

Performance of Strawberry (*Fragaria x ananassa* Duch.) in Different Growing Conditions

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ABSTRACT: A field experiment was conducted to evaluate the performance of strawberry (*Fragaria x ananassa* Duch.) in different growing conditions of Kerala. The study was carried at two locations viz., central midlands (altitude of 22.25 m above MSL which enjoys a warm humid tropical climate) and high ranges (altitude of 1000 m above MSL which enjoys a mild subtropical climate). The various growing systems (open-field, greenhouse and fan and pad system) and two time of planting (last week of September planting and last week of October planting) and two mulches (white and black) were evaluated under FRBD with three replications. In central midlands, planting in last week of September with black mulch in fan and pad system resulted in significantly higher plant height (17.70 cm) and plant spread (33.73 cm) and early flowering (55 days). However, systems of growing had no significant influence on number of leaves, number of flowers, number of clusters and yield per plant. In high ranges, planting in the last week of September with black mulch in open field recorded maximum number of leaves (25.73), number of flowers (27), number of clusters per plant (24.4), and highest yield per plant (110.07 g).

Key words: Strawberry, Greenhouse, Fan and pad, Open field, Planting time, Mulch.

INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) is the most refreshing and delicious fruit crop which belongs to the family Rosaceae. The fresh ripe fruits of strawberry are rich source of vitamins mainly vitamin A (60 IU/100g of fruit) and vitamin C (30-120 mg/100g of fruit) and has abundance of minerals like potassium, calcium and phosphorus and has high pectin (0.55 per cent) content (Mitra, 1991). It is the most widely distributed fruit crop due to its genetic diversity, highly heterozygous nature and broad range of environmental adaptations (Larson, 1994; Childers *et al.*, 1995). The major strawberry growing states in India are Jammu and Kashmir, Himachal Pradesh, Maharashtra, Uttarakhand, Haryana, Uttar Pradesh and Punjab. It is among the few fruit crops which give quick and very high returns per unit area on the capital investment, as the crop is ready for harvest within four months of planting. It is cultivated in the temperate and subtropical conditions of India (Singh, 1992; Dhillon, 2005). Kerala is blessed with different agro ecological conditions suitable to various crops.

Therefore, in this study an attempt was made to compare the performance of strawberry under three growing conditions in two agro ecological zones of Kerala viz., central midlands and high ranges.

MATERIALS AND METHODS

The present investigation was carried out at two locations viz., central midlands (College of Horticulture, Vellanikkara, Thrissur, Kerala, 10° 31'N, 76°03'E and 22.25 m altitude, with typical warm humid tropical climate) and high ranges (Krishi Vigyan Kendra, Ambalavayal, Wayanad, Kerala, 11.37°N, 76.12°E and 1000 m altitude, with mild sub-tropical climate) during September 2013 to March 2014. The experiment was laid out in 3x2x2 randomized block design (RBD) with three replications. One month old tissue cultured strawberry variety winter dawn was taken for the study. The treatments comprised of three growing systems viz., open field, greenhouse and fan and pad system, two mulches viz., transparent polyethylene sheet and black polyethylene sheet and two time of planting viz., last week of September and last week of

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October. Twelve raised beds of size 1.5 m x 1 m x 0.3 m were taken in each growing system. FYM @ 10 t ha⁻¹ was applied in the beds taken for planting. N: P: K @ 75:80:50 kg ha⁻¹ was given in two equal splits, first as basal and second 45 days after planting. Double row hill system of planting was done with a spacing of 30 cm x 40 cm. Holes were made on the mulch and planting was done by hand. Ten plants were planted in each plot. Observations were recorded from five randomly selected plants on plant height (cm), number of leaves, plant spread (cm), days to first flowering, number of flowers and number of clusters per plant and yield per plant (g). The details of soils of experimental site were analysed for salient properties following standard methods. The soil was of sandy loam texture having 1.99% organic carbon with pH of 5.7 and sandy clay loam texture having 0.96% organic carbon with pH of 4.95 in central midlands and high ranges respectively.

RESULTS AND DISCUSSION

Central midlands: The growth characters *viz.*, the plant height, number of leaves and plant spread were significantly influenced by growing systems (Table 1). Maximum plant height (17.7 cm) was recorded under fan and pad system. Plants in open field recorded significantly higher number of leaves per plant (63.04). This was in close conformity with Yahya and Atherton (1995) in strawberry, where plants under open field produced more leaves than under shaded condition. Plant spread was recorded maximum in fan and pad system up to 3 month after planting (36.26cm). Among the two time of planting, planting in the last week of September resulted in maximum number of leaves per plant (42.47). Rahman *et al.*, (2014) reported the favorable effect of planting strawberry in the last week of September in the subtropical climate of Bangladesh. Mulch and interactions had no significant influence on growth characters. Among different flowering attributes, early flowering (55.67 days) was recorded under fan and pad system (Table 2). Low temperature prevailing in the fan and pad system advanced the flowering (Table 4). Time of planting had no influence on flowering attributes. Plants mulched with black polyethylene recorded early flowering (57.11 days). This might have been influenced by favorable soil temperature and moisture conditions as influenced by black polyethylene mulch. Positive influence of black mulch on early flowering was reported in strawberry by Pollard and Cundari (1989); Abbott and Gough (1992); Hassan *et al.*, (2000); Singh and Asrey (2005); Singh *et al.*, (2006). Interaction effect between white

mulch and fan and pad system leads to early flowering of strawberry (55 days). There was no significant difference in yield per plant among different growing systems, time of planting and mulches.

High ranges: The growth characters *viz.*, the plant height, number of leaves and plant spread were significantly influenced by growing systems (Table 1). Plants in the greenhouse recorded significantly higher plant height (18.77 cm) and maximum plant spread (31.57 cm) compared to other growing systems. Number of leaves per plant was recorded maximum in open field (32.83). In general, time of planting and mulches had no significant influence on growth characters. Among the flowering attributes, early flowering (40-41 days) was observed irrespective of the system of growing. The favorable temperature, short day condition, high relative humidity prevailing in high ranges might have advanced flowering (Table 2). Significantly higher number of flowers (20.78), number of clusters (17.47) per plant was recorded in open field. Higher number of leaves was observed under open field, which might have influenced the production of maximum number of flowers and clusters per plant. The interactive effect of system of growing and mulch had positive and significant influence on production of maximum number of flowers (25.85) and clusters (21.57) per plant when planted in open field with black mulch mainly because of combined and beneficial effect of use of black polyethylene mulch in open field (Table 3). It may be attributed to synergistic and interactive influence of open field planting and black polyethylene mulch on creation of comparatively favorable environment and better moisture conservation, suppression in weed growth etc., which might have resulted in better flowering attributes (Rajbir *et al.*, 2007). Plants in the open field recorded significantly higher yield (80.35 g). Growing system and mulch interaction had significant influence on yield per plant in high ranges (Table 3). Black mulch in open field resulted in maximum yield (102.17 g). Earlier result indicated that significantly higher number of flowers and clusters were observed in plants planted in open field, mulched with black polyethylene. This might have resulted in higher yield per plant.

CONCLUSION

Results indicated that favorable conditions are prevailing for the growth, flowering and fruit setting of strawberry in central midlands and high ranges of Kerala. In central midlands, strawberry could be planted in last week of September with black or white polyethylene mulch in open field for maximum

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Table 1

Effect of growing systems, time of planting and mulch on plant height (cm), number of leaves and plant spread of strawberry cv. winter dawn at central midlands and high ranges

Treatments		Plant height (cm) Central midlands					Number of leaves Central midlands					Plant spread (cm) Central midlands				
		Months after planting (MAP)					Months after planting(MAP)					Months after planting(MAP)				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Growing systems (S)	S ₁	8.88	10.46	12.42	14.95	17.13	5.83	11.58	26.82	46.06	63.04	11.98	17.11	22.34	28.89	35.40
	S ₂	7.12	8.28	9.45	10.72	11.86	6.83	11.55	17.70	23.30	20.05	17.17	24.13	26.83	30.13	33.26
	S ₃	11.88	13.26	14.63	16.18	17.70	8.25	19.43	25.08	31.35	32.10	23.99	36.48	36.26	36.02	33.73
CD		1.66	1.82	1.86	1.80	1.85	0.81	2.86	3.62	5.66	9.30	2.61	4.92	5.03	NS	NS
Time of planting (P)	P ₁	9.94	11.34	12.78	14.66	16.24	7.99	16.94	26.18	36.73	42.47	18.87	28.11	30.60	33.65	35.60
	P ₂	8.64	9.99	11.55	13.24	14.89	5.96	11.43	20.22	30.41	34.32	16.55	23.71	26.35	29.71	32.66
CD		NS	NS	NS	NS	NS	0.66	2.33	2.96	4.62	7.59	2.13	4.02	NS	NS	NS
Mulch (M)	M ₁	9.33	10.70	12.23	13.94	15.47	6.72	13.92	23.63	35.37	41.93	17.08	25.24	27.49	30.41	33.52
	M ₂	9.26	10.63	12.09	13.95	15.66	7.22	14.46	22.77	31.77	34.86	18.34	26.58	29.45	32.95	34.74
CD		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatments		High range (cm)					High range					High range (cm)				
		Months after planting (MAP)					Months after planting(MAP)					Months after planting(MAP)				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Growing systems (S)	S ₁	10.57	12.67	15.18	16.33	17.22	7.27	11.87	26.42	32.83	23.00	15.48	19.30	23.86	26.35	27.75
	S ₂	11.27	13.67	16.42	17.58	18.77	7.82	10.77	15.95	19.07	13.15	14.85	19.80	24.73	28.43	31.57
	S ₃	6.35	7.67	8.96	10.25	11.13	7.33	8.75	10.07	11.25	7.17	10.30	14.41	17.91	19.85	22.00
CD		1.23	1.20	1.00	1.06	1.09	NS	1.59	3.95	6.25	4.35	1.23	1.79	2.17	2.23	2.49
Time of planting (P)	P ₁	8.97	10.89	13.04	14.61	15.32	7.92	11.69	19.09	22.11	14.20	13.43	17.68	22.49	24.44	26.69
	P ₂	9.82	11.78	14.00	14.83	16.09	7.02	9.23	15.87	19.99	14.68	13.66	17.99	21.84	25.31	27.52
CD		NS	NS	0.03	NS	NS	0.67	1.30	NS	NS	NS	NS	NS	NS	NS	NS
Mulch (M)	M ₁	9.19	11.00	13.28	14.61	15.51	7.40	10.74	16.93	21.17	14.20	14.08	18.23	22.47	24.69	26.93
	M ₂	9.60	11.67	13.76	14.83	15.90	7.54	10.18	18.02	20.93	14.68	13.01	17.44	21.86	25.06	27.28
CD		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.01	NS	NS	NS	NS

Table 2

Effect of growing systems, time of planting and mulch on flowering attributes and yield of strawberry cv. winter dawn at central midlands and high ranges

Treatments		Central midlands				High ranges			
		Days to first flowering	No. of flowers per plant	No. of clusters per plant	Yield per plant (g)	Days to first flowering	No. of flowers per plant	No. of clusters per plant	Yield per plant (g)
		Growing systems (S)	S ₁	62.83	7.15	3.63	32.67	40.00	20.78
	S ₂	56.92	5.45	3.02	23.75	40.83	11.07	8.97	61.27
	S ₃	55.67	7.97	4.17	40.90	40.00	8.69	4.29	41.52
CD		0.59	NS	NS	NS	NS	2.61	2.67	17.49
Time of planting (P)	P ₁	58.39	7.42	3.89	38.19	40.56	13.88	10.57	58.65
	P ₂	58.56	6.29	3.32	26.69	40.00	13.14	9.91	63.45
CD		NS	NS	NS	NS	NS	NS	NS	NS
Mulch (M)	M ₁	59.83	6.11	3.31	27.93	40.00	12.43	2.97	57.92
	M ₂	57.11	7.60	3.90	36.95	40.56	14.60	3.72	64.17
CD		0.84	NS	NS	NS	NS	NS	NS	NS

Table 3
Effect of P x M, S x P, S x M and S x P x M interactions on flowering attributes and yield of strawberry cv. winter dawn at central midlands and high ranges

Treatments		Central midlands				High ranges			
		Days to first flower	No. of flowers per plant	No. of clusters per plant	Yield per plant (g)	Days to first flower	No. of flowers per plant	No. of clusters per plant	Yield per plant (g)
P x M	P ₁ M ₁	59.78	6.47	3.47	31.78	40.00	12.43	9.46	52.76
	P ₁ M ₂	57.00	8.38	4.31	44.59	41.11	15.33	11.69	64.54
	P ₂ M ₁	59.89	5.76	3.16	24.09	40.00	12.42	9.46	63.08
	P ₂ M ₂	57.22	6.82	3.49	29.30	40.00	13.87	10.37	63.81
CD		NS	NS	NS	NS	NS	NS	NS	NS
S x P	S ₁ P ₁	62.50	8.10	4.10	38.09	40.00	20.92	18.83	77.20
	S ₁ P ₂	63.17	6.20	3.17	27.26	40.00	20.65	16.10	83.50
	S ₂ P ₁	57.00	5.30	3.00	27.60	41.67	11.10	8.07	54.87
	S ₂ P ₂	56.83	5.60	3.03	19.90	40.00	11.03	9.87	67.67
	S ₃ P ₁	55.67	8.87	4.57	48.87	40.00	9.63	4.82	43.88
	S ₃ P ₂	55.67	7.07	3.77	32.92	40.00	7.75	3.77	39.17
CD		NS	NS	NS	NS	NS	NS	NS	NS
S x M	S ₁ M ₁	64.83	5.47	2.83	23.27	40.00	15.72	13.37	58.53
	S ₁ M ₂	60.83	8.83	4.43	42.08	40.00	25.85	21.57	102.17
	S ₂ M ₁	58.33	5.30	3.07	19.05	40.00	13.23	10.90	71.87
	S ₂ M ₂	55.50	5.60	2.97	28.45	41.67	8.90	7.03	50.67
	S ₃ M ₁	56.33	7.57	4.03	41.48	40.00	8.33	4.10	43.36
	S ₃ M ₂	55.00	8.37	4.30	40.31	40.00	9.05	4.48	39.69
CD		0.84	NS	NS	NS	NS	3.70	3.78	24.62
S x P x M	S ₁ P ₁ M ₁	64.67	6.27	3.20	25.60	40.00	14.83	13.27	44.33
	S ₁ P ₁ M ₂	60.33	9.93	5.00	50.58	40.00	27.00	24.40	110.07
	S ₁ P ₂ M ₁	65.00	4.67	2.47	20.94	40.00	16.60	13.47	72.73
	S ₁ P ₂ M ₂	61.33	7.73	3.87	33.57	40.00	24.70	18.73	94.27
	S ₂ P ₁ M ₁	58.33	4.80	2.87	22.15	40.00	13.33	10.53	65.33
	S ₂ P ₁ M ₂	55.67	5.80	3.13	33.05	43.33	8.87	5.60	44.40
	S ₂ P ₂ M ₁	58.33	5.80	3.27	15.94	40.00	13.13	11.27	78.40
	S ₂ P ₂ M ₂	55.33	5.40	2.80	23.85	40.00	8.93	8.47	56.93
	S ₃ P ₁ M ₁	56.33	8.33	4.33	47.59	40.00	9.13	4.57	48.61
	S ₃ P ₁ M ₂	55.00	9.40	4.80	50.15	40.00	10.13	5.07	39.15
S ₃ P ₂ M ₁	56.33	6.80	3.73	35.37	40.00	7.53	3.63	38.11	
S ₃ P ₂ M ₂	55.00	7.33	3.80	30.47	40.00	7.97	3.90	40.23	
CD		NS	NS	NS	NS	NS	NS	NS	NS

Table 4
Weather parameters

Monthly mean temperatures (°C) during the period from September 2013 to March 2014 in different growing systems

Month	Open (S ₁)				Green house (S ₂)				Fan and pad (S ₃)			
	Central midlands		High ranges		Central midlands		High ranges		Central midlands		High ranges	
	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm
September 2013	23.84	28.88	19.58	25.09	24.59	31.98	19.38	26.19	22.89	26.90	18.93	24.28
October 2013	24.25	29.98	19.90	25.18	25.07	32.10	19.81	26.43	23.73	27.58	19.02	24.41
November 2013	25.15	31.62	19.60	25.95	26.23	33.84	19.64	27.72	24.78	29.18	18.49	25.01
December 2013	23.60	31.83	18.01	26.35	25.90	33.38	18.12	28.06	21.39	30.45	20.10	24.17
January 2014	24.24	32.16	17.51	27.63	26.62	33.41	17.57	29.95	21.74	30.01	19.69	28.18
February 2014	24.10	33.61	18.21	28.45	26.11	34.98	18.40	30.61	21.84	31.85	20.03	28.69
March 2014	25.75	34.47	20.28	30.66	28.30	37.13	20.38	31.46	23.59	31.66	21.85	28.86
Mean	24.42	31.79	19.01	27.04	26.12	33.83	19.04	28.63	22.85	29.66	19.73	26.23

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Monthly mean relative humidity (per cent) during the period from September 2013 to March 2014 in different growing systems

Month	Open (S_1)				Green house (S_2)				Fan and pad (S_3)			
	Central midlands		High ranges		Central midlands		High ranges		Central midlands		High ranges	
	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm	8.00 am	2.30 pm
September 2013	94.73	68.39	94.80	73.24	92.21	72.47	97.82	73.15	92.32	79.83	92.78	80.33
October 2013	95.87	69.68	95.32	78.16	92.94	71.68	98.32	79.16	92.55	80.19	93.32	84.16
November 2013	86.63	59.73	94.50	72.26	80.63	62.13	97.50	73.26	84.77	73.77	92.50	79.23
December 2013	75.97	49.90	90.71	61.39	74.00	51.94	93.71	63.61	77.68	65.16	88.71	68.71
January 2014	64.71	39.13	94.77	58.19	62.48	45.29	97.77	61.19	66.06	58.68	92.77	66.19
February 2014	72.36	42.75	96.23	59.19	71.46	45.32	98.87	62.19	74.29	54.50	93.87	67.19
March 2014	76.35	38.74	89.68	52.23	76.29	43.87	93.16	58.90	77.84	54.06	88.16	63.90
Mean	80.95	52.62	93.72	64.95	78.57	56.10	96.74	67.35	80.79	66.60	91.73	72.82

Monthly mean light intensity (lux) during the period from September 2013 to March 2014 in different growing systems

Month	Open (S_1)		Green house (S_2)		Fan and pad (S_3)		Central midlands	High ranges
	Central midlands	High ranges	Central midlands	High ranges	Central midlands	High ranges		
September 2013	79878.50	93500.30	7384.82	9056.00	14053.37	18380.00	344.1	193.4
October 2013	80512.9	94158.06	7474.84	9375.00	14300.00	18487.10	369.8	15.6
November 2013	88926.67	93603.23	8481.67	9076.13	16696.67	18435.16	82.0	42.2
December 2013	93864.52	107597.42	8708.07	10153.55	17493.55	20855.16	0.5	2.4
January 2014	88803.23	103014.19	8006.45	9452.55	16574.19	20179.03	0.0	0
February 2014	74882.14	88817.42	6753.57	8900.97	14232.14	17942.58	0.0	5.2
March 2014	79083.87	86400.32	7270.97	8590.97	15277.42	18141.29	0.0	7.2

number of leaves and early flowering. In high ranges, strawberry could be planted in last week of September with black polyethylene mulch in open field for maximum number of leaves, flowers, clusters and yield per plant. Yield obtained from high ranges is 8 t/ha and from central midlands is 3.3 t/ha when compared to national average is 4.5-10 t/ha.

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