.05) | 0.263 | 0.517 | 0.606 | 6.046 | 3.706 | 4.787 | 0.021 | 0.019 | 0.057 |
| Sub plot (foliar spray of micronutrient) | | | | | | | | | |
| M1- Control (No spray) | 45.73 | 46.25 | 45.99 | 338.33 | 340.00 | 339.17 | 2.54 | 2.62 | 2.58 |
| M2- Foliar spray of ZnSO ₄ @ 0.25% at tillering and booting stages. | 47.40 | 47.83 | 47.62 | 356.00 | 358.00 | 357.00 | 3.00 | 3.08 | 3.04 |
| M3- Foliar spray of Nano Zinc @ 0.5% at tillering and booting stages. | 48.17 | 48.67 | 48.42 | 368.67 | 370.00 | 369.33 | 3.07 | 3.12 | 3.10 |
| M4- Foliar spray of FeSO ₄ @ 0.25% at tillering and booting stages. | 46.97 | 47.91 | 47.44 | 350.33 | 352.33 | 351.33 | 2.90 | 2.96 | 2.93 |
| M5- Foliar spray of ZnSO ₄ @ 0.25% + @ 0.25% FeSO ₄ at tillering and booting stages. | 49.25 | 49.75 | 49.50 | 375.67 | 377.67 | 376.67 | 3.29 | 3.37 | 3.33 |
| S.Em, ± | 0.379 | 0.399 | 0.283 | 3.012 | 1.789 | 2.234 | 0.016 | 0.018 | 0.022 |
| C.D. (P=0.05) | 1.112 | 1.170 | 0.831 | 8.845 | 5.254 | 6.558 | 0.047 | 0.053 | 0.065 |
| Interactions | | | | | | | | | |
| S.Em, ± | 0.591 | 0.631 | 0.463 | 4.902 | 2.921 | 3.658 | 0.026 | 0.028 | 0.037 |
| C.D. (P=0.05) | NS | NS | NS | 14.895 | 8.892 | 11.164 | 0.076 | 0.084 | 0.114 |

Note: - RDF- (Recommended dose of fertilizers), FYM- (Farm yard manure), ZnSO₄- (Zinc Sulphate) and FeSO₄- (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

| Treatments | Test weight (g) | | | No of grain/spike | | | Grain yield (t/ha) | | | Straw 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) | | | | | | | | | | | | |
| F1- Control (100% RDF) | 36.37 | 37.08 | 36.72 | 44.66 | 45.76 | 45.21 | 4.45 | 4.65 | 4.55 | 6.39 | 6.51 | 6.45 |
| F2- 100 % RDF + Vermicompost @ 2.5t/ha. | 41.68 | 43.04 | 42.36 | 59.68 | 60.73 | 60.20 | 5.80 | 6.21 | 6.01 | 7.53 | 7.76 | 7.65 |
| F3- 100 % RDF + FYM @ 5t/ha. | 39.58 | 40.61 | 40.10 | 54.45 | 55.61 | 55.03 | 5.01 | 5.42 | 5.22 | 6.93 | 7.24 | 7.09 |
| S.Em, ± | 0.099 | 0.214 | 0.140 | 0.242 | 0.109 | 0.081 | 0.021 | 0.008 | 0.024 | 0.012 | 0.022 | 0.032 |
| C.D. (P=0.05) | 0.401 | 0.865 | 0.565 | 0.976 | 0.441 | 0.328 | 0.084 | 0.032 | 0.098 | 0.050 | 0.089 | 0.129 |
| Sub plot (Foliar spray of micronutrient) | | | | | | | | | | | | |
| M1- Control (No spray) | 37.81 | 38.92 | 38.36 | 46.68 | 47.87 | 47.27 | 4.24 | 4.47 | 4.35 | 5.85 | 6.00 | 5.92 |
| M2- Foliar spray of ZnSO ₄ @ 0.25% at tillering and booting stages. | 39.20 | 40.02 | 39.61 | 54.15 | 55.21 | 54.68 | 5.14 | 5.55 | 5.34 | 7.05 | 7.21 | 7.13 |
| M3- Foliar spray of Nano Zinc @ 0.5% at tillering and booting stages. | 39.57 | 40.79 | 40.18 | 55.19 | 56.35 | 55.77 | 5.37 | 5.73 | 5.55 | 7.35 | 7.57 | 7.46 |
| M4- Foliar spray of FeSO ₄ @ 0.25% at tillering and booting stages. | 38.62 | 39.65 | 39.13 | 52.43 | 53.48 | 52.96 | 4.90 | 5.28 | 5.09 | 6.72 | 6.98 | 6.85 |
| M5- Foliar spray of ZnSO ₄ @ 0.25% + @ 0.25% FeSO ₄ at tillering and booting stages. | 40.87 | 41.83 | 41.35 | 56.20 | 57.25 | 56.73 | 5.78 | 6.11 | 5.95 | 7.79 | 8.09 | 7.94 |
| S.Em, ± | 0.397 | 0.393 | 0.340 | 0.426 | 0.330 | 0.484 | 0.042 | 0.045 | 0.044 | 0.062 | 0.062 | 0.039 |
| C.D. (P=0.05) | 1.164 | 1.153 | 0.999 | 1.252 | 0.968 | 1.422 | 0.122 | 0.132 | 0.128 | 0.181 | 0.181 | 0.115 |
| Interactions | | | | | | | | | | | | |
| S.Em, ± | 0.622 | 0.645 | 0.545 | 0.703 | 0.522 | 0.755 | 0.068 | 0.070 | 0.072 | 0.096 | 0.098 | 0.069 |
| C.D. (P=0.05) | NS | NS | NS | 2.156 | 1.559 | 2.225 | 0.215 | 0.221 | 0.227 | 0.303 | 0.310 | 0.218 |

Note: - RDF- (Recommended dose of fertilizers), FYM- (Farm yard manure), ZnSO₄- (Zinc Sulphate) and FeSO₄- (Ferrous Sulphate) and DAS (day after sowing)

yield (ton/ha) was presented in Table 2. Number of grains/spike, Test weight (1000 grain wt.) (g) grain yield (ton/ha) and straw yield (ton/ha) was recorded highest under the treatments F₂- 100 % RDF + Vermicompost @ 2.5t/ha at harvest followed by F₃- 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 Singh et al. [5]; Fazily et al. [16]; Loura et al. [17], Among the foliar spray of micronutrient, M₅- Foliar spray of ZnSO₄ @ 0.25% + FeSO₄ @ 0.25% at tillering and booting stages recorded highest Number of grains/spikes, Test weight (1000 grain wt.) (g) grain yield (ton/ha) and straw yield (ton/ha) was presented in Table 2. Number of grains/spikes, Test weight (1000 grain wt.) (g) grain yield (ton/ha) and straw yield (ton/ha) which was at par with M₃- Foliar spray of Nano Zinc @ 0.5% at tillering and booting stages followed by, M₂- Foliar spray of ZnSO₄ @ 0.25%, and M₄- foliar spray of @ 0.25% FeSO₄ at tillering and booting stages respectively. It confirms the results corroborated with the findings of Mahil et al. [18]; Yadav and Tiwari [19]; Yadav et al. [20]

4. CONCLUSION

In organic manure + RDF, combined application of 100 % RDF + Vermicompost @ 2.5t/ha are found significantly with respect of growth, yield attribute and yield as well as of wheat crop. Moreover, the combined foliar spray of ZnSO₄ @ 0.25% + FeSO₄ @ 0.25% at tillering and booting stages proved to be best for growth parameters, yield attribute as well as yield of wheat crop as compared to others treatment combinations respectively.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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