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Response of Different Levels of Zinc and Iron on Growth, Yield and Yield Attributing Characters of Wheat (*Triticum Aestivum* L.)

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ABSTRACT
The field experiment was conducted in Factorial Randomized Block Design and seed quality parameters were assessed by using Complete Randomized Design with three replications during 2011-12 & 2012-13 at Experimental Research Farm, Nawabganj, Kanpur and Seed Testing Laboratory of Department of Seed Science and Technology, respectively with wheat variety K-9162 (Gangotri). Four doses of zinc viz. 0.0, 5.0, 10 and 15 kg ha^{-1} and iron viz. 0.0, 2.5, 5.0 and 7.5 kg ha^{-1} were applied. The best performance was recorded in 10 kg Zn ha^{-1} with respect to seed yield (38.90 q ha^{-1}), leaf area index at 90 DAS (3.94), days to 50 % heading (73.42), plant height (82.01 cm), number of tillers m^{-2} (314.08), number of spikelet's spike^{-1} (18.13), seed growth duration (35.25 days), days to maturity (116.46) and 1000 seed weight (47.06 g), As far as the iron levels as concerned the best values were recorded in 5.0 kg Fe ha^{-1} with regards to days to 50 % heading (74.00), plant height (79.56 cm), number of spikelet's spike^{-1} (17.79) and seed growth duration (35.71 days), The interaction combination i.e. 10 kg Zn x 5.0 kg Fe ha^{-1} (Zn_2 x Fe_2) showed significantly better values for LAI at 30 DAS (1.85), plant height (83.50 cm), number of tillers m^{-2} (320.67), seed yield (396.66 g m^{-2}). Thus, it is concluded that application of 10 kg zinc and 5.0 kg iron ha^{-1} either singly or in combination of both have been found most appropriate and economical for above.

Key Words: Zinc, Iron, Growth parameters, Yield, Wheat.

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INTRODUCTION
Wheat is considered as one of the most important cereal crops in India. It is the second important food crop being next to rice. India is the second largest producer of wheat in the world next only to China and the crop has registered fastest growth to Indian agriculture. In world, wheat is cultivated over an area of 304.18 m ha with total production and productivity of 92.29 million tonnes and 3.03 t ha^{-1}, respectively. However in India, it is cultivated an area of 30.40 m ha with total production and productivity of 94.88 mt and 3.18 t ha^{-1}, respectively. In Uttar Pradesh, the acreages, production and productivity of wheat is about 9.67 m ha, 30.01 mt and 3.11 t ha^{-1}, respectively **[1].** As staple food, wheat continues to assume greater significance in the years to come both from grain productivity as well as quality points of view. Providing required quantity of quality grains to the growing population is an everlasting challenge to the researchers. Based on the present rate of

population growth of 1.5 per cent and per capita consumption of 180 g of wheat per day in the country, India will have to produce 109 mt of wheat by 2020 **[2].**

The importance of micronutrients application in increasing crop production has been recognized in India and it is becoming evident that without the use of the micronutrient, it is not possible to get the maximum benefits of NPK fertilizers and high yielding varieties of wheat**.** The growth and yield of a plant is determined by the availability of some specific mineral nutrients that are absolutely essential for the completion of their life cycle**.** Excess or deficiency of certain elements from the crop can affect its yield, quality and subsequent post-harvest life. The bolder grains possessed relatively higher levels of copper, zinc and iron concentration at all the stages of grain development as compared to smaller grains. The results suggest that the grains reflected variable profiles with regards to distributions of nutrients within spike as well as spikelet of wheat **[3].**

The application of zinc increased zinc uptake in wheat grain and straw. Likewise, it also observed significant increase in grain yield of wheat due to the application of zinc to the soil. The fertilizer experiment of wheat responded well to applied Zn and removal of micronutrients by the annual cropping cycle depleted the availability of Zn **[4].** Different nutrients may interact with Zn by affecting the availability of each other from soils and their status in the plant through the process of growth or absorption, distribution and utilization. These interactions may reduce or enhance plant growth as a response to Zn **[5]**. The extent of iron (Fe) deficiency in India is next to that of Zn**.** Iron deficiency is a widespread nutritional problem in developing countries, causing impaired physical activity and cognitive development, as well as maternal mortality. The cost-effectiveness of iron bio-fortification compares favourably with other interventions **[6].** Iron deficiencies are mainly manifested by yellow leaves due to low levels of chlorophyll. Leaf yellowing first appears on the younger upper leaves in interveinal tissues. Severe iron deficiencies cause leaves to turn completely yellow or almost white, and then brown as leaves die. Iron deficiencies are found mainly on high pH soils, although some acid, sandy soils low in organic matter also may be iron-deficient. Cool, wet weather enhances iron deficiencies, especially on soils with marginal levels of available iron. Poorly aerated or compacted soils also reduce iron uptake by plants. Uptake of iron decreases with increased soil pH, and is adversely affected by high levels of available phosphorus, manganese and zinc in soils. Fe is present in two oxidation states i.e. Fe^{+3} ferric and Fe^{+2} ferrous. In general, Fe^{+2} is the species taken up by plants. Fe^{+3} therefore have to be reduced at root surface before root uptake. In the presence of O_2 Fe^{+2} is rapidly oxidized to Fe^{+3}, which is poorly soluble in water and which precipitates as oxides of Fe; mainly as Fe oxide, Fe hydroxide, Fe phosphate. Iron is one of the most important element essential for plant growth **[7]**. Iron also enters in to oxidation process that release energy from sugars and starches and reaction that convert nitrate to ammonium in plants. It plays an essential role in nucleic acid metabolism **[8].** Hence it is obvious to find out suitable level of Zinc and Iron requirement for optimal growth, better seed yield and yield attributing characters of wheat crop.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Research Farm, Nawabganj, Kanpur during the *Rabi* 2011-12 and 2012-13 for assessing the effect of zinc and iron levels on growth, yield and yield attributes. The seed quality parameters were assessed in the Seed Testing Laboratory of Department of Seed Science and Technology, C.S. Azad University of Agriculture and Technology, Kanpur. The experiment was laid out in Factorial RBD design with three replications. The mean annual rainfall is about 816 mm. Soil texture of experimental site was sandy loam having fine sand 62.50 and 62.20 %, silt 23.80 and 24.00 %, clay 13.70 and 13.80 %, pH 8.52 and 8.54, organic carbon 0.44 (Low) and 0.47 % (Low), EC 0.42 and 0.41 ds m^{-1}, available N 221 (Low) and 225 kg ha^{-1} (Low), available P 19 (Medium) and 20 kg ha^{-1} (Medium), available K 245 (Medium) and 249 kg ha^{-1} (Medium), available zinc 0.9 (Low) and 1.0 kg ha^{-1} (Low) and available iron 9.2 (Normal) and 9.4 kg ha^{-1} (Normal) during 2011-12 and 2012-13, respectively. The experiment was conducted on wheat var. K-9162 (Gangotri). Four doses of zinc (0, 5, 10, 15 Kg ha^{-1}) and iron (0, 2.5, 5.0, 7.5 Kg ha^{-1}) were applied as basal dose. The basal dose of fertilizer was applied at the rate of 150 kg N, 75 kg P_2O_5 and 60 kg K_2O ha^{-1} uniformly in all plots. The half of nitrogen and full dose of P_2O_5 and K_2O were applied in the soil before sowing. One fourth of the nitrogen was applied as top dressing after first irrigation and rest one fourth nitrogen given at heading stage. Crop was sown on 30^{th} November and 3^{rd} December during *Rabi* 2011-12 and *Rabi* 2012-13, respectively. Sowing was done manually with the help of hoe. Six rows were sown in each plot of 3×1.38 mat 23 cm apart. Growth parameter was recorded at 30, 60 and 90 DAS stage and yield parameters were recorded at harvest stage by taking five random plant samples from each treatment. The leaf area of five plants was measured by automatic leaf area meter at 30^{th}, 60^{th} and 90^{th} days after sowing of the crop. Leaf area index was calculated by the formula.

Leaf area index = leaf area / ground area

Plant height calculated ten plants from each plot were selected randomly. It was measured from the soil surface to apex of the main plant shoot in centimeter with meter scale. Plant height was measured at the time of maturity. The values of the 10 selected plants were averaged to calculate plant height per plant. Number of Tillers calculated In the central of each plot of every replication, a square ring was placed. The tiller fall inside the ring were counted. The observation was recorded at the time of harvesting. Number of Spikelet's Spike was observed ten spikes were selected randomly at the time of maturity in each treatment of every replication. After this process, number of spikelet's spike^{-1} was counted and averaged. The seed growth duration was measured in days from the anthesis (heading) to physiological maturity. Days to Maturity calculated When crop was matured, stem and leaf become yellowish and the other leaves too has lost its green chlorophyll colour and have turned brown, moisture content came down approximately below 17 per cent. The days to maturity was recorded for each plot in days. Spike Length ten spikes were selected randomly at the time of maturity in each treatment of every replication. Spike length was measured in cm from lower spike node up to tip of the panicle excluding awn. Seed yield the seed lot of each plot was converted in to seed yield q ha^{-1}.

RESULTS AND DISCUSSION

EFFECT OF ZINC AND IRON LEVELS ON GROWTH OF WHEAT VARIETY (K-9132):

Effect of nutrients viz. zinc (Zn) and iron (Fe) were found significantly effective for all growth characters i.e. days to 50% heading, plant height, leaf area index, Days of maturity and seed growth duration, interaction effect of zinc (Zn) x iron (Fe) was significant only for plant height. Effect of zinc level was showed significant effect on plant height. During both years and pooled data Zn_2 (81.72, 82.30 and 82.01 cm) was significantly superior over other treatments for producing tallest plant and next to Zn_1 (77.74, 79.30 and 78.52 cm). Smallest plant height was observed by application of Zn_0 (76.72, 77.46 and 77.09 cm) and it was at par to Zn_3 (76.87, 77.48 and 77.18 cm). This data pertaining to the effect of zinc (Zn) and iron (Fe) and their interaction on plant height are present in **Table 1**. The plant height observed in Fe_2 was significantly higher (79.15, 79.97 and 79.56 cm), but Fe_2 was at par to Fe_3 (78.84, 79.81 and 79.33 cm) in both years and pooled. During I year Zn_1 (77.74 cm), Zn_3 (76.87 cm) and Zn_0 (76.72 cm) showed at par performance to each other. Similarly, during II year and pooled analysis, Zn_3 (77.48 and 77.18 cm) and Zn_0 (77.46 and 77.09 cm) showed at par performance to each other. Interaction effect of zinc (Zn) and iron (Fe) had showed significant effect in 2012-13 and pooled. The combination Zn_2 x Fe_2 (83.65 and 83.50 cm) was significantly better and at par with Zn_2 x Fe_3 (83.06 and 82.63 cm) during 2012-13 and pooled for more plant height. While during I year interaction of zinc (Zn) and iron (Fe) interaction did not show significant effect. However, numerically maximum plant height was found in treatment combination of Zn_2 x Fe_2 i.e. 83.35 cm while lowest was recorded in Zn_0 x Fe_0 i.e. 75.16 during 2011-12. Similar results was reported by **[9], [10],** in case of seed growth duration Zn_2 showed significant difference and taken fewer periods for seed growth duration (days) as compared to other dose during both year as well as pooled analysis. During I, II year and pooled analysis Zn_2 took minimum number of days i.e. 34.75, 35.75 and 35.25 for SGD while maximum number of days i.e. 36.58, 36.75 and 36.67 were recorded in Zn_3. But during 2012-13 Zn_2 (35.75 days) was at par to Zn_1 (36.25 days) for seed growth duration. Result of Iron showed that Fe_2 treatment differ significantly to others and took minimum number of days (35.71) while treatment Fe_3 (36.04), Fe_1 (36.17) and Fe_0 (36.17) did not differ significantly for SGD in pooled analysis. For I and II year iron did not show significant effect with respect to seed growth duration. However, numerically lowest SGD i.e. 35.42 and 36.00 were observed in Fe_2 and highest value was recorded in control i.e. 35.75 and 36.58. Interaction of zinc and iron did not show any significant effect on SGD. These results are in conformity with the findings of **[11]**, **[12] and [13].**Effect of Zn_2 recorded significantly least days to maturity i.e. 116.33, 116.58 and 116.46 of wheat as compared to other treatment while maximum was found in treatment Zn_3 i.e. 117.67, 118.67 and 118.17 days for I year, II years and pooled analysis, respectively. In case of iron showed that Fe_2 treatment differ significantly to others and took minimum days to maturity (117.00), while treatment Fe_3 (117.33), Fe_1 (117.33) and Fe_2 (117.00) and Fe_0 (117.29) showed at par performance to each other in pooled analysis. During I and II year iron (Fe) did not show any significant effect on days to maturity. However, numerically lowest days to maturity i.e. 116.67 and 117.33 were observed in Fe_2 and highest were recorded in Fe_3 i.e. 117.08 during 2011-12 and 2012-13 in Fe_0 i.e. 117.67 days. Interaction of zinc and iron did not affect the days to maturity during both year as well as pooled data. LAI was recorded that zinc (Zn) had significant effect on LAI at 60 DAS and table showed the treatment exhibited significant variation during 1st, 2nd year and pooled analysis. Maximum LAI (3.24, 3.22 and 3.23) was recorded in the treatment Zn_3 which found at par with Zn_2 i.e. 3.21, 3.20 and 3.21. In case of iron showed significant effect on LAI at 60 DAS and various level of iron (Fe) differed significantly with respect to Leaf Area Index at 60 DAS during 1st year, 2nd year and pooled analysis. The maximum LAI was found in treatment Fe_3 i.e. 3.17, 3.16 and 3.17 but at par to Fe_2 i.e. 3.15, 3.13 and 3.14 during 1st year, 2nd year and pooled analysis, respectively. Interaction effect of zinc (Zn) and iron (Fe) showed non-significant effect with respect to LAI at 60 DAS. This study was supported by **[14], [15]** in wheat. Result depicted on days to 50% heading of wheat as influenced by different level of zinc (Zn) and iron (Fe) and their interaction (Zn x Fe) indicates that dose Zn_2 (10 kg ha^{-1}) showed significant difference and taken less period for days to 50% heading as compared to dose Zn_1 (5kg ha^{-1}), Zn_0 (0 kg ha^{-1}) and Zn_3 (15 kg ha^{-1}) during I, II year and pooled data, receptively. The treatment Zn_2 took minimum number of days i.e. 73.25, 73.58 and 73.42 days for 50% heading while maximum number of days i.e. 75.00, 75.33 and 75.17 were recorded in Zn_3 during both years and in pooled analysis, respectively. But iron (Fe) did not show significant effect with respect to days to 50% heading during 2012-13. However, numerically lowest days to 50% heading (74.17 days) were recorded in treatment Fe_2 and highest was recorded in Fe_3 (74.67 days) in II year. that dose Fe_2 (5 kg ha^{-1}) showed significant difference and taken less period for days to 50% heading as compared to rest doses during 2011-12 and pooled analysis. In 2011-12 and pooled analysis the treatment Fe_2 took minimum number of days i.e. 73.83 and 74.00 for 50% heading while maximum number of days i.e. 74.42 and 74.54 were recorded in Fe_3 but Fe_2 was at par to Fe_1 i.e. 74.08 and 74.25 day while, all means showed at par performance to each other. The interaction of zinc and iron did not show significant effect with respect to days to 50% heading during both the years and pooled data.

EFFECT OF ZINC AND IRON LEVELS ON YIELD AND YIELD ATRIBUTING CHARECTORS

Effect of number of tillers m^{-2} during both years and pooled data Revealed that Zn_2 (314.33, 313.83 and 314.08) showed significantly higher number of tillers m^{-2} than Zn_1 and Zn_0 treatment, but at par to Zn_3 i.e. 311.67, 312.25 and 311.96 number of tillers m^{-2}. This data presented in **Table 2**. The iron (Fe) level showed significant effect on number of tillers m^{-2} consistently for both year and as well as for pooled data. During both year and pooled analysis the statistical analysis revealed that Fe_3 (311.25, 309.33 and 310.29) showed significantly higher number of tillers m^{-2} than Fe_1 and Fe_0 treatment but at par to Fe_2 (309.42, 308.50 and 308.96 number of tillers m^{-2}). Interaction effect of zinc (Zn) and iron (Fe) had showed significant effect in pooled data only. The combination of Zn_2 x Fe_2 (320.67) was significantly better and at par with Zn_2 x Fe_3 (320.17). **S**imilar type result observed **[16], [17]** in wheat. In case of zinc showed that the application of different level of zinc (Zn) was significantly influenced the number of spikelet's $spike^{-1}$ during both year and as well as pooled data. Significantly maximum number of spikelet's $spike^{-1}$ (18.30 and 18.13) was observed in Zn_2 treatment while minimum number of spikelet's $spike^{-1}$ (17.37 and 17.21) of wheat was found in control in 2011-12 and pooled. In case of iron Fe_2 (17.97) was maximum and exhibited significant better from the rest of iron (Fe) dose applied Interaction of zinc (Zn) and iron (Fe) did not show significant effect on number of spikelet's $spike^{-1}$ during both the year as well as pooled. The data pertaining to spike length of wheat as influenced by different levels of zinc (Zn) and iron (Fe) and their interaction (Zn x Fe) have been presented in **Table 2**. Different level of zinc had significant influence on spike length during both year as well as pooled analysis. Revealed that all the treatment differed significantly to each other except Zn_3 and Zn_2. Maximum i.e. 9.94, 9.95 and 9.94 cm spike length was noticed in the treatment Zn_3 which was at par to Zn_2 i.e. 9.92, 9.89 and 9.90 cm while minimum was produced by control i.e. 9.40, 9.34 and 9.37 cm during I year, II year and pooled data, respectively. Application of iron (Fe) significantly influenced the spike length in both year as well as pooled analysis. Maximum spike length (9.80, 9.79 and 9.80

Table-1: Effect of Zinc and Iron levels on growth parameters of wheat Variety Gangotri (K-9162).

Levels of Zinc & Iron (kg ha-1)	Growth parameters														
	Plant Height (cm)			Days to 50% Heading			Leaf Area Index 60 DAS			Seed Growth Duration (Days)			Days to Maturity		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
0.0 (Zn0)	76.72	77.46	77.09	74.42	74.67	74.54	2.91	2.90	2.90	35.92	36.67	36.29	116.92	117.83	117.38
5.0 (Zn1)	77.74	79.30	78.52	73.83	74.17	74.00	3.07	3.06	3.06	35.50	36.25	35.88	116.75	117.17	116.96
10.0 (Zn2)	81.72	82.30	82.01	73.25	73.58	73.42	3.21	3.20	3.21	34.75	35.75	35.25	116.33	116.58	116.46
15.0 (Zn3)	76.87	77.48	77.18	75.00	75.33	75.17	3.24	3.22	3.23	36.58	36.75	36.67	117.67	118.67	118.17
SE (d)	0.40	0.28	0.24	0.18	0.20	0.13	0.03	0.03	0.02	0.22	0.27	0.17	0.22	0.23	0.16
CD (p=0.05)	0.81	0.58	0.49	0.37	0.40	0.27	0.06	0.06	0.04	0.46	0.54	0.35	0.45	0.48	0.32
0.0 (Fe0)	77.08	77.88	77.48	74.17	74.50	74.33	3.03	3.01	3.02	35.75	36.58	36.17	116.92	117.67	117.29
2.5 (Fe1)	77.99	78.87	78.43	74.08	74.42	74.25	3.09	3.08	3.08	35.83	36.50	36.17	117.00	117.67	117.33
5.0 (Fe2)	79.15	79.97	79.56	73.83	74.17	74.00	3.15	3.13	3.14	35.42	36.00	35.71	116.67	117.33	117.00
7.5 (Fe3)	78.84	79.81	79.33	74.42	74.67	74.54	3.17	3.16	3.17	35.75	36.33	36.04	117.08	117.58	117.33
SE (d)	0.40	0.28	0.24	0.18	0.20	0.13	0.03	0.03	0.02	0.22	0.27	0.17	0.22	0.23	0.16
CD (p=0.05)	0.81	0.58	0.49	0.37	NS	0.27	0.06	0.06	0.04	NS	NS	0.35	NS	NS	0.32

NS- non-significant, **DAS**- days after sowing

Table-2: Effect of Zinc and Iron on yield and yield attributing characters of wheat Variety Gangotri (K-9162).

Levels of Zinc & Iron (kg ha-1)	Seed yield and yield attributing characters														
	No. of tillers m-2			No. of Spikelet's Spike-1			Spike length (cm)			Test weight (g)			Seed Yield (q ha-1)		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
0.0 (Zn0)	294.08	292.50	293.29	17.37	17.23	17.21	9.40	9.34	9.37	43.59	45.95	44.77	32.86	33.22	33.04
5.0 (Zn1)	302.75	300.67	301.71	17.57	17.57	17.57	9.64	9.62	9.63	44.41	46.41	45.41	35.39	35.77	35.58
10.0 (Zn2)	314.33	313.83	314.08	18.30	17.95	18.13	9.92	9.89	9.90	45.99	48.12	47.06	38.27	39.53	38.90
15.0 (Zn3)	311.67	312.25	311.96	17.80	17.52	17.66	9.94	9.95	9.94	46.09	47.99	47.01	37.95	38.51	38.23
SE (d)	1.91	1.58	1.24	0.22	0.27	0.12	0.02	0.06	0.03	0.35	0.54	0.32	0.46	0.44	0.35
CD (p=0.05)	3.90	3.23	2.48	0.45	0.56	0.24	0.04	0.12	0.06	0.72	1.11	0.65	0.93	0.91	0.71
0.0 (Fe0)	298.17	297.83	298.00	17.43	17.43	17.40	9.60	9.54	9.57	44.51	46.57	45.54	35.48	36.07	35.78
2.5 (Fe1)	304.00	303.58	303.79	17.73	17.35	17.42	9.70	9.70	9.70	44.93	46.97	45.95	36.08	36.71	36.40
5.0 (Fe2)	309.42	308.50	308.96	18.07	17.87	17.97	9.79	9.78	9.78	45.27	47.32	46.30	36.84	37.50	37.17
7.5 (Fe3)	311.25	309.33	310.29	17.80	17.62	17.71	9.80	9.79	9.80	45.31	47.60	46.46	36.86	37.50	37.18
SE (d)	1.91	1.58	1.24	0.22	0.27	0.13	0.02	0.06	0.03	0.35	0.54	0.32	0.46	0.44	0.35
CD (p=0.05)	3.90	3.23	2.48	NS	NS	0.24	0.04	0.12	0.06	NS	NS	0.65	0.93	0.91	0.71

NS- non-significant

cm) was recorded with the application of higher dose of iron (Fe_3) which did not differ to Fe_2 (9.79, 9.78 and 9.78 cm). The minimum spike length (9.60, 9.54 and 9.57 cm) of wheat was recorded in control plot. The interaction effect of zinc and iron had showed significant effect in 2011-12 only. The combination of Zn_2 x Fe_2 (10.04 cm) was significantly better and at par with Zn_2 x Fe_3 (9.99 cm) for spike length during I year. While interaction of Zn x Fe in II year and pooled data did not show significant effect on spike length. The data with respect to the effect of zinc (Zn) and iron (Fe) and their interactions (Zn x Fe) on 1000 seed weight have been illustrated in **Table 2**. The influence of various doses of zinc (Zn) was found significantly effective for increasing test weight during both years and in pooled. During 2012-13 and in pooled analysis Zn_2 showed significantly maximum (48.12 and 47.06 g) test weight of wheat but was at par to Zn_3 (47.99 and 47.01 g) and significantly lowest was found in control i.e. 45.95 and 44.77 g. While during I year Zn_3 (46.09 g) showed significantly maximum test weight of wheat seed but it was at par to Zn_2 (45.99 g) and significantly lowest test weight was found in control (43.59 g). Effect of Iron Fe_3 treatment showed maximum (46.46 g) test weight of wheat seed but was at par to Fe_2 (46.30 g) and Fe_1 (45.95 g) and significantly minimum was found in control (45.54 g) in pooled analysis. During I and II year iron (Fe) dose did not show significant effect on test weight of seed. The interaction of zinc and iron did not affect the test weight of seed during both year as well as pooled data. These results are in conformity with the findings of **[18], [19]** *and* **[20]** in wheat.

Table 3 : Interaction Effect of Zinc and Iron on plant height (cm) in Wheat Variety Gangotri.

Iron / Zinc	2011-12				2012-13				Pooled			
	Fe_0	**Fe_1**	**Fe_2**	**Fe_3**	**Fe_0**	**Fe_1**	**Fe_2**	**Fe_3**	**Fe_0**	**Fe_1**	**Fe_2**	**Fe_3**
Zn_0	75.16	76.31	77.55	77.85	75.67	76.93	78.41	78.82	75.42	76.62	77.98	78.34
Zn_1	76.99	77.68	78.08	78.19	77.88	79.26	79.95	80.13	77.44	78.47	79.02	79.16
Zn_2	80.05	81.29	83.35	82.20	80.74	81.75	83.65	83.06	80.40	81.52	83.50	82.63
Zn_3	76.10	76.66	77.62	77.11	77.23	77.53	77.89	77.26	76.66	77.10	77.76	77.19
SE (d)	**0.80**				**0.57**				**0.49**			
CD (p=0.05)	**NS**				**1.16**				**0.98**			

NS- non-significant

Table 4 : Interaction Effect of Zinc and Iron on Number of Tillers (m^{-2}) in Wheat Variety Gangotri (K-9162).

Iron / Zinc	2011-12				2012-13				Pooled			
	Fe_0	**Fe_1**	**Fe_2**	**Fe_3**	**Fe_0**	**Fe_1**	**Fe_2**	**Fe_3**	**Fe_0**	**Fe_1**	**Fe_2**	**Fe_3**
Zn_0	287.33	293.00	297.00	299.00	285.00	291.33	296.00	297.67	286.17	292.17	296.50	298.33
Zn_1	293.67	299.67	305.67	312.00	292.67	299.67	304.00	306.33	293.17	299.67	304.83	309.17
Zn_2	303.67	312.00	321.33	320.33	303.67	311.67	320.00	320.00	303.67	311.83	320.67	320.17
Zn_3	308.00	311.33	313.67	313.67	310.00	311.67	314.00	313.33	309.00	311.50	313.83	313.50
SE (d)	3.82				3.16				2.48			
CD (p=0.05)	**NS**				**NS**				**4.96**			

NS- non-significant

Table 5 : Interaction Effect of Zinc and Iron on Spike Length (cm) in Wheat Variety Gangotri (K-9162).

Iron / Zinc	2011-12				2012-13				Pooled			
	Fe_0	**Fe_1**	**Fe_2**	**Fe_3**	**Fe_0**	**Fe_1**	**Fe_2**	**Fe_3**	**Fe_0**	**Fe_1**	**Fe_2**	**Fe_3**
Zn_0	9.26	9.37	9.45	9.52	8.97	9.40	9.45	9.54	9.12	9.38	9.45	9.53
Zn_1	9.48	9.60	9.71	9.76	9.50	9.61	9.68	9.72	9.49	9.60	9.70	9.74
Zn_2	9.76	9.88	10.04	9.99	9.76	9.84	10.00	9.96	9.76	9.86	10.02	9.97
Zn_3	9.90	9.94	9.95	9.95	9.92	9.95	9.97	9.96	9.91	9.94	9.96	9.95
SE (d)	0.04				0.12				**0.06**			
CD (p=0.05)	0.07				**NS**				**NS**			

NS- non-significant

In case of seed yield (q ha^{-1}) of wheat as influenced by different level of zinc, iron and their interaction have been presented in **Table 2**. Application of zinc doses significantly influenced the seed yield (q ha^{-1}) of wheat during both year as well as pooled analysis. During I year and pooled analysis Zn_2 showed significantly maximum (38.27 and 38.90 q ha^{-1}) seed yield but at par to Zn_3 (37.95 and 38.23 q ha^{-1}). Whereas during II year Zn_2 showed significantly higher seed yield (39.53 q ha^{-1}) of wheat followed by Zn_3 (38.51 q ha^{-1}). During both year and pooled analysis minimum seed yield of wheat i.e. 32.86, 33.22 and 33.04 q ha^{-1} was obtained in control. Doses of applied iron exhibited significant impact on seed yield (q ha^{-1}) in I, II year and pooled analysis. It showed significantly maximum (36.84 q ha^{-1}) seed yield which was at par to Fe_3 (36.86 q ha^{-1}) and Fe_1 (36.08 q ha^{-1}) and minimum was found in control (35.48 q ha^{-1}) during I year analysis. During II year Fe_3 dose of iron showed maximum seed yield i.e. 37.50 q ha^{-1} which was at par to Fe_2 (37.50 q ha^{-1}) and Fe_1 (36.71 q ha^{-1}) treatments. Similarly during pooled analysis Fe_3 treatment of iron showed maximum seed yield i.e. 37.18 q ha^{-1} which was at par to Fe_2 i.e. 37.17 q ha^{-1} and significantly lower seed yield was found in control (Fe_0) and Fe_1 i.e. 35.78 and 36.40 q ha^{-1}, respectively. Effect of Interaction of zinc (Zn) and iron (Fe) did not show significant influence on seed yield (q ha^{-1}) however, numerically maximum seed yield viz. 39.02, 40.32 and 39.67 q ha^{-1} in Zn_2 x Fe_2 and minimum viz. 32.86, 33.22 and 33.04 q ha^{-1} in Zn_0 x Fe_0 during I year, II year and pooled analysis, respectively. Similar result was observed **[**16], [17] and [21].

CONCLUSION

Thus, it is concluded that application of 10 kg zinc and 5.0 kg iron ha^{-1} either singly or in combination of both have been found most appropriate and economical for achieving the maximum growth, seed yield and yield attributing characters of wheat cv. K-9162 (Gangotri).

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