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Growth of Sweet Corn Hybrids (*Zea mays saccharata*) as Influenced by Soil and Foliar Application of Zinc

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ABSTRACT: One third of the world population is reported to be at the risk of zinc malnutrition due to inadequate dietary intake of zinc. A field experiment entitled "Performance of sweet corn hybrids (*Zea mays saccharata*) as influenced by soil and foliar application of zinc" was conducted during kharif 2018 at the Experimental Farm of the Division of Agronomy, Wadura, SKUAST-K. The experiment comprised of two factors with three sweet corn hybrids, *viz.,* Sugar 75, FSCH 75 and CMVL SC and four zinc levels, viz., soil application of $ZnSO_4$ @ 20 kg ha^{-1}, soil application of $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at knee high stage, soil application of $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at tasseling stage and $ZnSO_4$ @ 15 kg ha^{-1} + ZnSB @ 200 ml/kg of seed laid out in randomized complete block design (RCBD) with three replications. The results of the experiment revealed that among different sweet corn hybrids, Sugar 75 produced significantly higher growth parameters, *viz.,* plant height, leaf area index, dry matter accumulation and mean crop growth rate compared to other sweet corn hybrids whereas FSCH 75 recorded significantly lowest growth parameters. Among different zinc levels, soil applied $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at knee high stage recorded significantly higher growth parameters whereas soil applied $ZnSO_4$ @ 15 kg ha^{-1} + ZnSB @ 200 ml/kg of seed recorded lowest growth parameters.

Keywords: sweet corn, zinc, hybrids, growth.

INTRODUCTION

Maize *(Zea mays* L.) is emerging as the third most important cereal crop in the world after wheat and rice. It is called as the "Queen of Cereals", due to high productiveness, easy to process, low cost than other cereals (Jaliya *et al.*, 2008), besides serving as human food and animal feed, it also has the wide industrial applications. In world around 190 million hectares of area with production of about 1438 million tonnes is under maize cultivation (FAO, 2019). In India about 9.50 million hectares with annual production of 27.23 million tonnes and productivity of 2.87 tonnes $hectare^{-1}$ is under maize cultivation (DES, 2019). In the union territory of Jammu and Kashmir maize is the second most important cereal crop after rice and is grown on an area of 0.31 million hectare with production of 0.51 million tonnes with an average productivity of 1650 kg ha^{-1} (DES. 2019).

Due to its high content of carbohydrates, fats, proteins, vitamins and minerals, it has acquired a well deserved reputation world wide as poor mans' nutria-cereal (Sentayehu, 2008). It has been estimated that several million people in developing countries derive their protein and calorie (11.1 g and 342 kcal day^{-1}) requirement from maize (Gopalan *et al.*, 1999). It contributes nearly 9 percent to the national food basket. In the developing countries of the world, maize is a staple food and potential source of protein for human and animal diet and holds a promise as future protein crop. At global level, it accounts for 15 percent protein and 20 percent of calories in world food diet. But unfortunately the nutritional profile of maize is poor as it is deficient in essential amino acids such as lysine and tryptophan. This is leading to poor net protein utilization, malnutrition and low biological value of traditional maize varieties (Vasal, 1999). Speciality corn like Pop corn and Sweet corn are popular snack foods whereas Quality Protein Maize (QPM) is important since it is enriched with tryptophan and lysine which provides nutritious food and feed for poultry, cattle, sheep and to poor people particularly for those with maize as staple food, thereby providing food and nutritional security. Due to the sweet taste and tenderness of green cobs as well as quality of green fodder, cultivation of sweet corn is the first choice of farmers now-a-days. Sweet corn has sugar content greater than 25% at milking stage. Sweet corn kernels generally contain 16-20%, sugar, 2.2-4.5% of proteins, 1.2–2.7 % of fats, 3–20 % of starch, 1.0 –1.9 % of cellulose, 6.7 to 8 mg of vitamin C per 100 g, small amounts of vitamins A, B_1, B_2, and mineral components. Enzymes like Lipoxygenase and peroxidase are directly associated with off-flavour and other quality deteriorations. In sweet corn, aroma develops due to dimethyl sulphide (DMS) and hydrogen sulphide (Brecht *et al*., 1990).

Owing to low returns per unit area in case of normal maize, growers are fastly shifting to speciality corn i.e. sweet corn and pop corn production giving more returns and opening opportunities for employment generation. Out of various speciality corns, sweet corn has a very huge market potential and has great genetic variability and scope to improve its nutritive value. This high potentiality is not only in domestic market but in the international market as well. In addition to this, quality fodders (on the basis of sweetness) derived after harvest may be sold that brings handsome additional income to the farmers as it is highly relished by the cattle. Sweet corn industry is expanding because of increasing domestic consumption, export development and import replacement. It is an attractive crop for producers as it grows quickly hence considered as a valuable rotational crop where farming operations can be mechanized. Most sweet corn is grown for the processing sector ending up on the super market shelves as products which include canned kernels, frozen cobs and frozen kernels (Najeeb *et al*., 2011). A number of sweet corn varieties and hybrids have been developed so far by incorporating these recessive mutation(s).

It is well established fact that Zn plays an important role as metal component of various enzymes and is required in various biochemical reactions for chlorophyll formation. Maize (*Zea mays* L.) is a very high nutrient demanding crop but highly sensitive to zinc (Zn) deficiency in soil. Zinc deficiency in crops is the common micronutrient problem worldwide, therefore zinc malnutrition has become a major health issue among the resource poor people (Singh and Sampath, 2011). Singh (2010) reported that wide spread hidden hunger of zinc in seeds and feeds which is affecting a large segment of population i.e. resource poor families whose food comes mainly from cereals which are grown on zinc deficient soils. Intensive agriculture involving modern technologies with the introduction of high-yielding sweetcorn and the repeated use of high analysis fertilizers has finally lead to a deficiency of micronutrients, particularly zinc (Alloway 2004; Rakshit *et al.,* 2015). In Asia about 35 per cent of children between age group of 0 and 5 years suffer from Zn or Fe-deficiencies, 250 million suffer from vitamin A deficiency and 58 per cent of pregnant women in developing countries are anemic from iron deficiency (Cababallero, 2002). Application of Zn fertilizers could be a viable option to meet out the crop demand for Zn and also to increase its contents in grains. Biofortification is a process in which plants are allowed to take up the minerals (Zn) from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary zn requirements of humans. Application of Zn to plants grown under potentially Zn-deficient soils is effective in reducing uptake and accumulation of P in plants. This agronomic side effect of Zn fertilization may result in better bioavailability of Zn in the human digestive system. So, agronomic bio-fortification is a holistic approach to eliminate micronutrient deficiency in food crops through agronomic practices by means of soil and foliar application. Hence the present investigation entitled "Growth of sweet corn hybrids (*Zea mays saccharata*) as influenced by soil and foliar application of Zinc" was undertaken .

MATERIALS AND METHODS

The experiment comprised of two factors with three sweet corn hybrids viz., Sugar 75, FSCH 75 and CMVL SC and four zinc levels viz., soil application of $ZnSO_4$ @ 20 kg ha^{-1}, soil application of $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at knee high stage, soil application of $ZnSO_4$ @ 15 kg ha^{-1} + ZnSO4 (0.5%) foliar spray at tasseling stage and soil application $ZnSO_4$ @ 15 kg ha^{-1} + ZnSB @ 200 ml/kg of seed laid out in randomized complete block design with three replications. The various treatment combinations include T_1 : Sugar 75 + soil application of $ZnSO_4$ @ 20 kg ha^{-1}, T_2 : Sugar 75 + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + soil application of $ZnSO_4$ (0.5%) foliar spray at knee high stage, T_3 : Sugar 75 + soil application $ZnSO_4$ @ 15 kg ha^{-1} + soil application of $ZnSO_4$ (0.5%) foliar spray at tasseling stage, T_4 : Sugar 75 + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + ZnSB @ 200 ml/kg of seed, T_5 : FSCH 75 + soil application of $ZnSO_4$ @ 20 kg ha^{-1}, T_6 : FSCH 75 + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + soil application of $ZnSO_4$ (0.5%) foliar spray at knee high stage, T_7: FSCH 75 + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at tasseling stage, T_8 : FSCH 75 + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + ZnSB @ 200 ml/kg of seed, T_9 : CMVL SC + soil application of $ZnSO_4$ @ 20 kg ha^{-1}, T_{10}: CMVL SC + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at knee high stage, T_{11}: CMVL SC + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ (0.5%) foliar spray at tasseling stag and T_{12}: CMVL SC + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + ZnSB @ 200 ml/kg of seed.

Plant height of five tagged plants in penultimate rows of each plot at 15 days interval after sowing was recorded and averaged to plant height in centimeters. The plant height was taken from the base of plant touching soil surface to fully opened top leaf. For estimation of leaf area index five randomly plants were selected and measured. Leaves of the plants were separated and then leaf area was measured by leaf area meter. Leaf area index was computed by the using formula.

$$\text{Leaf area index (LAI)} = \frac{\text{Total leaf area}}{\text{Ground area}}$$

For determination of dry matter accumulation five randomly selected plants from penultimate row of each plot were harvested and chopped into small pieces, mixed homogeneously and oven dried at 60-65^{o}C temperature to a constant weight. After recording dry weight with the help of electronic balance, it was averaged and recorded as g plant^{-1} and converted into q ha^{-1}. At 15 days interval after sowing, data related to dry weight obtained was used to calculate crop growth rate using the formula;

W2-W1/T2-T1,

Where, W1= Dry weight of plant sample at time T1

W2= Dry weight of plant sample at time T2

RESULTS AND DISCUSSION

The results of the experiment revealed that Plant height (Table 1), Leaf area index (Table 2, Fig. 1) and dry matter accumulation (Table 3, Fig. 3) were significantly influenced by different hybrids at 15 days interval and it was found that hybrid Sugar 75 recorded significantly higher plant height, leaf area index and dry matter accumulation at 15 days interval from sowing upto harvest whereas, hybrid FSCH 75 recorded significantly lower values at the respective stages. Data presented in Table 4 revealed an increasing trend of crop growth rate till 45-60 DAS but decreasing trend was observed from 60 DAS upto harvest. Among different sweet corn hybrids Sugar 75 registered higher crop growth rate at 15-30 DAS, 30-45 DAS, 45-60 DAS, 60-75 DAS, 75-90 DAS and 90 DAS upto harvest (Fig. 5) compared to other hybrids whereas, hybrid FSCH 75 registered significantly lowest crop growth rate at the respective stages. The variation in plant growth parameters due to different hybrids might be due to difference in vigorous vegetative growth of sweet corn hybrids which may be attributed to difference in genetic character of the different hybrids. The results are in close conformity with the findings of Dekhane and Dumbre (2017).

The findings of the experiment also revealed that plant height (Table 1), leaf area index (Table 2, Fig. 2) and dry matter accumulation (Table 3, Fig. 4) were significantly influenced by various zinc levels and it was found that zinc level 15 Kg ha^{-1} (soil applied) + $ZnSO_4$ (0.5%) spray at knee high stage produced higher values of these growth parameters at 15 days interval from sowing upto harvest but the effect of zinc levels on plant height and leaf area index at 15 DAS was not significant. Lower values of growth parameters were recorded with treatment 15 Kg ha^{-1} (soil applied) + ZnSB (seed applied). Different Zinc levels significantly affected crop growth rate (Table 4, Fig. 6) and it was found that significantly higher crop growth rate with 15 Kg ha^{-1} (soil applied) + $ZnSO_4$ (0.5%) spray at knee high stage i.e. at 15-30 DAS, 30-45 DAS, 45-60 DAS, 60-75 DAS, 75-90 DAS and 90 DAS upto harvest compared to other treatments. Lower crop growth rate was recorded with the treatment 15 Kgha^{-1} (soil applied) + ZnSB treatment of seed. Significant increase in plant height with different levels of Zn along with RDF might be due to due to cell and internodal elongation, plant metabolism, there by promoting vegetative growth which is positively correlated to the productive potentiality of plant which corroborates with the results of Masood et al. (2011). Al-Doori and Al-Dulaimy (2011) also observed that Zinc application in soil coupled with a foliar application resulted in tallest plants in specialty corn. The increase in LAI could be attributed to significant increase in leaf expansion (length and breadth), high rate of cell division and cell enlargement, rapid growth and thereby enhancing vegetative growth due to applied Zn fertilizers along with RDF. The results are well supported by the findings of Bisht *et al.* (2012). The higher dry matter accumulation and mean crop growth rate with soil and foliar application of Zn could be attributed to increased plant height and leaf area index with that treatment. Zn content in plant is known to involve in the metabolic activity, controlled auxin levels and nucleic acids in plants thereby contributing towards increase in growth and development of plants. Significance of foliar spray of zinc along with soil application has also been demonstrated by Debnath (2014).

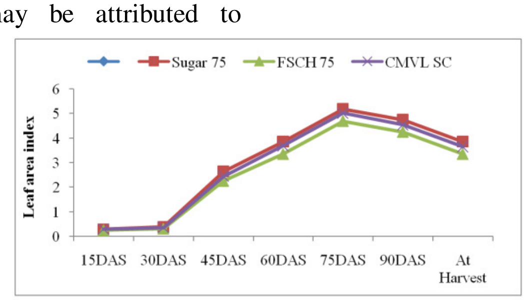

Fig. 1. Effect of different hybrids on leaf area index of sweet corn.

Table 1: Effect of sweet corn hybrids and zinc levels on plant height (cm).

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	At harvest
Hybrid							
Sugar 75	16.42	49.48	96.28	162.20	213.82	217.75	219.09
FSCH 75	13.34	39.18	89.03	153.34	194.29	203.54	206.44
CMVL SC	15.68	45.07	95.58	157.79	199.85	210.78	212.07
SEm±	**0.13**	**0.41**	**0.38**	**0.44**	**0.50**	**0.46**	**0.58**
CD ($p \leq 0.05$)	**0.38**	**1.22**	**1.12**	**1.32**	**1.50**	**1.37**	**1.71**
$ZnSO_4$ levels							
20 kg ha^{-1}	13.10	45.50	91.60	159.35	197.25	203.10	205.55
15 Kg ha^{-1}+ $ZnSO_4$ (0.5%) Spray at knee high stage	13.44	47.40	94.31	163.36	199.49	206.84	218.99
15 Kg ha^{-1}+$ZnSO_4$ (0.5%) Spray at tasseling stage	13.24	43.73	91.06	158.29	195.85	201.89	203.90
15 Kg ha^{-1}+ZnSB @ 200 ml/kg of seed	12.80	38.67	86.23	153.10	191.03	195.59	197.69
SEm±	**0.23**	**0.48**	**0.44**	**0.51**	**0.58**	**0.53**	**0.67**
CD ($p \leq 0.05$)	**NS**	**1.41**	**1.30**	**1.52**	**1.73**	**1.58**	**1.98**

Table 2: Effect of different sweet corn hybrids and zinc levels on leaf area index.

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	At harvest
Hybrid							
Sugar 75	0.30	0.38	2.64	3.51	5.68	3.48	2.38
FSCH 75	0.24	0.31	2.25	3.29	4.92	2.72	1.61
CMVL SC	0.28	0.36	2.54	3.50	5.64	3.44	2.16
SEm±	**0.01**	**0.01**	**0.02**	**0.02**	**0.04**	**0.04**	**0.05**
CD ($p \leq 0.05$)	**0.06**	**0.03**	**0.06**	**0.05**	**0.12**	**0.12**	**0.16**
$ZnSO_4$ levels							
20 $kgha^{-1}$	0.27	0.35	2.49	3.42	5.45	3.25	2.08
15 Kg ha^{-1}+ $ZnSO_4$ (0.5%) Spray at knee high stage	0.29	0.38	2.57	3.54	5.52	3.68	2.34
15 Kg ha^{-1}+$ZnSO_4$ (0.5%) Spray at tasseling stage	0.28	0.36	2.49	3.45	5.44	3.24	2.10
15 Kg ha^{-1}+ZnSB @ 200 ml/kg of seed	0.27	0.30	2.36	3.34	4.90	2.70	1.69
SEm±	**0.01**	**0.01**	**0.03**	**0.02**	**0.04**	**0.05**	**0.05**
CD ($p \leq 0.05$)	**NS**	**0.03**	**0.07**	**0.06**	**0.10**	**0.14**	**0.16**

Table 3: Effect of different sweet corn hybrids and zinc levels on dry matter accumulation (q ha^{-1}).

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	At harvest
Hybrid							
Sugar 75	5.48	17.10	55.47	104.51	113.24	126.09	128.83
FSCH 75	4.51	14.42	48.52	93.49	99.35	108.25	110.69
CMVL SC	5.17	16.12	54.20	102.96	109.45	120.59	123.17
SEm±	**0.13**	**0.29**	**0.39**	**0.53**	**0.45**	**0.78**	**0.78**
CD ($p \leq 0.05$)	**0.79**	**0.87**	**1.17**	**1.56**	**1.32**	**2.29**	**2.29**
$ZnSO_4$ levels							
20 $kgha^{-1}$	5.12	16.38	53.73	100.54	107.18	118.42	120.91
15 Kg ha^{-1}+ $ZnSO_4$(0.5%) Spray at knee high stage	5.31	21.18	54.28	102.29	108.97	120.92	123.41
15 Kg ha^{-1}+$ZnSO_4$ (0.5%) Spray at tasseling stage	5.07	15.55	52.07	99.76	107.44	117.76	120.45
15 Kg ha^{-1}+ZnSB @ 200 ml/kg of seed	4.74	10.42	51.20	98.70	105.79	116.15	118.83
SEm±	**0.16**	**0.34**	**0.46**	**0.61**	**0.52**	**0.90**	**0.91**
CD ($p \leq 0.05$)	**0.46**	**1.01**	**1.35**	**1.80**	**1.53**	**2.64**	**2.7**

Table 4: Effect of different sweet corn hybrids and zinc levels on crop growth rate (g m^{-2} day^{-1}).

Treatment	15 -30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS	90 DAS-Harvest
Hybrid						
Sugar 75	7.74	25.58	32.70	15.80	8.56	1.83
FSCH 75	6.61	22.73	29.98	13.89	5.93	1.62
CMVL SC	7.30	25.39	32.50	14.32	7.43	1.72
SEm±	**0.22**	**0.41**	**0.48**	**0.49**	**0.59**	**0.18**
CD (p≤0.05)	**0.66**	**1.20**	**1.39**	**1.44**	**1.74**	**0.51**
$ZnSO_4$ levels						
20 $kgha^{-1}$	7.52	22.64	31.58	14.40	7.49	1.67
15 Kg ha^{-1}+ $ZnSO_4$(0.5%) Spray at knee high stage	10.56	26.10	32.02	15.55	7.97	1.83
15 Kg ha^{-1}+$ZnSO_4$ (0.5%) Spray at tasseling stage	7.00	24.36	31.78	14.43	6.98	1.72
15 Kg ha^{-1}+ZnSB @ 200 ml/kg of seed	3.79	20.18	31.52	14.31	6.80	1.66
SEm±	**0.26**	**0.47**	**0.55**	**0.57**	**0.68**	**0.20**
CD (p≤0.05)	**0.76**	**1.38**	**1.61**	**1.66**	**2.01**	**0.59**

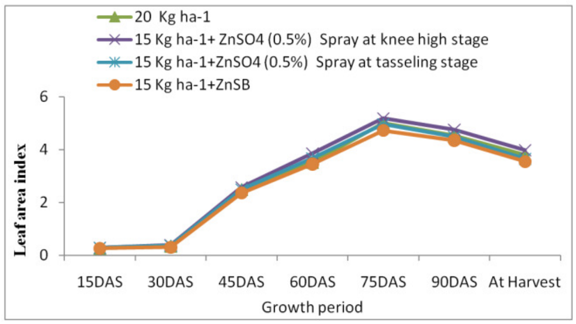

Fig. 2. Effect of different zinc levels on leaf area index of sweet corn.

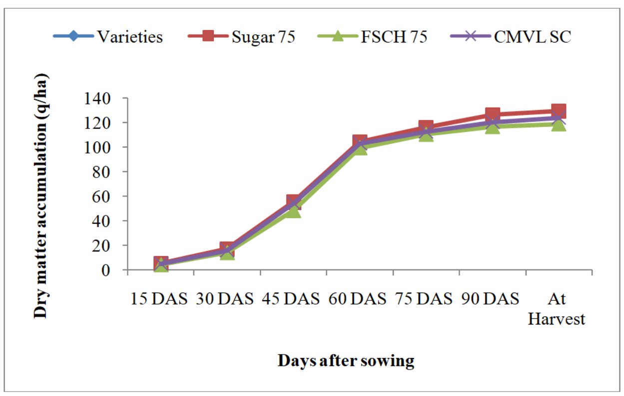

Fig. 3. Effect of hybrids on dry matter accumulation of sweet corn.

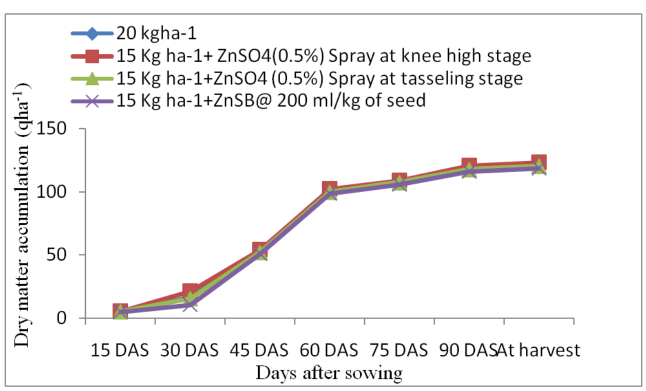

Fig. 4. Effect of zinc levels on dry matter accumulation of sweet corn.

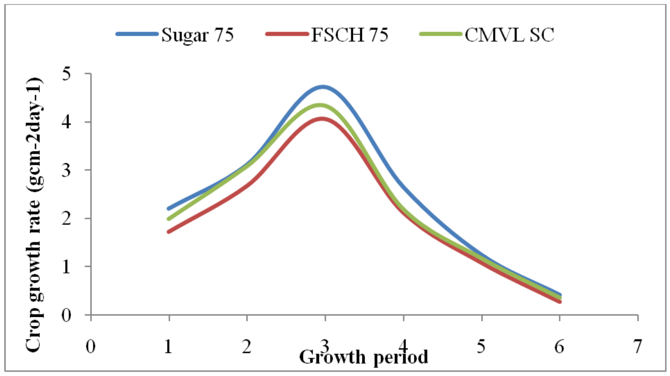

Fig. 5. Effect of hybrids on crop growth rate of sweet corn.

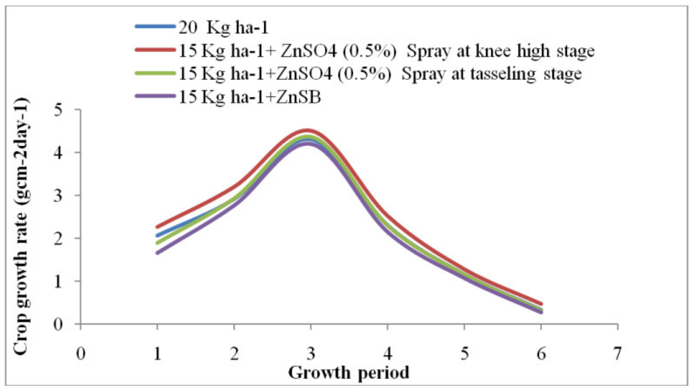

Fig. 6. Effect of different zinc levels on crop growth rate of sweet corn.

CONCLUSION

From the findings of the present investigation it can be concluded that in order to achieve better growth of sweet corn, The hybrid Sugar-75 applied with recommended dose of fertilizer along with the application of $ZnSO_4$ @ 15 Kg ha^{-1} (soil) + $ZnSO_4$ (0.5%) Spray at knee high stage is suitable.

FUTURE SCOPE

Zinc insufficiency in crops is a frequent micronutrient problem around the world, therefore zinc malnutrition has emerged as a serious health concern among the poor. Agronomic zinc biofortification could be a promising approach for meeting crop Zn requirement while also increasing grain zinc content. Further study is required to improve the zinc content in sweet corn or maize so that zinc malnutrition could be minimized.

Conflict of interest. None.

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