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Effect of plant growth regulators and micronutrients on flowering and fruiting of strawberry (*Fragaria x ananassa* Dutch.) cv. chandler

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Abstract
There are many factors which influence plant health. PGRs and micronutrients are such type of input factors. With the aim to understand the effect of foliar application of growth regulators and micronutrients on flowering and fruiting of Strawberry (*Fragaria x ananassa* Dutch) cv. Chandler was carried out at the Central Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Science, Prayagraj, (U.P.) during the year 2015-16 and 2016-2017, Pooled data and result found that the maximum days taken to first flower (44.41 and 41.46 days), no of flowers per plant (10.61 and 10.69), day taken to first fruit (67.88 and 62.75 days), fruit set (%) (65.43 and 67.37%), fruit length (4.86 and 4.69cm), Number of fruit per plant (10.61 and 10.70) and weight of fruit (22.03 and 22.96 gm) were recorded in successive year in T_{17} (GA_3 75ppm+ Zinc sulphate 0.4% + Boric acid 0.4%) and fruit width (3.95 and 3.99 cm) was recorded insuccessive year in T_{18} (Salicylic acid 50 ppm + Zinc sulphate 0.4% + Boric acid 0.4%) and minimum quality were observed in T_1.

Keywords: Strawberry, plant growth regulators and micronutrients

Introduction
Strawberry (*Fragaria* × *ananassa* Dutch.) belongs to the family Rosaceae. The cultivated strawberry was originated from the hybridization of two American species *viz*., *Fragaria* × *chiloensis* Dutch. And *Fragaria* × *virginiana* Dutch. Strawberry (*F. ananassa* Dutch.) is one of the most popular soft fruit cultivated in plains as well as in the hills up to an elevation of 3000 m in humid or dry regions. The chromosome number in strawberry is 2n=2x= 56. Strawberry belongs to the family Rosaceae. The commercially cultivated strawberry is an octaploid species. It is a short-lived (3-5 yrs.), perennial, vigorous, stoloniferous herb growing to 10-20cm height with a spread of about 0.3-1.0m. Leaves are trifoliate, on stalks which grow out from a central crown (a compacted stem, where many leaves are formed very close together); leaflets are oval-egg shaped, deep green with coarse serrations. Flowers are white, 1-2cm wide, bisexual with approximately 30 stamens and approximately 300 pistils on a swollen, conical, yellowish receptacle. The first flower opens at the top and centre of the crown and produce the bigger fruits; flowers that open later produce the small fruits. The true fruit of the strawberry is an achene, which is a small, dry seed loosely attached to the swollen ovary wall (receptacle). The flesh of the strawberry is, in fact, the ovary wall with many fruits/seeds on its surface. The roots are shallow so plants need regular moisture but not water logging (Vishal *et al*. 2016) [12].

Strawberry plant is a surface feeder therefore fertility, moisture, drainage and microbial status of the upper layer of soil have great impact on growth, development, fruit yield, quality and production of runners. Many plant growth regulating compounds (auxins, cytokinins and gibberellins) have been used in various crops in order to achieve larger fruit size. Use of GA_3 in strawberry has been reported in early flowering, increased duration of flowering and fruiting in strawberry. Application of NAA delays ripening and increases anthocyanin accumulation of strawberry fruits. It increases duration of flowering and fruiting.BA as a plant growth regulator is used for different purposes in fruit production. It enhances the size and shape of fruits, lateral bud break and lateral shoot growth, leading to improved branching in fruit trees. It influences fruit size and weight by increasing the number of cells per fruit through the stimulation of cell division. Reports are there that thinning with BA had a positive effect on increasing return bloom. Zinc is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory factor of a large number of enzymes.

Zinc induces pollen tube growth through its role on tryptophan as an auxin precursor biosynthesis. Growth of the receptacle is controlled primarily by auxin, which is synthesized in achenes, therefore $ZnSO_4$ is applied to increase fruit number, size and quality. The above explanation clearly highlights the affectivity of PGRs and micronutrients on flowering and production of plants. Hence, it is being attempted to quantify their effect on strawberry culture.

Method and materials

The experiment entitled "Effect of Plant Growth Regulators and Micronutrients on Flowering and Fruiting of Strawberry *(Fragaria X Ananassa* Dutch.) cv. Chandler" was carried out as a part of investigation. All facilities to carry out the experiment were available at the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the year 2015-2016, 2016-17 and Pooled data. The detail of proposed plan of work is given as under: Allahabad district is situated in the river basin of the Ganga and Yamuna and situated at $25^0.57$' N- latitude $81^0.5$' E- longitude with an altitude of 98m above the mean sea level. Annual rainfall is 1100 mm precipitating mostly in between middle of July to end of September - January is the coldest month when mercury may drop down to an average minimum of 5^0on the other hand May – June are the hottest month recording average high temperature above 46^0 C. Major *kharif* crops of the district are rice, maize and pulses etc. While in *rabi*, wheat, mustard, coriander and garlic etc. are main crops.

The experiment was conducted in Randomized Block Design with 19 treatments with three replication. Treatments details are T_1 Control, T_2 NAA 20 ppm, T_3 GA_3 75 ppm, T_4 Salicylic acid 50 ppm, T_5 BA (benzyl adenine) 20 ppm, T_6 Zinc sulphate 0.4%, T_7 Boric acid 0.4%, T_8 NAA 20 ppm + Zinc sulphate 0.4%, T_9 NAA 20 ppm + Boric acid 0.4%, T_{10} GA_3 75 ppm + Zinc sulphate 0.4%, T_{11} GA_3 75 ppm + Boric acid 0.4%, T_{12} Salicylic acid 50 ppm + Zinc sulphate 0.4% Salicylic acid 50 ppm + Boric acid 0.4%, T_{14} BA (benzyl adenine) 20 ppm + Zinc sulphate 0.4%, T_{15} BA (benzyl adenine) 20 ppm + Boric acid 0.4%, T_{16} NAA 20 ppm + Zinc sulphate 0.4% + Boric acid 0.4%, T_{17} GA_3 75 ppm + Zinc sulphate 0.4% + Boric acid 0.4% T_{18}Salicylic acid 50 ppm + Zinc sulphate 0.4% + Boric acid 0.4% and T_{19} BA (benzyl adenine) 20 ppm + Zinc sulphate 0.4% + Boric acid 0.4%. Analysis of variance for individual character was done on the basis of mean values as suggested by Panse and Sukhantme, 1967) [4].

Result and discussion

The results of the effect of PGRs and micronutrients on different characters are presented in Table 1 and 2. Significant differences were recorded among the treatments for all the characters. The character wise result has been discussed below

In the Floral and Fruiting characters, earliest flowering, number of flowers plant-1, Days taken to first fruit, Fruit length (mm) and Fruit width (mm) were significantly increased by different treatments of plant growth regulators and micronutrient.

Earliest flowering (44.41 and 41.46 days in two successive years) was recorded in T_{17} (GA_3 75 ppm+ Zinc sulphate 0.4% +Boric acid 0.4%) and earliest fruiting (67.88 and 62.75 days in two successive years) was recorded in T_{17} (GA_3 75 ppm+ Zinc sulphate 0.4% + Boric acid 0.4%)**(**Sharma and Singh, 2009,Yadav*et al.* (2017) [13] and maximum number of flowers plant^{-1} (10.61 and 10.69 in two years), Similar results have been reported by Tripathi and Shukla (2008) [11]; Prasad *et al.* (2012) [5] and Saima *et al*. (2014) [8].

Fruit length (4.86 and 4.69 cm in two successive years) were recorded in T_{17} (GA_3 75 ppm+ Zinc sulphate 0.4% + Boric acid 0.4%) (Richard, 2006) [7] While Fruit width (3.95 and 3.99 cm in two successive years) was recorded in T_{18} (Salicylic acid 50 ppm + Zinc sulphate 0.4% + Boric acid 0.4%). Minimum characters were recorded in T_1, Kazemi (2013) [2] and Yadav *et al.* (2017) [13].

In the number of fruit per plant, Fruit set (%), at different intervals (5 days after first picking) of picking, fruit weight, were significantly increased by different treatments of plant growth regulators and micronutrient at all successive stage of fruit attributes. Similar findings were reported by Qureshi *et al.* (2013) [6] and Bhople *et al.* (2019) [1]. Maximum Number of fruit plant^{-1} (10.61 and 10.70), Fruit set (%) (65.43 and 67.37%), fruit weight (22.03 and 22.96 g) were recorded in successive year in T_{17} (GA_3 75 ppm+ Zinc sulphate 0.4% + Boric acid 0.4%) and minimum flowers and fruiting characters were recorded in T_1.

Table 1: Effect of PGRs and micronutrients on flowering and fruiting parameters of Strawberry cv. Chandler.

Treatment	Days taken to first flower			No of flowers per plant			Days taken to first fruit			Fruit set (%)		
	2015-16	2016-17	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T1	71.83	72.16	72	8.26	8.47	8.37	80.02	79.23	79.63	38.32	40.64	39.48
T2	61.57	58.59	60.08	9.01	9.04	9.03	74.02	76.59	75.31	43.91	44.19	44.05
T3	56.8	60.32	58.56	9.79	9.86	9.83	72.12	71.29	71.71	49.46	50.33	49.9
T4	63.78	63.29	63.54	8.92	8.96	8.94	74.63	77.63	76.13	41.62	42.25	41.94
T5	65.78	66.02	65.9	8.76	8.8	8.78	75.23	78.26	76.75	40	40.72	40.36
T6	58.98	62.88	60.93	9.48	9.57	9.53	72.45	72.36	72.41	45.02	48.34	46.68
T7	62.85	63.54	63.2	9.06	9.12	9.09	76.32	72.89	74.61	42.85	46.08	44.47
T8	45.16	43.46	44.31	10.12	10.23	10.18	72.05	71.23	71.64	52.22	53.73	52.98
T9	47.54	45.17	46.36	9.3	9.32	9.31	72.52	71.45	71.99	51.48	51.7	51.59
T10	59.24	56.32	57.78	9.67	9.76	9.72	68.45	63.73	66.09	64.92	64.59	64.76
T11	59.86	59.52	59.69	9.18	9.21	9.2	69.23	65.72	67.48	58.63	60.98	59.81
T12	60.59	59.12	59.86	8.56	8.64	8.6	78.23	79.19	78.71	40.04	40.74	40.39
T13	61.82	59.63	60.73	8.88	8.92	8.9	77.23	76.29	76.76	41.86	42.63	42.25
T14	58.58	57.12	57.85	9.04	9.06	9.05	72.63	72.95	72.79	48.32	50.48	49.4
T15	62.55	57.6	60.08	8.89	8.94	8.92	73.07	72.63	72.85	47.94	48.22	48.08
T16	57.48	55.03	56.26	10.06	10.12	10.09	71.82	70.9	71.36	58.74	59	58.87
T17	44.41	41.46	42.94	10.61	10.69	10.65	67.88	62.75	65.32	65.43	67.37	66.4

T18	63.85	63.44	63.65	8.99	9.02	9.01	79.47	76.04	77.76	44.29	45.56	44.93
T19	59.1	53.97	56.54	9.18	9.23	9.21	72.02	71.86	71.94	50.48	51.78	51.13
CD value	2.08	2.06	1.91	0.34	0.88	0.47	2.00	2.21	1.91	1.81	1.76	1.73
S.Ed (±)	1.02	1.02	0.94	0.17	0.43	0.23	0.98	1.09	0.94	0.89	0.87	0.85

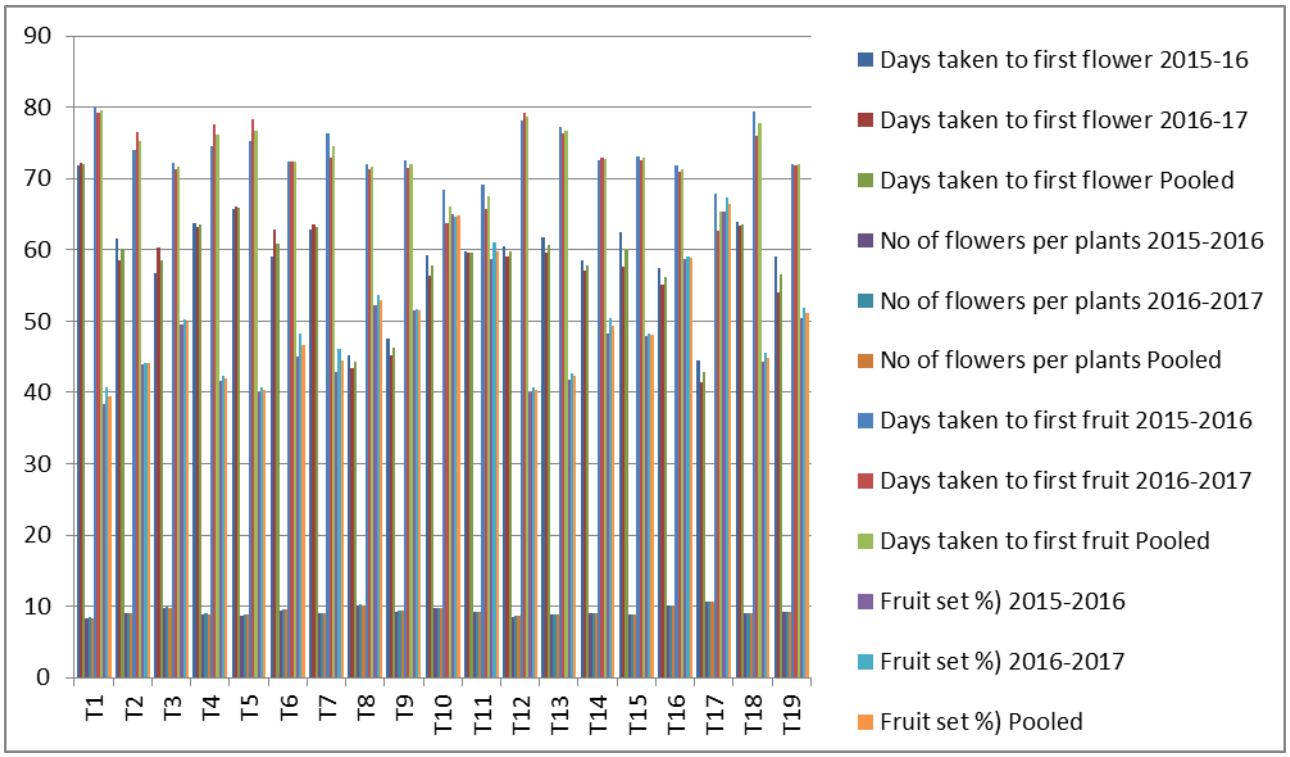
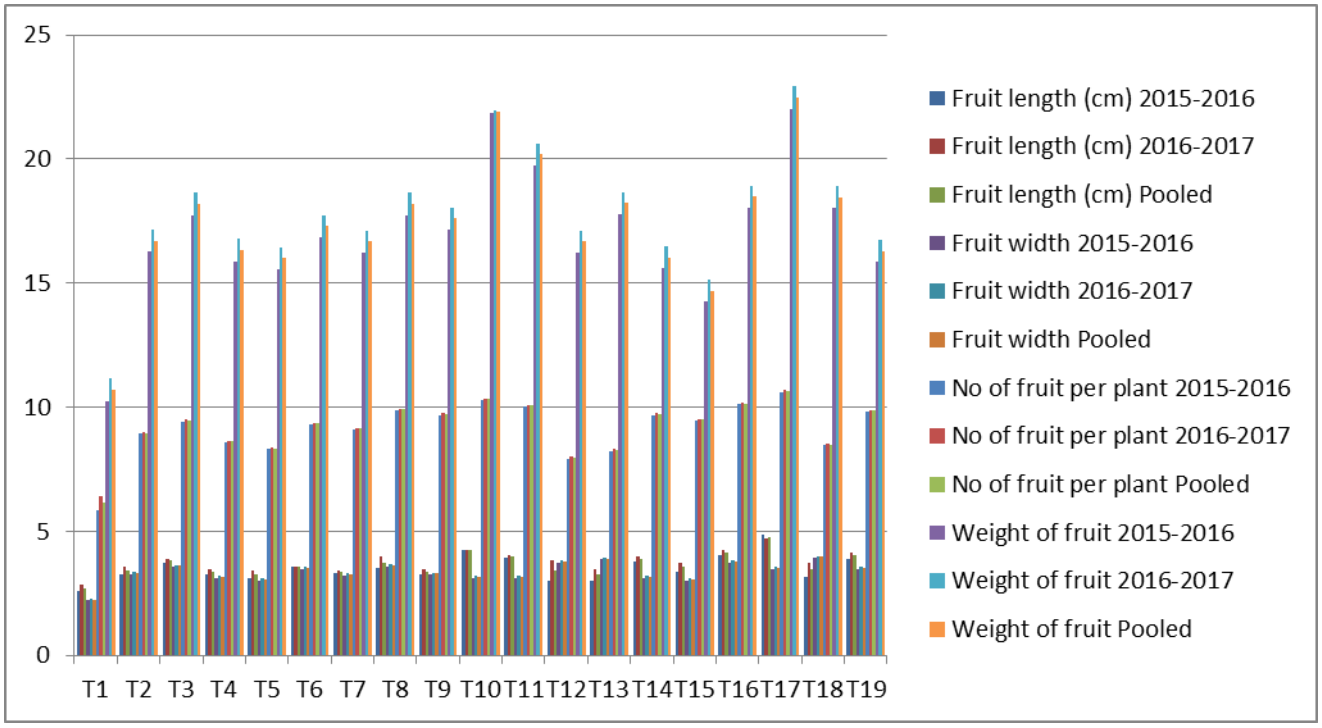


Table 2.

Treatment	Fruit length (cm)			Fruit width (cm)			No of fruit per plant			Weight of fruit (g)		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T1	2.57	2.86	2.72	2.22	2.28	2.25	5.86	6.42	6.14	10.25	11.14	10.7
T2	3.27	3.57	3.42	3.26	3.35	3.3	8.92	8.99	8.96	16.26	17.15	16.71
T3	3.75	3.86	3.81	3.56	3.65	3.61	9.43	9.51	9.47	17.75	18.64	18.2
T4	3.24	3.49	3.37	3.11	3.2	3.15	8.58	8.66	8.62	15.89	16.78	16.34
T5	3.12	3.4	3.26	3.02	3.1	3.06	8.32	8.37	8.35	15.56	16.45	16.01
T6	3.56	3.59	3.58	3.45	3.55	3.5	9.32	9.38	9.35	16.86	17.75	17.31
T7	3.32	3.4	3.36	3.23	3.32	3.27	9.11	9.16	9.14	16.24	17.13	16.69
T8	3.52	3.98	3.75	3.56	3.66	3.61	9.87	9.93	9.9	17.74	18.63	18.19
T9	3.26	3.46	3.36	3.25	3.34	3.29	9.69	9.76	9.73	17.16	18.05	17.61
T10	4.23	4.22	4.23	3.12	3.21	3.16	10.29	10.36	10.33	21.85	21.98	21.92
T11	3.96	4.03	4	3.11	3.2	3.15	10.03	10.09	10.06	19.75	20.64	20.2
T12	3.01	3.85	3.43	3.75	3.85	3.8	7.92	8	7.96	16.24	17.13	16.69
T13	3.02	3.46	3.24	3.89	3.91	3.9	8.21	8.3	8.26	17.78	18.67	18.23
T14	3.79	3.97	3.88	3.12	3.21	3.16	9.68	9.75	9.72	15.59	16.48	16.04
T15	3.35	3.74	3.55	3.02	3.1	3.06	9.46	9.51	9.49	14.25	15.14	14.7
T16	4.02	4.23	4.13	3.75	3.85	3.8	10.11	10.18	10.15	18.03	18.92	18.48
T17	4.86	4.69	4.78	3.45	3.55	3.5	10.61	10.7	10.66	22.03	22.96	22.5
T18	3.15	3.74	3.45	3.95	3.99	3.97	8.47	8.53	8.5	18.01	18.9	18.46
T19	3.88	4.16	4.02	3.45	3.55	3.5	9.84	9.89	9.87	15.85	16.74	16.3
CD value	0.35	0.37	0.36	0.31	0.13	0.17	0.73	0.29	0.39	0.64	0.75	0.50
S.Ed (±)	0.17	0.18	0.18	0.15	0.06	0.08	0.36	0.14	0.20	0.32	0.37	0.25



Conclusion

On the basis of present investigation in both successive year 2015-16 and 2016-17, it is concluded that the treatment T_{17} (GA_3 75ppm+ Zinc sulphate 0.4% + Boric acid (0.4%) was found best in terms of flowering and fruiting characters of strawberry. So application of this PGR and Micronutrient combination can be recommended to growers after few more conjunctive trials.

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