

Strawberry regeneration and assessment of runner quality in subtropical plains

R.M. Sharma^{1*}, A.K. Singh², Sushil Sharma³, F.A. Masoodi⁴ and Uma Shankar⁵

¹Division of Fruit Science, S.K. University of Agricultural Sciences and Technology, Jammu-180009. ²Department of Horticulture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand. ³Division of Agricultural Engineering, S.K. University of Agricultural Sciences and Technology, Jammu-180009. ⁴Institute of Home Science, University of Kashmir, ⁵Division of Entomology, S.K. University of Agricultural Sciences and Technology, Jammu-180009, India. *E-mail: rmsharma345@gmail.com

Abstract

Strawberry (*Fragaria x ananassa* Duch.) is one of the most important soft fruits and its cultivated area has increased significantly during the last few years in subtropics but the margin of profit is reduced due to lack of runnering caused by high temperature and high light intensity. The objective of the study was to exploit the possibility of its regeneration in subtropical areas by moderating the effect of high temperature and light intensity through the use of shading nets. Of the 4 shading levels, use of 50% shading tended to produce highest number of runners in Chandler (11.44/plant) and Oso Grand (16.33/plant) cultivars. The runners produced under shadings (25-75%) were significantly vigorous in respect of number of leaves (8.38/plant), leaf area (69.70 cm²), crown diameter (13.49 mm) and root length (11.26 cm) but the highest root dry matter (6.37 g/plant) was observed in the runners produced under 0% shading. In the plants regenerated under subtropical conditions, shadings resulted higher survival rate, early cropping, longer picking duration, higher fruit yield and average fruit weight than the plants raised under 0 % shedding in subtropical as well as temperate areas. The use of 50% shading treatment during regeneration tended to increase the picking duration (44.70 days), fruit yield (278.08 g/plant) and fruit weight (14.22g) of strawberries. The runners of Chandler excelled over Oso Grand statistically in respect of picking duration and fruit yield.

Key word: Shading, light, plant growth, runner production, survival, crop duration

Introduction

The strawberry has become a choicest crop of growers of subtropical areas, and being grown commercially around the various cities of northern India owing to its attractive appearance, unique taste, availability of fresh fruits during the period of fresh fruits scarcity in the market, short duration nature, high return per unit area, twice earnings in a year (through fruits during spring and runners during autumn) and wider acceptability of its processed products. Around Jammu city (J&K State) alone, the area under this fruit crop has been increased from 1.5 ha (2002-03) to 40 ha (2006-07), and the Strawberry Growers Associations are operative for its organized cultivation and marketing. Although, it is a quick and high return giving fruit crop, the margin of profit in strawberry cultivation under subtropical areas is greatly reduced due to regular annual investment (Rs 0.60 lakhs/ha) by the growers for the procurement of runner plants in every planting season (October) from temperate areas, as high temperature (>35 °C) and intense light following fruit harvesting restrict the runnering as well as survival of mother plants in these areas (Sharma and Yamdagni, 2000).

Light plays an important role in the environment, controlling the process associated with dry matter accumulation, and thus contributing to plant growth. The species adaptive plasticity to solar radiation depends on the adjustment of the photosynthesis apparatus, in order to render radiant energy conversion in carbohydrates highly efficient, and consequently, to promote

higher growth (Vilela and Ravetta, 2000). The chemical manipulation has shown the possibility of strawberry runner production to some extent in warmer areas (Sharma *et al.*, 2005), however, stunted runner growth due to high temperature and intense light ultimately affect the yield potential of runner plant. So keeping in view, the compulsion of dependence of strawberry growers for runner plants on temperate areas, to make them self sustainable for economic strawberry cultivation in subtropical plains, the present study was undertaken to improve the runner production capacity of strawberry cultivars by moderating the effect of high temperature and intense light through shadings during hot parts of the growing season and subsequently to assess the runners quality in relation to field survival, picking duration and fruit yield after their planting in fruiting beds.

Materials and methods

The present study was conducted at Udheywalla Research Farm of Division of Fruit Science of SKUAST-Jammu (32.39° N latitude, 74.54° longitude and 332 m altitude) during 2003 (October)- 2005 (May) under randomized block design with five replications. One hundred plants were taken per treatment per replication for recording the data. The whole programme of study was divided into two experiments. In first experiment, Chandler and Oso Grand cultivars were propagated under different shading treatments (0, 25, 50 and 75% of full sunlight) by using green coloured shade nets. In second experiment, the runners produced under subtropical climate were compared

with the runners procured from temperate areas for their field survival and yield potential. In the month of October (2003), the runner plants of both varieties were planted at Udhaywalla (Jammu) and allowed to produce fruits throughout the spring season (2004) and in the last week of April, they were covered with different shading nets for runner production till September, and the fresh plantings were done in 3rd week of October to study their performance and comparison in respect of fruiting of runners with the temperate runners procured from Advanced Centre for Horticulture Development, Ramban (J&K). All growth parameters were measured at the end of growing season, while the data pertaining to fruiting were recorded during subsequent fruiting seasons (spring, 2005). The mean values of average temperature, relative humidity and sunshine hours along with their ranges relating to experimental sites during the period of experimentation are given in Table 1.

Table 1. General weather conditions of experimental site (mean of 3 years)

Month	Average temperature in °C (range)	Relative humidity in per cent (range)	Sunshine hours (range)
January	10.7 (1.2-24.2)	81.7 (33-100)	4.3 (0.0-9.2)
February	14.6 (0.6-28.9)	76.1 (27-99)	5.4 (0.0-9.9)
March*	20.3 (5.4-33.8)	68.2 (29-100)	7.0 (0.0-11.6)
April*	25.5 (9.6-40.0)	53.3 (17-93)	6.7 (0.0-11.6)
May**	27.8 (14.0-43.8)	44.8 (13-95)	8.8 (0.0-12.3)
June**	31.7 (17.6-46.5)	53.6 (20-98)	8.3 (0.0-11.4)
July**	29.5 (20.5-39.6)	74.5 (37-99)	7.0 (2.1-11.1)
August***	28.9 (21.3-36.2)	81.5 (52-99)	4.0 (0.0-11.0)
September***	27.5 (17.0-36.2)	78.0 (44-98)	6.4 (1.2-9.8)
October****	22.9 (9.0-34.0)	67.5 (34-100)	6.1 (0.0-9.3)
November	18.1(5.1-30.0)	67.3 (30-98)	6.0 (0.0-9.2)
December	14.6 (0.6-27.2)	70.8 (22-99)	5.0 (0.0-8.4)

*Peak harvesting period; **Peak runnering period; ***Individual runner growth; ****Planting time

Root length of runner plants was measured with a scale, while leaf area was recorded with leaf area meter (Systronics, 211). Root dry matter was measured by subtracting the weight of dried root

from fresh root weight. The percentage of runners survival after planting was calculated one month after transplanting. The fruit yield per plant was recorded by adding the amount of total fruit weight harvested at different pickings.

Results

Runner production and vigour: The data pertaining to runner production and runner growth of Chandler and Oso Grand cultivars under various shading levels is given in Table 2. Oso Grand cultivar was better than Chandler producing 11.47 and 8.21 runners per plant, respectively. The number of runners per plant tended to increase significantly with the shading levels registering its highest value (13.89 runners per plant) with 50 % shading and declined thereafter. Chandler cultivar proved superior statistically in respect of average leaf area (68.91 cm²) and root dry matter (5.86 g per plant) over Oso Grand, however, both the cultivars were found statistically similar in respect of number of leaves per plant, crown diameter and petiole length.

The shading levels significantly influenced the runner growth, and the highest values for number of leaves (8.38 per plant), leaf area (66.73 cm²) and crown diameter (13.49 mm) were registered with shading level of 50 %, while highest root length (11.26 cm) and root dry matter (6.37 g) was registered with 75 and 0 % shading, respectively. The shading levels from 25-75 % proved statistically at par in respect of number of leaves, crown diameter and leaf area while, 0-50 and 50-75 % shading levels proved similar statistically in respect of root dry matter and root length, respectively. The data (Table 2) relating to root growth of runner plants under different shading levels clearly show similarity in varietal performance with respect to root length, while accumulation of dry matter was significantly higher in Chandler (5.86g/plant) than Oso Grand (5.74g/plant). The shading level individually and mutually with cultivar significantly influenced both the parameters relating to root growth during the course of present studies. The runners developed under 75 % shading tended to show the highest root

Table 2. Effect of shading levels on runnering of Chandler and Oso Grand strawberry cultivars

Parameter	Cultivar	Shading level (%)				Mean	LSD ($P=0.05$)		
		0	25	50	75		Cultivar (C)	Shading (S)	C x S
Number of runners/plant	Chandler	5.11	8.23	11.44	8.06	8.21	1.67	2.31	2.86
	Oso Grand	6.02	12.33	16.33	11.21				
	Mean	5.57	10.28	13.89	9.64				
Number of leaves/plant	Chandler	5.11	6.78	8.11	8.06	7.02	NS	1.86	2.31
	Oso Grand	5.73	8.21	8.65	8.13				
	Mean	5.42	7.50	8.38	8.10				
Crown diameter (mm)	Chandler	5.03	11.63	13.33	12.08	10.52	NS	2.64	3.10
	Oso Grand	6.66	11.83	13.65	11.45				
	Mean	5.85	11.73	13.49	11.77				
Leaf area (cm ²)	Chandler	62.33	68.33	72.66	72.33	68.91	2.86	3.42	4.01
	Oso Grand	51.18	65.33	66.73	64.21				
	Mean	57.76	68.83	69.70	68.27				
Root length (cm)	Chandler	6.56	8.28	11.50	11.66	9.50	NS	1.50	2.11
	Oso Grand	6.83	9.50	10.21	10.85				
	Mean	6.60	8.89	10.86	11.26				
Root dry matter (g/plant)	Chandler	6.43	6.21	5.98	4.81	5.86	0.06	0.90	1.20
	Oso Grand	6.30	6.06	5.83	4.78				
	Mean	6.37	6.14	5.91	4.80				

length (11.26 cm) without showing any significant difference with the root length under 50 % shading (10.86 cm). The runner produced under full sunlight (0 % shading) had smallest roots (6.70 cm). On the other hand, root dry matter accumulation showed the reverse trend and its highest value (6.37 g per plant) was noticed under 0 % shading, declined gradually and showed the lowest root dry matter accumulation (4.80 g/plant) under highest shading level *i.e.*, 75 %.

Assessment of runner quality: The performance of runner plants, multiplied under various conditions was tested during the fruiting season (2004 -05) and the relevant data are tabulated in Table 3. The runner plants multiplied under temperate conditions showed the least field survival (72.27 %) while, it was highest (97.31%) with the runners multiplied under 0% shading in subtropical plains. Rest of the shading levels were found statistically similar with respect to field survival of runner plants planted in October during 2004. The runners multiplied under 0% shading in subtropical area took the least number of days (127.89 days) to attain the harvesting stage with availability of fruits for the shortest period (25.72 days) and gave the lowest fruit yield (185.22 g per plant). The average fruit weight was also found to be the lowest (9.42 g) statistically. The plants procured from temperate area took the longest duration (136.17 days) to attain the first harvesting stage but was significantly better than the runners produced under 0% shading in subtropical area in respect of duration of fruit availability (37.14 days), fruit yield (210.43 g per plant) and average fruit weight (11.78 g).

Of the various shading treatments, the days taken to reach the first picking stage increased with the increase of shading level being lowest (132.64 days) with 25 % and highest (134.26 days) with 75 % shading without showing any significant mutual difference. Three shading treatments (25, 50 and 75%) also proved equally effective in respect of picking duration (40.04-41.88 days), however, fruit yield was highest (278.08 g per plant) statistically with 50 % shading and declined thereafter. The average fruit weight was recorded to be the highest (14.22 g) from the runners produced under 50 % shading which also showed similarly with all treatments except the runner produced under 0 % shading in subtropical areas. Chandler cultivar excelled over Oso Grand

statistically in respect of number of days to produce first crop, picking duration, higher fruit yield and average fruit weight.

Discussion

The natural strawberry runner production takes place in temperate areas where average temperature falls between 25-30 °C during growth season. Roberts and Kenworthy (1956) have found temperature range between 20-26 °C to be ideal for proper plant growth. High temperature (40 °C day/35 °C night) has been found more detrimental to photosynthesis and productivity of strawberries than the moderate or low temperatures (30/25 or 25/15 °C). High temperature also markedly reduced the CO₂ assimilation rate (Kadir *et al.*, 2006) and tended to show the high peroxidase isozyme and reduced total protein contents in strawberry leaves (Gulen and Eris, 2004). So the partial interruption of intense light to reduce the scorching effect of high temperature inside the shade house could be the possible reason of profuse runner production under shadings, and the variation in runner production in both the varieties under different shading levels could be the result of varietal specific requirement of shade for best growth.

Engel (1989) recorded highest means in height and leaf area of *Tabebuia avellanae* Lorentz ex Griseb during growth phase at 82 % shading. Neerakal *et al.* (2005) observed increased total dry matter yield, leaf area per plant and specific leaf area of *Adhatoda beddmei* C.B. Clarke cuttings with increasing shade and 60 % shade was found to be optimum. The effect of shade on relative growth rate can be attributed to reduced maintenance respiration and increased leaf growth. While studying the effect of shading levels (0, 30, 60 and 90%) on olive plants, Gregoriou *et al.* (2007) found olive to be adapted well to shade by a small reduction in stomatal and trichome density, palisade parenchyma and significant increase in leaf area. They observed that shade reduced leaf thickness due to the presence of only 1-2 palisade layers and reduced the length of palisade cells and spongy parenchyma. The number of thylakoids in grana as well as in stroma increased as shade increased, while the number of plastoglobuli decreased in proportion to the reduced photosynthetically active radiation.

Generally, the increase of leaf area with shading is one of the ways used to increase photosynthetic surface, ensuring a more efficient

Table 3. Assessment of runner plants propagated under different conditions

Regeneration conditions	Field survival after planting (%)			Days taken for first picking after planting			Duration of picking (days)			Fruit yield (g/plant)			Fruit weight (g/fruit)		
	Chandler	Oso Grand	Mean	Chandler	Oso Grand	Mean	Chandler	Oso Grand	Mean	Chandler	Oso Grand	Mean	Chandler	Oso Grand	Mean
0% shading in temperate areas	74.31	70.23	72.27	140.11	132.23	136.17	37.15	37.12	37.14	210.53	210.33	210.43	12.22	11.33	11.78
0% shading in subtropical area	98.36	96.25	97.31	130.16	125.62	127.89	28.29	23.15	25.72	180.21	190.22	185.22	9.33	9.50	9.42
25% shading in subtropical area	93.21	94.21	93.71	135.11	130.16	132.64	39.92	40.15	40.04	220.56	230.34	225.45	13.36	11.86	12.61
50% shading in subtropical area	93.26	93.83	93.55	132.33	127.23	129.78	44.23	45.16	44.70	275.82	280.34	278.08	15.21	13.22	14.22
75% shading in subtropical area	90.52	90.83	90.68	136.13	132.38	134.20	40.53	43.22	41.88	210.53	215.33	212.93	11.22	10.63	10.93
Mean	89.93	89.07		134.77	129.52		38.02	37.76		219.53	225.31		12.27	11.31	
CD _{0.05}															
Cultivar (C)			NS			2.13			NS			4.36			NS
Regeneration conditions (R)			4.53			4.11			3.22			6.83			1.89
C x R			6.88			6.03			5.83			8.91			3.94

yield in low light intensities, and consequently, compensating the low photosynthetic rates per leaf area, a characteristic of shaded leaves (Jones and McLeod, 1990). Light is considered one of the factors associated with chlorophyll metabolism (Brand, 1997). According to Kramer and Kozłowski (1979), chlorophyll is constantly synthesized and destroyed (photooxydation) in the presence of light. Under intense light, the degenerative process is very active. On the other hand, chlorophyll leaf concentration seems to increase under shading conditions (Brand, 1997) and balance is established under a relative radiation intensity. As per the studies of Wei *et al.* (2006), the petiole length, leaf area, chlorophyll and carotenoid under shading were higher than those of control in Toyonoka strawberry. Shading increased the leaf stomatal conductance (Gs) but the transpiration rate was lower than that of control, which was the result of lower temperature under shading. Shading also decreased the minimal fluorescence (Fo) but promoted the PSII maximal photochemical efficiency, implying that shading might protect integration of the photosynthetic membrane system and photochemical efficiency against the strong light stress.

Young plants of *Garcinia mangostana* L. showed reduced leaf area and higher dry matter translocation to root system under decreasing shading condition (Weibel *et al.*, 1994). Less shaded plants tended to accumulate more dry matter in roots as compared to more shaded area (Alvarenga *et al.*, 2003). They observed the increase in photoreceptors (leaf chlorophyll concentration) in *Croton urucurana* Baill. with the increase of shading, reaching the highest values in plants cultivated under 50 and 70 % shading. The photosynthetic rate was found to be approximately constant under full sunlight and in levels up to 50 % of shading, with a drop in higher levels.

Generally the procurement of plants from temperate areas and subsequently their planting in subtropical areas is minimum 3-4 days long process, hence lead to higher plant mortality than the plants produced and planted in the same conditions located in nearby area with a time difference of few hours. Besides, prolonged transplanting shock (3-4 days) and poor growth of temperate runners (due to short growing season from June – September against May – October in subtropical areas) are the major causes to attain the delayed harvesting stage. The least mortality in plants and earliest crop from runners produced under 0 % shading could be the result of proper acclimatization of planting materials due to similar growing climate. The poor and stunted runner growth due to heat shock in these runner plants could be the possible cause of shortest picking duration and lowest fruit yield. The proper runner growth under shading especially under 50-75 % shading in subtropical areas resulted the higher fruit yield and availability of fruits for longer duration than rest of the treatments tested in the present studies. Vigorous runner growth due to shading treatments and longer growing season in subtropical areas could be the possible reason for prolonged harvesting season and high fruit yield.

The study revealed that strawberry cvs. Oso Grand and Chandler can be successfully regenerated with vigorous runners by growing under 50% light in subtropical areas. Such practice may help to make strawberry cultivation more remunerative under warmer areas by substituting traditional practice of transporting runners from distant temperate places.

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