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EFFECT OF SPACING AND FERTILIZER INTERACTIONS ON GROWTH OF CAPE GOOSEBERRY (GOLDEN BERRY) IN ANDHRA PRADESH, INDIA

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ABSTRACT

The study was conducted at Dr. Y.S.R. Horticulture University, Andhra Pradesh, during 2021-22 and 2022-23 to assess the interactions between plant spacing and NPK fertilization in Cape gooseberry. The experiment was carried out using a randomized block design (FRBD) with 20 treatment combinations, replicated three times. The results indicated that both plants spacing and NPK fertilization had a significant impact on growth parameters. At 150 days after transplanting (DAT), the maximum plant height (114.83 cm) was recorded in the 60 x 60 cm spacing with 250:160:160 kg NPK/ha, while the minimum height (76.66 cm) was observed in the 100 x 80 cm spacing with no NPK application. Conversely, the highest number of branches (24.49 per plant) and leaf area (89.44 cm²) were recorded in the 100 x 80 cm spacing with 250:160:160 kg NPK/ha, while the lowest values (4.29 branches per plant and 80.15 cm² leaf area) were observed in the 60 x 60 cm spacing with no NPK application. In terms of physiological parameters, the highest specific leaf weight (23.05 g and 29.28 g), leaf relative water content (73.52% and 76.10%) and chlorophyll content (21.65 SPAD units and 16.22 SPAD units) were observed in the 100 x 80 cm spacing with 250:160:160 kg NPK/ha, at the vegetative and reproductive stages, respectively. In contrast, the lowest specific leaf weight (19.27 g and 23.48 g), leaf relative water content (62.29% and 64.69%) and chlorophyll content (16.19 SPAD units and 12.06 SPAD units) were recorded in the 60 x 60 cm spacing with no NPK application. The results indicate that wider spacing improves light penetration, reduces resource competition and promotes better overall growth. Additionally, higher NPK levels significantly enhanced physiological performance by improving nutrient availability. These findings underscore the importance of plant spacing and NPK fertilization in optimizing growth and physiological efficiency. Further research is needed to explore the long-term effects on fruit yield and quality.

Key words : Cape gooseberry, Golden berry, *Physalis peruviana*.

Introduction

Cape gooseberry (*Physalis peruviana* L.), belonging to the Solanaceae family, is an important fruit crop known for its nutritional and economic value. Native to Peru and Chile (Legge, 1974), Cape gooseberry has been widely introduced to tropical, sub-tropical, and even temperate regions. It thrives in similar conditions to tomatoes, making it adaptable to diverse climates (Morton, 1987). Due to its exceptional nutritional properties, including high levels of provitamin A, vitamin C and essential minerals like phosphorus, iron, and dietary fiber, Cape gooseberry has seen increased consumption in recent years (Rehm and Espig, 1991). The fruit's composition includes water (79-86%), carbohydrates (11-14%), protein (0.5-2.3%), fat (0.4-1.3%), fiber (2.9-4.9%), calcium (7-14 mg), phosphorus (21-39 mg), iron (1.1-1.7 mg), vitamin A (748 IU), niacin (0.8 mg) and vitamin C (11-20 mg) per 100 g of fruit. These qualities make Cape gooseberry a highly sought-after crop for both nutritional and commercial purposes.

In the cultivation of Cape gooseberry, proper plant spacing is a key factor influencing growth and yield. Optimizing plant spacing ensures better light penetration, reduces competition for water and nutrients, and promotes overall plant health. Research on related crops, such as tomato (Reid *et al.*, 2023; Nkansah *et al.*, 2021), has shown that wider spacing can improve physiological traits. However, closer spacing may lead to higher plant density, which can reduce growth performance due to increased resource competition.

Fertilization also plays a crucial role in enhancing the growth, development, and yield of Cape gooseberry. Proper nutrient management, particularly through balanced NPK (Nitrogen, Phosphorus and Potassium) fertilization, is essential for achieving optimal plant health and productivity. Phosphorus supports energy metabolism and photosynthesis (Yan *et al.*, 2021), while potassium plays a key role in carbohydrate and protein metabolism (Hassanein *et al*., 2021). An appropriate balance of NPK fertilizers directly influences nutrient absorption, assimilation, and, consequently, plant growth (Yildirim *et al*., 2011). Previous studies on crops like tomato (Singh *et al*., 2010; Hariyadi *et al*., 2019) have shown that NPK fertilization significantly improves plant growth, leaf area, biomass, and fruit yield.

The combination of optimal plant spacing and NPK fertilization is crucial for maximizing Cape gooseberry's growth and yield potential. Research on other crops suggests that the right nutrient balance and plant spacing can enhance growth and yield parameters (Ali *et al.*, 2017 in Cape gooseberry; Law-Ogbomo and Egharevba, 2008 in tomato). These findings highlight the importance of these agronomic practices in improving the productivity and quality of Cape gooseberry fruits.

Given the increasing commercial interest in Cape gooseberry cultivation, understanding how plant spacing and NPK fertilization interact to affect growth and yield is essential for developing effective management strategies. This study aims to fill this gap by evaluating the impact of plant spacing and NPK fertilization on the growth and physiological parameters of Cape gooseberry, drawing parallels with research on related crops like tomato.

Materials and Methods

The present investigation was carried out two seasons under agro-climatic conditions of coastal region of Andhra Pradesh during post monsoon season of 2022-23 and 2023-24. The experiment was conducted in the experimental block at College of Horticulture, Venkataramannagudem, Andhra Pradesh. Venkataramannagudem is situated in the West Godavari district of Andhra Pradesh. The region experiences a tropical climate with hot summers, moderate winters and significant seasonal rainfall, primarily influenced by the *south-west* monsoon. It lies at a latitude of approximately 16°53' N, longitude 81°16' E and an altitude of about 34 meters above sea level. The experiment was conducted in factorial randomized block design (FRBD) with four levels of spacing and five levels of fertilizer rates comprising 20 treatments *viz*. Levels of plant spacing (60 x 60 cm, 80 x 60 cm, 80 x 80 cm and 100 x 80 cm) and levels of NPK (0:0:0, 100:40:40, 150:80:80, 200:120:120 and 250:160:160 kg/ha). Data were collected from ten randomly selected plants per plot. Measured vegetative growth parameters included plant height, number of branches, and leaf area, while physiological parameters included specific leaf weight, leaf relative water content, and chlorophyll content. Seedling height was measured from the collar region to the shoot apex at 30, 60, 90, 120 and 150 days after transplanting (DAT) using a measuring tape, and the average was calculated. The number of branches per plant was recorded and averaged for the same intervals. Leaf area was measured using a Leaf Area Meter on 20 randomly selected leaves from the top, middle, and bottom portions of tagged plants. The data were expressed in square centimeters (cm^2) as averages for each time point. Physiological growth parameters, including specific leaf weight (SLW), relative water content (RWC) and total chlorophyll content were measured at the vegetative stage (45 DAT) and reproductive stage (180 DAT). SLW was calculated as leaf weight (g) divided by leaf area (cm^2).

RWC was determined using Weatherley's (1950) method: fresh leaf discs (8 mm diameter) were weighed, imbibed in distilled water for 4-6 hours, surface-dried, reweighed, oven-dried at 70°C for 24 hours, and reweighed.

RWC was calculated as

$$RWC = \frac{(\text{Fresh weight} - \text{Oven dry weight})}{(\text{Turgid weight} - \text{Over dry weight})} \times 100$$

Total chlorophyll content was measured using a digital chlorophyll SPAD meter on five randomly selected plants per treatment replication, and the average was expressed in SPAD units.

Results and Discussion

Vegetative growth characters

Plant height

Among the interaction, the highest plant height (114.83 cm) was recorded in 60 x 60 cm + 250:160:160 NPK kg/ha followed by 60 x 60 cm + 200:120:120 NPK kg /ha (110.16 cm) and the lowest plant height (76.66 cm) was noticed in the control (Table 1).

At closer spacing, competition for light and space might be the reason for increased plant height (Karpe *et al.*, 2024 and Torres *et al.*, 2023 in Tomato). The probable reason for increased plant height with highest level of NPK application is obvious as more uptake of these nutrients during plant growth and is needed for more protein and protoplasm synthesis for higher rate of meiosis, resulting better photosynthesis and plant growth and ultimately increased the plant height (Sollapur *et al.*, 2017 in brinjal). Maximum availability of nitrogen directly affects the growth of plant, thus leads to increase in plant height (Abdel *et al.*, 2007 in tomato).

The interaction between plant spacing and NPK fertilization influenced the plant height significantly. At closer spacings (60 x 60 cm), the plants grew taller when high NPK levels (250:160:160 kg NPK/ha) were applied, likely due to the higher nutrient availability and increased protein synthesis. However, the combination of wider spacing (100 x 80 cm) with no fertilizer application resulted in the lowest plant height, indicating that while spacing allowed for better root development, the absence of nutrients limited overall growth. This suggests that both adequate spacing and fertilizer are necessary for optimal plant height development (Gupta and Shukla, 1997 in tomato).

Table 1 : Plant height (cm) of Cape gooseberry as influenced by plant spacing and NPK levels interactions.

Plant spacings (cm)	NPK levels (kg/ha)					S.Em± C.D. (P=0.05)
	0:0:0	100:40:40	150:80:80	200:120:120	250:160:160	
30 DAT						
60 x 60	27.49	32.81	37.29	41.66	44.45	
80 x 60	25.81	31.16	36.04	39.16	41.61	
80 x 80	25.40	28.27	30.56	32.83	36.18	0.141
100 x 80	23.55	24.66	27.32	29.27	31.87	0.417
60 DAT						
60 x 60	47.88	52.21	62.55	70.20	73.49	
80 x 60	46.61	52.21	57.05	65.45	70.89	
80 x 80	48.93	49.45	50.27	52.73	56.61	0.118
100 x 80	45.31	45.55	48.93	51.10	53.83	0.348
90 DAT						
60 x 60	68.12	74.12	81.67	86.88	92.87	
80 x 60	68.98	76.98	82.89	81.23	83.12	
80 x 80	64.12	68.34	70.12	75.57	81.23	0.181
100 x 80	59.12	63.98	69.98	69.98	74.12	0.535
120 DAT						
60 x 60	87.67	93.29	98.55	104.29	108.16	
80 x 60	82.79	91.93	95.77	102.42	105.62	
80 x 80	82.15	89.72	93.05	95.30	98.55	0.132
100 x 80	70.30	73.87	78.16	82.28	87.23	0.389
150 DAT						
60 x 60	92.87	94.92	101.98	110.16	114.83	
80 x 60	86.52	92.23	96.19	100.62	104.74	
80 x 80	82.61	86.94	91.66	94.95	100.11	0.150
100 x 80	76.66	80.75	85.70	88.96	94.41	0.444

Table 2: Number of branches/plant of Cape gooseberry as influenced by plant spacing x NPK-levels interactions.

Plant spacings (cm)	NPK levels (kg/ha)					S.Em± C.D. (P=0.05)
	0:0:0	100:40:40	150:80:80	200:120:120	250:160:160	
30 DAT						
60 x 60	1.14	1.37	1.56	1.63	2.19	
80 x 60	2.20	3.21	3.34	3.51	3.77	
80 x 80	3.22	3.32	3.66	4.25	4.42	0.066
100 x 80	3.40	3.58	4.62	4.65	5.37	0.380
60 DAT						
60 x 60	2.19	2.42	2.62	3.08	4.14	
80 x 60	4.75	4.76	5.25	5.48	5.37	
80 x 80	6.24	5.99	7.42	7.48	8.51	0.094
100 x 80	8.71	9.02	9.82	10.09	10.19	0.278
90 DAT						
60 x 60	2.50	3.53	4.30	4.70	5.30	
80 x 60	4.30	5.02	5.60	6.61	8.46	
80 x 80	8.51	9.35	9.67	10.48	11.30	0.099
100 x 80	11.27	12.34	12.61	14.02	15.40	0.293
120 DAT						
60 x 60	3.30	4.12	4.49	5.17	6.21	
80 x 60	5.21	5.43	7.91	8.81	8.90	
80 x 80	9.37	12.39	12.92	14.65	16.57	0.069
100 x 80	12.01	13.91	16.51	17.33	19.98	0.139
150 DAT						
60 x 60	4.29	4.71	5.47	5.80	6.42	
80 x 60	5.74	6.79	8.74	9.92	10.26	
80 x 80	11.60	13.62	14.55	17.49	19.78	0.095
100 x 80	16.19	17.52	19.29	23.02	24.49	0.281

Number of branches per plant

Among the interactions, the highest number of branches (24.49 per plant) was recorded in 100 x 80 cm + 250:160:160 NPK kg/ha, followed by 100 x 80 cm + 200:120:120 NPK kg/ha (23.02 per plant). The lowest (4.29 per plant) was observed in 60 x 60 cm without NPK application (Table 2).

The wider spacing favoured the greater number of branches per plant due to lesser competition for space moisture, light and nutrients (Hussain *et al.*, 2016) in tomato. Increase in number of branches per plant due to NPK application attributed to more availability of applied nutrients, specialty nitrogen which tends to vigorous growth of plant remitting profuse branching (Raksun *et al.*, 2022 and Manoj *et al.*, 2018) in tomato.

The number of branches per plant was significantly influenced by the interaction between spacing and NPK fertilization. The wider spacing (100 x 80 cm) provided more room for lateral growth, and when combined with high NPK levels (250:160:160 kg NPK/ha), the plants exhibited greater branching due to the reduced competition for light, space and nutrients. Conversely, the closer spacing (60 x 60 cm) with no fertilization resulted in a dramatic reduction in branching, possibly due to limited resources for branch development. Thus, the interaction between adequate spacing and high NPK fertilization promoted optimal branching. which might be due to more growth at wider spacing accompanied with higher level of fertilizers (Moccia and Katcherian, 1997) in cherry tomato.

Leaf area

Among the combinations, the maximum leaf area (89.44 cm²) was observed in 100 x 80 cm + 250:160:160 NPK kg/ha, followed by 80 x 80 cm + 250:160:160 NPK kg/ha (88.97 cm²). The minimum (80.15 cm²) was recorded in 60 x 60 cm without NPK application (Table 3).

The maximum leaf area under widest spacing is

Table 3 : Leaf area (cm^2) of Cape gooseberry as influenced by plant spacing x NPK-levels interactions.

Plant spacings (cm)	NPK levels (kg/ha)					S.Em± C.D. (P=0.05)
	0:0:0	**100:40:40**	**150:80:80**	**200:120:120**	**250:160:160**	
30 DAT						
60 x 60	29.07	31.09	32.76	35.20	37.35	
80 x 60	29.32	31.19	33.44	35.44	37.51	
80 x 80	29.57	31.61	33.78	35.53	38.13	0.200
100 x 80	29.86	32.22	35.83	36.96	38.81	0.591
60 DAT						
60 x 60	39.19	42.06	47.99	53.32	54.63	
80 x 60	39.55	42.12	48.16	53.71	54.98	
80 x 80	39.72	42.29	48.98	53.99	55.41	0.155
100 x 80	39.97	42.63	49.07	54.17	55.84	0.460
90 DAT						
60 x 60	59.21	60.60	62.38	64.92	65.71	
80 x 60	59.83	60.69	62.72	65.05	66.28	
80 x 80	59.96	61.07	63.02	65.27	66.95	0.085
100 x 80	60.26	61.84	63.16	66.20	68.08	0.252
120 DAT						
60 x 60	69.63	71.84	73.79	75.61	76.82	
80 x 60	69.75	71.97	73.94	75.75	77.10	
80 x 80	69.90	72.17	74.15	75.88	77.27	0.048
100 x 80	70.32	72.53	74.37	76.76	77.84	0.143
150 DAT						
60 x 60	80.15	80.84	83.13	85.75	87.57	
80 x 60	80.33	81.63	83.80	86.16	87.90	
80 x 80	80.89	81.81	84.85	86.94	88.97	0.042
100 x 80	81.01	82.06	85.17	87.25	89.44	0.124

probably due to the fact that the plant had more branches, space for spread and also seems to have less competition for soil nutrients, solar energy and air space (Bhattarai *et al.,* 2015 and Singh *et al.,* 2005) in tomato. The increase in leaf area due to NPK application might be due to the fact that these nutrients have a key role in assimilation of amino acids, nucleic acids and regulation of many metabolic processes which in turn increased photosynthetic efficiency (Tisdale, 1997).

Leaf area was maximized when wider spacing (100 x 80 cm) was coupled with high NPK levels (250:160:160 kg NPK/ha). This combination likely facilitated better light penetration, reduced competition, and promoted greater leaf expansion. Plants under narrower spacing (60 x 60 cm) and no NPK application showed a significantly smaller leaf area, which could be attributed to competition for light and nutrients. Therefore, the interaction between wide spacing and high NPK fertilization positively influenced leaf area, which is critical for efficient photosynthesis. This might be attributed to increased growth at wider spacing, coupled with higher fertilizer levels. As a result, the leaf area expanded due to the interaction effect of spacing and fertilizer dosage (Bhattarai *et al.,* 2017) in cherry tomato.

Physiological growth parameters

Specific leaf weight

The findings in Table 4 show that plant spacing and NPK interactions significantly impacted specific leaf weight at both vegetative and reproductive stages. The highest values (23.05 g and 29.28 g) were recorded in 100 x 80 cm + 250:160:160 NPK kg/ha, followed by 80 x 80 cm + 260:160:160 NPK kg/ha (22.80 g and 28.45 g) while the lowest (19.27 g and 23.48 g) were observed in 60 x 60 cm without NPK application.

The study found that wider spacing increased leaf weight by enhancing light penetration, reducing competition and improving air circulation. This allowed better resource access, resulting in heavier leaves (Azadbakht *et al.,* 2016) in tobacco. Higher NPK levels

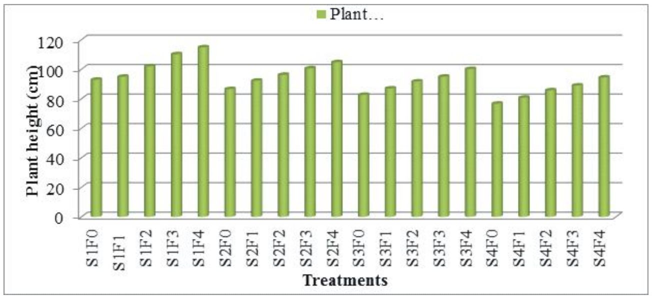

Fig. 1 : Effect of spacing and fertilizer dose on plant height (cm) at 150 DAT in Cape gooseberry (*Physalis peruviana* L.). Spacing (S) - S_1: 60 x 60 cm, S_2: 80 x 60 cm, S_3: 80 x 80 cm, S_4: 100 x 80 cm; Fertilizer (F) -F_0: Control, F_1: 100:40:40 kg ha^{-1}, F_2: 150:80:80 kg ha^{-1}, F_3: 200:120:120 kg ha^{-1}, F_4: 250:160:160 kg ha^{-1}.

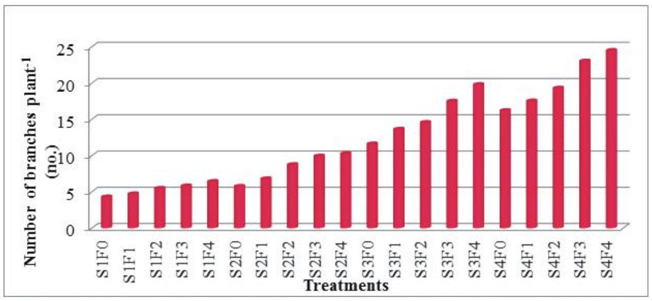

Fig. 2 : Effect of spacing and fertilizer dose on number of branches (no.) at 150 DAT in Cape gooseberry (*Physalis peruviana* L.). Spacing (S) - S_1: 60 x 60 cm, S_2: 80 x 60 cm, S_3: 80 x 80 cm, S_4: 100 x 80 cm; Fertilizer (F) -F_0: Control, F_1: 100:40:40 kg ha^{-1}, F_2: 150:80:80 kg ha^{-1}, F_3: 200:120:120 kg ha^{-1}, F_4: 250:160:160 kg ha^{-1}.

significantly boosted leaf weight in Cape gooseberry by enhancing leaf area, root development, and water regulation (Ali *et al*., 2020) in tomato.

Specific leaf weight (SLW) was higher in plants grown at wider spacings (100 x 80 cm) with higher NPK levels (250:160:160 kg NPK/ha). This interaction suggests that the combination of more space for plant growth and nutrient availability resulted in heavier, more robust leaves. Conversely, at closer spacing (60 x 60 cm) with no fertilizer, SLW was lower, likely due to limited leaf expansion and nutrient deficiency. Thus, the interaction between wide spacing and NPK fertilization enhanced SLW by supporting better overall plant health and development. This may be attributed to the interaction between plant spacing and NPK fertilization, which influences leaf development and weight, potentially affecting SLW.

Leaf relative water content

Among the interactions, the highest leaf relative water content (73.52% and 76.10%) was recorded in 100 x 80 cm + 250:160:160 NPK kg/ha, followed by 80 x 80 cm + 250:160:160 NPK kg/ha (72.72% and 74.47 %). The lowest (62.29 % and 64.69 %) was observed in 60 x 60 cm with control (no fertilizer application) at the vegetative and reproductive phases, respectively (Table 5).

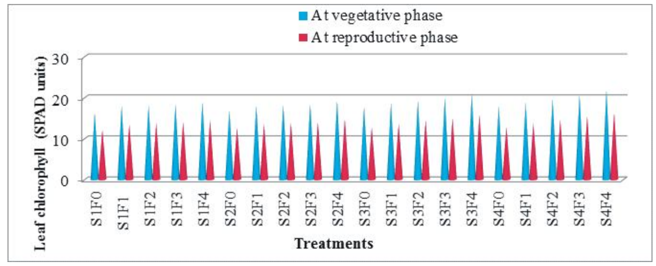

Fig. 3 : Effect of spacing and fertilizer dose on leaf chlorophyll content (SPAD units) at vegetative and reproductive phase in Cape gooseberry (*Physalis peruviana* L.). Spacing (S) - S_1: 60 x 60 cm, S_2: 80 x 60 cm, S_3: 80 x 80 cm, S_4: 100 x 80 cm; Fertilizer (F) -F_0: Control, F_1: 100:40:40 kg ha^{-1}, F_2: 150:80:80 kg ha^{-1}, F_3: 200:120:120 kg ha^{-1}, F_4: 250:160:160 kg ha^{-1}.

Increased plant spacing positively affected leaf water content in Cape gooseberry by reducing competition for resources, allowing plants to maintain higher water content and improve overall vigor (Chakma *et al.*, 2021) in tomato. Increased NPK fertilization enhanced leaf area, weight, biomass and relative water content in Cape gooseberry. Nitrogen boosted leaf area, phosphorus improved root development and potassium strengthened cell walls and water regulation, leading to higher leaf weight and water content (Ali *et al*., 2020) in tomato.

The interaction of plant spacing and NPK fertilization had a significant effect on leaf relative water content (RWC). The highest RWC values were recorded in plants grown at wider spacing (100 x 80 cm) with high NPK application (250:160:160 kg NPK/ha), indicating that better nutrient availability and reduced competition enabled better water retention. On the other hand, the lowest RWC was observed at closer spacing (60 x 60 cm) with no fertilizer application, possibly due to higher competition for water resources. Although, specific research on the interaction between plant spacing and NPK fertilization on RWC is scarce, it is reasonable to infer that optimal combinations of these factors could synergistically improve RWC by reducing inter-plant competition and ensuring adequate nutrient availability, thereby enhancing the plant's ability to retain water.

Leaf chlorophyll content

Among the interactions, the highest leaf chlorophyll content (21.65 and 16.22 SPAD units) was recorded in 100 x 80 cm + 250:160:160 NPK kg/ha, followed by 80 x 80 cm + 250:160:160 NPK kg/ha (20.83 and 15.84 SPAD units). While, the lowest (16.19 and 12.06 SPAD units) was observed in 60 x 60 cm with control (no fertilizer) at

Table 4: Specific leaf weight (g) of Cape gooseberry as influenced by plant spacing x NPK-levels interactions.

Plant spacings (cm)	NPK levels (kg/ha)					S.Em± C.D. (P=0.05)
	0:0:0	100:40:40	150:80:80	200:120:120	250:160:160	
45 DAT						
60 x 60	19.27	19.45	19.98	20.92	21.84	
80 x 60	20.08	20.07	21.29	21.45	22.02	
80 x 80	20.23	20.78	21.49	22.16	22.80	0.061
100 x 80	20.45	21.06	21.62	22.26	23.05	0.181
180 DAT						
60 x 60	23.48	23.81	25.71	26.72	27.33	
80 x 60	23.97	24.35	25.85	27.07	28.00	
80 x 80	24.61	24.71	26.14	27.14	28.45	0.031
100 x 80	24.72	26.00	27.69	27.83	29.28	0.091

Table 5 : Leaf relative water content (%) of Cape gooseberry as influenced by plant spacing x NPK-levels interactions.

Plant spacings (cm)	NPK levels (kg/ha)					S.Em± C.D. (P=0.05)
	0:0:0	100:40:40	150:80:80	200:120:120	250:160:160	
45 DAT						
60 x 60	62.29	63.88	65.19	67.58	70.91	
80 x 60	62.45	63.89	65.32	68.22	71.40	
80 x 80	63.19	64.10	65.93	69.46	72.72	0.063
100 x 80	63.47	64.25	66.12	70.67	73.52	0.187
180 DAT						
60 x 60	64.69	64.29	66.73	69.73	72.60	
80 x 60	65.19	65.20	67.56	70.25	73.47	
80 x 80	65.26	66.16	67.94	71.66	74.47	0.071
100 x 80	66.03	71.69	68.69	72.63	76.10	0.210

Table 6: Leaf chlorophyll content (SPAD units) of Cape gooseberry as influenced by plant spacing x NPK-levels interactions.

Plant spacings (cm)	NPK levels (kg/ha)					S.Em± C.D. (P=0.05)
	0:0:0	100:40:40	150:80:80	200:120:120	250:160:160	
45 DAT						
60 x 60	16.19	17.87	18.05	18.29	18.87	
80 x 60	16.78	18.02	18.06	18.36	19.10	
80 x 80	17.58	18.51	19.21	19.94	20.83	0.114
100 x 80	17.84	18.66	19.55	20.59	21.65	0.336
180 DAT						
60 x 60	12.06	13.39	13.75	13.98	14.40	
80 x 60	12.57	13.45	13.80	13.95	14.65	
80 x 80	12.63	13.52	14.42	14.96	15.84	0.086
100 x 80	12.76	13.62	14.57	15.40	16.22	0.225

the vegetative and reproductive phases, respectively (Table 6).

Wider plant spacing increased leaf chlorophyll content due to improved light availability, as denser plantings reduce light penetration to lower canopy levels, leading to decreased chlorophyll. Wider spacing enhances light penetration, promoting greater chlorophyll production (Dimri and Lal, 1997) in tomato. Nitrogen, a key component of chlorophyll, plays a crucial role in its synthesis (Lehninzer, 1992). Higher NPK levels increased total chlorophyll content (Rajkumar, 1994) in peaches and Singh *et al.*, 2003) in sapota.

Leaf chlorophyll content was significantly influenced by the interaction between plant spacing and NPK fertilization. The highest chlorophyll content was recorded in plants grown at wider spacing (100 x 80 cm) with high NPK application (250:160:160 kg NPK/ha), likely due to improved light penetration and enhanced nitrogen availability, which play a crucial role in chlorophyll synthesis and photosynthetic efficiency. Conversely, the lowest chlorophyll content was observed in plants at closer spacing (60 x 60 cm) with no fertilizer application, possibly due to limited light availability and nutrient deficiency. This might be due to the combined effect of appropriate plant spacing and balanced NPK fertilization, which enhances leaf chlorophyll content by improving light availability, ensuring adequate nutrient uptake and reducing inter-plant competition.

Conclusion

The present study evaluated the effects of plant spacing and NPK fertilization on the vegetative growth and physiological parameters of Cape gooseberry. The interaction between 60 x 60 cm spacing and 250:160:160 kg NPK/ha resulted in the highest plant height, while 100 x 80 cm spacing with no NPK application produced the lowest plant height. The maximum number of branches, leaf area, specific leaf weight, leaf relative water content, and leaf chlorophyll content were observed in the treatment combination of 100 x 80 cm spacing with 250:160:160 kg NPK/ha. Conversely, the lowest values for these parameters were recorded under 60 x 60 cm spacing with 0:0:0 kg NPK/ha. These findings underscore the importance of optimizing plant spacing and NPK fertilization to enhance the growth and physiological attributes of Cape gooseberry, aligning with similar results observed in other crops such as tomato and brinjal.

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