Agric Res J **58** (5) : 840-844, *October* 2021
DOI No. 10.5958/2395-146X.2021.00120.4

PHENOLOGY AND YIELD ATTRIBUTES OF CAPE GOOSEBERRY AS AFFECTED BY PLANT DENSITY

Monika Gupta*, Gagandeep Kaur and Harminder Singh
Department of Fruit Science, Punjab Agricultural University, Ludhiana-141004, Punjab

ABSTRACT

The study was conducted to determine the ideal inter- and intra-row spacing of cape gooseberry to attain the optimum yield and yield components. The experiment was set in a completely randomized block design with three replications in two inter-row (0.75 m and 0.90 m) and two intra-row spacings (0.30 and 0.60m). Significant effect of inter- and intra-row spacing was recorded for plant height, flower initiation, days to maturity, fruit weight and yield. The tallest (1.15 m) plants were observed at 0.75X0.30 m spacing while plants were short in height at wider spacing. Further heat units required by cape gooseberry for maturity under sub tropics varied from 2034.7 to 2146.3. Correlation analysis indicated that plant height had significant negative correlation with yield and yield components such as fruit number but significantly positively correlated with ascorbic acid and carotenoids. The highest fruit yield (0.587 kg per plant) was obtained at interaction of 0.75 × 0.60 m spacing, while the lowest (0.133 kg per plant) was obtained from 0.75 × 0.30 m spacing. Thus, it may be concluded that 0.75 × 0.60 m spacing is optimum for cape gooseberry cultivation under sub tropics.

Keywords: Cape gooseberry, Heat units, Spacing, Yield

Cape gooseberry, botanically known as *Physalis peruviana* L., belongs to Solanaceae family. It can be grown in tropical, sub-tropical as well as temperate regions. Worldwide, there are only few countries left who are not engaged in cultivation of cape gooseberry. It is highly popular in Colombia, South Africa and Kenya which are involved in intensive breeding programme. Moreover, in Colombia, it is the second highest exported fruit crop after banana (Salazar *et al.,* 2008). In India, it is being commercially cultivated in Uttar Pradesh, Punjab, West Bengal and Madhya Pradesh. Cape gooseberry fruits are rich in vitamins, ascorbic acid, minerals, anthocyanins and antioxidants. The fruits are anti-inflammatory, anti-cancerous and have many other medicinal properties. Cape gooseberries may be consumed for table purpose, also as desserts, puddlings, mousse, ice-cream, jam, jellies and cheese cakes (Nandi and Gupta, 2017). The cultivation of cape gooseberry represents an important diversification opportunity for Indian farmers owing to availability of suitable climate, short duration of crop, high monetary returns, nutritional value and multiple uses. The cultivation of cape gooseberry has not been taken up commercially yet under Punjab conditions due to lack of awareness and non-availability of standard cultivation practices. Plant spacing plays a vital role to enhance the yield, productivity and profitability of annual crops by ensuring the proper vegetative growth and reproductive development (Gond *et al*., 2018). The decrease in space between the cape gooseberry plants results an increase in production per unit area by using the given area in a better way (Moura *et al*., 2016). However, very limited research has been done regarding most favorable agro techniques such as plant spacing for the efficacious cultivation of cape gooseberry, exclusively under the agro-climatic conditions of Punjab. Growers can harness economic benefits from the increasing demand of cape gooseberry fruit by local cultivation and this necessitates the development of standard cultivation techniques so that the production can be taken up on commercial scale. Therefore, the present investigation has been undertaken to enumerate the effect of plant spacings on growth, yield and quality of cape gooseberry under Punjab conditions.

*Corresponding author : monika-fzr@pau.edu
Date of receipt: 10.08.2020, Date of acceptance: 09.04.2021

MATERIALS AND METHODS

The study was conducted at Punjab Agricultural University, Ludhiana located in trans-Gangetic agro-climatic zone that represents the Indo-Gangetic alluvial plains located at latitude 30° 56' N, longitude 75° 52' E and 247 m altitude above the mean sea level, during 2018-19. The climatic conditions of this site represent sub-tropical nature having hot summers with very cool winters. The soil characteristics of experimental site were recorded as pH 8.1, organic carbon 0.26%, $CaCO_3$ 1.00%, EC 0.20 mmhos/cm and texture was sandy loam. The experimental field was thoroughly ploughed and leveling was also done. Soil application of fertilizers was done in two split doses through urea (@ 26 kg/acre), single super phosphate (@06 kg/acre) and muriate of potash (@12 kg/acre), before flowering and after fruit set in all the treatments. Cape gooseberry *cv.* Bangalora (Local) is propagated through seeds. The seeds were extracted at fruit ripening stage. The seeds were sown in the month of July. The seedlings of identical height and uniform vigor were transplanted in first week of September during both the years. Light irrigation was given immediately after transplanting of the seedlings. Thereafter, need based irrigation was given. Various cultural practices were performed uniformly throughout the experiment. The plot size was 9m^2 and replicated thrice. Cape gooseberry plots have been allocated the different row and plant spacings as given below:

Treatment	Plant spacing (m)
S_1	0.75 X 0.30
S_2	0.75 X 0.60
S_3	0.90 X 0.30
S_4	0.90 X 0.60

The observations on physico-chemical parameters *viz*. plant height (m), time to flowering (DAP), days to maturity (DAF), no. of fruits/plant, fruit weight (g), fruit yield (kg/plant), heat units, total soluble solids, acidity, maturity index, vitamin C and carotenoids were recorded. The data pertaining to plant height was measured by using common measuring tape starting from ground level to the terminal end of the main leader. Time to flowering was calculated by counting number of days from date of transplanting of seedlings till the anthesis of first flower. The data on days to maturity was calculated as days from 75% flower opening to appearance of orange colour of the fruit. To record per plant fruit number, fruits on six randomly selected plants per replication were counted and their averages were calculated. Fruit weight was recorded in grams by weighing total fruits on six randomly selected plants using electronic weighing balance and presented as their average. Fruit yield was calculated by summation of weight of all fruits present per plant and replicated ten times in each treatment. During the crop development period, maximum (T_{max}) and minimum (T_{min}) temperature (^{0}C) were recorded with automatic weather station. The accumulation of heat units (HU, ^{0}C.d^{-1}) at different phonological stages was calculated by the residual method as given by Snyder (1985):

$$\text{Heat Unit (HU)} = \frac{T_{max} + T_{min} - BT}{2}$$

Where BT is the base temperature (6.3^{0}C) (Salazar *et al.*, 2006)

Total soluble solids (^{0}brix) were measured from fruit juice using digital refractometer (ATAGO, PAL, Model 3810, Japan). The acidity in terms of citric acid was recorded using N/10 NaOH and phenolphthalein as indicator by standard formula. Maturity index was given as TSS: acid ratio. Vitamin C content of the juice was determined by using the dye 2, 6-dichlorophenol-indophenols (DCPIP) visual titration method (Ranganna, 2000). Data were subjected to analysis of variance and means were compared at 5% significance, using the SAS software.

RESULTS AND DISCUSSION

The data presented in Table 1 regarding impact of plant spacing on the vegetative growth and flowering attributes reveals that plant height was significantly affected by planting density. Plants were taller in dense planting as compared to wider planting. The tallest (1.15 m) plants were observed in the plots having 0.75X0.30 m spacing, while the shortest plants (0.9 m) were recorded in 0.9X0.60m spacing. The more plant height recorded in narrower spacing might be due to the excessive competition for space and illumination thus forcing the plants to turn out to be taller. Wider spacing S2 and S4 were found to be responsible for the short as well as stout plants because of accessibility of additional growing space wherein plants were capable to exploit more nutritional elements from the earth and light thus accumulating more photo assimilates. Similar rise in plant developmental rate at closer spacing was observed and reported by Gond *et al.* (2018) in cape gooseberry.

Statistical analysis showed that plant spacing had significant effect on days to flower initiation (Table 1). Initiation of flowering was recorded to be late (124 days) at plant spacing of 0.9X0.60 m, however early flower initiation (117 days) was recorded at 0.75X0.30 m spacing. The initiation of flowering was delayed by one week in 0.9X0.60 m spaced plants, which showed significant variation when compared with the rest of the treatments. Late flower initiation recorded at wider spacing might be due to less competition among plants for nutrition, luminosity and water uptakes resulting in enhanced vegetative phase of the plants and delay in flowering. On an average, fruit took 62 to 66 days after flowering to reach maturity. Fruit maturity was also recorded to be delayed at wider spacing while minimum number of days was taken by fruits planted at closer spacing.

Perusal of data showed that plant spacing significantly influenced number of fruits per plant. The highest fruit number per plant (85.0) was counted in plots with wider spacing at 0.75X0.60 m, however; less number of fruits (26.0) was observed in narrow plots at 0.75X0.30 m row spacing. Increased production of fruits per plant at wider spacing might be recorded due to more accumulation of photosynthates resulting in more vegetative growth and better reproductive

Table 1. Effect of plant spacing on vegetative, flowering, yield and physico-chemical characters of fruits of Cape gooseberry

Plant Spacing (m)	Plants/acre (Number)	Plant height (m)	Days to flowering	Days to maturity (DAF)	Fruit number /plant	Fruit yield (Kg/ plant)
0.75X0.30	17778	1.15[a]	117[b]	63[bc]	26.0[d]	0.133[d]
0.75X0.60	8889	0.95[ab]	122[a]	64[b]	85.0 [a]	0.587[a]
0.9X 0.30	14815	1.00[ab]	120[ab]	62[c]	34.0[c]	0.204[cd]
0.9X0.60	7407	0.90[b]	124[a]	66[a]	66.0 [b]	0.495[b]
Plant Spacing (m)	**Fruit weight (g)**	**TSS (^{0}Brix)**	**Acidity (%)**	**Maturity Index**	**Vitamin C (mg/100g flesh weight)**	**Carotenoids (mg/100g flesh weight)**
0.75X0.30	5.1[d]	13.4[a]	1.9[a]	7.05	40.5[a]	1.93[a]
0.75X0.60	6.9[b]	13.1[a]	1.83[a]	7.16	41.0[a]	2.62[b]
0.9X 0.30	6.0[c]	13.3[a]	1.85[a]	7.19	39.2[b]	1.72[bc]
0.9X0.60	7.5[a]	13.3[a]	1.88[a]	7.07	38.5[b]	1.58[c]

Means among each set of data labelled by the same letter are not significantly different (P < 0.05)
DAF – days after flowering

capacity of fruit plants. The decrease in number of fruits on individual plants at narrower spacing is attributed to the lesser availability of food assimilates, due to excessive competition between plants. The results are in agreement with those achieved by Machado *et al*. (2007) in tomato.

The data pertaining to effect of row spacing for average fruit weight (Table 1) revealed that it has significant influence on fruit weight per plant. Maximum fruit weight (7.5 g) was observed in plot size of 0.9X0.60m followed by plants (6.9g) with spacing 0.75X0.60m; however, significantly lesser fruit weight (5.1 g) was produced by plants spaced at 0.75X0.30m. At higher planting density, plants have more competition for light and direct greater energy for cellular growth and thus reduction in translocation of sugars to fruit leading to decreased fruit weight and size (Carvalho and Tessarioli Neto, 2005).

Fruit quality attributes like TSS and acidity were not affected by various treatments. In general, it is decreased with the increasing plant population and increased with wider spacing. It could be attributed to increased light penetration and assimilation of photosynthates in widely spaced plantations having positive influence on TSS content. These findings are in line with Kirimi *et al.* (2011) who obtained higher TSS at wider spacing which might be due to translocation of assimilates (a major constituent of TSS) affected by growing conditions through the rate of assimilate export from the leaves. Narayan *et al.* (2017) reported that higher fruit number in cherry tomato corresponded with lower TSS as compared to plants with lesser number of fruits.

The spacing treatments showed significant influence on ascorbic acid content of the fruits (Table 1). The ascorbic acid content of fruit was found higher

Table 2. Pearson's Correlation coefficient between vegetative, flowering, yield and physico-chemical attributes of cape gooseberry fruits grown at different plant spacing

	Plant height	Days to flower	Days to maturity	Fruit number	Fruit weight	Yield	Vitamin C
Plant height	1						
Days to flower	-0.6338*	1					
Days to maturity	-0.2093	0.3910*	1				
Fruit number/plant	-0.4936*	0.7663*	-0.0743	1			
Fruit weight	-0.4636*	0.8657*	0.3234*	0.7051*	1		
Fruit Yield	-0.4966*	0.8207*	0.0332	0.9745*	0.8240*	1	
Vitamin C	0.6046*	-0.3971*	-0.7603*	0.1023*	-0.2784*	0.0024	1
Carotenoids	0.2576*	-0.0305	-0.6556*	0.5343	-0.0052	0.4450	0.7414*

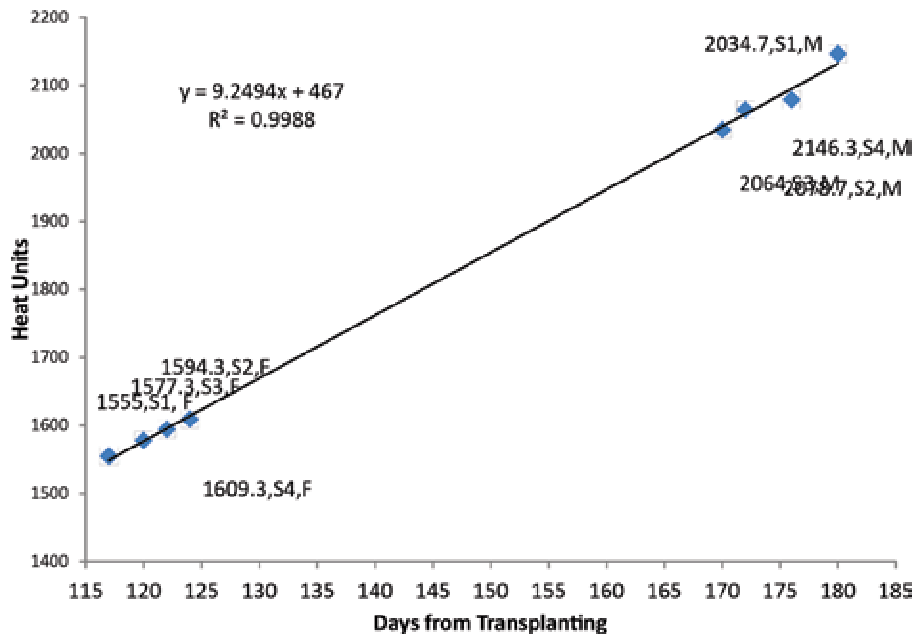

Fig. 1. Heat units accumulated at different plant spacings during flowering and maturity of cape gooseberry (S1-0.75X0.30, S2-0.75X0.60, S3-0.9X 0.30, S4-0.9X0.60) F- Flowering, M-Maturity

with the S2 (0.75X0.60 m) but it was statistically at par with S1 (0.75X0.30 m) treatment. At higher plant density, not only there are changes caused in the amount and quality of intercepted light, but also the distribution of photo assimilates between vegetative and reproductive twigs is altered which ultimately is responsible for determination of fruit quality (Policarpo *et al.*, 2006). Carotenoids content varied between 1.58 to 2.62 mg/100g flesh weight. Reduction in the planting spaces increased the carotenoids content of the cape gooseberry fruits. This might be associated with higher radiation interception at wavelength of 450-550 nm in lesser biomass canopy which may have direct influence on carotenogenesis. Therefore, a compromise between all quality requirements must be found for a good yield.

Heat unit accumulation

The Heat unit accumulation during the crop cycle is presented in Fig. 1, the totals at flowering were 1555.0, 1594.3, 1577.3 and 1609.5HU, for the spacing 0.75X0.30, 0.75 X 0.60, 0.9 X 0.30 and 0.9X0.60 m, respectively. The wider planted cape gooseberry crop showed higher consumption of heat units as compared to dense planting (Table 4). This might be due to delayed flowering in wider spaced crop as compared to closer planting. It is probable that this tendency is also due to the greater nutrient availability due to low competition at wider spacing, which favours vegetative growth. Similarly, the accumulation of 2078.7 heat units (Fig.1) were recorded at maturity stage in plants spaced at 0.75 X 0.60 m. The results of the present study are similar to those of Mora-Aguilar *et al*. (2006), who reported a total of 2,047 HU from emergence to physiological maturity in a cape gooseberry ecotype from Peru.

Correlation analysis of different traits

Pearson's coefficient of correlation was used to study the relationship between various attributes (Table 2). Plant height has significant negative association with flower initiation, fruit number, fruit weight and fruit yield. However, plant height has significantly positive correlation with ascorbic acid and carotenoids. Days to flower have significantly positive association with days to maturity, fruit number, fruit weight and fruit yield. Days to maturity variable has negative correlation with number of fruits, however, has non–significant positive association with yield. Days to maturity variable has significant positive correlation with fruit weight. Ascorbic acid and carotenoids showed significantly negative correlation with days to maturity. Fruit number has significant positive correlation with all the yield and quality attributes such as fruit weight, fruit yield, ascorbic acid and carotenoids. The results are in line with Emami (2014) who also reported that fruit yield in tomato was positively associated with number of fruits per plant (r=0.66**). Previous studies also reported a significantly positive correlation between fruit yield per plant, fruit number and average fruit weight in tomato (Souza *et al.*, 2012). Fruit yield has significant positive correlation with ascorbic acid and carotenoids. Ascorbic acid and carotenoids have significant positive association.

The growth and yield of cape gooseberry was highly affected by the plant spacing. Higher the plant density, lower was the fruit number leading to lesser yield per plant. Based on agronomic performance, use of 0.75 × 0.60 m spacing accommodating 8889 plants per acre was found promising for Cape gooseberry production in Ludhiana district and similar agro-ecological region.

Authors' contribution

Conceptualization of research work and designing of experiments (MG, GK, HS); Execution of field/lab experiments and data collection(MG,GK); Analysis of data and interpretation (MG,GK); Preparation of manuscript (MG,GK,HS)

LITERATURE CITED

Carvalho L A and Tessarioli Neto J 2005. Yield of tomato under protected environment in relation to spacing and number of branches per plant. *Hort Brasileira* **23**: 986-89.

Emami A 2014. Effect of transplanting dates on fruit yield and related quality traits of tomato genotypes (*Lycopersicun escutentum* Mill.).*Int J Curr Res Acad Rev* **2**(8): 1-9.

Kirimi J K, Itulya F M and Mwaja V N 2011. Effects of nitrogen and spacing on fruit yield of tomato. *Afric J Hortic Sci* **5**:50-60

Machado A Q, Alvarenga M A R and Florentino C E T 2007. Production of Italian tomato (saladete) in different plant densities and pruning systems aiming at in natura **consumption.** *Hort Brasileira* **25**:149-53.

Mora-Aguilar R, Peña-Lomelí A, López-Gaytán E, Ayala-Hernández J J and Ponce-Aguirre D 2006. Agrophenology of *Physalis peruviana* L. under greenhouse and ferti-irrigation conditions. *Rev Chapingo Serie Hortic***12**(1):57-63.

Moura P H A, Coutinho G, PioR, Bianchini F G and Curi P N 2016. Plastic covering, planting density, and pruning in the production of cape gooseberry (*Physalis peruviana* l.) in subtropical region. *Rev Caatinga* **29**(2):367-74.

Gond M, Dwivedi D H and Maji S 2018. Flowering and fruiting in Cape gooseberry (*Physalis peruviana* L.) as influenced by organic manures and spacing. *Int J Minor Fruits Medicinal Aromatic Pl* **4**(2):07-12.

Nandi P and Gupta M 2017. Cape gooseberry. *Minor fruits: Nutraceutical importance and cultivation*, Ghosh S N (Ed)., pp. 161-88, Jaya Publishing House, Delhi.

Policarpo M, Talluto G and Bianco R L 2006. Vegetative and productive responses of Conference' and 'Williams' pear trees planted at different in-row spacings. *Sci Hortic* **109**:322-31.

Ranganna S 2000. *Handbook of Analysis and Quality Control for fruit and vegetable products*. Tata Mc Graw Hill Publications Co. Ltd, New Delhi, India. 1112p.

Narayan S, Makhdoomi M I, Nabi A, Khan S H, Mufti S, Afroza B, Mushtaq F, Hussain K and Khan F A 2017. Effect of plant spacing and pruning on growth and yield of cherry tomatoes under polyhouse conditions in Kashmir. *The Bioscan* **12**(1): 359-61.

Salazar M R, Chaves-Córdoba B, Cooman A and Jones J W 2006. Simple phenological and potential production model for cape gooseberry (*Physalis peruviana* L.). *Acta Hort* **718**:105-11.

Salazar M R, Jones J W, Chaves B and Cooman A 2008. A model for the potential production and dry matter distribution of cape gooseberry (*Physalis peruviana* L.). *Sci Hortic* **115**:142-48.

Snyder R L 1985. Hand calculating degree days. *Agric For Met* **35**(1-4): 353-58.

Souza L M, Melo P C T, Luders R R and Melo A M T 2012. Correlations between yield and fruit quality characteristics of fresh market tomatoes. *Hort Brasileira* **30**: 627-31.