Original Research Article

Performance of integrated nutrient management and Foliar spray of micronutrients on growth, yield attribute and yield of wheat (*Triticum aestivum* L.)

ABSTRACT

A field experiment was conducted during rabi seasons of 2021-22 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.) The experiment was caried out in SPD(Split Plot Design) with fifteen treatment combination 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 (100% RDF, Foliar application $ZnSO_4$ @ 0.25% at tillering and booting stage, spray of Nano Zinc @ 0.5% spray at tillering and booting stage, 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 booting stage) 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/m^2, 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 F_2- 100 % RDF + Vermicompost @ 2.5t/ha treatments. Among the sub plot,M_5- foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and booting stage produced significantly maximum highest grain yield (6.11 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. comesunder thefamily"*Poaceae*"andgenus"*Triticum*" It is a crop of temperate climate with winter season crop and hot summer beingvery favorable for its growth and maturity. Among the cereal wheat is the one of the mostimportant sources of energy, carbohydrateand protein for the world population and wheatproduction is considerably important for food security. It's grown under different agro climateconditions. If occupies 220.29 million ha. area with would the production of 780.59 milliontones and productivity is 3390 kg ha^{-1}. rank second inproduction of wheat in the world after China. Important wheat producing state are UttarPradesh(30milliontons),Punjab(16.4milliontons),Haryana(11.6milliontons),witharea 9.75m/ha,3.59 mha,2.52 mha,respectively.Uttar Pradeshhasfirstpositioninareaandproduction of wheat in India. Although productivity of wheat (2661 kg ha^{-1}) is still less thanthe national average **(Anonymous, 2022-23)**.Due to

continuous use of high doses of synthetic chemical fertilizer without use of organic source and intensive system of cultivation practices, 3 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*., 2007 and Pullicinoa*et al*., 2009).** Judicious use of FYM improves soil physical,chemical and biological properties and improves crop productivity. It also helped in arrestingthe emerging deficiencies of macro and micro nutrients favorable and achieving economyand efficiency in fertilizers use. In view of shrinkage of land resources for cultivation, shortsupply and escalating cost of chemical fertilizers, environmental pollution and ill effects onsoils, animals and human health, there is need to use farm yard manure with nano fertilizersfor achieving the objective of environmentally and ecologically sustainable agriculture Thepresent investigation was, therefore, carried out to study the effect of FYM on yield attribute and yield, nutrientuptake and quality of wheat. **(Kumar *et al.,* 2015).** The vermin-compost is the excreta of the earth warms, and farm yard manure is theproduct of decomposition of the liquid and solid excreta of the livestock. As the source ofnutrients, these materials may also reduce the cost of fertilizer input and improve the soilphysio-chemical properties. It is imperative to develop strategy touse organic manures up to their maximum potential with proper technology to meet theshortageoffertilizersandforsustainingsoilfertilityonlongtermbasis.Sinceorganic manures are known to improve the soil health increase water retention and supply of most ofthe nutrients to the plants, hence the use of these in the form of farm yard manure and vermincomposting will certainly boost up crop production from the soil. Theorganic material suchas vermin compost and farm yard manure available in abundance at nominal cost in easternUttarPradesh maybethealternativefor theorganic manures**(Singh*et al*. 2020)**which has worsened the quality of cereal staple in terms of Zn. 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*., 2004).**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 **(Mutangadura 2004).**Fertilizers are necessary for enhancing productivity in crops especially in wheat, maximumuseof macro nutrients andlowuseofmicronutrientsleadingtoanimbalanceinsoilfertility.A balance fertilization program with macro nutrients and micronutrients in plant nutrition isvery essential in the high production of crops with good quality products, so there is a needbalance use of fertilizers and agronomic procedures are needed to increase yield of this crop.Thefunctionofmicronutrientsisvital roleincropnutritionforimprovedyield attribute, growth and development and quality of wheat crop.**(Saeed*et. al.,* 2012).**

2. MaterialsandMethods

2.1. Experimental site:

The experiment was conducted during the rabi season2021-22 at Students' Instructional FarmofChandraShekharAzadUniversityofAgricultureandTechnology, Kanpur, which is situated in the alluvial tract ofIndo - Gangetic plains in central plain zone of Uttar Pradesh. A field experiment was conducted consecutive two season of 2021-2022-23 at Students' Instructional Farm Department of agronomy. College of agriculture, Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.). Thesoiltypeandfertilitystatusweredeterminedbythemechanicalandchemicalanalysisofthesoil .Inordertoascertainphysico-chemicalpropertiesoftheexperimentalsoil, primary soil samples were drawn randomly up to 15cmdepth from different spots of the entire experimental area. Thesoil of the experimental field was sandy loam in texture, welldrained, plane topography,slightly 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. Experiment Details

Afield 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 micronutrient practices were applied as sub treatments *viz:* M_1- control (100% RDF), M_2- Foliar application @ 0.25% $ZnSO_4$ at tillering and booting stage, M_3- Nano Zinc @ 0.5% spray at tillering and booting stage, M_4- Foliar application @ 0.25% $FeSO_4$ at tillering and booting stage and M_5- Foliar application @ 0.25% $ZnSO_4$ + 0.25% $FeSO_4$ 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 2021-22 and 2022-23 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 varietyK-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 rowspacing on both rabi seasons of 2021-22 and 2022-23.

2.4.1 Manure and Fertilizers application

The experimental crop was uniformly fertilizedaccordingtotreatments, Farm yard manure (FYM) 5 t/ha, and Vermicompost (VC) 2.5 t/haapplied Before 15-20 days of sowing.Thebasalapplicationoffertilizers@ 120kg 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 booting stageweredoneaccordingtotreatmentsand remainingnitrogenwastopdressedintwosplits.

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 asper need of the crops coincide with critical stages of the crop during both the years.

2.5. 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 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.

Result and discussions

3.1 Growth characters

The data plant height, number of tillers/m^2, 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/m^2 and leaf area index was recorded under the treatments F_2- 100 % RDF + Vermicompost @ 2.5t/ha at 60 DAS, 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. Similar type of experimental finding reported by **Mohan *et al.,* (2018), Bairagya*et al*., (2019) and Tiwari *et al*., (2022)**Among micronutrient foliar application M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at tillering and booting stage recorded tallest plant height (cm), number of tillers/m^2 which was at par withM_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 booting stage60 DAS. Whereas minimum plant height (cm) and number of tillers/m^2 was recorded in control (No spray) for both the years as well as on pooled basis. Highest growth characters under these treatmentsmaybeduetomicronutrient spray whichgavebetterenvironmentforcropgrowthanddevelopment. Itconfirmstheconclusion drawn by **Solanki *et al.,* (2020) and Akhtar *et al*., (2022)**However, the maximum leaf area index recorded in M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% followed by M_3- Spray of Nano Zinc @ 0.5% spray followed by M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage and M_4- foliar application of $FeSO_4$ @ 0.25% at tillering and heading stage 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*., (2020).**

3.2 Yield attribute and yield

Data on 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/spike, Test weight (1000 grain wt.) (g) grain yield (ton/ha) and straw yield (ton/ha) was recorded highest under the treatments 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 **Singh *et al*., (2020), Fazily*etal*.,(2021) and Loura *et al*., (2022)**Among the foliar

application of micronutrient, M_5- Foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% 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 withM_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.Itconfirmsthe results corroborated with the findings of **Mahil*etal*.,(2019),Yadav and Tiwari (2022) and Yadav *et al.,* (2023)**

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)									
F_1- Control (100% RDF)	43.83	44.41	44.12	313.60	315.40	314.50	2.10	2.17	2.14
F_2- 100 % RDF + Vermicompost @ 2.5t/ha	51.44	51.71	51.58	399.80	401.40	400.60	3.94	4.03	3.99
F_3- 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)									
M_1- Control (No spray)	45.73	46.25	45.99	338.33	340.00	339.17	2.54	2.62	2.58
M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage.	47.40	47.83	47.62	356.00	358.00	357.00	3.00	3.08	3.04
M_3- Spray of Nano Zinc @ 0.5% spray at tillering and booting stage.	48.17	48.67	48.42	368.67	370.00	369.33	3.07	3.12	3.10
M_4- Foliar application of $FeSO_4$ @ 0.25% at tillering and booting stage.	46.97	47.91	47.44	350.33	352.33	351.33	2.90	2.96	2.93
M_5- Foliar application of $ZnSO_4$ @ 0.25% + @ 0.25% $FeSO_4$ at tillering and booting stage.	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), $ZnSO_4$ – (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	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)												
F_1- 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
F_2- 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
F_3- 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)												
M_1- 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
M_2- Foliar application of $ZnSO_4$ @ 0.25% at tillering and booting stage.	39.20	40.02	39.61	54.15	55.21	54.68	5.14	5.55	5.34	7.05	7.21	7.13
M_3- Spray of Nano Zinc @ 0.5% spray at tillering and booting stage.	39.57	40.79	40.18	55.19	56.35	55.77	5.37	5.73	5.55	7.35	7.57	7.46
M_4- Foliar application of $FeSO_4$ @ 0.25% at tillering and booting stage.	38.62	39.65	39.13	52.43	53.48	52.96	4.90	5.28	5.09	6.72	6.98	6.85
M_5- Foliar application of $ZnSO_4$ @ 0.25% + @ 0.25% $FeSO_4$ at tillering and booting stage.	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), $ZnSO_4$ – (Zinc Sulphate) and $FeSO_4$ – (Ferrous Sulphate) and DAS (day after sowing`

Conclusion

In organic manure + RDF, 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 $ZnSO_4$ @ 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 respectively.

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