

## Productivity of wheat (*Triticum aestivum*) as influenced by zinc fertilization under semi-arid conditions of Kandahar, Afghanistan

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### ABSTRACT

A field experiment was conducted during winter (*rabi*) season of 2019–20, at research farm of the Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan, in randomized complete-block design to find out the effect of zinc on growth, yield and yield-attributing characters of wheat (*Triticum aestivum* L.). Results revealed that, plant height (100.3 cm), number of tillers/m<sup>2</sup> [346 at 60 days after sowing (DAS) and 576 at 90 DAS], leaf-area index (1.98), dry-matter production (291 g/m<sup>2</sup>), number of spikes/m<sup>2</sup> (319), spikelets/spike (20.7), grains/spike (51.1) and 1,000-grain weight (52.2 g) obtained with the application of 2.5 kg Zn/ha as basal + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub>, were significantly higher over rest of the treatments. Grain yield (4.09 tonnes/ha), straw yield (6.39 tonne/ha), biological yields (10.2 tonne/ha) and harvest index (40%) too were recorded higher under the application of 2.5 kg Zn/ha as basal + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub>. Gross returns (147.23 × 10<sup>3</sup> ₹/ha), net returns (103.39 × 10<sup>3</sup> ₹/ha) and benefit: cost ratios (3.19) were also higher with the application of 2.5 kg Zn/ha as basal + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub>. Overall, the soil application of 2.5 kg Zn/ha as basal through ZnSO<sub>4</sub> + 2 foliar sprays of ZnSO<sub>4</sub> @ 0.5% was best in terms of growth, yield and profitability of wheat.

**Key words:** Foliar spray, Wheat, Zinc fertilization, ZnSO<sub>4</sub> and ZnO

Wheat (*Triticum aestivum* L.) being the most important foodgrain in Afghanistan; is grown in about 2.5 million ha in the country. Approximately 80% of the total cultivated area under all cereals is dominated by wheat. The total wheat production in 2017 was recorded 4.3 million tonnes, which accounts for 79% of all cereals produced in Afghanistan (FAO, 2018). The production of wheat is mainly limited by nutrient disorders in the soil. Among which micronutrient deficiencies have become a common problem in agriculture in Afghanistan soil. Specifically, Zn deficiency is considered to be one of the major micronutrient problems in field crops and is responsible for limiting the crop yield and quality, particularly in cereal crops which are cultivated mainly in arid and semi-arid regions. The

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deficiency of zinc appears more in calcareous soils than in neutral or acidic soils. Currently, in Afghanistan, very little research is done on zinc (Zn) application in field crops. Therefore, the farmers in Afghanistan do not have much awareness about the method and application of zinc fertilizer for improving the crop quality and productivity. In view of the above factors, a study was conducted to evaluate the effects of zinc on the growth and yield of wheat at Kandahar, Afghanistan.

A field experiment was conducted during the winter (*rabi*) season of 2019–20 at research farm of the Afghanistan National Agricultural Sciences and Technology University (ANASTU) in Kandahar of Afghanistan (31° 27' 58" N, and 65° 51' 58" E, 985 m above the sea-level). The climate of Kandahar is tropical to subtropical. The coldest months are December, January and February and the hottest are June, July and August. The average annual rainfall is 277 mm. Soil (0–15 cm depth) of the experimental site was sandy clay loam in texture (sand 75.2%, silt 13.5% and clay 11.3%) with slightly alkaline, having pH of 7.15, cation-exchange capacity of 80.6 meq/100 g and electrical conductivity (ECe) of 2.29 ds/m. The available N, P and K contents were 125, 7.9 and 159 kg/ha respectively.

The experiment consisted of 8 treatments: T<sub>1</sub>, control; T<sub>2</sub>, 5.0 kg Zn/ha as basal through ZnSO<sub>4</sub>·7 H<sub>2</sub>O (21% Zn); T<sub>3</sub>, 5.0 kg Zn/ha as basal through ZnO (80% Zn); T<sub>4</sub>, 2.5 kg Zn/ha through ZnSO<sub>4</sub>·7 H<sub>2</sub>O (21% Zn) + 2.5 kg Zn/ha through ZnO (80% Zn); T<sub>5</sub>, 2 foliar sprays of 0.5% ZnSO<sub>4</sub>·7 H<sub>2</sub>O at maximum tillering and flowering stage, T<sub>6</sub>; 2 foliar sprays of 0.2% Zn through ZnO at maximum tillering and flowering stage; T<sub>7</sub>, 2.5 kg Zn/ha as basal through ZnSO<sub>4</sub>·7 H<sub>2</sub>O + 2 foliar sprays of 0.5% ZnSO<sub>4</sub>·7 H<sub>2</sub>O at maximum tillering and flowering; T<sub>8</sub>, 2.5 kg Zn/ha as basal through ZnO (80% Zn) + 2 foliar sprays of 0.2% ZnO at maximum tillering and flowering were laid out in a randomized complete-block design, replicated thrice. The seed of variety 'Chonte # 1' was used @ 100 kg/ha. Other agronomic practices were followed as per recommendations. Growth parameters, yield attributes and yields were recorded using standard procedure. The data recorded at different growth stages and on yield attributes and the gross and net returns were analysed statistically by using analysis of variance (ANOVA) and treatment means were compared using least significance difference at 5% level of significance.

Application of 2.5 kg Zn/ha as basal + 2 foliar sprays @ 0.5% Zn through ZnSO<sub>4</sub>; (T<sub>7</sub>), resulted in the maximum plant height of 10.6 cm, 15.0 cm, 52.7 cm and 100.0 cm at 30, 60, 90 DAS and at harvesting, respectively. It was at par with treatment T<sub>2</sub> and significantly better than all the other treatments. The minimum plant height of 6.46 cm, 10.7 cm, 36.6 cm and 78.8 cm was recorded at 30, 60, 90

DAS and at harvesting respectively, from the control (Table 1). Our results confirm the findings of Kumar *et al.*, (2020). The leaf-area increased with age up to 90 DAS. The maximum leaf-area index of 1.98 at 90 DAS was recorded under soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> (T<sub>7</sub>), being statistically at par with soil application of 5 kg Zn/ha through ZnSO<sub>4</sub> (1.75) (T<sub>2</sub>) but significantly better than all the other treatments. The minimum leaf area index at all stages of growth was recorded in control plots. These results support the findings of Ghasal *et al.*, (2017), who also reported maximum growth of wheat particularly in terms of leaf-area index with application of Zn at 1.25 kg/ha through (Zn- Diethylene-triamine-penta-acetate) + 0.5% foliar spray at maximum tillering and booting stages. The higher dry-matter was produced due to the application of 2.5 kg Zn/ha + 2 foliar spray @ 0.5% through ZnSO<sub>4</sub>, followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub> and soil application of 2.5 kg Zn/ha through ZnSO<sub>4</sub> + 2.5 kg Zn/ha through ZnO at 30, 60, 90 DAS and harvesting stage. Maximum total number of tillers/m<sup>2</sup> was recorded with soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> at 60 DAS and 90 DAS, followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub> respectively (Table 2). Our findings supported the results of Shivay *et al.*, (2008). They have reported that, application of Zn fertilizer significantly and positively influenced number of tillers/m<sup>2</sup> in wheat. Maximum number of spike/m<sup>2</sup> was recorded with the application of 2.5 kg Zn/ha as basal + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub>, fol-

**Table 1.** Effects of soil and foliar application of ZnSO<sub>4</sub> and ZnO on growth parameters of wheat

Treatment	Plant height (cm)				Leaf-area index			Dry-matter accumulation (g/plant)		
	30 DAS	60 DAS	90 DAS	Harvesting	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T <sub>1</sub> Control	6.46	10.7	36.6	78.8	0.04	0.19	0.95	2.66	12.6	138.8
T <sub>2</sub> 5 kg Zn/ha through ZnSO <sub>4</sub> ·7H <sub>2</sub> O	9.88	14.7	52.1	98.3	0.06	0.37	1.75	4.35	21.1	265.9
T <sub>3</sub> 5 kg Zn /ha through ZnO	7.83	12.8	45.3	88.0	0.04	0.24	1.30	3.42	16.3	183.3
T <sub>4</sub> 2.5 kg Zn/ha through ZnSO <sub>4</sub> ·7H <sub>2</sub> O + 2.5 kg Zn/ha through ZnO	8.69	13.1	46.4	89.3	0.05	0.28	1.46	3.96	18.8	234.6
T <sub>5</sub> 2 foliar spray @ 0.5% Zn through ZnSO <sub>4</sub> ·7H <sub>2</sub> O at MT and flowering	8.11	12.1	44.1	88.0	0.05	0.24	1.27	3.34	14.0	191.3
T <sub>6</sub> 2 foliar spray @ 0.2% Zn through ZnO at MT and flowering	8.25	12.8	45.5	88.8	0.04	0.25	1.37	3.49	16.7	205.0
T <sub>7</sub> 2.5 kg Zn /ha through ZnSO <sub>4</sub> ·7H <sub>2</sub> O + 2 foliar sprays of 0.5% (source) at MT and flowering	10.6	15.0	52.7	100	0.07	0.39	1.98	4.90	23.6	290.7
T <sub>8</sub> 2.5 kg Zn /ha through ZnO + 2 foliar sprays of 0.5% (source) at MT and flowering	7.53	12.3	43.7	87.7	0.04	0.22	1.20	3.08	14.8	166.0
SEm±	0.36	0.40	1.20	1.00	0.003	0.022	0.141	0.174	1.91	16.64
CD (P=0.05)	0.78	0.86	2.57	2.13	0.007	0.048	0.302	0.373	4.10	35.70

DAS, Days after sowing; MT, maximum tillering

lowed by soil application of 5 kg Zn/ha through ZnSO<sub>4</sub> and the 5 kg Zn/ha of 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> at maximum tillering and flowering stage. Our results support the findings of Shahane *et al.*, (2017). The soil application of 2.5 kg Zn/ha as basal + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> (T<sub>7</sub>) resulted in maximum number of spikelets/spike, confirming the findings of Zain *et al.*, (2015) and Esfandiari *et al.*, (2016). The maximum grains/spike were recorded with the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> (T<sub>7</sub>), followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub> (T<sub>2</sub>). Both being at par with each other produced significantly a greater number of spikelets/spike than rest of the treatments. This could be owing to application of Zn at optimum levels which might have stimulated crop growth, thereby increasing the length of the spike and hence a greater number of grains/spikes was observed in the respective plots. The higher 1,000-grain weight was recorded significantly with the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through

ZnSO<sub>4</sub>, followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub>, soil application of 2.5 kg Zn/ha through ZnSO<sub>4</sub> + 2.5 kg Zn/ha through ZnO and 2 foliar sprays @ 0.2% through ZnO at maximum tillering and flowering stages. Similar findings were reported by Firdous *et al.*, (2018).

Higher grain yield was obtained with the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> (Table 2). This significant increase in grain yield may be owing to the higher yield-attributing parameters like productive tillers spikes/m<sup>2</sup>, number of grains/spike and 1,000-grain weight. These findings support the results of Firdous *et al.*, (2018). Kumar *et al.*, (2020) who reported that, the soil fertilized with Zn alone and with foliar applied zinc @ 0.5% through ZnSO<sub>4</sub> at different stages of crop growth significantly and positively affected the grain and straw yields of wheat. The maximum straw yield was recorded with the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> (T<sub>7</sub>), followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub> (T<sub>2</sub>) and soil application of

**Table 2.** Effects of soil and foliar application of ZnSO<sub>4</sub> and ZnO on yield attributes, yields and economics of wheat

Treatment	Spikes/ m <sup>2</sup>	Spikelets/ spike	Grains/ spike	1,000- grain weight (g)	Grain yield (tonnes/ ha)	Straw yield (tonnes/ ha)	Biological yield (tonnes/ ha)	Harvest index (%)	Cost of cultivation (×10 <sup>3</sup> ₹/ha)	Net returns (×10 <sup>3</sup> ₹/ha)	Benefit: cost ratio
T <sub>1</sub> , Control	212.7	15.6	32.0	35.1	2.76	4.98	7.82	35	0.38	0.86	2.25
T <sub>2</sub> , 5 kg Zn/ha through ZnSO <sub>4</sub> .7 H <sub>2</sub> O	305.9	20.0	45.1	51.6	3.79	6.07	10.04	38	0.41	1.25	3.08
T <sub>3</sub> , 5 kg Zn/ha through ZnO	253.7	18.0	37.6	45.2	3.57	5.5	9.12	39	0.49	1.07	2.20
T <sub>4</sub> , 2.5 kg Zn/ha through ZnSO <sub>4</sub> .7 H <sub>2</sub> O + 2.5 kg Zn/ha through ZnO	263.0	18.3	39.9	47.0	3.77	5.88	9.7	39	0.45	1.20	2.69
T <sub>5</sub> , 2 foliar sprays @ 0.5% Zn through ZnSO <sub>4</sub> . 7H <sub>2</sub> O at MT and flowering	270.7	17.7	36.7	43.6	3.66	5.67	9.33	39	0.41	1.18	2.88
T <sub>6</sub> , 2 foliar sprays @ 0.2% Zn through ZnO at MT and flowering	258.0	18.3	38.0	46.2	3.31	5.15	8.4	39	0.43	1.01	2.36
T <sub>7</sub> , 2.5 kg Zn/ha through ZnSO <sub>4</sub> .7 H <sub>2</sub> O + 2 foliar sprays of 0.5% at MT and flowering	319.4	20.7	51.1	52.2	4.09	6.39	10.16	40	0.43	1.36	3.19
T <sub>8</sub> , 2.5 kg Zn /ha through ZnO + 2 foliar sprays of 0.5% at MT and flowering	248.0	17.7	36.9	41.8	3.43	5.36	8.83	39	0.45	1.04	2.30
SEm±	8.7	0.5	2.2	2.0	0.21	0.14	0.25	0.02	-	0.07	0.18
CD (P=0.05)	18.7	1.0	4.7	4.3	0.46	0.30	0.54	NS	-	0.16	0.39

DAS, Days after sowing; MT, maximum tillering

2.5 kg Zn/ha @ ZnSO<sub>4</sub> + 2.5 kg Zn/ha @ ZnO (T<sub>4</sub>). Firdous *et al.*, (2018) also reported that, the straw yield increased significantly owing to the application of 5 kg Zn/ha in soil + 2 foliar sprays. The higher harvest index was recorded in the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> and this treatment was at par with the other treatments. The findings are in line with Zain *et al.*, (2015).

Cost of cultivation of wheat under the treatment of soil application of 5 kg Zn/ha @ ZnO followed by soil application of 2.5 kg Zn/ha through ZnO + 2 foliar sprays @ 0.2% through ZnO (Table 2). Increasing Zn application rate reflected proportionally in the higher cost of production. In the current study, significantly higher gross returns of wheat were registered with soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub> as compared to other treatments. Our findings support the results of Ghasal *et al.*, (2017), Shahane *et al.*, (2017) and Zulfiqar *et al.*, (2020). The higher gross return was mainly owing to higher grain and straw yields of wheat in the respective treatments. Higher net returns were obtained from the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub>, followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub>, followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub>. Shahane *et al.*, (2017) and Rehman *et al.*, (2018) also reported such findings. Higher benefit: cost ratio was registered with the soil application of 2.5 kg Zn/ha + 2 foliar spray @ 0.5% through ZnSO<sub>4</sub> (3.19), followed by soil application of 5 kg Zn/ha @ ZnSO<sub>4</sub> (3.08). However, the significantly lower benefit: cost ratio was recorded under soil application of 5 kg Zn/ha @ ZnO (2.2) and the control (2.25). Shahane *et al.*, (2017) and Ghasal *et al.*, (2017) also reported similar results.

It may be concluded that, the soil application of 2.5 kg Zn/ha + 2 foliar sprays @ 0.5% through ZnSO<sub>4</sub> at maximum tillering and flowering stage resulted higher growth,

yield attributes, yields and net returns of wheat in Kandahar region of Afghanistan.

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