Journal of Horticulture
ISSN: 2376-0354
OPEN ACCESS Freely available online
Research Article

Evaluation of Fruit Yield in Two Gooseberry Cultivars Grown under Water Stress Conditions with Supplemental Irrigation

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ABSTRACT

Cape gooseberry falls under the underutilised fruit crop in Kenya in spite of its significant nutritional and medicinal value. The objective of this study was to compare the yield potential of two introduced varieties of Cape gooseberry – Colombia and Netherlands – grown under water stress conditions with supplemental irrigation. A better-performing variety between the two could do relatively well in drier regions. From the results, the differences in the parameters measured, i.e., flowers buds, flowers, fruits, and branches, are not statistically significant ($p \leq 0.05$), vegetative branching showed a stronger correlation with floral density for Colombia than for the Netherlands variety ($r=0.771$ vs. 0.687, respectively). Additionally, the average reproductive components measured, i.e., fruits and flowers, were higher in Colombia than in Netherlands, indicating that it can perform better under drought conditions (with supplemental irrigation).

Keywords: Cape gooseberry; Water stress; Fruit yield; Kenya

INTRODUCTION

The botany of cape gooseberry

Cape gooseberry (*Physalis peruviana* L.) is a short perennial shrub that is a member of the Solanaceae family and classified as an underutilised fruit crop in Kenya where under the USAID's Feed the Future (FtF) program Colombia, Netherlands, Peru, and South Africa varieties have been introduced [1]. This study focuses only on Colombia and Netherlands varieties. Culture of gooseberry is prized for entering early bearing, regular higher productivity, food quality and high herbal, fruits universal use. The content of pectin substances in fruit allows the list to include barberry ant radiate cultures. Cape gooseberry thrives well in tropical and subtropical regions [2]. It has numerous nutritional and medicinal benefits. It is rich in antioxidants, vitamins (A, B, C and K), essential fats, etc., [3]. In Kenya, commercial cultivation of gooseberries is underdeveloped with only Delmonte carrying out large-scale production in 2004-2006 in Kibwezi for a jam brand [2]. In spite of these nutritive parameters, commercial cultivation of this crop by farmers will only be ensured if well-adapted, high-yielding cultivars are released to them. Water availability is expected to be a growth limiting factor that would affect fruit yield in Cape gooseberry due to reduced flower set and elevated floral abscission rate [4]. Furthermore, the maximum yield potential of gooseberries under water stress conditions is unclear. The objective of this study is to compare expected fruit yield between two gooseberry cultivars grown under supplemental irrigation. A potentially high-yielding variety under water stress conditions would be ideal for drier agro-ecological zones. On highly fertile alluvial soil, there is much vegetative growth and the fruits fail to color properly. Very good crops are obtained on rather poor sandy ground. Where drainage is a problem, the plantings should be on gentle slopes or the rows should be mounded. The plants become dormant in drought.

Planting cape gooseberry

Cape gooseberry plants are easily grown from seed, sown in spring, after all danger of frost has passed. Although the plants are perennials, they are frost tender, so need to be treated as annuals in colder areas. The seed should be sown as early as possible to allow the three to four months needed from sowing until the fruit is ready for harvest. In warmer climates, late sowing means the plant won't set fruit until its second season.

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Received:05-Dec-2022, Manuscript No. JOH-22-22339;**Editor assigned:** 07-Dec-2022, PreQC No: JOH-22-22339 (PQ); **Reviewed:** 21-Dec-2022, QC No: JOH-22-22339; **Revised:** 28-Dec-2022, Manuscript No: JOH-22-22339 (R). **Published:** 02-Jan-2023; DOI:10.35248/2376-0354.22.9.313

Citation: Harun Odhiambo, Lusike Wasilwa, Job Maangi, Mercyline Ong'awa, Vincent Ochieng (2022) Evaluation of Fruit Yield in Two Gooseberry Cultivars Grown under Water Stress Conditions with Supplemental Irrigation. J Hortic. 9:313

Seed is available from specialist seed suppliers, and plants are sometimes available from garden centers. Once established they self-sow readily.

Cape gooseberry seeds are usually fairly easy to germinate though germination time can be a bit longer than other vegetable seeds. Cape gooseberry seeds should be sprouted in small containers, preferably 4" or smaller. In-ground germination is not recommended because conditions are not as easily controlled. Use a standard potting mix that is well drained. Make sure potting mix is damp prior to planting the seeds. With very small seeds such as Cape gooseberry, watering overly dry soil can cause the seeds to dislodge from their position and sink deep into cracks in the soil. Seeds that sink deeply into soil will not be able to reach the soil surface once germinated. Seeds are planted in 1/4" deep in the soil. Cover with soil and water carefully. Over watering can cause fungal growth which leads to seed rot. Excess water can also bury seeds deep in the soil where they will not be able break the surface. Water when the soil surface just begins to dry. Multiple seeds can be planted in a single starter container, but should be thinned once seedlings appear so only a single plant remains.

Germination time usually ranges from 2-6 weeks under ideal conditions. For successful germination, soil should be kept consistently warm, from 70-85 ˚F. Cool soils, below about 60-65 ˚F, even just at night, will significantly delay or inhibit germination. Hot soils above 95 ˚F will also inhibit germination.

Caring for seedlings is key to influencing the entire life of the plants and should be accorded much attention. Once a few true leaves have developed, seedlings should be slowly moved outside (if sprouted indoors) to ambient light. Care should be taken not to expose seedlings to direct, scorching sun so plants may need to be hardened off via slow sun exposure. Hardening off can be done using a shaded or filtered light location, as well as protection from strong winds, rain or low humidity. Hardening off time varies, but can take 5-10days.

Planting out or transplanting to the main field or ground should be done once danger of frost has past and daytime temperatures consistently reach 65 ˚F.

Field management practices

The irrigation plan should well designed since the plant needs consistent watering to set a good fruit crop, but can't take “wet feet”. Where drainage is a problem, the plantings should be on a gentle slope or the rows should be mounded. Irrigation can be cut back when the fruits are maturing. The plants become dormant during drought.

The Cape gooseberry seems to thrive on neglect. Even moderate fertilizer tends to encourage excessive vegetative growth and to depress flowering. High yields are attained with little or no fertilizer. Farm yard manure should be applied at the rate of 1 kg per plant at planting time and before the onset of flowering. Very little pruning is needed unless the plant is being trained to a trellis. Pinching back of the growing shoots will induce more compact and shorter plants.

In areas where frost may be a problem, providing the plant with some overhead protection or planting them next to a wall or a building may be sufficient protection. Individual plants are small enough to be fairly easily covered during cold snaps by placing plastic sheeting, etc. over a frame around them. Plastic row covers will also provide some frost protection for larger plantings. Potted specimens can be moved to a frost-secure area.

Propagation: The plant is widely grown from seed. There are 5,000 to 8,000 seeds per ounce, which are sometimes mixed with pulverized soil or ashes for uniform sowing. High humidity is required for good germination. The plants can also be propagated from 1 year old stem cuttings treated with a rooting hormone. Plants grown this way flower early and yield well but are less vigorous than seedlings.

Pest and diseases: Cape gooseberries are bothered by several diseases, including Alternaria spp. and powdery mildew. The plants are also prone to root rots and viruses when grown on poorly drained soil. A host of insect pests also attack the plants, namely cut worm, stem borer (Heliotis suflixa), leaf borer (Epiatrix spp.), fruit moth (Phthorimaea), Colorado potato beetle, flea beetle and striped cucumber beetle (Acalymma vittata). Greenhouse grown plants are attacked by white fly and aphids. The stored fruit can be adversely affected by Penicillium and Botrytis molds.

Harvest: The fruit is harvested when it falls to the ground, but not all fallen fruits may be in the same stage of maturity and must be held until they ripen. It may take some experience to tell when the calyx-enclosed fruits are fully ripe. Properly matured and prepared fruits will keep for several months.

The ripe fruit can be eaten out of hand or used in a number of other ways. The unique flavor of the fresh fruit makes it an interesting ingredient in salads and cooked dishes. Cape gooseberries cooked with apples or ginger make a very distinctive dessert. The fruits are also an attractive sweet when dipped in chocolate or other glazes or pricked and rolled in sugar.

The high pectin content makes Cape gooseberry a good preserve and jam product that can be used as a dessert topping. The fruit also dries into tasty “raisins”.

Cape gooseberry distribution

The crop is native to Latin America but has been widely introduced in tropical, subtropical, and even temperate areas of the world. Cape gooseberries are a native of South America. They made their way to Australia (then New Zealand) via Cape Town in South Africa, hence the “cape” in their name. They are also known as ground cherries, poha and sometimes Physalis, from their botanical name *Physalis peruviana*-a name that doesn’t do the berries or their lanterns justice, since Physalis means bladder.

Based on the cultural background, geographical location and levels of civilization across the globe the identity of cape gooseberries is highly varied. Among the common names in Kenya include nyamtonglo for the Luo, nathi for the Kikuyu, chinsobosobo for the Kisii, ngondu forthe Kamba and chilolo for the Kipsigis. Cape gooseberries have been growing wildly in Kenyan forests such as Kakamega forest, Kodera forest in Homabay and small bushes around rural gardens and can survive in a wide range of ecological zones. However, in the recent times, cape gooseberries has been established as one of the under- utilized fruits in most countries (Shusmita, 20018). The Cape gooseberry is a plant of the solanaceae family, with indeterminate grow habit and it has caused great interest for production in the south, southwest and northwest states of Brazil (Kuhn et al., 2012; Velasquez et al., 2007; Andrade, 2008).

MATERIALS AND METHODS

The study area

The study was carried out in Busia ATC in Busia County of Western Kenya. Busia ATC is located at 0.46 ˚N, 34.11 ˚E and experiences a tropical humid climate with an annual temperature range of 14.7 ˚C-30.4 ˚C and annual rainfall range of 1,200mm-1,800mm (mean=1690mm p.a.). However, the area usually experiences a dry spell during the months of December through March. It lies at an altitude of 1,220m above sea level. The soils where the Cape gooseberry mother block was established are shallow murram/medium deep sandy-clay rhodic feral soils. The potential evaporation of the site is 1831mm p.a.

Design and treatments

Two varieties of Cape gooseberry (Colombia and Netherlands) were established using a paired comparison experimental design from transplanted nursery-raised seedlings in an underutilised fruit tree mother block (measuring 81m by 28m) at Busia ATC, Western Kenya between the 2nd and 4th of January 2019. The pairwise comparisons were done between the two treatments without a control. The land was ploughed and 3-4 week-old seedlings transplanted into pre-watered holes (about 1ft deep). The plant spacing parameters were as follows: inter-row spacing was 3m and intra-row (plant-to-plant) spacing was 2m. The crops were grown during a dry spell and the watering frequency was at alternating days at a rate of 2 liters per plant using watering cans. Gapping was done on 12th February 2019 for 95 plants that had died due to the effects of drought.

Agronomic practices, including farm yard manure application, pest, and disease control were performed to ensure good plant growth and development. Manure application (2 tons/ha) and mulching (organic mulch) were carried out on the 1st of February 2019 using the ring placement method. Pest management involved spraying of a pesticide (Escort) at the rate of 10mls/20L weekly for the first four weeks (28th January to 18th February 2019) and discontinued after the population of red spider mites and mealybugs decreased significantly. Plant nutrient supplements were also provided through foliar feed at the rate of 8mls per 20L of water on the 28th of January 2019.

The first flowering date was 12th of February 2019, while the first fruit appeared on 20th February 2019. Data on the number of flower buds, flowers, and fruits were collected on 6th and 7th March 2019. These agronomic data were collected from 354 plants comprising of 271 plants of the Colombia variety and 83 of the Netherland variety planted in 27 rows. In this study, only 12 rows comprising of six rows of Colombia (N=84) and six of Netherlands (N=83) were analysed as their planting date was similar. The variables were measured 21-22 days after the onset of flowering.

Data Analysis

Independent sample t-test was used to compare parameters for the two gooseberry varieties, at a probability of $p \leq 0.05$. Correlation (Pearson r) analysis was performed on the data to determine the correlation between the number of flowers, flower buds, or fruits and the number of branches for the two varieties. All analysis was performed in IBM SPSS Statistics, version 23.

RESULTS

Agronomic data on cape gooseberry varieties in western Kenya

The total number of flowers, flower buds, branches, and fruits for the two varieties is indicated in Table 1.

Table 1: Agronomic data of Colombia and Netherland gooseberry varieties in Busia County, Kenya.

	Columbia (n=84)*	Netherlands (n=83)	p-value	t-value
Number of flowers	750	748	0.33	0.99
Number of flower buds	4520	4170	0.28	1.1
Number of branches	822	832	0.72	-0.37
Number of fruits	1591	1310	0.21	1.27

*n represents the number of plants

The average number of flowers, flower buds, branches, and fruits per plant for the two varieties is displayed in Table 2.

Table 2: Average number of flowers, flower buds, branches and fruits per plant of Columbia and Netherlands gooseberry varieties in Busia County, Kenya.

	Columbia (n=84)*	Netherlands (n=83)	p-value	t-value
Number of flowers	9	9	0.33	0.99
Number of flower buds	53	50	0.28	1.1
Number of branches	10	10	0.72	-0.37
Number of fruits	19	16	0.21	1.27

*n represents the number of plants

The net fruit yield potential (calculated here as the average number of fruits, flower flowers, and flower buds) for the two varieties is indicated in Table 3.

Table 3: Yield potential of Colombia and Netherland gooseberry varieties in Busia County, Kenya.

	Columbia (n=84)*	Netherlands (n=83)	p-value	t-value
Average number of flowers, flower buds, and fruits per plant	82.9	72.6	0.27	1.12
Average number of branches per plant	9.8	10.0	0.72	-0.37

*n represents the number of plants

The correlation between the fruit number and vegetative branching for the two varieties is illustrated in Figure 1 and Figure 2.

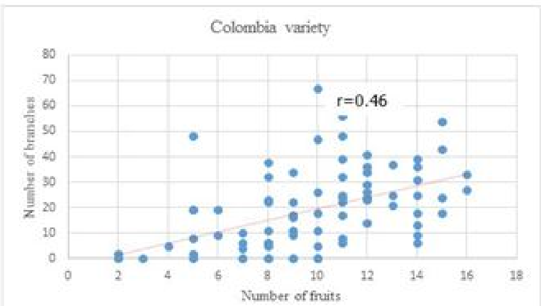

Figure 1: Correlation between fruit number and vegetative branching for Columbia gooseberry variety in Busia County, Kenya.

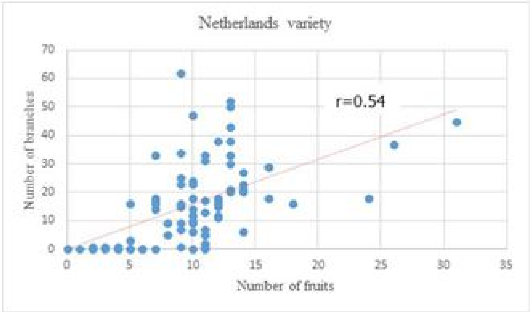

Figure 2: Vegetative branching for Columbia gooseberry variety in Busia County, Kenya.

DISCUSSION

On the agronomic traits of the two cultivars investigated, Colombia variety outperforms the Netherlands variety in all reproductive components, i.e., the number of flowers, flower buds, and fruits. However, the Netherlands has a higher number of branches than Colombia (832 vs. 822). Vegetative growth is known to affect the fruiting and yield and complicate harvesting in Cape gooseberry [5]. Therefore, Netherlands higher vegetative growth but inferior reproductive components suggest that its yield potential is lower than that of Colombia. Although the agronomic trait differences are not statistically significant ($p \leq 0.05$), Colombia can be ideal for commercial cultivation to maximise yield in smaller farms due to its less branching characteristic but higher expected reproductive output. However, the two varieties can perform relatively well in drier conditions. Gooseberry culture is resistant to drought, but in exceptional cases to reduce the influence of high temperatures and lack of rainfall on fruit production is necessary to apply irrigation on plantation development in critical moments-intensive plant growth and fruit maturation, submission buds fruits.

On average, the reproductive components (flowers, flower buds, branches, and fruits) per plant are higher in the Colombia variety than in in the Netherlands variety (82.9 vs. 72.6). This could be attributed to its dense vegetative growth. According to Malla et al., plant height and number of main branches are critical factors influencing the productivity of Cape gooseberry plants. Therefore, while the differences in reproductive components and branching between the two varieties are not statistically significant ($p \leq 0.05$), the lower vegetative growth in Colombia indicate that it is a more productive variety than Netherlands, as enhanced branching is a major morphological feature that lowers productivity in gooseberries [6].

In terms of yield potential, Colombia has a higher expected fruit than Netherlands. This is because it has a higher average combined reproductive components (number of flowers, flower buds, and fruits) per plant than Netherlands (82.9 vs. 72.6). Our results suggest that vegetative growth is a constraint to the yield potential of the two varieties, which is consistent with earlier studies [5,6].

A strong positive linear relationship was found between floral density and vegetative growth (branching) in the Colombia variety (r=0.77) compared to Netherlands' r=0.67. Further, the correlation between vegetative growth and the number flower buds and between vegetative growth and the number of fruits was found to be moderate, at r=0.496 and 0.463, respectively, implying a drop in flower bud and fruit setting. In comparison, a strong positive correlation was found between branching and the number of flowers (r=0.67) as well as between branching and the number of flower buds (r=0.70) in the Netherlands variety. However, the correlation between the number of fruits and the number of branches was moderate (r=0.54).

Since vegetative growth precedes the reproductive phase, and therefore is a constant, the variation in the correlation coefficients between the flower bud and flower stages can be attributed to accelerated bud-to-flower change under high temperatures, resulting in more flowers than flower buds in Colombia variety. Elevated root zone temperatures have been found to increase the photosynthetic rate and dry matter accumulation in gooseberries [7]. Netherlands' strong correlation between branching and number of flower buds indicates an extended holding of the bud stage in response to water stress. Early abscission of flowers due to high temperature-induced stomatal closure and leaf wilting (reduced leaf area) could explain the lower number of fruits for both varieties [8]. However, on average, Colombia has a higher flower and fruit density (53 and 19) per plant than Netherlands (50 and 16), indicating that it has lower sensitivity to drought [9-11].

CONCLUSION

This study compared expected fruit yield based on measured reproductive components of two gooseberry cultivars-Colombia and Netherlands-grown under supplemental irrigation. Though the differences in the number of flower buds, flowers, fruits, and branches are not statistically significant, correlation analysis found a stronger association between floral density and vegetative growth in Colombia than in Netherlands. A key finding of this study is that Colombia has a higher average reproductive component (flower and fruit density) than Netherlands, indicating that Colombia is a better performing variety under drought conditions supplemented with irrigation than Netherlands variety. It is thus a potentially high-yielding variety under water stress conditions that is ideal for drier agro-ecological zones.

REFERENCES

1. Lusike W, Kirigua V, Ochieng V, Mwanzia S, Wayua F, Omari F. Cape gooseberry (*Physalis peruviana* L.). 2019.
2. Mulwa S, Akuku B, Kimani I. KALRO gooseberry. 2019.
3. Puente LA, Pinto-Muñoz CA, Castro ES, Cortés M. *Physalis peruviana* Linnaeus, the multiple properties of a highly functional fruit: A review. Food Res Int. 2011;44(7):1733-1740.
4. Lebon G, Wojnarowiez G, Holzapfel B, Fontaine F, Vaillant-Gaveau N, Clément C. Sugars and flowering in the grapevine (Vitis vinifera L.). J Exp Bot. 2008;59(10):2565-2578.
5. Panayotov N, Popova A. Vegetative and productive behaviors of Cape gooseberry (*Physalis peruviana* L.), grown by direct sowing outside under conditions of Bulgaria. Turkish J Agri Nat Sci. 2014;1(1):1141-1146.
6. Malla AA, Sharma RM, Singh AK, Masoodi FA. Propagation and pinching studies in cape gooseberry (*Physalis peruviana* L.). J Res. 2008;7:128-139.
7. Fischer G. Effect of root zone temperature and tropical altitude on the growth, development and fruit quality of Cape gooseberry (*Physalis peruviana* L.). 1996.
8. Aldana F, García PN, Fischer G. Effect of waterlogging stress on the growth, development and symptomatology of cape gooseberry (*Physalis peruviana* L.) plants. Rev Academia Colomb Cienc. 2014;38(149):393-400.

9. Mota RV. Federal Technological University of Parana, Campus of Dois Vizinhos, 2009. 2006.

10. Mota RV. Characterisation of black-berry juice prepared in a domestic extractor. Food Sci Technol. 2006;26(2):303-308.

11. Sola AJ, Ehrlen J. Vegetative phenology constrains the onset of flowering in the perennial herb Lathyrus vernus. J Ecol. 2007;95(1):208-216.