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Screening of strawberry (*Fragaria ×ananassa*) varieties under organic production system for Kashmir valley*

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Strawberry (*Fragaria ×ananassa* Duch.) is one of the most important soft fruits acclaimed for its refreshing characteristics, aroma, lucrative appearance and good nutritive values. Among the fruits and vegetables strawberry ranked highest in health-promoting antioxidants and folate. Antioxidants help combat the damaging effects of free radical activity to cellular structures and DNA, whereas folate is important for protein metabolism and formation of red blood cells. They are also rich in vitamin C and silicon making them very useful for arterial and all connective tissue repairs and help strengthen the teeth and gums. The presence of ellagic acid prevents cancer and occurrence of heart disease. Temperate climatic conditions of Kashmir valley offers immense potentiality for quality strawberry production as most of the varieties are day length sensitive and long day types and does not flowers below certain photo-period. Though development of some certain day neutral cultivars make it possible to grow in sub-tropic regions but produce of higher altitude (above 860 m above mean sea level) have better quality (higher ascorbic acid, dry matter content and sugars) as compared to lower altitudes produce. Higher demand of organic strawberry due to health and environment consciousness vis-a-vis much involvement of non-renewal energy and extensive use of chemical fertilizers under conventional farming system affects the soil, environment and fruit quality (Macit *et al.* 2007) which lead towards organic farming to produce the fruit with least toxic effects, besides restoring the soil fertility and environmental health (Chaurasia *et al* 2004).

Organic farming involves slow releasing organic manures and requires the varieties responsive to these slow-releasing organic manures with less prone to diseases and pests. Inclination of growers towards organic strawberry production is increasing day by day due to high prices of organic produce in the market. Screening of strawberry varieties responsive to organic fertilizers and microbial inoculants are of utmost importance for commercial organic strawberry cultivation (Asray and Singh 2004). Keeping in view the importance of such study, 18 strawberry varieties were evaluated to find out their suitability for organic production system in Kashmir valley.

The field experiment was conducted at Experimental Farm Division of Pomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar (J&K) during 2006–2008. The experimental site was situated at an elevation of 1395 m and lies between 34°75´ north latitude and 74°50´ east latitude with average annual rain fall of 600 mm. Temperature often goes below the freezing point during December to March. Experimental field which was fallow since last three years was selected for the study. The soil of the experimental field was clay loam (sand 21.8%, silt 41.7% and clay 33.6%) with slight acidic reaction (*p*H 6.70) having organic carbon 0.69 %, available N 338 .44 kg/ha, available P_2O_5 17.505kg/ha and K_2O 335.6 kg/ha. The recommended dose of NPK (ie 340:150:340 kg/ha) was applied through poultry manure (1.25% N, 1.5% P_2O_5 and 2.15% K_2O) + *Azotobacter chroccoocum* + ash wood (6.25 % K_2O) + phosphate solublizing bacteria + oil-cake (5.5 % N, 1.75% P_2O_5, 1.2 % K_2O). Poultry manure and wood ash were applied 15 days prior to planting. Runners were treated with *Azotobacter* and PSB before transplanting where as well rotten oil cake was applied 45 days after planting. Transplanting was done on raised beds at 45 × 45 cm between inter- and intra- row spacing on 15 October during both the year of study. Data were recorded on growth and yield-attributing parameters by using standard methods. Fifty per cent flowering was recorded after the reference date, i e 15 March. The fruits were analyzed for physico-chemical properties from 20 randomly selected fruits from

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each variety. Fruit size was recorded by measuring length and breadth using the Digital Vernier Caliper, whereas fruit weight was taken using top pan digital balance. Total soluble solids were determined with Erma Hand Refractrometer (0–32° Brix). Titrable acidity was determined by standard method. Total sugars was estimated by method described by Rangana (1994). The photosynthetic efficiency (i e CO_2 reference and difference, photosynthetic active radiation, transpiration, GS, stomata conductance and calorie intake) of each variety was determined by using the CIRAS-2 portable photosynthesis system at three times between 12 noon to 2 pm at 15 days interval starting from flowering during both the year of study. Pooled data was analyzed by using the method out lined by Gomez and Gomez (1984).

Days taken to 50 % flowering ranged from 9.5 days to 15 days from the reference date (i e 31 March). Variety Confutura took minimum number of days (9.5 days) for 50 % flowering, whereas variety Senga Sengana took maximum number of days to 50% flowering from reference date, however, the differences were statistically non-significant. Average number of trusses/plant varied significantly from 5.20 to 15.30 among the evaluated genotypes. Variety Jutogh Special recorded maximum number of flower trusses (15.30) followed by Adie, Dana, and Catskill, whereas minimum were in Pajoro (5.20). Further cultivar Gorella recorded maximum number of flowers/plant (45.67), followed by Adie (43.45) and Catskill (42.37) and minimum in Senga Sengana (22.25). Crowns (18.33) and number of leaves (52.00) were recorded maximum in Gorella and Missionary respectively. The maximum number of flowers in Gorella than Jutogh Special were due to higher number of flower /truss in this variety. Cultivar Gorella recorded highest fruit set (89.60%) as well as yield/plant (262.50g). Varieties Confutura (260.21g), Chandler (259.37g) and Brighton (258.50g) also registered yield at par with Gorella. The growth and yield parameters observed in present study were in agreement with other workers (Lal and Rao 2010, Das *et al.* 2007; Singh *et al.* 2008). There were no definite relationship in recorded parameters like number of trusses/plants with number of flowers, average number of crowns and number of leaves as Jutogh special have maximum number of leaves but maximum number of flowers were recorded in variety Gorella. Such type of relationships also has been reported by Singh *et al* (2010). However, there was a positive relationship between the number of flowers and number of fruit/plant. (Table 1)

Different cultivars studied showed significant variation for weight and size which have a positive relationship with total yield. Cultivar Chandler recorded maximum berry weight (9.60 g) followed by Confutura Howard . However, maximum berry length was observed in Jutogh Special (36.28mm), followed by Catskill (35.55mm), whereas maximum breadth was in Senga Sengana (24.62mm), followed by Chandler (23.29mm) and Confutura (22.28mm). These variations may be due to genetic make up of these genotypes (Sharma and Sharma 2006) and growing (Dwiwedi *et al.* 2004). Varieties

Table 1 Phenological and yield performance of strawberry varieties under organic production system (pooled data of two years)

Variety	Days taken to flowering a r d .(31 March)	Flower trusses/plant	Flowers/ plant	Crowns/ plant	Leaves/ plant	Fruit set (%)	Fruits / plant	Yield/ plant (g)
Red Coat	11.4	5.80	35.00	4.66	20.67	72.30	30.25	128.56
Pajaro	12.4	5.20	35.67	5.33	18.50	67.80	33.80	152.10
Howard	10.4	10.60	40.00	6.66	23.68	83.30	39.33	140.42
Larsen	12.0	8.60	35.00	10.33	16.87	71.50	34.10	119.35
Gorella	13.0	12.70	45.67	18.33	23.43	89.60	42.70	262.50
Shastha	10.5	9.70	29.56	8.00	24.33	74.30	28.80	125.60
Adie	12.20	13.60	43.45	6.33	19.00	72.80	37.50	160.63
Jutogh Special	11.00	15.30	32.33	5.66	44.66	63.40	33.50	259.61
Catskill	9.06	12.20	42.37	7.66	41.86	77.70	38.50	257.85
Dana	10.00	12.30	35.75	9.33	44.35	82.10	28.50	191.70
Belrubi	10.40	10.10	35.33	4.33	39.66	83.20	33.35	169.85
Missionary	11.60	7.80	27.66	6.33	52.00	86.20	25.70	142.17
Chandler	12.00	11.60	35.50	6.33	27.85	78.60	30.50	259.37
Seascape	12.60	8.90	25.66	4.00	43.46	78.80	23.00	129.25
Osoland	11.50	10.7	30.33	3.99	28.96	72.10	28.90	183.88
Confutura	9.50	8.00	36.67	10.33	49.67	69.90	21.80	260.21
Brighton	11.80	8.60	26.56	6.33	48.21	74.80	20.80	258.50
Senga Sengana	13.20	6.20	22.25	5.66	33.36	88.10	23.80	225.80
CD (0.05)	NS	1.90	3.47	1.47	4.89	6.30	3.71	12.75
SEM		0.95	1.72	0.74	2.58	3.15	1.85	6.38

also manifested significant variation in total soluble solids Red Coat recorded highest total soluble solids (14.50° Brix) followed by Jutogh Special and Pajaro (Table 2). These conformity with findings of Singh *et el* (2008). However, more dependable to environmental conditions during growth and development of fruit than genetic inheritance. Maximum mean acidity was recorded in cultivar Gorella (1.45%), followed by Larson and Red Coat, whereas minimum acidity observed in Shastha (0.80%), followed by Belrubi (0.82%). Varietal differences in respect to acidity was also reported by Chandel and Badiyala (1996) which may be due to genetic and environmental effects as cooler night and warmer days promote more synthesis of acidity in fruits (Wani *et al.* 2007). A significant different varieties were observed for total sugar content which ranged from 4.81 to 8.69%. Missionary recorded highest total sugar (8.69%), followed by Senga, Sengana and Catskill, whereas, highest TSS/Acidity ratio was observed in Shastha (15.25), followed by Pajaro and Bellrubi.These variations may be due to genetic and environmental effect. These results are in conformity with findings of Lal and Rao (2010).

Photosynthetic potential of any varieties depends on environmental variables and genetic make up of plants which is an important process for crop growth and fruit quality. Maximum CO_2 reference was observed in variety Seascape (438 ppm), followed by variety Gorella and Chandler at same time maximum CO_2 difference was observed with variety Brighton (–7.33 ppm), followed by Osoland (–8.73 ppm). However no definite relationship was observed between CO_2 reference and CO_2 difference irrespective of varieties. CO_2 difference showed a negative correlation with stomatal conductance. Maximum stomatal conductance was observed with minimum CO_2 difference. These findings are in accordance with Baunce (2000) and Morison (2001) who have also reported decrease in stomatal conductance with elevated CO_2 concentrations. Variety Larson recorded highest photo-synthetically active radiation (1920 µmol/m²/s), followed by (Howard) and Chandler, whereas minimum photosynthetically active radiation was observed in Gorella (1188.33 µmol/m²/s). Temperature affects the photosynthetic activity of the plant and a positive relation was observed between air and leaf temperature. Maximum leaf temperature was observed in variety Osoland (31.76°C), followed by variety Brighton (31.43°C).This is in accordance with the findings of Allen *et al* (2003). Highest energy intake was observed in variety Confutura (364 calories), followed by Larson, Gorella, Chandler and Brighton (Table 3). This may be due to high PAR in these varieties. Stomatal conductance of these varieties was also more efficient for PAR and ultimately there was more plant growth and yield. On the basis of PAR, stomatal conductance and yield, these varieties can be recommended for cultivation under organic farming production systems in temperate region of Kashmir valley.

Table 2 Physico-chemical characteristics of fruits of different strawberry varieties under organic production system (pooled data of two years)

Variety	Av. fruit weight (g)	Fruit length (mm)	Fruit width (mm)	TSS (°Brix)	Acidity (%)	Total sugars (%)	TSS/acidity ratio	Total sugars acidity ratio
Red Coat	4.99	29.81	16.73	14.50	1.25	7.89	11.60	6.31
Pajaro	5.20	30.25	17.51	13.50	0.92	6.53	14.21	7.09
Howard	8.67	27.14	16.69	10.50	1.05	7.01	10.00	6.68
Larsen	5.93	25.15	16.50	9.50	1.30	7.30	7.30	5.62
Gorella	6.33	26.52	18.08	11.00	1.45	5.96	7.59	4.11
Shastha	6.82	27.00	16.69	12.20	0.80	5.53	15.25	6.66
Adie	7.00	29.81	15.73	12.00	1.01	6.14	11.88	6.07
Jutogh Special	5.24	36.28	19.46	14.00	1.00	5.31	13.00	5.31
Catskill	7.30	35.55	19.90	9.00	1.21	8.12	7.44	6.71
Dana	8.10	34.02	19.17	12.00	1.03	6.96	11.65	6.75
Belrubi	7.50	32.03	18.50	11.50	0.82	6.43	14.02	7.84
Missionary	5.75	32.90	20.63	10.00	0.91	8.69	10.98	9.54
Chandler	9.60	26.87	23.29	11.00	1.08	8.16	10.19	7.55
Seascape	6.85	26.82	19.09	11.50	0.95	7.14	11.37	7.51
Osoland	5.65	24.14	19.84	11.00	1.28	4.81	8.59	3.75
Confutura	9.28	29.00	22.28	11.20	0.89	6.54	12.58	7.34
Brighton	7.90	26.44	17.09	11.00	0.95	5.87	11.57	6.17
Senga-Sengana	8.25	30.20	24.62	11.50	0.92	8.43	12.50	9.16
$CD_{@5\%}$	1.64	1.14	0.97	0.41	0.24	0.69	0.73	2.46
SEM	0.82	0.57	0.47	0.21	0.14	0.34	0.37	1.24

Table 3 Photosynthetic performance of strawberry varieties under organic production system (pooled data of two years)

Variety	CO_2 reference (ppm)	CO_2 deference (ppm)	PAR (μmol/m²/s)	Air temperature (^{0}C)	Leaf temperature (^{0}C)	Transpiration (mol/m²/s)	GS stomatal conductance (mol/m²/s)	Calories
Red Coat	387.70	–10.96	1602.67	29.93	30.80	3.05	98.00	281.00
Pajaro	399.27	–11.60	1695.33	30.06	31.26	3.39	75.53	289.33
Howard	414.10	–10.67	1886.33	25.83	27.30	2.50	92.33	318.33
Larsen	402.43	–10.63	1920.00	28.45	29.83	2.64	96.33	360.00
Gorella	428.63	–13.50	1188.33	28.97	30.20	2.65	89.33	365.00
Shastha	408.17	–14.13	1715.00	29.17	30.03	2.80	77.00	307.33
Adie	389.57	–8.97	1681.00	29.67	30.70	2.83	100.30	280.87
Jutogh Special	411.33	–15.83	1847.00	29.53	31.03	3.22	63.33	279.33
Catskill	404.07	–17.40	1861.00	29.76	30.93	3.08	60.64	315.67
Dana	400.07	–13.30	1661.33	29.83	30.67	3.03	65.37	264.67
Belrubi	391.53	–12.33	1744.00	30.13	30.17	3.83	83.00	298.67
Missionary	391.93	–11.93	1695.33	30.37	31.33	3.11	93.33	286.33
Chandler	437.40	–11.03	1885.00	30.47	31.10	3.13	94.66	340.67
Seascape	438.13	–17.73	1700.00	30.70	31.37	3.23	60.83	294.67
Osoland	406.07	–8.73	1893.00	29.87	31.76	3.41	110.92	334.33
Confutura	388.87	–11.03	1690.67	30.23	31.37	3.23	90.95	364.67
Brighton	403.53	–7.33	1705.33	28.56	31.43	3.42	110.33	337.67
Senga–Sengana	419.17	–9.97	1837.35	30.10	31.17	3.10	88.33	328.00
CD (5%)	21.17	4.23	144.32	0.56	0.71	1.12	22.31	24.89
SEM	10.42	2.13	72.01	0.27	0.35	0.54	11.16	14.24

SUMMARY

Eighteen strawberry varieties were tested for organic production system under temperate region. Variety Gorella recorded maximum fruit yield/plant (262.50 g), followed by variety Confutura (260.20g), Chandler (259.37g) and Brighton (256.50 g).Variety Confutura recorded largest fruit size (9.28g) which was at par with varieties Howard and Senga Sengana. Variety Larson recorded highest photosynthetically active radiation (1920 μmol/m²/s), followed by variety Howard (1886.33 μmol/m²/s). Highest energy intake for photosynthetic activities was observed in variety Confutura (364 calories), followed by Larsen, Gorella, Chandler and Brighton. On the basis of PAR, stomatal conductance and yield, varieties Confutura, Larsen, Gorella, Chandler and Brighton may be recommended for cultivation under organic farming production system in temperate region of Kashmir valley.

REFERENCES

Allen Jr L H, Deyun Pan , Booti KJ, Pikering NB and Jones JW. 2003. Carbon dioxide and temperature effect on evapotranspiration and water use efficiency of soyabean. *Agronomy Journal* **95**:1071–81.

Asery R and Singh R. 2004. Evaluation of strawberry varieties under semi arid irrigated region of Punjab. *Indian Journal of Horticulture* **61**:122–24

Bunce J A. 2000. Response of stomatal conductance to light, humidity and temperature in wheat barley grown at three concentrations of CO_2 in the field. *Global Change Biology* **6**:371–82.

Chaurasia S N S, De Nirmal and Singh K P. 2004. Effect of organic source of nutrients on growth, yield and yield attributing traits of cabbage (*Brassica Oleracia Var.capitata*). (*in*) *Organic Farming in Horticulture*, pp158–61. Pathak, R K, Khan R M and Ram RA (Eds). CISH, Lucknow.

Das B, Vishal Nath, Jana B R, Dey P, Parmanik K K, Kisore D K. 2007. Parformence of strawberry cultivars grown on different mulching material under sub humid sub tropical plateau conditions of eastern India. *Indian Journal of Horticulture* **64**:137–43.

Dwiwedi S K, Abdul Kareem and Raut B. 2004. Introduction and evaluation of strawberry cultivars for cold arid conditions of Ladakh. *Progressive Horticulture* **36**:207–10.

Gomez A A and Gomez K A. 1984. *Statistical Procedure for Agricultural Research*, pp 68. John Wiley and Sons Inc New York.

Lal B and Rao B K. 2010. Physico-chemical characteristics of some strawberry (*Fragaria* × *ananassa*) genotypes under Garhwal region of Uttarakhand. *Indian Journal of Agricultural Sciences* **80**(4): 342–4.

Macid I, Koc A, Guler S and Deligoz I. 2007. Yield, quality and nutritional status of organically and conventionally strawberry cultivars. *Asian Journal of Plant Sciences* .**6**:1131–6.

Morison J I L. 2001. Increasing atmospheric CO_2 and stomata. *New Phytol.* **149**:154–56.

Rangana S. 1994. *Handbook of Analysis and Quality Control*

for Fruits and Vegetable Products, edn 2. Tata Mc Grow Hill Publication Co. Ltd, New Delhi.

Sharma G and Sharma O C. 2006. Correlation and path analysis in strawberry (*Fragaria* ×*ananassa* Duch). *The Horticulture Journal* **19**: 1–4.

Sharma R M and Yamdagni R. 2000. *Modern Strawberry Production.* 172 pp, Kalyani Publishers, New Delhi.

Singh Akath, Patel R K , De L C and Lolly S Perceira. 2008. Performance of strawberry cultivars under sub tropic of Meghalaya. *Indian Journal of Agricultural Sciences* **78**: 575–80.

Singh S R, Zargar M Y, Singh U and Ishaq M. 2010. Influence of bio-inoculants and inorganic fertilizers on yield, nutrient balance, microbial dynamics and quality of strawberry (*Fragaria* × *ananassa*) under rainfed conditions of Kashmir valley. *Indian Journal of Agricultural Sciences* **80**: 275–81.

Wani M S, Rather B A, Sharma M K and Singh S R. 2007. Effect of different planting times and mulches on flowering, yield and quality of strawberry. *The Horticulture Journal* **20**:5–7.