academicJournals

Vol. 6(3), pp. 31-37, April, 2014
DOI: 10.5897/JHF2014.0337
Article Number: 07C506344184
ISSN 2006-9782

http://www.academicjournals.org/JHF

Journal of Horticulture and Forestry

Full Length Research Paper

Interactive influence of planting date and cultivar on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.)

M. Moshiur Rahman

Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701, Bangladesh.

Received 6 January, 2014; Accepted 13 March, 2014

Interactive effect of four planting dates viz. 1-September, 1-October, 1-November and 1-December with five promising strawberry cultivars viz. Sweet Charlie, Festival, Camarosa, FA 008 and BARI strawberry-1 were studied under subtropical climatic conditions of Bangladesh during the period of winter 2009-10 and 2010-11. Among the interactions, the cultivar Camarosa planted on 1 September exhibited the tallest plants (35.67 cm) followed by Festival (30.67 cm) planted on same date while plants of BARI Strawberry-1 had the shortest plants (14.67 cm) planted on 1 December. The highest number of leaves plant^{-1} (55.33) was obtained in Festival followed by Camarosa (52.33) when planted on 1 September, while plants of FA 008 produced lowest (23.00) leaves plant^{-1} when planted on 1 December. Plants of Festival planted on 1 September exhibited maximum mortality percent (21.33%) followed by Camarosa (20.00%) and Sweet Charlie (19.67%) planted on same date. On the other hand, plants of BARI Strawberry-1 planted on 1 December exhibited only 4% of plant mortality. Among the cultivar studied, Sweet Charlie planted on 1 October produced the highest yield per hectare (16.77 ton), while BARI Strawberry-1 when planted on 01 December planting produced the lowest per hectare (2.247 ton). Total soluble solids (TSS) and ascorbic acid content of fruits were highly influenced by interaction effect of date of planting and cultivar and found that regardless of cultivar, fruits of early planted plants contained more TSS and ascorbic acid than late planted plants.

Key words: Strawberry, sub-tropical region, planting date, total soluble solids, ascorbic acid.

INTRODUCTION

There is substantial evidence that genetic factors control the growth, yield and fruit quality in strawberry (Avigdori-Avidov, 1986), but the cultivars are significantly influenced by the weather conditions, and planting time (Zheng et al., 2009). 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. However, there are several reports available in the literature indicating that strawberry can be planted on different times of the year depending on the variety, location and climates (Sharma and Sharma, 2004). So, planting time of strawberry is important for partitioning the assimilates, which directly influence the growth and yield of strawberry. Rahman et al. (2014) observed that in strawberry, delayed planting significantly reduced the yield. According to Anna et al.

E-mail: moshiur.bari@yahoo.com. Tel: +88029261667, +880201716838586.

(2003) for successful strawberry cultivation, time of planting plays a very significant role and its optimization is prerequisite.

The temperature in Bangladesh starts decreasing from the second half of October, thus allowing the active growth of plants. This favourable growing period lasts until the end of February, after it starts rising (Ahmad and Uddin, 2012). So, a very short growing season is available for strawberry cultivation in Bangladesh that extends from October to April (Ahmad and Uddin, 2012). In Bangladesh, strawberry is usually planted in second fortnight of November with traditional methods, which restricts its fruiting season for 45 to 60 days only. Furthermore, higher profitability and productivity of strawberry are being taken in many countries either through manipulating planting time or with the use of different cultivars. However, tuning of planting time and selection of suitable cultivars are the important ways of achieving higher yield of strawberries. But, such agro-techniques have not yet been standardized in Bangladesh. Hence, the present study was conducted to study the interactive effect of planting date on growth yield and quality of selected strawberry cultivars.

MATERIALS AND METHODS

Experiment site

The studies were conducted at the Fruit Research Farm of Horticulture Research Centre of Bangladesh Agricultural Research Institute (Latitude 23°59′ N, Longitude 90°24′ E, Altitude 14.33 m), Gazipur, Bangladesh during winter season of 2009-2010 and 2010-2011. Monthly mean weather data during the winter season of 2009-2010 and 2010-2011 was shown in Appendix (Table A1). This region falls in sub-tropical zone having hot summers (May-August) and mild winter (December-February). Cumulative rainfall of about 119 mm during August to May with average 82.9% relative humidity. The mean maximum and minimum temperature during cropping period were 26.29 and 15.75°C, respectively. Soil of the experimental farm was clay loam, having pH 6.2 (slightly acidic), which was low in organic carbon (0.95%), very low in available phosphorus (9 ppm) and low in potash (0.17 meq/100 g soil).

For execution of the objective five cultivar viz., Sweet Charlie, Festival, Camarosa, FA 008 and BARI Strawberry-1 were selected and four planting dates viz., 1-September, 1-October, 1- November and 1-December were attempted.

Experimental design and layout

The experiment was conducted in a strip-plot design with three replications. Four time of planting viz. 1-September, 1-October, 1-November and 1-December were assigned in main strip plot and five cultivars viz. Sweet Charlie, Festival, Camarosa, FA 008 and BARI Strawberry-1 were in sub strip plot of the experiment. The unit plot size was 100 × 600 cm and the plants were spaced 50 × 40 cm on beds. Single bed was used as single treatment. Beds were raised 30 cm above main field with 50 cm drain in-between 2 beds. Each plot contained double row accommodating 30 plants. Daughter plants of different strawberry cultivars were planted in 01 September, 01 October, 01 November and 01 December, 2009 and 2010.

Intercultural operations

Runners were removed at every 3 to 4 days intervals in order to make the crown capable to initiate flowers. Straw 2 to 3 cm think mulch was applied around the plants as a normal practice in order to conserve soil moisture, decreasing weed and to provide healthy condition for the fruits. Weeds were removed whenever necessary to keep the crop weed free. Irrigation was given whenever necessary to keep the soil moisture available in the field for better plant growth. All other necessary cultural practices and plant protection measures were followed uniformly for all the plots and treatments during the entire period of experimentation.

Harvesting

Strawberries were harvested by hand picking during early in the day while environment was cool, at an interval of 3 to 4 days and handled very carefully. The fruits were harvested at commercial maturity when >80% of the fruit surface turned red colour. Immediately after harvest, strawberries were sorted to eliminate damaged fruit, and selected for uniform size and colour for collecting data.

Observations recorded

Data were collected from inner plants from each row to avoid border effect. In each unit plots twenty plants were selected randomly for recording data on different morphological, vegetative, yield and chemical attributes. The data were recorded on the following parameters- plant height (cm), leaves per plant, yield (t ha^{-1}), total soluble solid (TSS) and ascorbic acid contents of fruit.

Data analysis

Two year's data on different morphological, vegetative, reproductive, yield contributing and chemical attributes were pooled and analyzed, following strip-plot design using MSTAT-C program. The mean comparison was done following the Duncan's multiple range test (DMRT).

RESULTS

Plant height

Plant height of different strawberry cultivars was significantly influenced by interaction effect of planting time and cultivars of strawberry (Table 1) and found that, plants of Camarosa and Festival planted on 01 September (35.67) had the maximum plant followed by Camarosa planted on 01 October (30.67 cm), while minimum plant height was recorded from BARI Strawberry-1 planted on 01 December (14.67 cm).

Leaves per plant

Significant influence was observed in number of leaves $plant^{-1}$ in different strawberry cultivars with time of planting. The trend of performance of cultivars against the four planting times was more or less similar (Table 1).

Table 1. Interaction effect of planting date and cultivars on plant height, number of leaves and plant mortality in strawberry.

Treatment	Plant height (cm)	Leaves plant^{-1} (No.)	Plant mortality (%)
1 Sep. x Sweet Charlie	27.00^{b-d}	45.00^{b}	19.67^{a-c}
1 Sep. x Festival	30.67^{b}	55.33^{a}	21.33^{a}
1 Sep. x Camarosa	35.67^{a}	52.33^{a}	20.00^{ab}
1 Sep. x FA 008	22.67^{e-g}	39.67^{b-d}	16.67^{d-f}
1 Sep. x BARI Strawberry-1	22.33^{e-g}	39.67^{b-d}	17.00^{de}
1 Oct. x Sweet Charlie	24.67^{c-f}	38.33^{b-d}	14.33^{gh}
1 Oct. x Festival	28.67^{bc}	41.33^{bc}	18.00^{cd}
1 Oct. x Camarosa	30.67^{b}	39.00^{b-d}	19.00^{bc}
1 Oct. x FA 008	21.00^{f-h}	33.00^{d-f}	11.33^{ij}
1 Oct. x BARI Strawberry-1	20.00^{g-i}	33.00^{d-f}	10.33^{jk}
1 Nov. x Sweet Charlie	21.33^{f-h}	33.00^{d-f}	13.00^{hi}
1 Nov. x Festival	23.00^{d-g}	35.00^{c-e}	15.00^{fg}
1 Nov. x Camarosa	26.00^{c-e}	34.00^{de}	16.00^{e-g}
1 Nov. x FA 008	19.33^{g-j}	28.33^{e-g}	8.33^{l}
1 Sep. x BARI Strawberry-1	16.67^{i-k}	28.67^{e-g}	8.00lm
1 Dec. x Sweet Charlie	17.33^{h-k}	25.33^{g}	6.33^{mn}
1 Dec. x Festival	15.00^{k}	26.33^{fg}	8.33^{l}
1 Dec. x Camarosa	21.67^{fg}	25.00^{g}	9.33^{kl}
1 Dec. x FA 008	15.67^{jk}	23.00^{g}	5.00^{no}
1 Dec. x BARI Strawberry-1	14.67^{k}	23.33^{g}	4.00^{o}
Level of significance	**	**	**
CV (%)	**8.03**	**5.00**	**5.80**

Figures having the same letter(s) in a column do not differ significantly by DMRT. Level of significance: ** and * means significant at 1 and 5% level, respectively.

In every month, the cultivar Festival performed well and produced large number of leaves plant^{-1}, while FA 008 produced small number of leaves. Plants of Festival planted on 01 September had the highest number of leaves (55.33) followed by Camarosa planted on same time (52.33) and those were statistically similar, while plant of FA 008 planted on 01 December had the lowest number of leaves plant^{-1} (30.67).

Plant mortality (%)

Plant mortality in different strawberry cultivars was significantly influenced by time of planting and the highest plant mortality was recorded in Festival, Camarosa and Sweet Charlie planted on 01 September (21.33, 20.00 and 19.67%, respectively) which was statistically alike. Whereas, BARI Strawberry-1 and FA 008 planted on 01 December exhibited the lowest effect (4.00 and 5.00%, respectively) shown in Table 1.

Yield (ton per hectare)

Among all the planting time, the cultivar Sweet Charlie produced the maximum yield (16.77 t ha^{-1}) which was at par with Festival (15.17 t ha^{-1}) when planted on 01 October followed by Festival (15.17 t ha^{-1}) planted on the same date, while BARI Strawberry-1 produced the minimum yield (2.247 t ha^{-1}) when planted on 01 December (Table 2).

Total soluble solids

Total soluble solids (TSS) was highly influenced by the interaction of time of planting and cultivars and varied significantly. The cultivar Camarosa contained the maximum of 8.63% TSS in 01 September planting followed by 8.47% in 01 October planting, while FA 008 had only 6.27% TSS in 01 December planting (Table 2).

Ascorbic acid content

The cultivar Sweet Charlie and Festival planted on 01 September had the maximum ascorbic acid content (80.50 mg 100 g^{-1}) followed by Sweet Charlie (79.67 mg 100 g^{-1}), Festival (79.33 mg 100 g^{-1}) planted on 01 October, while BARI Strawberry-1 had the minimum

Table 2. Interaction effect of planting date and cultivars on yield, and fruit quality of strawberry.

Treatment	Yield ha^{-1} (ton)	TSS (%)	Ascorbic acid (mg 100 g^{-1})
1 Sep. x Sweet Charlie	5.657^{gh}	7.57^{f}	80.50^{a}
1 Sep. x Festival	11.383^{c}	8.33^{bc}	80.50^{a}
1 Sep. x Camarosa	10.473^{cd}	8.63^{a}	75.50^{de}
1 Sep. x FA 008	8.907^{de}	7.07^{i}	73.67^{ef}
1 Sep. x BARI Strawberry-1	5.340^{gh}	6.83^{j}	66.00^{hi}
1 Oct. x Sweet Charlie	7.743^{ef}	7.50^{fg}	79.67^{ab}
1 Oct. x Festival	16.770^{a}	8.00^{d}	79.33^{a-c}
1 Oct. x Camarosa	15.170^{a}	8.47^{ab}	73.17^{f}
1 Oct. x FA 008	13.403^{b}	6.73^{jk}	72.17^{fg}
1 Oct. x BARI Strawberry-1	6.930^{fg}	6.60^{kl}	65.00^{hi}
1 Nov. x Sweet Charlie	4.790^{h}	7.30^{gh}	77.33^{cd}
1 Nov. x Festival	9.393^{de}	7.80^{de}	78.17^{bc}
1 Nov. x Camarosa	10.613^{cd}	8.30^{bc}	72.83^{fg}
1 Nov. x FA 008	9.627^{d}	6.53^{kl}	72.00^{fg}
1 Sep. x BARI Strawberry-1	4.637^{h}	6.43^{lm}	64.00^{i}
1 Dec. x Sweet Charlie	2.247^{i}	7.10^{hi}	79.00^{a-c}
1 Dec. x Festival	3.920^{hi}	7.60^{ef}	75.67^{de}
1 Dec. x Camarosa	4.770^{h}	8.23^{c}	72.00^{fg}
1 Dec. x FA 008	4.787^{h}	6.27^{m}	71.00^{g}
1 Dec. x BARI Strawberry-1	2.413^{i}	**	**
Level of significance	**	**3.22**	**2.23**
CV (%)	**8.99**		

Figures having the same letter(s) in a column do not differ significantly by DMRT. Level of significance: ** and * means significant at 1 and 5% level, respectively.

ascorbic acid content (65.47 mg 100 g^{-1}) in 01 December planting (Table 2).

DISCUSSION

Plant height and number of leaves

The interaction effect of time of planting and cultivars was significant (Table 1). Singh et al. (2007) found maximum crown height and number of leaves in strawberry plants in early (mid September) planting perhaps because of congenial climatic conditions, which were favourable for growth and development of plants. Thus, availability of low temperature, high relative humidity and low light intensity for plants of mid-October and mid-November planting in our study might have favoured good growth in the plants of strawberry cultivars. In every planting time, the cultivar Camarosa performed well and attained the maximum plant height as well as produced large number of leaves plant^{-1}, while FA 008 exhibited the shortest plant and produced the less number of leaves plant^{-1}. Strawberry is temperature and day length sensitive plant. The flower initiation in Bangladesh started at last week of November. According to Pérez-de-Camacaro et al. (2002) the reproductive development may antagonize vegetative growth of strawberry. So, later planted plants might have less time for plant height and leaf production.

Plant mortality (%)

The earlier planted plants of Festival, Camarosa and Sweet Charlie revealed higher plant mortality (Table 1) perhaps because the cultivar Festival, Camarosa and Sweet Charlie are exotic and less adaptive to Bangladesh conditions. On the other hand, during September the climatic condition of Bangladesh are unfavorable to strawberry. During early planting time high temperature coupled with high moisture content accelerated disease infection and enhanced plant mortality. Similarly Lee et al. (2005) stated that damage caused by mites, thrips and powdery mildew increased with increasing duration of the high temperature period.

Yield

Significant influence of cultivars and planting time was observed on yield plant^{-1} as well as yield per hectare

(Table 2). The difference in yield plant^{-1} due to planting time might be the differences in growing environment and in vegetative growing phase, which was supported by Chandler et al. (1991). The cultivar Sweet Charlie performed well and produced the maximum fruit per hectare and was at par with Festival when planted on 1-October, while BARI Strawberry-1 produced the minimum yield on 01 December planting (Table 2). Chercuitte et al. (1991) reported that 'Kent' cultivar produced the highest yield in 8-May planting and the lowest in 1-August planting. Menzel and Smith (2011) stated that planting date affected yield in nearly all cases. Cropping was generally best when the stock was planted in early to mid-October, which is equivalent to the stock planted in early to mid-April in southeastern Queensland. In most cases, 01 October planted plants produced higher fruit yield than the plants planted in other three planting time, which might be due to 01 October planted plants acquired more favourable growing condition before fruiting. On the other hand, 01 September planted plants required 16 days more for flowering than 01 October planted plants due to unfavourable environment, which led to produce large number of leaves during reproductive phase; these leaves acted as sink. While 01 November and 01 December planted plants got less time for optimum vegetative growth, which might have led to less yield. This statement was supported by Chercuitte et al. (1991) and Menzel and Smith (2011). Chandler et al. (1991) found that 'FL-4925' planted on 01 October produced the highest yield followed by 'Oso' planted on the same date, while 'Dover' planted on 01 October produced the lowest yield, which was partially in agreement with present findings. According to Chercuitte et al. (1991) careful consideration must be given to optimization of correlated vegetative characters and yield components. The poor performance was attributed to failure to produce an adequate number of flowers.

Total soluble solids and ascorbic acid content

Total soluble solids (TSS) and ascorbic acid content of fruits were highly influenced by interaction effect of time of planting and cultivars (Tables 2) and found that fruits of early planted plants contained more TSS and ascorbic acid than late planted plants might be due to the fruits from early planted plants had more exposure to favourable environment, and got enough time for sugar and acid accumulation, which resulted in high TSS and ascorbic acid content than those of late planted plant. The trend of cultivars performance against four planting time was more or less similar. Rahman et al. (2014) stated that fruits of early planted plants contained more TSS and ascorbic acid due to exposure under favourable environment. Capocasa et al. (2008) indicated that the effect of the cultivar on strawberry nutritional quality was stronger than that of the cultivation conditions. Due to the onset of spring, the fruit development was very fast in plants of later plantings, which might have resulted in accumulation of lesser sugars or other quality parameters than fruit of mid-September planting, which got sufficient time for development (Singh et al., 2007; Rahman et al., 2014). The fruits of late planted plants were more exposed to high temperature which obstructed TSS and ascorbic acid content in strawberry fruits, this might be due to high temperature had negative effect on fruit quality in strawberry (Hassan et al., 2000).

Conclusion

Considering vegetative growth, plant mortality, yield and quality of fruits 1-October planting was found to be most suitable for strawberry cultivation under subtropical conditions of Bangladesh. From this observation, Sweet Charlie was found to be most superior and considered best for early planting, while Festival and Camarosa were found to be suitable for late plantings.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Ahmad AR, Uddin ASMM (2012). Strawberry production in Bangladesh. In: Book of Abstracts. Yun-tao Zhang (ed.). VII International Strawberry Symposium, ISHS, Beijing, China. P. 29.

Anna D, Tapichino G, Incalcalerra G (2003). Influence of planting time and runner order on strawberry plug plants grown under plastic tunnels. Acta Hortic. 614(1):123-129.

Avigdori-Avidov H (1986). Strawberry. In: Handbook of fruit set and development. S P Monselise (ed.). Boca Raton, CRC Press. USA. pp. 419-448.

Capocasa F, Scalzo J, Mezzetti B, Battino M (2008). Combining quality and antioxidant attributes in the strawberry: The role of cultivar. Food Chem. 111:872-878. http://dx.doi.org/10.1016/j.foodchem.2008.04.068

Chandler CK, Albregts EE, Howard CM (1991). Planting time affects early season Strawberry production in West Central Florida. Proc. Fla. State Hortic. Soc. 140:227-228.

Chercuitte L, Sullivan JA, Desjardins YD, Bedard R (1991). Yield potential and vegetative growth of summer-planted strawberry. J. Am. Soc. Hortic. Sci. 116(6):930-936.

Hassan GI, Godara AK, Jitender K, Huchche AD, Kumar J (2000). Effect of different mulches on the yield and quality of 'Oso Grande' strawberry (*Fragaria x ananassa*). Indian J. Agric. Sci. 70(3):184-185.

Lee JN, Lee JG, Lee EH, Ryu SY, Yeoung YR, Pak HY (2005). Growth response on ever-bearing strawberry for off-season production in highlands. Korean J. Hort. Sci. Technol. 23(2):153-158.

Menzel CM, Smith L (2011). Effect of time of planting, plant size, and nursery-growing environment on the performance of 'Festival' strawberry in a subtropical environment. Hort. Technol. 21(1):56-66.

Pérez de Camacaro ME, Camacaro GJ, Hadley P, Battey NH, Carew JG (2002). Pattern of growth and development of the strawberry cultivars Elsanta, Bolero and Everest. J. Am. Soc. Hortic. Sci. 127(6):901-907.

Rahman MM, Rahman MM, Hossain MM, Khaliq QA, Moniruzzaman M (2014). Effect of planting time and genotypes on growth, yield and quality of strawberry (Fragaria x ananassa Duch.). Scientia Hortic. 167:56-62. http://dx.doi.org/10.1016/j.scienta.2013.12.027

Sharma RR, Sharma VP (2004). Plant growth and albinism disorder in different strawberry cultivars under Delhi condition. Indian J. Hort. 61(1):92-93.

Singh R, Sharma RR, Goyal RK (2007). Interactive effects of planting time and mulching on 'Chandler' strawberry (*Fragaria x ananassa* Duch.). Scientia Hortic. 111:344-351. http://dx.doi.org/10.1016/j.scienta.2006.11.002

Zheng J, Yang B, Tuomasjukka S, Ou S, Kallio H (2009). Effects of latitude and weather conditions on contents of sugars, fruit acids, and ascorbic acid in black currant (*Ribes nigrum* L.) juice. J. Agric. Food Chem. 57(7):2977-2987. http://dx.doi.org/10.1021/jf8034513 PMid:19265382

APPENDIX

Table A1. Monthly mean weather data during the crop growing periods of strawberry at BARI, Gazipur, Bangladesh.

Year	Month	Temperature (°C)		Relative humidity (%)	Cumulative Rainfall (mm)
		Maximum	Minimum		
2009-2010	August	27.69	22.01	87.22	463
	September	27.93	21.84	86.88	144
	October	26.79	19.30	86.31	157
	November	25.91	15.32	80.77	15
	December	21.67	11.24	79.75	00
	January	20.10	9.35	79.25	00
	February	23.89	11.51	71.49	15
	March	28.37	17.84	66.55	12
	April	25.94	21.21	77.46	42
	May	28.33	20.89	78.46	234
2010-2011	August	27.69	22.40	84.93	185
	September	26.78	21.91	87.73	64
	October	27.05	20.80	85.16	110
	November	25.33	16.04	80.88	02
	December	21.84	11.29	79.86	53
	January	22.64	10.22	81.65	00
	February	23.64	13.42	69.33	06
	March	28.54	16.87	67.49	15
	April	28.42	21.09	76.48	55
	May	28.77	18.66	85.31	74

Source: Physiology Division, Bangladesh Rice Research Institute, Joydebpur, Gazipur-1701, Bangladesh.