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**Research Paper**

# Growth and productivity of bread wheat (*Triticum aestivum*) as affected by integrated nutrient management and foliar application of iron

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## ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2016–17 to 2017–2018 on loamy sand soil of Jobner, Rajasthan, to study response of bread wheat (*Triticum aestivum* L.) to integrated nutrient management and foliar application of iron (Fe). The study showed that, application of 50% recommended dose of fertilizer (RDF) + vermicompost (VC) @ 4 t/ha resulted significant increase in dry-matter accumulation (DMA)/m row length (230.5 g), yield attributes, viz. spike length (8.30 cm), number of effective tillers/m row length (75.8), grains/spike (43.1), test weight (38.34 g), grain yield (4.7 t/ha) and straw yield (6.1 t/ha). Application of 50% RDF + VC @ 4 t/ha also showed significantly higher total uptake of N (124.3 kg/ha), P (32.1 kg/ha), K (100.6 kg/ha) and Fe (2261 g/ha) by bread wheat crop. Application of 0.5% $FeSO_4$ as foliar spray at tillering + flowering stages resulted in significantly higher dry-matter accumulation (244.8 g), higher yield attributes and grain (4.1 t/ha) and straw yields (5.7 t/ha) with higher total nutrient uptake. Interaction effect on grain yield was found significant between integrated nutrient management treatments and foliar spray of iron. Application of 50 % RDF +VC @ 4 t/ha along with foliar application of iron 0.5 % ferrous sulphate at tillering + flowering stage gave significantly higher yield over the control.

***Key words***: Productivity, Foliar spray, Iron, Recommended dose of fertilizers, Vermicompost

Wheat is one of the most important staple food crops of India as well as world not only in terms of acreage, but also in terms of its versatility for adoption under wide range of agro climatic conditions and crop growing situations. Soft wheat is used for making chapaties, bread, cake, biscuits, pastry and other bakery products.

On account of continuing world energy crisis and spiraling price of chemical fertilizer, the use of organic manure as a renewable source of plant nutrients is assuming importance. In this endeavour, proper blend of organic and inorganic fertilizer is important not only for enhancing yield but also for sustaining soil health (Pullicinoa *et al.,* 2009). Farmyard manure improves the physical, chemical and biological properties of soil and increases water-holding capacity for maximum utilization of water. Integration of FYM with inorganic N sources increases productivity and monetary returns of wheat and improves soil fertility. Poultry manure is rich in NPK content (3.03% N, 2.63% $P_2O_5$ and 1.4% $K_2O$) because there is no urine loss since the solid and liquid are extracted together. Vermicompost raises porosity, aeration, drainability and water-holding capacity and contains nutrients in readily available form to the plants such as nitrate, exchangeable phosphorus, soluble K, Ca and Mg. A proper combination of animal and crop residues in the form of FYM, vermicompost and poultry manure may provide a substantial supply of nutrients to the system.

Iron plays vital role in energy transfer within the plant and constituent of certain enzymes (peroxidase, catalase etc.) and proteins. It has an essential role in plant growth and enters in root cells involved in nitrogen fixation. Iron is a structural component of porphyrin molecules, cytochromes, heams, hematin, ferrichrome and legheamoglobin involved in oxidation-reduction reactions in respiration or in root nodules. Iron in chloroplast reflects the presence of cytochromes for performing various photosynthetic reduction processes. The ferrodoxins are Fe-S proteins and are the first stable redox compound of the photosynthetic electron-transport chain. At higher *p*H, the ionic form of iron changes to hydroxide form, which is insoluble and unavailable to plants. Keeping the above facts in view, a field experiment was conducted to assess

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the effect of integrated nutrient management along with foliar application of iron on growth and productivity of bread wheat.

## MATERIALS AND METHODS

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner, Rajasthan, during the winter (*rabi*) season of 2016–17 and 2017–18. The soil of the experimental field was loamy sand, alkaline (*p*H 8.2), low in organic carbon (0.18–0.21), low in available N (130.1–132.7 kg/ha), low in Olsen's available $P_2O_5$ (17.8 kg/ha), medium in available K (150 kg/ha) and low in available Fe (2.25–2.30 mg/kg). The experiment was laid out in split-plot design and replicated thrice. The experiment consisted of 32 treatment combinations, comprising 8 eight treatments of integrated nutrient management (control, 100% recommended dose of fertilizer (RDF), FYM 24 t/ha, poultry manure @ 10 t/ha, vermicompost @ 8 t/ha, 50% RDF + FYM @ 12 t/ha, 50% RDF + poultry manure @ 5 t/ha, 50% RDF + vermicompost @ 4 t/ha) in main plots and 4 levels of $FeSO_4$ foliar spray (control, at tillering, at flowering and tillering + flowering) in subplots. The nutrient content of organic sources used in experiment was 0.52 : 0.30 : 0.45, 1.25 : 0.75 : 1.08 and 1.48 : 1.22 : 0.10% N : $P_2O_5$ : $K_2O$ in FYM, vermicompost and poultry manure, respectively. The seeds of wheat variety 'Raj 3765' were sown at 22.5-cm-row spacing using 100 kg seed/ha on 24 November 2016 and 16 November 2017 and harvested on 15 April 2017 and 05 April 2018, respectively. The gross plot size was 4.0 m × 2.25 m. The recommended dose of fertilizers (RDF) is 120 kg N/ha and 20 kg $P_2O_5$ /ha for zone III A. In RDF, nitrogen was applied through urea and phosphorus through single super phosphate. Half dose of N of RDF was drilled basal at the time of sowing and remaining N was top-dressed in 2 splits. FYM and poultry manure were applied in the respective beds as per treatments and were thoroughly incorporated into the soil and vermicompost was applied just before sowing. In order to minimize weed competition, hoeing cum-weeding was done 1 month after sowing with the help of hand-hoe. The crop was irrigated at critical growth stages during both the years. In all, 5 irrigations were given in each year till maturity to raise a good crop. Prior to sowing, the seed was treated with bavistin @ 2.5 g/kg to protect from seed-and soil-borne diseases.

Dry-matter accumulation at harvesting stages was recorded by removing plants from 1 m row length from the sample rows in each plot. The root portion of the plants was removed and the samples were dried in air for some time and finally in an electric oven at 70°C till constant weight and expressed as g/m row length. The numbers of tillers having fully-developed spikes were counted from the plants used for total tillers count in each plot at maturity of the crop. These were averaged and expressed per plant. At harvesting, the length of 5 randomly selected spikes from each plot was measured in cm and average length of spike was calculated. The above-randomly selected productive spikes were threshed separately, number of grains were counted and average number of grains/spike were then recorded. At maturity, the net plots were harvested and sun-dried. The weight of the thoroughly sun-dried harvested produce of each plot was recorded separately before threshing and expressed as biological yield in t/ha. After threshing, cleaning and drying, the seed yield was recorded. Straw yield was obtained by subtracting seed yield from the total biological yield.

Nitrogen in samples was estimated by colorimetric method (Snell and Snell, 1949). Phosphorus content was estimated using vanadomolybdophosphoric acid to develop yellow colour after wet digestion of plant samples (Jackson, 1973). Potassium content of samples was determined by flame-photometer method (Metson, 1956). The uptake of nitrogen, phosphorus, potassium and Fe by wheat crop at harvesting was computed using nutrient concentration in grain and straw and it multiplication in their yield.

The experimental data recorded for growth, yield and nutrient uptake were subjected to statistical analysis by adopting appropriate method of analysis of variance assuming homogeneity. Pooled analysis of the data was carried out to establish the trend of treatments applied as per Gomez and Gomez (1984). Significance of differences among treatment effects was tested by 'F' test as described by Panse and Sukhatme (1985) for split-plot design experiments.

## RESULTS AND DISCUSSION

### *Dry-matter, yield attributes and yield*

Dry-matter accumulation/m row length in wheat was significantly increased owing to integrated nutrient-management treatments. Application of 50% recommended dose of fertilizer (RDF) with vermicompost (VC) 4 t/ha, poultry manure (PM) 5 t/ha and FYM @ 12 t/ha resulted significantly higher dry-matter accumulation/m row length at harvesting over the control, FYM 24 t/ha, PM 10 t/ha and vermicompost 8 t/ha. Application of RDF 50% + VC @ 4 t/ha enhanced the dry matter accumulation by 41.9% at harvesting over the control (Table 1). The favourable effect of organic manure on dry-matter was probably because of improved photosynthetically active leaf area for longer period during vegetative and reproductive phases which led to more absorption and utilization of radiant energy which ultimately resulted in higher dry-matter accumulation. The results of present investigation are in agreement with those reported by Patidar and Mali (2004) in

sorghum, Sain and Chaplot (2014) in wheat and Choudhary (2013) in barley.

Foliar spray of 0.5% ferrous sulphate significantly influenced the dry-matter accumulation/m row length at all the stages except 30 days after sowing (DAS). Among the foliar treatments, application of 0.5% ferrous sulphate at tillering + flowering recorded maximum and significantly higher dry-matter accumulation, showing an increase of 47.56% over the control. This might be owing to on account of improved photosynthetic efficiency and chlorophyll formation (Kamali *et al.,* 2020). Similarly, increased plant dry matter ($g/m^2$) at various growth stages (active tillering, panicle initiation, flowering and at harvesting) with iron application was also reported by Rakesh *et al*. (2012). The overall growth of plant increased in terms of plant height and leaf area which contributed for higher dry-matter production. The soil was low in iron content with higher *p*H which reduced its availability. Hence, the plants responded quickly to foliar application of 0.5% $FeSO_4$.

Different yield attributes of wheat were significantly enhanced by treatments of integrated nutrient management (Table 1). Application of 50% RDF + VC @ 4 t/ha, RDF 50% + PM @ 5 t/ha , RDF 50% + FYM @ 12 t/ha, Vermicompost @ 8 t/ha, Poultry manure @ 10 t/ha, FYM @ 24 t/ha and 100% RDF resulted in significantly higher number of effective tillers/m row length and test weight over the control and remained at par with each other. Spike length and grains/spike of wheat were significantly enhanced by application of 50% RDF + VC @ 4 t/ha over the control. This is owing to contribution in supplying additional plant nutrients by the treatments and increasing solubility of native soil nutrients. The sink capacity of plant depends mainly on vegetative and reproductive growth of the plant which affected positively by application of organic manures, i.e. FYM and vermicompost, and supply of photosynthates for the formation of yield components. Kumawat (2003) observed significantly higher number of spikes/m row length, spike length and grains/spike in barley owing to application of VC @ 4.5 t/ha over VC @ 1.5 and 3 t/ha, FYM @ 5, 7.5 and 10 t/ha. Choudhary *et al*. (2017) and Kaur *et al*. (2018) also observed similar results in wheat. Foliar application of 0.5% ferrous sulphate treatment at tillering + flowering stage significantly increased the number of effective tillers/m row length (77.1), spike length (8.69), grains/spike (43.9) and test weight (37.84 g) and found superior to rest of the treatments. Similar results were also obtained by Zeidan *et al*. (2010), who reported that foliar application of 0.1% $FeSO_4$ significantly increased the spikes/$m^2$ and grains/spike of wheat over the control.

The highest grain and straw yield was obtained by application of 50% RDF + VC @ 4 t/ha which remained at par with RDF 50% + PM @ 5 t/ha and RDF 50% + FYM @ 12 t/ha and recorded a significant increase of 105.3, 102.9,

**Table 1.** Effect of integrated nutrient management and foliar application of iron on dry-matter accumulation (DMA)/m row length, yield attributes and grain, straw and biological yields and harvest index of bread wheat (pooled data of 2 years)

| Treatments | DMA at harvesting | Effective tillers/m row length | Spike length (cm) | Grain/ spike | Test weight (g) | Grain yield (t/ha) | Straw yield (t/ha) | Biological yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|
| *Integrated nutrient management* | | | | | | | | | |
| Control | 162.5 | 68.4 | 6.69 | 34.6 | 34.32 | 2.3 | 3.6 | 6.0 | 38.64 |
| RDF 100% | 196.5 | 73.8 | 7.38 | 38.2 | 36.74 | 3.5 | 5.2 | 8.8 | 40.52 |
| FYM @ 24 t/ha | 198.0 | 73.6 | 7.53 | 38.7 | 36.30 | 3.6 | 5.3 | 8.98 | 40.64 |
| Poultry manure @ 10 t/ha | 199.2 | 74.3 | 7.72 | 39.0 | 36.98 | 3.7 | 5.3 | 9.1 | 40.87 |
| Vermicompost @ 8 t/ha | 200.9 | 74.7 | 7.78 | 39.4 | 36.64 | 3.9 | 5.4 | 9.3 | 41.77 |
| RDF 50% + FYM @ 12 t/ha | 226.0 | 75.2 | 8.16 | 42.4 | 37.55 | 4.6 | 6.0 | 1.06 | 43.22 |
| RDF 50% + PM @ 5 t/ha | 229.4 | 75.3 | 8.23 | 42.9 | 38.02 | 4.7 | 6.1 | 1.08 | 43.52 |
| RDF 50% + VC @ 4 t/ha | 230.5 | 75.8 | 8.30 | 43.1 | 38.34 | 4.7 | 6.1 | 1.09 | 43.58 |
| SEm ± | 3.3 | 1.2 | 0.12 | 0.7 | 0.75 | 0.06 | 0.08 | 0.013 | 1.13 |
| CD (P=0.05) | 9.5 | 3.6 | 0.35 | 1.9 | 2.16 | 0.19 | 0.24 | 0.37 | 3.27 |
| *Foliar spray of iron* | | | | | | | | | |
| Control | 165.9 | 68.2 | 6.19 | 35.4 | 35.58 | 3.4 | 4.8 | 8.2 | 41.69 |
| 0.5% Ferrous sulphate at tillering stage | 210.8 | 74.6 | 8.10 | 40.2 | 36.87 | 3.9 | 5.5 | 9.5 | 41.43 |
| 0.5% Ferrous sulphate at flowering stage | 200.0 | 75.4 | 7.92 | 39.7 | 37.16 | 4.0 | 5.6 | 9.7 | 41.67 |
| 0.5% Ferrous sulphate at tillering + flowering stage | 244.8 | 77.1 | 8.69 | 43.9 | 37.84 | 4.1 | 5.7 | 9.8 | 41.59 |
| SEm± | 2.3 | 0.9 | 0.08 | 0.4 | 0.44 | 0.05 | 0.05 | 0.09 | 0.77 |
| CD (P=0.05) | 6.4 | 2.5 | 0.21 | 1.2 | 1.22 | 0.14 | 0.15 | 0.27 | NS |

NS, Non-significant; VC, vermicompost; PM, poultry manure; FYM, farmyard manure; RDF, recommended dose of fertilizer

98.4% in grain and 67.2, 65.6 and 63.9% in straw yield over the control, respectively (Table 1). Integrated nutrient management significantly enhanced the biological yield and harvest index with 50% RDF + VC @ 4 t/ha but in harvest index it remained at par with rest of the treatments except the control. The significant increase in grain yield was function of improved growth and consequent increase in different yield attributes as mentioned above. Significant increase in straw yield could be because of greater accumulation of dry matter by virtue of increased photosynthetic efficiency and nutrient accumulation. These results are in agreement with the findings of Neelam *et al*. (2013). Our results substantiate the findings of Suryavanshi *et al*. (2019), who reported that combination of recommended dose of fertilizer N with FYM or vermicompost gives better wheat yield. Since, biological yield is a function of grain and straw yields, representing vegetative and reproductive growth of the crop, the profound influence of balanced nutrition led to realization of higher biological yield. Similarly, Kumar *et al.* (2019) reported that the application of 100% recommended dose of fertilizer (RDF) + vermicompost at 2.5 t/ha + $ZnSO_4$ at 20 kg/ha resulted in the highest grain yield (4.91 t/ha) and straw yield (6.75 t/ha) followed by 100% RDF + FYM at 5 t/ha + $ZnSO_4$ at 20 kg/ha in wheat. Our findings corroborate the results of Kumar and Pannu (2012).

**Table 2.** Interactive effect of integrated nutrient management (INM) and iron on grain yield (t/ha) of bread wheat (pooled data of 2 years)

| Treatment | Control | 0.5% $FeSO_4$ at T | 0.5% Fe $SO_4$ at F | 0.5% $FeSO_4$ at T+F |
|---|---|---|---|---|
| Control | 2.0 | 2.3 | 2.3 | 2.49 |
| RDF 100% | 3.3 | 3.6 | 3.7 | 3.6 |
| FYM @ 24 t/ha | 3.2 | 3.7 | 3.8 | 3.8 |
| PM @ 10 t/ha | 3.2 | 3.7 | 3.9 | 3.9 |
| VC @ 8 t/ha | 3.3 | 3.9 | 4.1 | 4.2 |
| RDF 50% + FYM @ 12 t/ha | 3.9 | 4.6 | 4.8 | 5.0 |
| RDF 50% + PM @ 5 t/ha | 4.0 | 4.7 | 4.9 | 5.1 |
| RDF 50% + VC @ 4 t/ha | 4.0 | 4.8 | 5.0 | 5.2 |
| | | | SEm± | CD (P=0.05) |
| Foliar spray of iron at same level of INM | | | 0.014 | 0.39 |
| INM at same level and different level of foliar spray of iron | | | 0.24 | 0.71 |

T, Tillering; F, flowering; VC, vermicompost; PM, poultry manure; FYM, farm yard manure; RDF, recommended dose of fertilizer

**Table 3.** Effect of integrated nutrient management and foliar application of iron on total uptake of nitrogen, phosphorus, potassium and iron of wheat (pooled data of 2 years)

| Treatment | Total N uptake (kg/ha) | Total P uptake (kg/ha) | Total K uptake (kg/ha) | Total Fe uptake (g/ha) |
|---|---|---|---|---|
| *Integrated nutrient-management* | | | | |
| Control | 60.1 | 14.8 | 48.0 | 1,129 |
| RDF 100% | 94.1 | 23.5 | 74.7 | 1,718 |
| FYM @ 24 t/ha | 96.5 | 24.2 | 76.8 | 1,762 |
| Poultry manure @ 10 t/ha | 98.6 | 24.8 | 78.4 | 1,807 |
| Vermicompost @ 8 t/ha | 102.8 | 25.9 | 80.9 | 1,857 |
| RDF 50% + FYM @ 12 t/ha | 120.1 | 30.8 | 97.0 | 2,178 |
| RDF 50% + PM @ 5 t/ha | 122.7 | 31.6 | 99.1 | 2,227 |
| RDF 50% + VC @ 4 t/ha | 124.3 | 32.1 | 100.6 | 2,261 |
| SEm± | 2.1 | 0.5 | 1.8 | 29.6 |
| CD (P=0.05) | 6.1 | 1.4 | 5.2 | 85.8 |
| *Foliar spray of iron* | | | | |
| Control | 87.3 | 21.9 | 66.7 | 1,556 |
| 0.5% ferrous sulphate at tillering stage | 104.1 | 26.4 | 82.9 | 1,901 |
| 0.5% ferrous sulphate at flowering stage | 107.3 | 27.3 | 86.1 | 1,959 |
| 0.5% ferrous sulphate at tillering + flowering stage | 110.9 | 28.4 | 92.1 | 2,052 |
| SEm± | 1.3 | 0.3 | 1.0 | 23.0 |
| CD (P=0.05) | 3.6 | 0.9 | 2.9 | 64.5 |

VC, Vermi compost; PM, poultry manure; FYM, farmyard manure; RDF, recommended dose of fertilizer

Harvest index indicates the percentage of total biological yield, partitioned to the economic part of the plant, viz. the grain, in terms of dry matter (Verma *et al*., 2015) in wheat. Foliar spray of 0.5% ferrous sulphate caused a favourable effect on the biological yield of wheat with application at tillering + flowering stage. Application of 0.5% ferrous sulphate at tillering, flowering and tillering + flowering stages failed to increase harvest index significantly. The results of present study are in close conformity with the findings of Rawashdeh and Sala (2015) who reported that foliar and soil application of Fe alone or in association with other micronutrients to wheat grown on Fe-deficient soils enhanced the yield and yield components. Results of are in close conformity with those of Yadav (2002) in mungbean , Yadav and Chhipa (2007) in wheat and Choudhary (2013) in barley.

Interactive effect of 0.5% ferrous sulphate foliar spray and different integrated nutrient management treatments on grain yield was found significant (Table 2). Increased yield was noted with RDF 50% + VC 4 t/ha than any other treatment, but was statistically at par with RDF 50% + poultry manure @ 5 t/ha and RDF 50% + FYM @ 12 t/ha with 0.5% ferrous sulphate spray at tillering or flowering stage.

*Effect on nutrient uptake*

The total nutrient uptake of nitrogen, phosphorus, potassium and iron in wheat was significantly influenced by the application of integrated nutrient-management treatments (Table 3). Higher uptake of NPK and Fe was recorded with the application of RDF 50% + VC 4 t/ha followed by RDF 50% + poultry manure @ 5 t/ha and RDF 50% + FYM @ 12 t/ha. Combination of FYM @ 12 t/ha and poultry manure @ 5 t/ha with 50% RDF recorded a significant increase of 106.8, 104.1 and 99.8% in N uptake; 116.9, 113.5 and 108.1% in P uptake; 109.6, 106.5 and 102.1% in K uptake; and 100.3, 97.3 and 92.9% in Fe uptake, respectively, over the control. The positive influence of integrated nutrient management on nitrogen, phosphorus, potassium and iron content appears to be owing to improved nutritional environment both in root zone and plant system. Increased yield, availability of these nutrients in root zone coupled with increased metabolic activities at the cellular level probably increased the nutrient uptake and accumulation in the vegetative parts. Increased seed and straw yields coupled with higher nutrient content (nitrogen, phosphorus, potassium and iron) in plant seemed to have the increased uptake of nitrogen, phosphorus, potassium and iron by the crop owing to application of different treatments. Similar results were reported in wheat with poultry manure by Subehia (1998), Yadav (2001) and Reena *et al*. (2017). Mohan *et al.* (2018) reported that the INM with 100% RDF + 25% N through vermicompost was obtained the suitable combination of fertilizers and organic manures for increased nutrients availability in wheat.

Foliar spray of iron at tillering + flowering stage resulted maximum total NPK and Fe uptake and found significantly superior to rest of the treatments. This might be owing to increased supply of Fe and good response by the plants to them leading to enhanced translocation of nutrients to reproductive structures, viz. spikes and grains. The application of iron through foliar spray of 0.5% ferrous sulphate had favourable effect on the absorption of various nutrients which is supported by lower concentration of P and higher concentration of Fe in grain and straw. The beneficial role of iron in chlorophyll content and involved in large number of metabolically active compounds like cytochromes and other functional metallo proteins is well understood. Iron is related to vitamins and certain enzymes which help in Cu, Zn, Mn and Mg metabolic process of plant. Abbas *et al.* (2012) reported that application of Fe increased NPK uptake significantly over the control in wheat. Our results are also in agreement with those of Sur *et al*. (1993) and Yang *et al.* (1994).

It may be concluded that conjunctive application of 50% RDF + VC @ 4 t/ha combined with foliar application of 0.5% iron sulphate at tillering + flowering stage recorded higher grain yield (5.2 t/ha) followed by 50% RDF + poultry manure @ 5 t/ha (5.1 t/ha grain yield). Further, these treatments also recorded higher total nutrient uptake (N,P,K and Fe). Therefore, treatment 50% RDF + VC @ 4 t/ha or 50% RDF + poultry manure @ 5 t/ha with 0.5% foliar application of ferrous sulphate at tillering + flowering is recommended for getting higher productivity of wheat crop.

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