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Effect of micronutrients on growth, yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn in the *Gangetic* Alluvial Region of West Bengal

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ABSTRACT

The present investigation was carried out during 2016-17 and 2017-18 at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia to study the effect of micronutrients on growth, yield and quality of strawberry (Fragaria × ananassa Duch.) cv. Winter Dawn grown under shade net in the Gangetic alluvial region of West Bengal. The experiment was laid out in RBD, replicated 3 times with nine treatments, viz., Boric acid @ 0.2 and 0.4%, Zinc sulphate ($ZnSO_4$) @ 0.2 and 0.4%; Copper sulphate ($CuSO_4$) @ 0.2 and 0.4%, Iron sulphate ($FeSO_4$) @ 0.2 and 0.4% and control (water spray), applied as foliar spray at 15 and 30 DAP. Application of both $ZnSO_4$ and $FeSO_4$ @ 0.4% significantly improved vegetative growth, flowering, fruiting and fruit quality parameters over control and almost same value of estimated B:C ratio (2.69 and 2.68, respectively). However, $ZnSO_4$ @ 0.4 % resulted in significantly highest fruit weight (21.50 g) and also improved productivity (2.58 t ha^{-1}) and fruit quality in terms of TSS (6.29 ^{0}Brix), ascorbic acid (57.22 mg 100^{-1} g pulp) and anthocyanin content (62.86 mg/100 g pulp). From this study, foliar spray of $ZnSO_4$ @ 0.4 % at 15 and 30 days after planting was suggested for improvement of plant growth, productivity and fruit quality of strawberry grown in the Gangetic alluvial region of West Bengal.

Keywords: Fruit quality, micronutrients, strawberry, winter dawn and yield

The cultivated octaploid strawberry (*Fragaria* × *ananassa* Duch.), having chromosome no. 2n=8x=56, an aggregate fruit, of the family Rosaceae, is one of the most luscious refreshing soft fruits of the world. Strawberries are rich in natural anti-oxidants (Wang *et al*., 1996). In India, strawberry cultivation was confined to only the temperate regions like Jammu and Kashmir, Himachal Pradesh, but in recent years, development of new varieties adaptable to wide range of climatic condition and standardization of new agro-techniques has resulted in strawberry cultivation in non-traditional provinces of India (Sharma and Sharma, 2004). Strawberry is cultivated throughout India in an area of 0.6 thousand hectares producing 4.3 thousand metric tons for local consumption as well as for export purpose (Anon., 2018). Marketing and profit of strawberry cultivated in the Gangetic alluvial zone of West Bengal are suffering due to lack of desired quality and size of fruit. Micronutrients being involved in virtually all metabolic and cellular functions taking place within the plant play important role in improving quality and sustain production of strawberry (Hansch *et al*., 2009) and their deficiencies often limit crop productivity and quality. Keeping in view the present investigation was planned to standardize the dosage of micronutrients to overcome the problem of low yield and quality of strawberry fruits.

MATERIALS AND METHODS

The present investigation on the effect of micronutrients on growth, yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn was carried out during 2016-17 to 2017-18 at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia under shade net condition. The experimental field was situated at 23.5 ^{0}N latitude and 89 ^{0}E longitude with an elevation of 9.75 m above mean sea level. The experimental area belongs to sub-tropical humid climate under Gangetic new alluvial plains of West Bengal. The soil texture of the experimental field was alluvial in nature and sandy loam in texture, having 64.8% sand, 10.4% silt and 24.8% clay, pH-6.96, organic carbon- 0.51%, available N- 175.61 kg ha^{-1}, available P_2O_5- 26.06 kg ha^{-1}, available K- 76.27 kg ha^{-1}, available Zn- 1.07 mg kg^{-1}, available B- 0.11 mg kg^{-1}, available Fe- 20.24 mg kg^{-1}, and available Cu- 0.72 mg kg^{-1}. The experiment was laid out in Randomized Block Design (RBD), replicated thrice, having plot size 4 × 1 m, accommodating 28 tissue cultured plants (variety Winter Dawn) in each bed with a spacing of 45 × 30 cm between the rows and plants, leaving a space of 0.45 m between different beds for better crop management. The plants were dipped in Bavistin solution (1 g l^{-1}) before planting. The double row planting of the one month old plants was done in the month of November. Black polythene mulch (300 gauge thickness) was applied at the time of planting. Nine treatments (T_1- Boric acid @ 0.2%; T_2- Boric acid @ 0.4%; T_3- Zinc sulphate @ 0.2%; T_4- Zinc sulphate @ 0.4%; T_5-Copper sulphate @ 0.2%; T_6-Copper sulphate @ 0.4%; T_7-Iron sulphate @ 0.2%; T_8-Iron sulphate @ 0.4%; T_9-Control as water spray only) were imposed for two times at 15 and 30 days after planting

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(DAP). Well decomposed farmyard manure @ 5 t ha^{-1} and Vermicompost @ 500 kg ha^{-1} were incorporated uniformly into the soil 20 days before planting. N: P: K @ 100:80:100 kg ha^{-1} were applied 10 days before planting. Fungicides like, Bavistin @ 1g l^{-1} and Blitox @ 3g l^{-1} and insecticides like Confidor @ 1 ml l^{-3} and Dursban @ 3 ml l^{-1} were sprayed simultaneously at 15 days interval. Statistical inference of the data was obtained following the analysis of variance (ANOVA) for Randomized Block Design (RBD) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Vegetative parameters

Results presented in the table 1 showed significant increased in all growth related parameters due to application of different micronutrients at all successive stages of growth as compared to control plants (T_9) during the period of investigation. $FeSO_4$ @ 0.4% (T_8) produced the maximum plant height (17.38 cm), plant spread (34.02 cm), petiole length (15.10 cm) and number of shoots $plant^{-1}$ (20.67), number of leaves $plant^{-1}$ (19.56 cm), leaf area (91.06 cm^2), number of runners $plant^{-1}$ (4.63), which was followed by $ZnSO_4$ @ 0.4% (T_4), while minimum plant height (10.95 cm), plant spread (23.53 cm), petiole length (7.82 cm) and number of shoots $plant^{-1}$ (12.68), number of leaves $plant^{-1}$ (11.94 cm), leaf area (77.33 cm^2), number of runners $plant^{-1}$ (1.34) was observed in case of control plants. Zinc is required for the synthesis of tryptophan, which is a precursor of auxin (Skoog, 1940) which might have resulted in increase in apical growth. The results are in full conformity with the earlier findings of Nazir *et al*. (2006).

Reproductive parameters

The data on flowering and fruiting parameters *viz.*, duration of flowering, fruit setting and fruit maturity, number of flowers $plant^{-1}$, fruit set %, number of fruits $plant^{-1}$ presented in the table 2 showed significant variation. The application of $FeSO_4$ @ 0.4% (T_8) effectively influenced earlier flower initiation (29.23 days), earlier fruit set (4.20 days), days required from fruit set to fruit maturity (20.02 days), which was followed by (T_4) $ZnSO_4$ @ 0.4% treatment (30.42 days, 4.48 days and 21.46 days, respectively). However, number of flowers $plant^{-1}$ (27.95), fruit set % (77.07%) and number of fruits/plant (21.54) were recorded maximum in plants treated with $FeSO_4$ @ 0.4% (T_8), and was statistically at par with $ZnSO_4$ @ 0.4% (T_4). An inquisition of the data in the study revealed that 0.4% $ZnSO_4$(T_4) application resulted in maximum fruit weight (21.50 g) and volume (16.12 cc) of fruits, fruit yield (451.89 g $plant^{-1}$) and productivity (2.58 $tonnesha^{-1}$) (Table 3). Increase in fruit weight and size with the application of $ZnSO_4$ was reported earlier by Samant *et al*. (2008) in ber, Babu *et al*. (2007) in mandarin, Ali *et al*. (1991) in Guava and Mohamed *et al*. (2011) in strawberry. Abdollahi *et al*. (2012) reported increased inflorescence and fruit size with $ZnSO_4$ application because of its important role in pollination and fruit set in strawberry cv. Selva. It appears that micronutrient zinc rapidly increases the photosynthetic activity and translocation of photosynthates, resulting in enlargement of fruit size (Graham *et al*., 2000).

Fruit quality parameters

The observations recorded on fruit quality such as total soluble solids (TSS), acidity, ascorbic acid (vitamin C) and anthocyanin content of fruit indicated that the micronutrient treatments significantly improved the fruit quality parameters, with respect to increased TSS, ascorbic acid content, anthocyanin content, but reduced the acidity percentage of fruit as compared to control (Table 4). Application of 0.4% $ZnSO_4$ (T_4) recorded highest (6.29 ^{0}Brix) total soluble solids content, TSS:acid ratio (11.45), total sugar (5.42%) and reducing sugar (4.19%), ascorbic acid (57.22 mg 100^{-1} g pulp) and anthocyanin content (62.86 mg 100^{-1} g pulp). The minimum titrable acidity (0.55 %) was recorded in T_4 treatment ($ZnSO_4$ @ 0.4 %). Lower acidity in fruits might have resulted due to higher accumulation of sugars, better translocation of sugars into fruit tissues and conversion of organic acids into sugars (Kumar *et al*., 2015). These biological processes are supposed to be related with enzymatic activities and carbohydrate metabolism. As a component of proteins, zinc acts as a functional, structural, or regulatory cofactor of a large number of enzymes and involved in carbohydrate metabolism (Mousavi *et al*., 2013). Our present finding regarding effect of micronutrients on fruit quality confirms the earlier findings by Chaturvedi *et al*. (2005) in strawberry and Arora and Singh (1970) in guava.

Benefit : cost ratio

The treatment based on $ZnSO_4$ @ 0.4 % (T_4) has been found to be the most effective dose by giving highest net return mainly due to the production of larger and uniform sized fruits with better quality, which attracted the consumer and provided good market price. The application of $ZnSO_4$ @ 0.4% (T_4) came up with greatest benefit:cost ratio (2.69 : 1), which was almost same (2.68 : 1) with $FeSO_4$ @ 0.4% (T_8).

On the basis of the results obtained in the present investigation, the inference can be drawn that different levels of micronutrients had considerable effect on growth, yield and qualitative parameters of strawberry. Among them, application of both $ZnSO_4$ and $FeSO_4$ @ 0.4% at 15 and 30 DAP along with RDF (5 t FYM + 500 kg Vermicompost and NPK @ 100:80:100 kg ha^{-1}) significantly improved vegetative growth, flowering, fruiting and fruit quality parameters over control and almost same value of estimated B:C ratio.

Table 1: Effect of micronutrients on growth parameters of strawberry cv. Winter Dawn at 60 DAP

Treatments	Plant height (cm)	Plant spread (cm)	Petiole length (cm)	Number of shoots plant^{-1}	Number of leaves plant^{-1}	Leaf area (cm^2)	Number of runners plant^{-1}
T_1- Boric acid (0.2%)	13.96	28.76	11.15	16.63	15.80	84.67	2.43
T_2- Boric acid (0.4%)	14.73	29.88	11.77	17.17	16.55	85.60	3.06
T_3- Zinc sulphate (0.2%)	15.44	31.56	13.02	17.98	17.78	86.71	3.45
T_4- Zinc sulphate (0.4%)	16.82	33.18	14.35	19.74	19.12	89.32	4.28
T_5- Copper sulphate (0.2%)	11.68	25.63	8.60	14.17	12.86	82.45	1.67
T_6- Copper sulphate (0.4%)	12.11	26.48	8.89	15.17	13.65	83.19	2.15
T_7- Iron sulphate (0.2%)	15.84	32.39	13.74	18.94	18.14	87.66	3.95
T_8- Iron sulphate (0.4%)	17.38	34.02	15.10	20.67	19.56	91.06	4.63
T_9- Control	10.95	23.53	7.82	12.68	11.94	77.33	1.34
SEm (±)	**0.11**	**0.34**	**0.14**	**0.18**	**0.16**	**0.97**	**0.03**
LSD (0.05)	**0.33**	**1.03**	**0.43**	**0.55**	**0.48**	**NS**	**0.09**

Table 2: Effect of micronutrient on flowering and fruit setting of strawberry cv. Winter Dawn

Treatments	Duration in days			Number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit set (%)
	Flowering	Fruit setting	Fruit maturity			
T_1- Boric acid (0.2%)	35.60	5.80	25.06	24.13	17.71	73.43
T_2- Boric acid (0.4%)	35.00	5.60	24.10	25.03	18.55	74.09
T_3- Zinc sulphate (0.2%)	32.89	5.26	22.64	25.95	19.53	75.26
T_4- Zinc sulphate (0.4%)	30.42	4.48	21.46	27.48	21.01	76.49
T_5- Copper sulphate (0.2%)	38.36	6.41	26.91	23.08	16.57	71.83
T_6- Copper sulphate (0.4%)	37.46	6.27	25.88	23.55	17.03	72.37
T_7- Iron sulphate (0.2%)	32.30	4.85	22.01	26.79	20.34	75.93
T_8- Iron sulphate (0.4%)	29.23	4.20	20.02	27.95	21.54	77.07
T_9- Control	41.92	6.73	27.37	18.63	12.98	69.72
SEm (±)	**0.44**	**0.05**	**0.21**	**0.19**	**0.21**	**0.94**
LSD (0.05)	**1.32**	**0.14**	**0.63**	**0.58**	**0.64**	**2.84**

Table 3: Effect of micronutrient on fruit characters, yield and B:C ratio of strawberry cv. Winter Dawn

Treatments	Fruit volume (cc)	Length: diameter ratio	Fruit weight (g)	Fruit yield (g plant^{-1})	Productivity (t ha^{-1})	B:C ratio
T_1- Boric acid (0.2%)	14.67	1.51	19.30	341.84	1.95	1.62
T_2- Boric acid (0.4%)	14.99	1.45	19.68	365.13	2.08	1.88
T_3- Zinc sulphate (0.2%)	15.75	1.38	20.89	408.23	2.33	2.25
T_4- Zinc sulphate (0.4%)	16.12	1.39	21.50	451.89	2.58	2.69
T_5- Copper sulphate (0.2%)	13.84	1.47	18.19	301.67	1.72	1.21
T_6- Copper sulphate (0.4%)	14.21	1.52	18.39	313.27	1.79	0.98
T_7- Iron sulphate (0.2%)	15.27	1.36	20.25	412.24	2.36	2.38
T_8- Iron sulphate (0.4%)	15.53	1.42	20.54	442.84	2.52	2.68
T_9- Control	13.07	1.47	16.89	219.59	1.25	0.64
SEm (±)	**0.19**	**0.02**	**0.21**	**5.70**	**0.03**	**-**
LSD (0.05)	**0.60**	**0.07**	**0.64**	**17.25**	**0.10**	**-**

Table 4: Effect of micronutrient on chemical parameters of fruit quality of strawberry cv. Winter Dawn

Treatments	TSS (°Brix)	Acidity (%)	TSS:Acid ratio	Total sugar (%)	Reducing sugar (%)	Ascorbic acid content (mg 100^{-1} g pulp)	Anthocyanin content (mg 100^{-1} g pulp)
T_1- Boric acid (0.2%)	5.53	0.66	8.38	4.65	3.30	52.75	58.52
T_2- Boric acid (0.4%)	5.67	0.63	8.99	4.70	3.45	54.43	59.95
T_3- Zinc sulphate (0.2%)	6.09	0.60	10.19	5.06	3.81	56.85	60.59
T_4- Zinc sulphate (0.4%)	6.29	0.55	11.45	5.42	4.19	57.22	62.86
T_5- Copper sulphate (0.2%)	5.25	0.68	7.78	4.42	3.09	50.00	55.94
T_6- Copper sulphate (0.4%)	5.41	0.65	8.39	4.54	3.18	51.60	56.94
T_7- Iron sulphate (0.2%)	5.85	0.62	9.48	4.77	3.62	55.67	61.14
T_8- Iron sulphate (0.4%)	6.21	0.59	10.43	5.19	4.00	56.52	62.21
T_9- Control	5.14	0.73	7.61	4.25	2.90	42.24	41.96
SEm (±)	**0.07**	**0.01**	**0.15**	**0.05**	**0.05**	**0.60**	**0.73**
LSD (0.05)	**0.21**	**0.02**	**NS**	**0.15**	**0.14**	**1.81**	**2.20**

But, $ZnSO_4$ @ 0.4 % resulted in significantly highest fruit weight, productivity as well as improved fruit quality. From this study, foliar spray of $ZnSO_4$ @ 0.4% at 15 and 30 DAP was suggested for improvement of plant growth, productivity and fruit quality of strawberry cv. Winter Dawn grown in the Gangetic alluvial region of West Bengal.

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