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Comparative Study of Planting Time, Growth Regulator and Biofertilizer on Growth, Yield S and Quality of Strawberry Cv Chandler

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ABSTRACT

Climate, growth promoting hormones and soil nutrition are all necessary conditions for the production of any crop. The primary job is also to determine the ideal planting period for optimum crop yield. In order to improve strawberry growth, yield, and quality parameters a field experiment was carried out to evaluate the comparative study of planting time, growth regulator and biofertilizer on growth, yield and quality of strawberry cv Chandler at Horticultural Research Center, Chauras Campus, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand, India, during two growing seasons 2018-19 and 2019-20. The present experiment consists of three factors with a total of 08 treatments which was replicated thrice on strawberry cultivar Chandler at different planting time viz., 15th August, 5th September, 25th September and 15th October with the application of various GA_3 concentration viz., no GA_3 (without application), 50 ppm GA_3, 75 ppm GA_3, 100 ppm GA_3 and with and without treatment with *Azotobacter*. The treatment under15th October planting time, 75 ppm GA_3 concentration with *Azotobacter* was found most effective for most of the growth, yield and quality traits viz.,plant height (34.57 cm), leaf area (104.66 cm^2), number of runners/plant (8.60), days taken to full blooming (202.00), fruit setting % (89.17), days taken to final harvest (214.44), fresh weight of fruit (15.93 g), fruit yield/plant (327.09 g), TSS (9.07 ^{0}Brix), vitamin C (67.70 mg/100g), sugar content (7.08%) and juice content (91.06%) whereas the minimum values for most of the characters was observed with 15th August planting time and without application of GA_3 and *Azotobacter* treatment.

Keywords Biofertilizer, Growth, Plant, Planting, Regulator, Strawberry, Yield.

INTRODUCTION

It is a universal truth that, no diet is nutritious or balanced without the fruits and vegetables. Fruits and vegetables form the most nutritious menu of man and tone up his energy and vigour. They are appreciated for their tempting succulence, pleasing flavor and high nutritive value. Being rich source of various essential substances such as vitamins, minerals, protein and carbohydrates fruits and vegetables are necessary for human health. This fact is more important for a

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country like India, where the majority of the population is vegetarian. For all these reasons the use of fruits and vegetables in the daily diet is essential (Kunte and Yawalker 1980). Fruits are not only good source of food; they are serving as medicine and treat ailments.With diverse soil and climate, India comprising various agro-ecological regions provides ample possibility to grow a variety of fruit crops.

Botanically strawberry is an octaploid (2n=8x=56), dicotyledonous, low growing herb grown in most arable regions of the world and millions of people are enjoyed this in all kinds of climates (Kumar *et al.* 2012). In India, strawberry was introduced in the year of 1766 as an exotic species by Antone Nicholas Duchesne. Although strawberry is cultivated as fruit crop in temperate climate, but it can also profitably be cultivated in tropical hills up to an elevation of 3000 meter and in subtropical regions of India (NHB 2018). In India, it is mainly grown in Maharashtra and in the hills of Himachal Pradesh, J&K and Uttarakhand.

In India, the winter months are when strawberry thrives well and October to November are the ideal months to plant it so that it can finish its life cycle before March. Being a crop for the winter, it must deal with many natural adversities, particularly during flowering and fruiting, such as deficient soil moisture and temperature fluctuations (Sharma *et al.* 2013). Due to the short winters in Srinagar, Garhwal region, strawberry planting season is limited. Additionally, strawberry output is highly influenced by daytime temperature, humidity, and day length. Weather patterns and planting time have a major impact on cultivars, with the latter directly affecting day and night temperatures, day light intensity, and photoperiod, which have an impact on floral induction, fruit size, quality, and output (Zheng *et al.* 2009). As a result, the strawberry planting period is crucial for dividing the assimilates which directly affect strawberry growth and yield (Rahman *et al*. 2014).

Plant growth regulators are the chemical substances modify the growth of plants usually by stimulating part of natural growth regulatory system which when applied in small amounts. Among growth regulators, in the development of morphological characters of plants and their fruits, gibberellic acid plays a vital role. To influence the seed germination, plant growth, development, flowering and fruit characters, gibberllins is used. These growth regulators can also be used to produce fruits in an environmentally friendly and sustainable manner. Additionally, strongly encourage using fewer artificial fertilizers (Katel *et al*. 2022).

Therefore, it is essential to consider the use of alternative sources of safe fertilizers that could increase crop yield sustainably without harming soil qualities or creating environmental hazards, as well as lower cultivation costs (Kumar *et al.* 2019). In order to increase the quality and quantity of internal resources while minimizing external inputs and maximizing outputs, biofertilizers are regarded as an environmentally friendly and fiscally viable option. By increasing the quantity and biological activity of desired microorganisms in the root environment, these biofertilizers, which are meant for seed or soil application, serve as carriers for beneficial microorganisms in a viable state and aid in plant development (Gabr *et al.* 2001).

The prerequisite of any crop production is the climatic factors as well as growth promoting hormones and nutritional level of soil. Therefore, the major task is to find out the appropriate planting time to get maximum crop yield. So, the combined use of optimum planting time, growth hormones and bio-fertilizers very effective to enhance the growth, yield and quality parameters of strawberry because, the optimum planting time provides the required temperature, light intensity, photoperiod, intercepted photosynthetically active radiation and soil temperature. While, the GA_3 enhance the cell division, rapid multiplication of meristematic cells, reduce the dormancy, increase the flowering and fruiting capacity. On the other hand, *Azotobacter* improve the availability of essential nutrients, synthesized the essential plant growth hormones. Therefore, keeping the above facts under consideration, the present investigation was focused on comparative study of planting time, growth regulator and biofertilizer on growth, yield and quality of strawberry cv Chandler.

MATERIALS AND METHODS

A field experiment was conducted during two consecutive seasons of 2018-19 and 2019-20, at Horticultural Research Center, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand to examine the comparative effect of various planting time, growth regulator and biofertilizer on growth, yield and quality of Strawberry cv Chandler. The experiment was laid out in three-factor experimental design consisting of four different planting time viz., 15thAugust, 5th September, 25th September and 15th October applied with four GA_3 concentration viz., no GA_3 concentration, 50 ppm, 75 ppm and 100 ppm GA_3 concentration and plant with and without treatment with *Azotobacter* which were arranged in a Factorial Randomized Block Design with three replications. Geographically, the Horticultural Research Center, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand, is situated at Alaknanda Valley between 780 46' 56" E longitude and 300 13' 7" N latitude, right in the heart of Garhwal region 132 km away from Haridwar on Haridwar-Badarinath Dham Highway at an elevation of 540 m above MSL, in the lesser Himalayan region. Runners of Strawberry cv Chandler was planted in well prepared raised beds of 3.24 m^2 covered with black polyethylene mulch at 60 x 45 cm spacing within the holes. GA_3 was applied thrice; first spray after 30 days of planting and rest of the spray was applied at 15 days interval as per treatment combinations. The runners were cultured with *Azotobacter* before planting. The *Azotobacter* was diluted in jaggery solution and then the runners were dipped in the solution. All the agronomic practices recommended for the successful crop growth were followed and time to time irrigation was given to maintain the proper moisture in the field for better growth and development of the plants. Five plants from each treatment were randomly selected and tagged for recording the following observations viz., plant height, leaf area, number of runners per plant, days taken to full blooming, fruit setting %, days taken to final harvest, fresh weight of fruit, fruit yield per plant, TSS, vitamin C, sugar content and juice content. The data were analyzed according to the procedure of analysis for factorial Randomized Block Design (RBD) given by (Cochran and Cox 1992).The significance of variation among the treatments was observed by applying ANOVA and least significant differences (LSD) test at 1% and 5% level was calculated to compare the mean values of treatments for all the characters.

RESULTS AND DISCUSSION

The data presented in Tables 1– 3 and depicted in

Table 1. Comparative study of planting time, growth regulator and biofertilizer on growth characters of strawberry cv Chandler.

Treatments		Plant height (cm)			Leaf area (cm^2)			Number of runners per plant			Days taken to full blooming		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
	G_0A_0	20.41	21.73	21.07	88.08	92.99	90.54	3.49	3.90	3.69	170.31	172.23	171.27
	G_0A_1	21.49	22.48	21.98	88.75	93.80	91.28	3.82	4.07	3.94	175.32	177.48	176.40
	G_1A_0	25.37	27.90	26.63	95.45	97.09	96.27	4.22	4.86	4.54	182.55	184.35	183.45
D_1	G_1A_1	27.51	30.50	29.01	98.11	101.24	99.68	4.85	5.01	4.93	188.54	190.11	189.33
(15th	G_2A_0	30.7	33.91	32.30	102.11	102.09	102.10	6.12	6.72	6.42	193.37	195.17	194.27
August)	G_2A_1	31.60	34.14	32.87	104.21	105.11	104.66	7.59	8.10	7.84	199.56	201.08	200.32
	G_3A_0	26.35	29.45	27.90	96.43	99.75	98.09	5.85	5.99	5.92	184.53	187.31	185.92
	G_3A_1	29.14	32.66	30.90	99.20	101.19	100.20	6.69	7.08	6.88	190.68	192.04	191.36
	G_0A_0	19.91	21.89	20.90	87.18	89.34	88.26	3.00	3.70	3.35	164.94	167.76	166.35
	G_0A_1	20.48	22.75	21.62	88.39	90.80	89.60	3.62	4.05	3.83	170.32	173.14	171.73
	G_1A_0	23.18	25.59	24.38	93.47	96.40	94.94	4.75	4.94	4.84	175.42	177.87	176.64
D_2	G_1A_1	23.74	26.68	25.21	95.72	97.75	96.74	4.72	4.98	4.85	180.78	182.90	181.84
(5th	G_2A_0	26.76	28.90	27.83	96.48	98.53	97.51	5.59	5.98	5.78	190.13	193.00	191.56
September)	G_2A_1	27.28	30.05	28.66	97.53	99.74	98.64	6.88	7.03	6.95	195.01	197.10	196.05
	G_3A_0	26.28	30.59	28.44	95.57	98.47	97.02	6.00	6.50	6.25	180.52	182.90	181.71
	G_3A_1	26.68	31.08	28.88	96.44	99.90	98.17	6.44	7.01	6.72	185.52	188.20	186.86
	G_0A_0	19.22	23.18	21.20	85.15	88.09	86.62	3.28	4.05	3.66	165.37	166.34	165.86
	G_0A_1	20.26	24.05	22.16	88.11	89.28	88.70	3.75	4.18	3.96	168.49	170.62	169.55

Table 1. Continued.

Treatments		Plant height (cm)			Leaf area (cm^2)			Number of runners per plant			Days taken to full blooming		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
	G_1A_0	22.49	26.51	24.50	92.53	93.47	93.00	4.36	5.05	4.7	182.55	184.97	183.76
D_3	G_1A_1	23.52	27.05	25.28	93.27	94.08	93.68	5.05	5.90	5.47	185.37	187.93	186.65
(25^{th}	G_2A_0	25.84	30.91	28.37	95.58	97.69	96.64	5.59	6.50	6.04	192.62	194.05	193.33
September)	G_2A_1	27.30	31.33	29.32	96.83	98.76	97.80	7.07	7.90	7.48	195.34	197.13	196.24
	G_3A_0	25.28	31.13	28.21	94.77	99.72	97.25	5.88	5.96	5.92	180.37	182.93	181.65
	G_3A_1	26.17	31.85	29.01	95.88	100.38	98.13	6.72	7.16	6.94	186.48	189.14	187.81
	G_0A_0	20.45	23.50	21.97	86.13	87.90	87.02	3.52	4.10	3.81	160.43	165.57	163.00
	G_0A_1	22.66	23.44	23.05	87.01	88.50	87.76	4.11	4.96	4.53	166.31	168.87	167.59
D_4	G_1A_0	26.52	28.58	27.55	93.67	94.61	94.14	5.34	6.06	5.70	180.74	183.500	182.12
(15^{th}	G_1A_1	27.61	29.67	28.64	95.08	96.24	95.66	7.30	7.88	7.59	185.97	189.00	187.48
October)	G_2A_0	31.12	34.05	32.58	98.23	99.94	99.09	6.85	7.30	7.07	195.82	198.52	197.17
	G_2A_1	33.11	36.02	34.57	99.42	101.02	100.22	8.25	8.95	8.60	200.00	204.00	202.00
	G_3A_0	27.32	30.31	28.81	93.15	96.10	94.63	7.18	7.80	7.49	186.53	188.88	187.70
	G_3A_1	30.27	33.22	31.75	95.74	100.73	98.24	7.54	8.00	7.77	190.55	193.37	191.96
SEm ±		**0.06**	**0.06**	**0.09**	**0.34**	**0.06**	**0.06**	**0.39**	**0.15**	**0.07**	**0.06**	**0.33**	**0.23**
CD at 5%		**0.16**	**0.16**	**0.26**	**0.97**	**0.16**	**0.16**	**1.09**	**0.45**	**0.19**	**0.19**	**0.92**	**0.65**

Table 2. Comparative study of planting time, growth regulator and biofertilizer on yield characters of strawberry cv Chandler.

Treatments		Fruit setting %			Days taken to final harvest			Fresh weight of fruit (g)			Fruit yield per plant (g)		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
	G_0A_0	53.33	53.72	53.52	180.45	178.22	179.33	4.18	5.86	5.02	50.52	60.50	55.51
	G_0A_1	55.26	56.32	55.79	188.51	189.62	189.06	4.92	6.06	5.49	58.19	70.60	64.40
	G_1A_0	66.64	67.400	67.02	191.62	195.04	193.33	5.23	7.05	6.14	79.12	92.07	85.59
D_1	G_1A_1	69.76	70.67	70.22	199.62	203.56	201.59	5.77	8.28	7.02	86.25	100.50	93.38
(15^{th}	G_2A_0	72.14	75.49	73.81	205.64	209.44	207.54	8.20	9.48	8.84	150.24	160.39	155.31
August)	G_2A_1	75.74	77.29	76.52	212.75	216.13	214.44	9.10	10.93	10.02	174.67	175.64	175.16
	G_3A_0	69.42	70.28	69.85	198.68	202.08	200.38	7.52	9.03	8.27	148.12	150.47	149.30
	G_3A_1	71.25	72.43	71.84	204.37	208.40	206.39	7.52	9.99	8.75	155.25	158.92	157.08
	G_0A_0	56.75	57.75	57.25	178.81	177.17	177.99	4.54	6.06	5.30	60.13	80.12	70.13
	G_0A_1	58.50	59.83	59.16	182.53	183.41	182.97	5.14	6.95	6.04	70.12	91.52	80.82
	G_1A_0	62.35	63.60	62.98	186.35	190.51	188.43	6.29	7.80	7.05	95.55	110.32	102.93
D_2	G_1A_1	64.92	66.05	65.49	193.56	196.46	195.01	6.98	8.54	7.76	112.13	130.50	121.31
(5^{th}	G_2A_0	75.66	77.79	76.73	200.19	203.14	201.67	9.25	10.22	9.74	146.38	181.77	164.07
September)	G_2A_1	80.27	82.51	81.39	208.38	212.01	210.20	10.05	11.47	10.76	184.52	200.91	192.72
	G_3A_0	77.21	77.38	77.30	192.37	195.45	193.91	7.22	9.10	8.16	149.54	167.05	158.30
	G_3A_1	78.51	79.77	79.14	197.66	200.47	199.06	7.62	10.04	8.83	152.23	181.18	166.71
	G_0A_0	59.27	61.27	60.27	172.22	170.20	171.21	5.15	7.02	6.09	77.14	90.78	83.96
	G_0A_1	61.32	63.12	62.22	174.38	175.35	174.87	5.29	7.87	6.58	94.37	105.32	99.85
	G_1A_0	65.64	66.21	65.93	190.47	194.75	192.61	6.35	8.20	7.28	152.56	177.85	165.21
D_3	G_1A_1	68.31	69.76	69.03	193.31	197.11	195.21	6.94	8.95	7.95	165.75	192.88	179.32
(25^{th}	G_2A_0	80.44	80.69	80.56	201.29	205.26	203.28	10.47	11.04	10.76	184.14	201.86	193.00
September)	G_2A_1	83.46	84.40	83.93	206.14	210.04	208.09	12.21	13.02	12.62	212.32	253.38	232.85
	G_3A_0	79.40	80.21	79.81	189.32	193.46	191.39	9.98	10.19	10.08	178.16	192.51	185.33
	G_3A_1	80.20	81.51	80.86	195.47	199.46	197.46	10.31	11.08	10.70	189.12	200.89	195.01
	G_0A_0	65.29	65.17	65.23	169.11	171.16	170.14	5.64	8.54	7.09	103.34	150.48	126.91
	G_0A_1	68.26	70.17	69.22	175.97	178.70	177.34	6.01	9.86	7.94	150.12	183.38	166.75
D_4	G_1A_0	73.50	75.03	74.27	191.18	195.38	193.28	7.85	10.58	9.21	187.67	222.37	205.02
(15^{th}	G_1A_1	78.34	79.723	79.03	195.36	198.26	196.81	8.03	11.15	9.59	200.37	251.40	225.89
October)	G_2A_0	83.88	85.14	84.51	204.19	209.38	206.79	13.53	14.61	14.07	213.18	279.93	246.56
	G_2A_1	88.66	89.68	89.17	209.33	213.23	211.28	15.34	16.52	15.93	298.56	355.63	327.09
	G_3A_0	78.89	80.14	79.52	195.44	200.09	197.77	12.51	13.03	12.77	202.16	244.41	223.29

Table 2. Continued.

Treatments	Fruit setting %			Days taken to final harvest			Fresh weight of fruit (g)			Fruit yield per plant (g)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
G_3A_1	81.20	83.33	82.26	199.22	203.50	201.36	14.04	14.52	14.28	253.64	288.89	271.27
SEm ±	**0.18**	**0.28**	**0.20**	**0.22**	**0.17**	**0.54**	**0.05**	**0.02**	**0.24**	**2.76**	**2.91**	**4.71**
CD at 5%	**0.50**	**0.80**	**0.56**	**0.63**	**0.47**	**1.51**	**0.14**	**0.07**	**NS**	**7.80**	**8.23**	**13.32**

Table 3. Comparative study of planting time, growth regulator and biofertilizer on quality characters of strawberry cv Chandler.

Treatments		TSS (^{0}Brix)			Vitamin C (mg/100g)			Sugar content (%)			Juice content (%)		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
	G_0A_0	6.02	6.52	6.27	52.28	53.78	53.03	5.020	5.21	5.12	80.12	81.05	80.59
	G_0A_1	6.12	6.70	6.41	53.30	53.92	53.61	5.050	5.29	5.17	80.98	81.99	81.49
	G_1A_0	6.58	6.92	6.75	55.78	55.98	55.88	5.513	5.60	5.56	84.32	84.61	84.47
D_1	G_1A_1	7.00	7.04	7.02	56.24	57.07	56.65	5.550	5.77	5.66	85.52	86.22	85.87
(15^{th}	G_2A_0	7.01	7.16	7.08	58.69	59.32	59.00	5.970	6.01	5.99	89.17	90.17	89.67
August)	G_2A_1	7.25	7.60	7.43	59.67	60.03	59.85	5.990	6.05	6.02	90.58	91.54	91.06
	G_3A_0	6.87	7.07	6.97	57.22	58.15	57.69	5.480	5.62	5.55	88.27	89.01	88.64
	G_3A_1	6.91	7.14	7.03	57.55	59.29	58.42	5.370	5.87	5.62	89.32	90.05	89.69
	G_0A_0	6.03	6.61	6.32	53.22	54.23	53.72	5.030	5.23	5.13	81.72	82.04	81.88
	G_0A_1	6.15	6.82	6.48	53.64	55.03	54.34	5.040	5.40	5.22	82.58	82.94	82.76
	G_1A_0	6.47	6.98	6.72	54.15	56.04	55.10	5.510	5.78	5.64	88.34	89.35	88.85
D_2	G_1A_1	6.67	7.06	6.86	55.38	56.93	56.15	5.920	5.99	5.95	89.57	90.14	89.86
(5^{th}	G_2A_0	7.04	7.24	7.14	58.34	59.04	58.69	6.000	6.10	6.05	87.32	88.24	87.78
September)	G_2A_1	7.37	7.64	7.50	60.12	60.45	60.29	6.340	6.44	6.39	88.67	89.52	89.10
	G_3A_0	6.87	7.16	7.01	57.13	58.02	57.58	5.540	5.84	5.69	79.52	80.60	80.06
	G_3A_1	7.02	7.21	7.12	58.92	59.11	59.01	5.980	6.01	5.99	80.28	83.48	81.88
	G_0A_0	6.06	7.01	6.54	55.57	56.04	55.80	5.050	5.50	5.27	85.52	86.23	85.88
	G_0A_1	6.38	7.26	6.82	56.34	57.15	56.74	5.087	5.58	5.33	86.33	86.91	86.62
	G_1A_0	6.94	7.97	7.46	58.14	59.10	58.62	5.470	5.99	5.73	89.92	90.08	90.00
D_3	G_1A_1	6.99	8.18	7.59	58.96	59.96	59.46	5.920	6.14	6.03	90.01	91.03	90.52
(25^{th}	G_2A_0	7.23	8.34	7.78	60.32	60.86	60.59	6.040	6.32	6.18	86.54	88.32	87.43
September)	G_2A_1	7.97	8.96	8.46	62.53	64.67	63.60	6.550	6.90	6.72	88.31	89.06	88.69
	G_3A_0	7.03	8.00	7.51	59.17	59.82	59.50	5.820	6.04	5.93	78.00	80.44	79.22
	G_3A_1	7.34	8.19	7.77	59.31	60.46	59.88	5.930	6.21	6.07	78.22	83.82	81.02
	G_0A_0	6.37	7.06	6.71	56.34	57.01	56.67	5.090	5.89	5.49	79.35	80.24	79.80
	G_0A_1	6.59	7.57	7.08	58.32	58.67	58.49	5.350	5.98	5.66	84.52	85.43	84.98
D_4	G_1A_0	6.890	8.06	7.47	60.34	61.12	60.73	5.810	6.15	5.98	85.13	85.94	85.54
(15^{th}	G_1A_1	7.05	8.53	7.79	60.58	62.40	61.49	6.050	6.57	6.31	86.41	87.07	86.74
October)	G_2A_0	7.98	8.97	8.47	65.37	67.35	66.36	6.620	6.98	6.80	88.26	89.16	88.71
	G_2A_1	8.52	9.62	9.07	66.51	68.89	67.70	6.970	7.19	7.08	89.17	90.08	89.63
	G_3A_0	7.27	8.47	7.87	61.38	63.01	62.20	6.013	6.56	6.29	87.97	88.62	88.30
	G_3A_1	7.81	9.02	8.41	61.89	65.29	63.59	6.510	6.95	6.73	88.59	89.98	89.29
SE m±		**0.04**	**0.02**	**0.12**	**0.03**	**0.04**	**0.21**	**0.02**	**0.02**	**0.05**	**0.18**	**0.08**	**0.30**
CD at 5%		**0.11**	**0.05**	**NS**	**0.09**	**0.10**	**0.60**	**0.06**	**0.07**	**0.15**	**0.52**	**0.22**	**0.83**

Figs. 1–3 strongly strongly revealed that there was a significant ($P<0.05$) effect of date of planting, GA_3 concentrations and *Azotobacter* on horticultural traits of strawberry plants.

The strawberry plants planted on 15^{th} October (D_4) proved to be superior to all other GA_3 and *Azotobacter* treatments by achieving the highest values of plant height (34.57 cm), leaf area (104.66 cm^2), number of runners/plant (8.60), days taken to full blooming (202.00), fruit setting % (89.17), days taken to final harvest (214.44), fresh weight of fruit (15.93

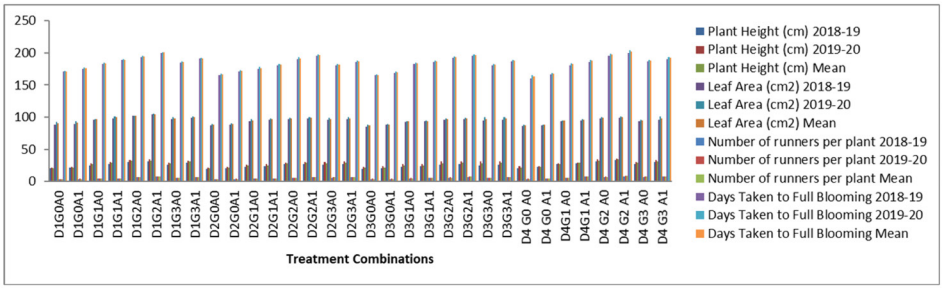

Fig. 1. Comparative study of planting time, growth regulator and biofertilizer on growth characters of strawberry cv Chandler.

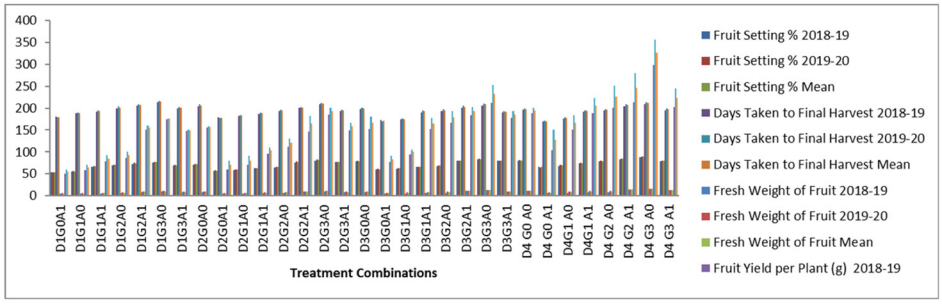

Fig. 2. Comparative study of planting time, growth regulator and biofertilizer on yield characters of strawberry cv Chandler.

g), fruit yield/plant (327.09 g), TSS (9.07^{0}Brix), vitamin C (67.70 mg/100g), sugar content (7.08 %) and juice content (91.06%). On the other hand, D_1 (15th August planting) showed minimum values for most of the growth, yield and quality characters viz., fruit setting % (53.33), fresh weight of fruit (4.18 g), fruit yield/plant (50.52 g), TSS (6.02 ^{0}Brix), vitamin C (52.28 mg/100g), sugar content (5.02 %).

The maximum growth, yield and quality traits of strawberry cv Chandler was observed during 15th October planting time. Planting time has direct effect on day and night temperature, day light intensity and photoperiod, which affect the floral induction, fruit size, quality and production. Because 90 to 95% of a plant's dry weight is derived from photosynthesis (Biscoe and Gallagher 1978). Similar results were also found by Kher *et al*. (2010), they reported that plant height, leaf area, fresh fruit weight, fruit yield and runners per plant were significantly higher in

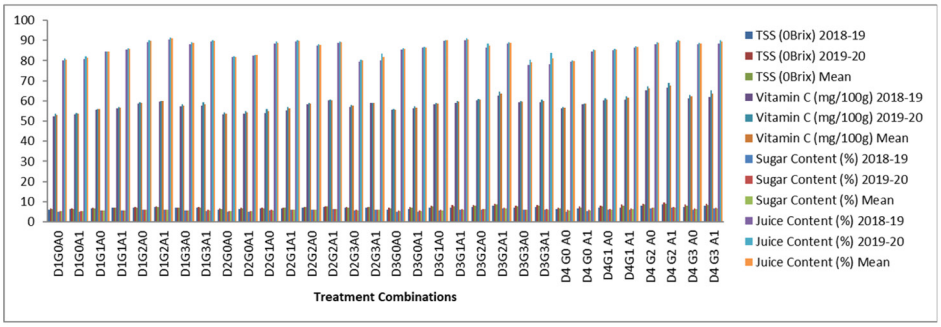

Fig. 3. Comparative study of planting time, growth regulator and biofertilizer on quality characters of strawberry cv Chandler.

October planting than plants planted on other dates. This result at different planting dates was due to the temperature differences together with other environmental factors.

Under the present study, GA_3 concentrations significantly increased the plant height, leaf area and plant spread over control. Among different GA_3 concentrations, G_2 (GA_3 @ 75 ppm) showed the maximum plant height, leaf area and plant spread of the plants. The maximum increase in plant height and spread of strawberry cv Chandler in this treatment might be due to fact that gibberellins regulate the growth of strawberry plants by causing cell elongation in plant systems. These results are in conformity with Pathak (1971). This could be due to fact that gibberellins increased the cell division, cell elongation and a corresponding increase in epidermal and parechyma's cell length. Present findings are in accordance with the findings of Saima *et al.* (2014) and Saravanan *et al.* (2013).

The increase in vegetative growth and other parameters might be due to the production of more chlorophyll content with inoculation of nitrogen fixers. The other reason for increased vegetative growth may be the production of plant growth regulators by microorganism in rhizosphere, which are absorbed by the roots. Therefore, increased vegetative growth may be attributed to the increased biological nitrogen fixation (Mohandas 1987).Whereas production of growth regulators by the *Azotobacter* in the root zone which gets absorbed by the plant roots that results the increasing in leaf area which has been reported by (Rana and Chandel 2003).Obtained results from the present experiment were in the line of experiment conducted by (Singh and Singh 2009) and (Tanuja and Rana 2019) on strawberry.

CONCLUSION

From the above mention findings, it could be concluded that the treatment combination $D_4G_2A_1$ (15^{th} October planting, 75 ppm GA_3 and with *Azotobacter*) was found most effective to obtain the highest values for most of the growth, yield and quality contributing characters of strawberry cv Chandler under Srinagar Garhwal condition.

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