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Effect of zinc fertilization on growth, yield and quality of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was carried out at Agronomy Instructional Farm, C.P. College of Agriculture, S.D.A.U., Sardarkrushinagar, Gujarat during the *rabi* season of the year 2018-19 to study the effect of zinc fertilization on growth, yield, and quality of wheat (*Triticum aestivum* L.). Ten treatments *viz.*, T_1: RDF, T_2: RDF + 10 kg $ZnSO_4$/ha (Soil application), T_3: RDF + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages), T_4: RDF + Seed priming (1% Zn solution), T_5: RDF + Seed priming (2% Zn solution), T_6:T_2+ Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages), T_7: T_2 + Seed priming (1% Zn solution), T_8: T_2+ Seed priming (2% Zn solution), T_9: T_2+ Foliar Spray of $ZnSO_4$@ 0.5% (at flowering & milking stages) + Seed priming (1% Zn solution) and T_{10}: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) were tried in RBD with four replications. Results inferred that wheat GW 451 when fertilized with T_{10} showed a positive effect on the growth and yield attributes and resulted in maximum yield and higher monetary returns.

Keywords: Growth, wheat, quality, yield, zinc

Introduction
Wheat (*Triticum aestivum* L.) is the most important cereal crop for the majority of the world's population as a staple food, contributing about two billion people (36% of the world population). It is recognized as the "king of cereal or stuff of life". Cereal crops are certainly grasses, a composite term which refers to monocot plant under the family Poaceae or Gramineae. It is the third most-produced cereal after maize and rice. The optimum temperature for wheat growth is 25 ºC with minimum and maximum growth temperatures of 3 ºC to 4 ºC and 30 ºC to 32 ºC, respectively.

India ranks second amongst the wheat-growing countries of the world after China in terms of area and production. Wheat is grown in all the states in India including Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan, and Bihar which are the major wheat-producing states and accounts for almost 91% of total production in India.

The area, production, and productivity of wheat of the Gujarat state during 2016-17 was 9.96 lakh ha, 29.38 lakh tonnes, and 29.50 q/ha, respectively. Wheat grains are a comparatively superior source of protein consumed in India. About 10-12% protein requirement is met by wheat. The application of different fertilizers could increase the productivity of the wheat crop and the protein content. In Gujarat, comparatively lower productivity is present due to several constraints like lack of irrigation facilities, imbalanced use of fertilizer, and lack of knowledge of modern agro techniques such as suitable genotypes, proper sowing times, seed rate, spacing, weed control, fertilization, plant protection measures etc.

Micronutrients are important for plant nutrition and a deficiency of just one nutrient can greatly reduce the yield. The available Zn in Gujarat soils ranges between 0.04 to 72.1 mg/kg. Nearly half of the Indian soils and 24% of soils of Gujarat state are Zn deficient and around 58% soils of North Gujarat are found deficient to medium in available Zn status (Dangarwala, 1994) [3]. Zn deficiency in agricultural soils affect both the yield and quality of crops. Though cereal crops play an important role in satisfying the daily calorie intake in the developing world, they are inherently very low in zinc concentration in grain, particularly when grown under Zn deficient soils (Cakmak, 2008) [2].

Zinc is essential for the formation of chlorophyll and growth hormones such as Indole Acetic Acid (IAA). It is involved in many enzymatic activities and is essential for the normal healthy growth and reproduction of plants, animals, and humans. When the supply of plant-available zinc is inadequate, crop yields are decreased and the quality of crop products is frequently diminished. In plants, zinc plays a key role as a structural constituent or regulatory co-factor of different enzymes and proteins in many important biochemical pathways and these are mainly concerned with carbohydrate metabolism, photosynthesis, in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, formation, maintenance of the integrity of biological membranes and resistance to infection by certain pathogens.

Severe zinc deficiency in the soil may cause yield losses of up to 30% in cereal crops. Zinc deficient plants show a marked reduction in plant height and develop whitish-brown patches, which turn necrotic with the increasing severity of deficiency. Wheat crops on zinc deficiency show dusty brown spots on upper leaves of stunted plants, shoots growth is more inhibited than root growth, tillering decreases, spikelet sterility increases, midrib becomes chlorotic particularly near the leaf base of younger leaves, leaves lose turgidity and turn brown as brown blotches and streaks appear on the lower leaves. Symptoms may be more pronounced during the early growth stages due to zinc immobilization. Zinc as fertilizer can significantly enhance the quality and yield of crops and Zinc sulfate is the most common source of Zn used in the crop production.

Material and Methods

The experiment was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat during the rabi season of the year 2018-19. The soil of the experimental field was loamy sand in texture, low in organic carbon (0.21%) and available nitrogen (164.9 kg/ha), medium in available phosphorus (41.05 kg/ha), and available potash (264.61 kg/ha) with soil pH of 7.56. Various growth and yield attributing characters of wheat such as plant population, plant height, number of effective tillers/m row length, length of ear head, number of grains/ear head, 1000 grain weight, grain yield, and straw yield were estimated under different treatment of zinc fertilization.

Wheat variety GW 451 was sown with seed rate @ 120 kg/ha and with inter-row spacing of 22.5 cm, after the seed treatment with Fipronil 5 S.C/6 ml/kg seed. The seeds were uniformly sown manually 4 – 4.5 cm deep in a previously opened furrow.

The required quantity of well-decomposed FYM was broadcasted in each plot individually as common treatments and incorporated into the soil in respective plots before sowing. The entire quantity of phosphorus and half dose of N in form of DAP and urea, respectively, were manually applied before sowing of the wheat crop in the furrows as per the treatments. The remaining half dose of N as per the treatments was applied in the form of urea in two equal splits (25% at CRI and 25% at flag leaf stage), after the1st and the 4th irrigation to each plot. The zinc was applied in the form of zinc sulfate (21% Zn), as basal application, as per the treatments and the recommended practices of the region were followed for raising the crop. The observations recorded for the growth, yield attributes, and quality parameters were put to the statistical analysis in accordance with the analysis of variation method as suggested by Fisher (1950) for randomized complete block design (RCBD).

Results and Discussion

Effect on growth attributes

A perusal of data presented in Table 1, indicated that plant population per meter row length at 21 DAS (Days after sowing) of wheat did not affect significantly due to different treatments. The results indicated that plant population per meter row length was uniform.

Plant height at 30, 60, 90 DAS and at harvest were significantly higher (31.98, 70.31, 85.86 and 88.22 cm) under treatment T_{10}: RDF + 10 kg $ZnSO_4$/ha (Soil application) + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) except at 30 DAS. While lowest plant height at 30, 60, 90 DAS and at harvest was recorded as 30.29, 59.00, 73.25, and 73.70 cm under treatment T_1 (RDF), respectively.

This might be due to an improvement in the availability of major nutrients by Zn and thereby the increased metabolic and enzymatic activities would have increased the cell division and cell elongation resulting in the increasing plant height. These findings were in close vicinity with the findings of Yang *et al.*, Keram *et al.*, Mauriya *et al.*, Yadav *et al.*, Arif *et al.*, Kandoliya *et al.* and Vora *et al.*

Table 1: Effect of zinc fertilization on plant population per meter row length at 21 DAS, Plant population per meter row length, and Plant height (cm) at the harvest of wheat

Treatments	Plant population Per meter row length 21 DAS	Plant population per meter row length at harvest	Plant height (cm) at harvest	Days to physiological maturity
T_1: RDF (120:60:00 kg NPK/ha)	52.05	50.45	73.70	104
T_2: RDF + 10 kg $ZnSO_4$/ha (Soil application)	52.50	51.00	81.52	103
T_3: RDF + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages)	53.05	51.10	75.95	103
T_4: RDF + Seed priming (1% Zn solution)	52.30	50.85	76.98	103
T_5: RDF + Seed priming (2% Zn solution)	52.65	50.95	78.37	102
T_6: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages)	53.65	52.20	82.78	102
T_7: T_2 + Seed priming (1% Zn solution)	53.30	51.90	83.83	102
T_8: T_2 + Seed priming (2% Zn solution)	53.60	51.90	84.79	103
T_9: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (1% Zn solution)	54.85	52.35	87.26	102
T_{10}: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution)	54. 90	52.60	88.22	100
S.Em±	0.67	0.58	3.11	0.85
CD *(P = 0.05)*	NS	NS	9.02	NS
CV (%)	2.53	2.25	7.65	1.66

Effect on yield attributes and yield

A perusal of data presented in Table 2, indicated that the maximum value of 1000 grain weight (42.45 g) was noted in the treatment receiving RDF + 10 kg ZnSO4/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) (T_{10}) but found at par with T_2, T_5, T_6, T_7, T_8, and T_9 treatments. The 1000 grains weight noted with the treatment T_{10} (42.45g) was 18.27% higher as compared to treatment T_1 (35.89 g). The minimum value of 1000 grain weight (35.89 g) was recorded under treatment receiving (T_1).

Such effects of Zn application might be due to the pivotal role of Zn in crop growth, including the photosynthesis processes, respiration, and nitrogen metabolism-protein synthesis. It also plays an important key role in the biosynthesis of IAA, regulating the auxin concentration in plant and other biochemical and physiological activities, initiation of primordia for reproductive parts. These results were in line with those reported by Jat *et al.*, Zeidan *et al.*, Yadav *et al.*, Mauriya *et al.*, Keram *et al.* [8] and Arif *et al.*

Table 2: Effect of zinc fertilization on 1000 grain weight, grain yield, straw yield and harvest index of wheat

Treatments	1000 grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T_1: RDF (120:60:00 kg NPK/ha)	35.89	3558	4550	43.91
T_2: RDF + 10 kg $ZnSO_4$/ha (Soil application)	39.82	4164	4650	44.02
T_3: RDF + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages)	37.79	3653	4907	43.99
T_4: RDF + Seed priming (1% Zn solution)	38.47	3850	5031	43.94
T_5: RDF + Seed priming (2% Zn solution)	39.50	3953	5303	44.03
T_6: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages)	39.94	4319	5467	44.02
T_7: T_2 + Seed priming (1% Zn solution)	40.78	4409	5608	44.04
T_8: T_2 + Seed priming (2% Zn solution)	41.72	4485	5709	44.02
T_9: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (1% Zn solution)	42.18	4641	5897	44.00
T_{10}: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution)	42.45	4795	6093	44.05
S.Em±	1.31	250.97	309.92	0.49
CD *(P = 0.05)*	3.79	728.26	899.32	NS
CV (%)	6.56	12.00	11.65	2.22

The data on grain yield (kg/ha) as influenced by different treatments are presented in table 2 and it was observed that among the different tested treatments, an application of RDF along with 10 kg $ZnSO_4$/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) (T_{10}) produced significantly higher grain yield (4795 kg) as compared to other treatments and was at par with T_9, T_8, T_7, T_6, and T_2. There was 34.76% increment in grain yield under T_{10} as compared to T_1 treatment. The minimum grain yield of 3558 kg was obtained under treatment T_1.

Increased grain yield due to treatment T_{10} might be because of the abundant supply of Zn nutrition and balanced N, P and K, which increased the photosynthesis processes, respiration, nitrogen metabolismprotein synthesis, and other biochemical and physiological activities. This in turn increased the values of all growth and yield attributing parameters, which was finally reflected in the increased grain yield. These results were in complete agreement with those of Nawab *et al.*, Kulhare *et al.*, Mauriya *et al.*, Arif *et al.*, Firdous *et al.*, and Jat *et al.*,

The straw yield was significantly affected by different Zn fertilization treatments. Among different treatments tested, an application of RDF along with 10 kg $ZnSO_4$/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) (T_{10}) produced a significantly higher straw yield (6093 kg) as compared to other treatments, but it was at par with T_9, T_8, T_7, T_6, and T_5. The minimum straw yield of 4550 kg was obtained under treatment T_1.

Increased straw yield due to treatment RDF + 10 kg $ZnSO_4$/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering and milking stages) + Seed priming (2% Zn solution) (T_{10}) might be due to abundant supply of Zn nutrition and balanced NPK, waUUhich increased the photosynthesis processes, respiration, nitrogen metabolism-protein synthesis, and other biochemical and physiological activities. This in turn increased the values of all growth and yield attributing parameters, which finally reflected in the increased straw yield. These findings were in accordance with the reports of Nawab *et al.*, Kulhare *et al.*, Mauriya *et al.*, Arif *et al.*, Firdous *et al.* and Jat *et al.*

A perusal of data presented in Table 2 indicated that the harvest index of wheat did not surpass the level of significance due to different treatments. Though the highest harvest index (44.05%) was recorded with the application of RDF + 10 kg $ZnSO_4$/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) in T_{10} treatment followed by T_7 (44.04%), the lowest harvest index (43.91%) was obtained under treatment T_1.

Effect on quality parameters

The data of the protein content in grains as influenced by different treatments were significant and are presented in Table 3. The highest percentage of protein content in grain (11.61%) was recorded under treatment receiving T_{10}: RDF along with 10 kg $ZnSO_4$/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) which was at par with T_6, T_7, T_8 and T_9 treatments. The lowest percentage of protein content in grain (10.57%) was recorded under control (T_1). Such effects of Zn application on protein content in grain might be due to the fact that Zn increased the N-metabolism, which enhanced the accumulation of amino acids and drastically increased the rate of protein synthesis and consequently, the grain protein content. The more or less similar results were also found by Zeidan *et al.*, Keram *et al.* [8] and Jat *et al.* The data on protein yield (kg/ha) as affected by different treatments were significant and are presented in Table 3. The highest value of protein yield (560.55 kg/ha) was recorded under the application of RDF along with 10 kg $ZnSO_4$/ha + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) (T_{10}) which was at par with T_6, T_7, T_8 and T_9 treatments. The lowest value of protein yield in seed (376.58 kg/ha) was recorded under control (T_1). On the basis of experimental outcomes, it can be inferred that wheat GW 451 fertilized with RDF + 10 kg $ZnSO_4$/ha (Soil application) + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution) showed a positive effect on growth and yield attributes and resulted in the maximum yield.

Table 3: Effect of zinc fertilization on protein content and protein yield of wheat grain

Treatments	Protein content (%)	Protein yield (kg/ha)
T_1: RDF (120:60:00 kg NPK/ha)	10.57	376.58
T_2: RDF + 10 kg $ZnSO_4$/ha (Soil application)	10.72	448.15
T_3: RDF + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages)	10.79	394.93
T_4: RDF + Seed priming (1% Zn solution)	10.90	420.01
T_5: RDF + Seed priming (2% Zn solution)	11.01	436.03
T_6: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages)	11.23	491.44
T_7: T_2 + Seed priming (1% Zn solution)	11.38	501.64
T_8: T_2 + Seed priming (2% Zn solution)	11.46	515.14
T_9: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (1% Zn solution)	11.50	535.80
T_{10}: T_2 + Foliar Spray of $ZnSO_4$ @ 0.5% (at flowering & milking stages) + Seed priming (2% Zn solution)	11.61	560.55
S.Em±	0.24	37.82
CD (P = 0.05)	0.69	109.74
CV (%)	4.30	16.16

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