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EFFECT OF ZINC SULPHATE APPLICATION ON QUALITY AND YIELD OF POTATO (SOLANUM TUBEROSUM L.)

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ABSTRACT

A field experiment was conducted entitled "Effect of zinc on growth, yield attributes and yield of potato (*Solanum tuberosum* L.)" during the winter season 2021-22 at main experiment station, Department of vegetable science of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). The experiment was carried out in randomized block design with four replications and six treatments. The maximum starch content of potato tuber (16.91 %) was recorded under treatment T4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting) which was at par with the treatment T3 (RDF + Zinc sulphate @ 25 kg/ha at the time of planting) and T6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting). The total number of A, B, C, and D grade tubers of potato hill^{-1} was significantly increases with zinc application. Number of A grade tuber hill^{-1} (2.40) was recorded highest under treatment T4 (RDF+ Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with T6 (+ Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) and superior over rest of the treatments. The minimum value (1.60 hill^{-1}) was recorded under T1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O).
***Keywords* :** Potato, foliar application, Zinc sulphate, Haulm, Tuber

Introduction

Potato (*Solanum tuberosum* L.) is one of the important food and tuber crop of world as well as of India. It is grown in more than 120 countries and consumed almost every day by more than a billion people. Potato cultivation is expanding rapidly in the developing countries because of its nutritional and economical values. About 50% of the potato produced in the world is utilized as a human food (Shekhawat, 2001). It is used as a staple diet in many ways in the countries especially in the west. Developing countries are now the world's biggest importers of potato products (Lutaladio *et al.*, 2009). It was originated in Andean hills of Bolivia and Peru in South America. The potato is first mentioned in Terry's account of a banquet at Ajmer hosted by Asaph khan, the mughal king, to Sir Thomas Roc in 1615 AD., in which potato was served as a cooked vegetable. It is believed that potato was introduced by Portuguese in 17th century in India. Potato became so widely distributed in Europe that it is often called the "Irish or European potato". It is also a very popular staple food crop of world. Zinc deficiency is extensively reported on major soil types in India. The common basis for determination of Zn deficiency is soil and plant testing. The deficiency ranged between 60-70% in the states of Haryana, Madhya Pradesh and Uttar Pradesh; 50-59% in Andhra Pradesh and Punjab; 30-49% in Kerala, Bihar and Tamil Nadu; 20-29% in Delhi, Gujarat, Karnataka and Rajasthan, and less than 20% in Jammu and Kashmir and Pondicherry. The solubility of zinc in soils and its uptake by plants falls rapidly as the soil pH increases. Sometimes. Zinc may be present in the soil, but not available to the plants due to high pH and high reactivity with clay. Consequently, crops under such soil conditions with other nutrients such as zinc could result in negative impact to potato or rotational crops. Foliar spray of microelements is very helpful when the roots cannot provides all the necessary nutrients (Kinaci and Gulmezoglu, 2007; Babaecian *et al.*, 2011). Moreover, soil application of micronutrients increases soil pollution. Crop roots are unable to absorb some important nutrients such as zinc, because of soil properties, such as high pH, lime or heavy texture, thus, in this situation, foliar spray is better as compared to soil application (Kinaci and Gulmezoglu, 2007).

Materials and Methods

The experiment entitled "Effect of zinc on growth, yield attributes and yield of potato (*Solanum tuberosum* L.)" was conducted during winter season of 2021-22. The field experiment was laid out at Main Experiment Station, Department of Vegetable Science of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) situated in the semi-arid region. The experimental soil was silty loam in texture with slightly alkaline (pH 8.0), low in organic carbon and nitrogen, medium in phosphorous. Field experiment was laid out in randomised block design with four replication and six treatments *viz.,* T_1(RDF of NPK), T_2 (T_1+ Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting), T_3(T_1+ Zinc sulphate @ 25 kg/ha at the time of planting), T_4(T_1+ Zinc sulphate @ 30kg/ha at the time of planting), T_5(T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 days after planting), T_6(T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting). The recommended dose of fertilisers *i.e.* 150:100:120 kg N, P_2O_5, K_2O/ha, respectively were applied according to the treatments. Full dose of phosphorus and potassium was applied at the time of planting with half dose of nitrogen at the time of planting and remaining at 30 days after planting i.e. during earthing-up. Potato crop was fertilised with zinc sulphate according to different treatments of experiments.

Well sprouted, disease free, medium sized tubers (2.5-4.0 cm diameter) having 30-50 gram weight, whole tubers were selected. Planting was done in well prepared plots on 14th November through ridge method with the spacing of 45cm x 15cm apart during 2021-22, respectively. The data was subjected to analysis of varience (ANOVA) through computer by using OPSTAT, designed and developed by Computer section, CCS HAU, Hisar.

I. Dry matter content in tuber (%):

The dry matter content in tubers was determined on the fresh weight basis. Five samples of 100 g tubers from each treatment were taken, cut into small pieces and dried in oven at 60±2°C for 8-10 hours per day till the complete drying to have constant weight and dry weight and dry matter per cent was calculated as:

$$\text{Dry matter content (\%)} = \text{Dry matter of tuber (g)} / \text{Fresh weight of tuber (g)} \times 100$$

II. Starch content in tuber (%):

A representative sample of tubers was taken from each plot after harvesting. These tubers were chopped into small pieces and a fine paste is made in pestle and mortar. From this paste the starch content in tubers was recorded by using Lane and Eynon method (1923).

Procedure

50 g paste of potato tuber was mixed with 100 ml distilled water and neutralized with 0.1 N NaOH solution using phenolphthalein as indicator, added in the solution and allowed to stand for ten minutes. Then 8 ml of potassium oxalate solution was added and total volume was made up to 250 ml by adding distilled water, 5 ml of the extract was taken in burette and titrated against 10 ml mixed Fehling solution (5ml Fehling solution A+ 5 ml Fehling solution B) using methylene blue as indicator. The end point was indicated decolourization of the solution. The following formula was used for determining the total sugar in vegetable:

$$\text{Total sugars (\%)} = \text{Factor for Fehling solution} \times \text{Dilution} \times 100\ \text{Titrate value} \times \text{weight of sample taken} \times 100$$

$$\text{Starch content (\%)} = \text{Total sugar (\%)} \times 0.9$$

Where,

0.9 factor for starch conversion

Results and Discussion

Quality parameters

Dry Matter Content of Tuber (%)

The data pertaining to dry matter content of potato tuber with respect to different zinc treatments has been presented in Table1 and illustrated in Fig.1. Data revealed that the maximum dry matter content of potato tuber (19.27 %) was recorded under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with treatment T_3 (RDF + Zinc sulphate @ 25 kg/ha at the time of planting) and T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) while significantly superior over rest of the treatments.

The minimum value (16.30%) was recorded under treatment T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O).

It is revealed from the data (Table 1) dry matter content of potato tuber increased with increase in the level of zinc because of positive correlation between dry matter and starch content of tuber. Mousavi *et al.* (2007) found that starch content of potato tubers increased with zinc sulphate fertilization. These findings are in agreement partially with the results of Ahmed *et al.* (2011) who observed that maximum dry matter content of potato tubers with zinc at 300 ppm. These findings are also supported by Bari *et al.* (2001) and Joshi and Raghav (2007), Al Jobori and AI-Hadithy (2014) and Sati *et al.* (2017).

Starch Content in Tuber (%)

The data pertaining to starch content of potato tuber with respect to different zinc treatments has been presented in Table 1 and illustrated in Fig. 1.

The maximum starch content of potato tuber (16.91 %) was recorded under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting) which was at par with the treatment T_3 (RDF + Zinc sulphate @ 25 kg/ha at the time of planting) and T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) while significantly higher than rest of the treatment. The minimum value (13.70 %) was recorded under treatment T_1 (RDF (150:100:120 kg/ha N: P_2O_5: K_2O)

It is evident from the data (Table1) that starch content of potato tuber improved with increase in levels of zinc because zinc activates enzyme like aldolase and carbonic anhydrase, which helps in translocation of carbohydrates from leaves to tubers. Puzina (2004) suggested that zinc improves diameter of isodiametric cells of the perimedullary tuber zone, these cells are characterized by the most intense starch accumulation. These findings are in agreement partially with the results of El-Hadded and Award (2007), Ahmed *et al.* (2011). Panitnok *et al.* (2013) and Mousavi *et al.* (2007), Sati *et al.* (2017).

Potato yield parameter

Effect of zinc application on total number A, B, C, and D grade tubers of potato hill^{-1} has been presented in Table 2 and illustrated in Fig. 2.

It is evident from the table that total number of A,B,C, and D grade tubers of potato hill^{-1} was significantly increases with zinc application. Number of A grade tuber hill^{-1} (2.40) was recorded highest under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) and superior over rest of the treatments. The minimum value (1.60 hill^{-1}) was recorded under T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O). Number of B grade tuber hill^{-1} (2.90) was highest under treatment T_4 (T_1+ Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) while significantly superior over rest of the treatments. The minimum value hill^{-1} (1.90) was recorded under T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O). Number of C grade tuber hill^{-1} (3.50) was highest under treatment T_2 (T_1+ Zinc sulphate (21% Zn) @ 20kg/ha at the time of planting), which was statistically at par with T_5 (T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 days after planting) while superior over rest of the treatments. Number of D grade tuber hill^{-1} (3.50) was highest under treatment T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O), which was statistically at par with T_2 (RDF + Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting) while superior over rest of the treatments.

It is evident from the data (Table 2) that number of tubers hill^{-1} of potato plant increased with the application of zinc because zinc effects the hormonal status of potato plant. On the other hands, zinc improves the IAA/ABA and cytokinin/ABA ratio, which induces the formation and growth of stolons mainly due to decrease in ABA content with increase in gibberellins content of plant Puzina (2004).These results were confirmed by the findings of Bari *et al.* (2001). Raghav and Singh (2004) found that number of medium and large size tubers was highest with zinc at 8 kg as basal application.

Effect of zinc application on weight of A, B, C, and D grade tubers of potato gm hill^{-1} has been presented in Table 3 and illustrated in Fig. 3.

It is evident from the data that weight of A, B, C, and D grade tubers of potato gm hill^{-1} was significantly increases with zinc application. Weight of A grade tuber (184gm hill^{-1}) was recorded highest under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) while significantly superior over rest of the treatments. The minimum value (123.20 gm hill^{-1}) was recorded under T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O). Weight of B grade tuber (191.40 gm hill^{-1}) was highest under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) while significantly superior over rest of the treatments. The minimum value

(125.40 gm $hill^{-1}$) was recorded under T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O). Weight of C grade tuber (157.50 gm $hill^{-1}$) was highest under treatment T_2 (RDF + Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting), which was significantly higher over rest of treatments. While weight of 'C' grade tuber (108 gm $hill^{-1}$) was highest under treatment T_4 (RDF + Zinc sulphate (@ 30kg/ha at the time of planting) and T_5 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 days after planting).Weight of D grade tuber (69.8gm $hill^{-1}$) was highest under treatment T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O), which was significantly higher than rest of the treatments.

A critical observation of the data (Table 3) revealed that weight of tubers gm $hill^{-1}$ of potato increased with the increasing dose of application of zinc because it is positively correlated with total number and size of tubers, Raghav and Singh (2004) found that weight of medium and large size tubers was highest with basal application of zinc at 10 kg/ha. Similar finding was also reported by Ahmed *et al.* (2011). Parmar *et al.* (2016) reported that foliar supplementation of zinc at 15 ppm gave maximum tuber yield per plant i.e., 564.57 g.

Effect of zinc application on weight of A, B, C, and D grade tubers of potato kg $plot^{-1}$ has been presented in Table 4 and illustrated in Fig.4.

It is evident from the table that weight of A, B, C, and D grade tubers of potato kg $plot^{-1}$ was significantly increases with zinc application. More specifically, A-grade tuber was recorded highest (17.55 kg $plot^{-1}$) under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting) which was statistically at par with T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) and superior over rest of treatments. The minimum value (11.30 kg $plot^{-1}$) was recorded under T_2 (RDF + Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting). B grade was significantly increased with the increase in Zn levels. Number of 'B' grade tuber (18.20 kg $plot^{-1}$) was highest under treatment T_4 (RDF + Zinc sulphate @ 30kg/ha at the time of planting), which was statistically at par with T_6 (RDF + Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting) and superior over rest of treatments. The minimum value (10.80 kg $plot^{-1}$) was recorded under T_2 (RDF + Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting). Number of C grade tuber (13.56 kg $plot^{-1}$) was highest under treatment T_2 (RDF + Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting), which was statistically at par with T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O) and T_3 (RDF + Zinc sulphate @ 25kg/ha at the time of planting) and superior over rest of treatments. Number of D grade tuber (5.24 kg $plot^{-1}$) was highest under treatment T_2 (RDF + Zinc sulphate (21%Zn) @ 20kg/ha at the time of planting), which was superior over rest of treatments.

This might be due to the stimulating effect of Zn on the vegetative growth coupled with its probable influence on the productive part (tuber), which may provide an explanation of its Zinc Uptake and Zn-use Efficiency (ZUE) of Potato effect on the yield components Kumar *et al.* 2008a.

Table 1: Dry Matter and Starch Content of Tuber

Treatments		Dry matter content of tuber (%)	Starch content in tuber (%)
T1	RDF (150:100:120 kg/ha N: P_2O_5: K_2O)	13.70	16.30
T2	T_1+ Zinc sulphate (21%Zn) @20kg/ha at the time of planting	14.05	16.72
T3	T_1+ Zinc sulphate @ 25 kg/ha at the time of planting	16.10	17.98
T4	T_1+ Zinc sulphate @ 30kg/ha at the time of planting	16.91	19.27
T5	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 days after planting	14.75	17.31
T6	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting	16.25	19.13
	SEm±	0.313	0.504
	CD at 5%	0.931	1.496

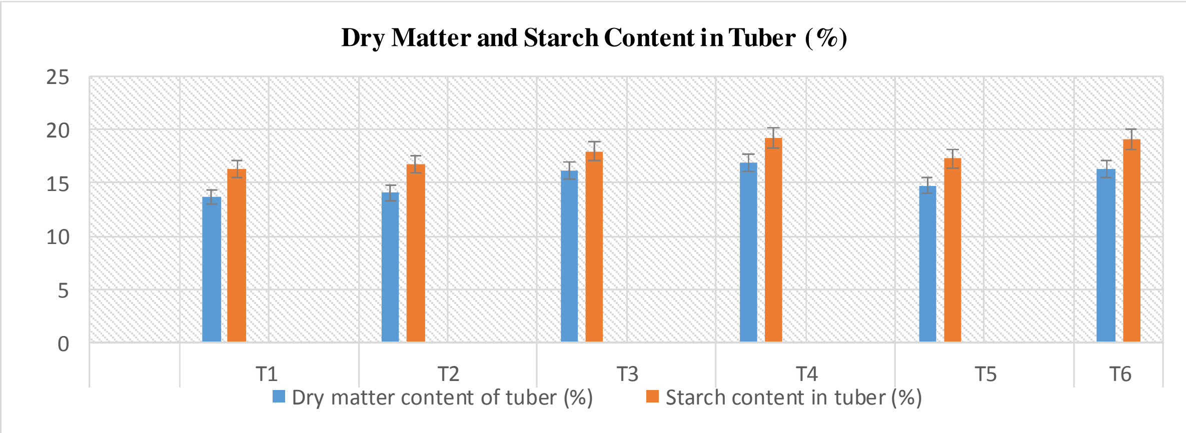

Fig. 1 : Dry Matter and Starch Content of Tuber

Table 2 : Effect of Zinc Sulphate Application on Number of A, B, C and D Grade Tubers hill^{-1}

Treatments		Number of A grade tuber hill^{-1}	Number of B grade tubers hill^{-1}	Number of C grade tubers hill^{-1}	Number of D grade tubers hill^{-1}
T_1	RDF (150:100:120 kg/ha N: P_2O_5: K_2O)	1.60	1.90	3.00	4.60
T_2	T_1+ Zinc sulphate (21%Zn) @20kg/ha at the time of planting	1.90	2.30	3.50	4.00
T_3	T_1+ Zinc sulphate @ 25 kg/ha at the time of planting	2.20	2.60	2.40	2.00
T_4	T_1+ Zinc sulphate @ 30kg/ha at the time of planting	2.40	2.90	2.40	1.00
T_5	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 days after planting	2.20	2.60	3.00	2.00
T_6	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting	2.30	2.80	2.60	1.00
	SEm±	0.060	0.074	0.080	0.071
	CD at 5%	0.178	0.218	0.235	0.209

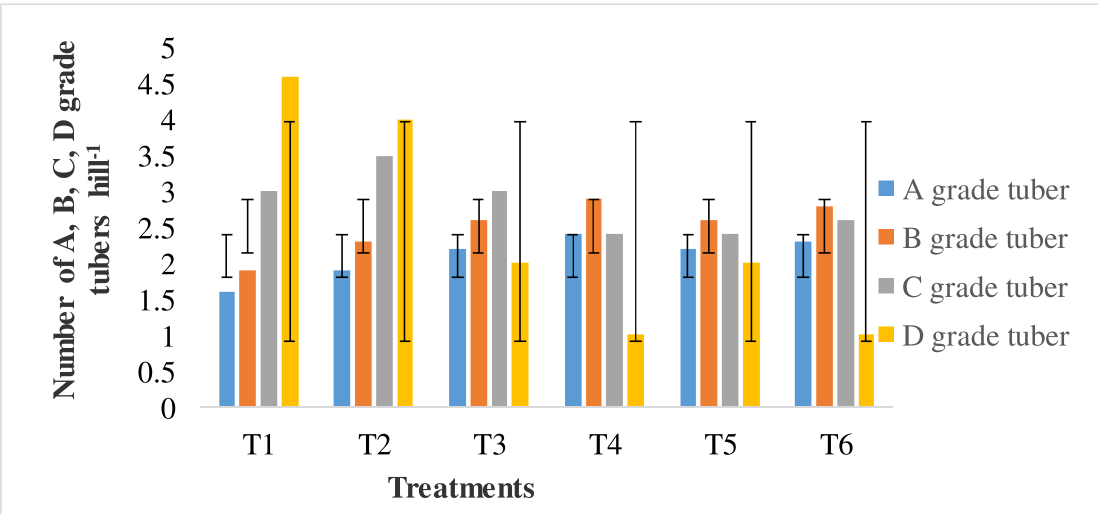

Fig. 2 : Effect of Zinc Sulphate Application on Number of A, B, C and D Grade Tubers hill^{-1}

Table 3 : Effect of Zinc Sulphate Application on Weight of A, B, C and D Grade Tuber gm $hill^{-1}$

	Treatments	Weight of A grade tuber gm $hill^{-1}$	Weight of B grade tuber gm $hill^{-1}$	Weight of C grade tuber gm $hill^{-1}$	Weight of D grade tuber gm $hill^{-1}$
T_1	RDF (150:100:120 kg/ha N: P_2O_5: K_2O)	123.20	125.40	135	69.80
T_2	T_1+ Zinc sulphate (21%Zn) @20kg/ha at the time of planting	146.30	151.80	157.50	60.96
T_3	T_1+ Zinc sulphate @ 25 kg/ha at the time of planting	169.40	171.60	135	17.48
T_4	T_1+ Zinc sulphate @ 30kg/ha at the time of planting	184.80	191.40	108	11.38
T_5	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 days after planting	169.40	171.60	108	11.33
T_6	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting	177.10	184.80	117	7.75
	SEm±	4.634	4.870	3.592	0.923
	CD at 5%	13.671	14.367	10.596	2.724

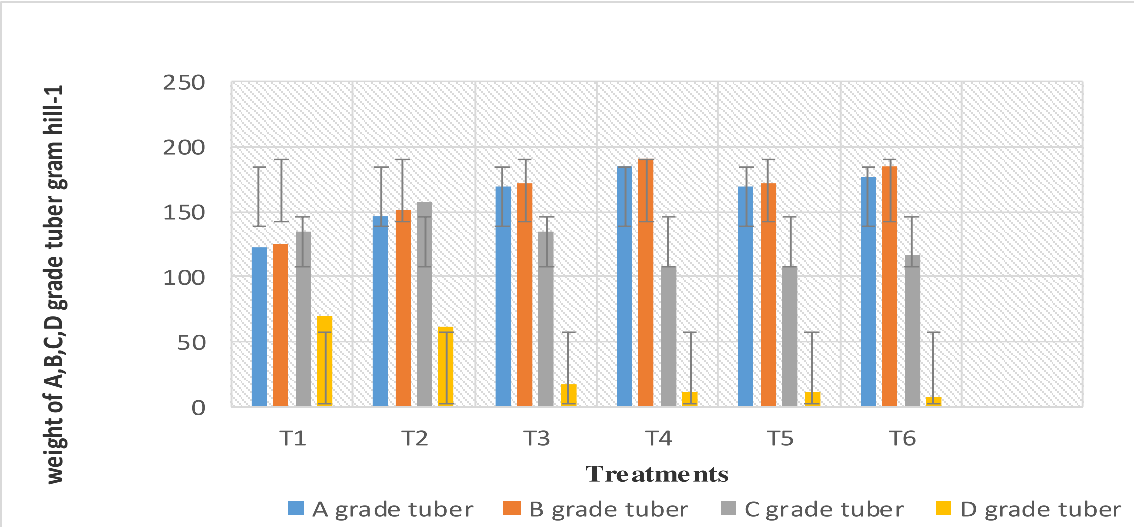

Fig. 3 : Effect of Zinc Sulphate Application on Weight of A, B, C and D Grade Tuber gm $hill^{-1}$

Table 4 : Effect of Zinc Sulphate Application on Weight of A, B, C and D Grade Tuber kg $plot^{-1}$

	Treatments	Weight of A grade tuber kg $plot^{-1}$	Weight of B grade tuber kg $plot^{-1}$	Weight of C grade tuber kg $plot^{-1}$	Weight of D grade tuber kg $plot^{-1}$
T_1	RDF (150:100:120 kg/ha N: P_2O_5: K_2O)	11.70	11.90	12.80	3.27
T_2	T_1+ Zinc sulphate (21%Zn) @20kg/ha at the time of planting	11.30	10.80	13.56	5.24
T_3	T_1+ Zinc sulphate @ 25 kg/ha at the time of planting	16.10	16.40	12.80	1.60
T_4	T_1+ Zinc sulphate @ 30kg/ha at the time of planting	17.55	18.20	10.26	1.09
T_5	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 days after planting	12.91	17.30	11.30	1.85
T_6	T_1+ Foliar application of Zinc sulphate @ 0.5% at 25 and 50 days after planting	16.8	19.24	11.10	0.80
	SEm±	0.380	0.664	0.632	0.312
	CD at 5%	1.13	1.394	1.327	0.926

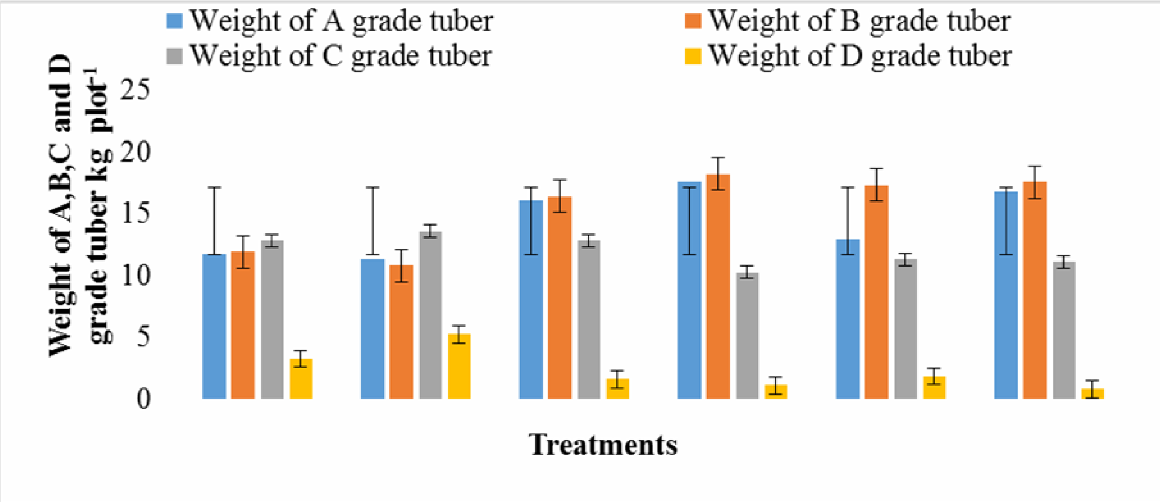

Fig. 4 : Effect of Zinc Sulphate Application on Weight of A, B, C and D Grade Tuber kg plot^{-1}

Conclusion

On the basis of present investigation, the application of zinc significantly influenced the quality attributes and yield components of potato tubers. Among the treatments, T_4 (RDF + Zinc sulphate @ 30 kg/ha at planting) consistently recorded the highest values of dry matter content (19.27%), starch content (16.91%), and weight of A and B-grade tubers both on hill^{-1} and plot^{-1} basis. This treatment was statistically at par with T_3 (25 kg $ZnSO_4$/ha at planting) and T6 (foliar $ZnSO_4$ @ 0.5% at 25 and 50 DAP), but significantly superior over the rest.

Higher number and weight of A and B grade tubers under these treatments clearly indicate that adequate zinc supply enhances tuber bulking and improves quality attributes like dry matter and starch content. Conversely, T_1 (RDF 150:100:120 kg/ha N: P_2O_5: K_2O) produced the lowest dry matter, starch, and marketable tuber yield, with a higher proportion of unmarketable D grade tubers.

Thus, it may be concluded that soil application of zinc sulphate at 30 kg/ha T_4 (RDF + Zinc sulphate @ 30 kg/ha at planting) or foliar spray at critical stages T_6 (foliar $ZnSO_4$ @ 0.5% at 25 and 50 DAP) is effective in improving the yield, quality, and marketable produce of potato, while ensuring higher economic returns.

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