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Study on response of different doses of nitrogen on vegetative growth, flowering, fruiting and fruit quality of Cape gooseberry (*Physalis peruviana* L.)

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Abstract
The present study was carried out at Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj (U.P) during October 2020 to March 2021 to study the response of different doses of nitrogen on vegetative growth, flowering, fruiting and fruit quality of cape gooseberry. The experiment was conducted in Randomized Block Design (R.B.D) with nine treatments and three replications. The treatments were T_1 (Nitrogen @ 120 Kg/ha), T_2 (Nitrogen @ 115 Kg/ha), T_3 (Nitrogen @ 110 Kg/ha), T_4 (Nitrogen @ 105 Kg/ha), T_5 (Nitrogen @ 100 Kg/ha), T_6 (Nitrogen @ 95 Kg/ha), T_7 (Nitrogen @ 90 Kg/ha), T_8 (Nitrogen @ 85 kg/ha), T_9 (Nitrogen @ 80 Kg/ha) and Phosphorous, Potash at a constant dose of 60 Kg/ha. Nitrogen was applied in form of urea and Phosphorous, Potash in form of SSP and MOP. Treatment T_1 (120N: 60P: 60K) Kg/ha was found best for vegetative parameters like plant height, number of leaves, leaf area but first flower initiation and fruiting was delayed and it took minimum days in treatment T_9 (Nitrogen @ 80 Kg/ha). Treatment T_3 (110N: 60P: 60K) Kg/ha was found best for the parameters like number of branches, TSS, ascorbic acid whereas high acidity content was recorded for T_1 (Nitrogen @ 120 Kg/ha).

Keywords: Cape gooseberry, urea, single super phosphate, murate of potash

1. Introduction

Cape gooseberry is a potential underutilized fruit crop of the world which comes under Solanaceae family. It is indigenous to South America but was cultivated in South Africa in the region of Cape of Good Hope during 19th century imparting the common name, "Cape gooseberry." It is grown in tropical (as perennial) and subtropical (as annual) in different regions of the world (Morton, 1987). The plant is herbaceous in nature and reaches 2 to 3 feet in height under favorable growing conditions. The fruit bears a globular shape, each include in inflated calyx, which become pepary on maturity and gives a look like Chinese lantern. Cape gooseberry is known by different names in different parts of world commonly like Poha or Poha berry (Hawaii), Golden berry (South Africa and U.K.), Peruvian ground cherry or Peruvian cherry (U.S.), Uvilla (Ecuador), Uchuva (Colombia). In India it is known as Rashbhari, Makoi, jam fruit or Tepari (Gupta and Roy, 1980; Morton, 1987; Sarangi *et al.*, 1989).

Cape gooseberry is a quick growing herbaceous crop which can be easily propagated by seeds and cuttings. It has a wide adaptability to different soil types and climatic conditions. In Northern India it is not cultivated above 1200 m, but in Southern India it thrives up to 1800 m above the mean sea level. It is an herbaceous, semi-shrub that is upright, perennial in subtropical zones and can grow until reaches 0.9 m. The fruit is 4–5 g in weight, remains protected by a calyx and covered by a brilliant yellow peel (Mayorga, *et al.*, 2001).

The plant like sunny, frost free location and sheltered from strong winds. It can thrive in mild cold up to 5 ^{0} C and higher temperature upto 35 ^{0}C. It is said to succeed wherever tomato can be grown, however, temperature around 21 ^{0} C is ideal for good crop. The cape goose berry can be grown in any well drained soil of neutral pH but it does best in sandy loam soil having adequate porosity for drainage (Chattopadhyaya, 1996). It also contains higher amount of vitamin C than orange and is good source of dietary fiber. Many medicinal properties have been attributed to Cape gooseberry, including anti asthmatic, antiseptic and strengthener for the optic nerve, treatment of throat infections and elimination non- intestinal parasites, amoebas as well as albumin from kidneys.

Nitrogen plays an important role in imparting better growth and development of plant. Higher nitrogen doses help in attaining the increased plant height, number of branches, number of leaves, plant spread, number of fruits and yield. The quality of fruits, in terms of total soluble solids was also improved due to nitrogen application. Nitrogen nutrition promotes flowering and fruit set, but excess of it delayed fruit maturity. Increasingly higher levels of nitrogen delays fruiting, fruit setting and fruit maturity. The vigorous growth of Cape gooseberry plants required high nitrogen application especially under soils with poor fertility such as sandy soil. Increase in nitrogen levels and spacing resulted in the production of quality fruits. Adequate supply of nitrogen is essential for vegetative growth, and desirable yield.

2. Material and Methods

The details of the various materials used and methods adopted in laid out the experiment are presented below:

2.1 Experimental Site

The present experiment entitled "Study on response of different doses of nitrogen on yield attributes of Cape gooseberry (*Physalis peruviana L.)"* was carried out at the field of Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Science and Technology, Prayagraj. The experimental site is situated at an elevation of 98 meters above sea mean level (MSL) at 25.45^0 North latitude and 81.84^0 East longitudes. This region has a sub-tropical climate prevailing in the South-East part of Uttar Pradesh with both the extremes in temperature, *i.e*., the winter and the summer. In cold winters, the temperature sometimes is as low as 32^0F in December – January and very hot summer with temperature reaching up to 115^0F in the months of May and June. During winter, frosts and during summer, hot scorching winds are also common. The average rainfall is around 1013.4 (mm) with maximum concentration during July to September months with occasional showers in winters.

Table 1: Show the treatment details

Sl. No.	Treatment notations	Treatment Combination (Kg/ha)
1.	T_1	120 (Nitrogen): 60 (Phosphorous): 60 (Potash)
2.	T_2	115 (Nitrogen): 60 (Phosphorous): 60 (Potash)
3.	T_3	110 (Nitrogen): 60 (Phosphorous): 60 (Potash)
4.	T_4	105 (Nitrogen): 60 (Phosphorous): 60 (Potash)
5.	T_5	100 (Nitrogen): 60 (Phosphorous): 60 (Potash) (RDF)
6.	T_6	95 (Nitrogen): 60 (Phosphorous): 60 (Potash)
7.	T_7	90 (Nitrogen): 60 (Phosphorous): 60 (Potash)
8.	T_8	85 (Nitrogen): 60 (Phosphorous): 60 (Potash)
9.	T_9	80 (Nitrogen): 60 (Phosphorous): 60 (Potash)

3. Results and Discussion

3.1 Growth parameters

The study on different doses of nitrogen on vegetative growth under different treatments is described below.

The maximum plant height attained after 20 days of transplanting was 30.35 cm in T_2 (Nitrogen @ 115 Kg/ha) whereas the minimum height 15.44 cm was recorded in treatment T_9 (Nitrogen @ (80 Kg/ha). The maximum plant height recorded after 40 days of transplanting was recorded in treatment T_3 (Nitrogen @110 Kg/ha) at 48.76cm and the minimum plant height was recorded in treatment T_9 (31.60 cm). Plant height recorded maximum after 60 days of transplanting in treatment T_1 (Nitrogen @ 120 Kg/ha) at 74.51cm whereas minimum plant height was recorded in case of treatment T_9 (Nitrogen @80 Kg/ha) at 53.78 cm. The probable reason for increased plant height was possibly due to the readily available nitrogen, which might have encouraged more vegetative growth and development. Girapu and kumar (2006) [9] found similar result for plant height with nitrogen at the rate of 120 Kg/ha.

The maximum number of leaves at 20 days after transplanting was recorded in T_2 (Nitrogen @ 115 Kg/ha) showing (9.17) per plant whereas minimum number of leaves 5.83 was recorded in T_9 (Nitrogen @ 80Kg/ha). The maximum number of leaves (44.87) recorded after 40 days of transplanting in T_1 (Nitrogen @ 120 Kg/ha) and minimum was recorded in case of T_9 (Nitrogen @ 80Kg/ha) at 29.44. At 60 days after transplanting the maximum number of leaves (91.58) was found in T_1 (Nitrogen @ (120 Kg/ha) and minimum no of leaves (49.22) was found in T_9 (Nitrogen @ 80 Kg/ha). The probable reason for increased number of leaves due to increased soil fertility which attributed to more availability of applied nutrients, specially nitrogen which tends to vigorous growth of plant remitting profuse branching and leaf production. The similar findings were also reported by Ali and Singh (2015) [1] in cape gooseberry.

The maximum leaf area (25.32 cm^2) after 20 days of transplanting was noted under T_3 (Nitrogen @ 110 Kg/ ha) and T_9 (22.29 cm^2) recorded minimum leaf area. At 40 days after transplanting the maximum leaf area (52.01 cm^2) was observed in T_1(Nitrogen @ 120 Kg/ ha) whereas minimum leaf area was recorded in T_9 (Nitrogen@ 80 Kg/ha) with (38.46 cm^2). At 60 days after transplanting significantly the maximum leaf area (70.86 cm^2) was found in T_1(Nitrogen @ 120 Kg/ ha) whereas the minimum leaf area was recorded in T_9 (Nitrogen @ 80Kg/ha) with 51.88 cm^2. The reason for increase in leaf area with increasing nitrogen dose might be due to nitrogen being a constituent of protein and chlorophyll plays a vital role in photosynthesis, it enhances accumulation of carbohydrates which increases growth of plants while phosphorus function is to promote cell division as well as photosynthetic activity and flowering which together increased leaf area. Similar findings were obtained by Kaur and Singh (2017) [12].

The maximum number of branches (5.67) was observed in T_1(Nitrogen @ 120 Kg/ ha) whereas the minimum number of branches (2.83) was observed in T_9 (Nitrogen @ 80kg/ha). At 60 days after transplanting T_3 (Nitrogen @ 110 Kg/ ha) showed maximum no of branches (11.5) however, it was observed lowest (6.33) in T_9 (Nitrogen @ 80 Kg/ha). The possible reason for the increase in number of branches per plant is due to increased soil fertility which attributes to more availability of applied nutrients, specially the supply of nitrogen which tends to vigorous plant growth remitting profuse branching and leaf production. Similar finding was also reported by Girapu and Kumar (2006) [9].

3.2 Flowering and fruiting parameter

In this parameter data recorded with respect of days to first flowering, days to first fruiting and number of flowers are described below.

The number of days taken for flower initiation varied significantly due to different doses of nitrogen application. The maximum number of days taken for first flowering was recorded in T_1(Nitrogen @ 120 Kg/ha) followed by T_2 (Nitrogen @115 Kg/ha) *viz*., 64.67 days and 62 days respectively. However, it was observed lowest in T_9 (Nitrogen @ 80 Kg/ha) 47.33 days. The probable reason for the delay in flowering initiation with the increase in nitrogen concentration was that there was more vegetative growth which took more days for flower initiation. Similar research findings were also observed by Girapu and Kumar (2006) [9] when nitrogen was taken at the rate of 120 Kg/ha in cape gooseberry.

The maximum days to first fruit set was recorded for T1(Nitrogen @ 120 kg/ha) 73 days while the minimum number of days taken for fruit set (56.67 days) was recorded in T_9 **(**Nitrogen @ 80 kg/ha). The reason for delay in fruiting with the increase in nitrogen doses was that nitrogen increases the vegetative phase and delayed flowering which also delayed fruiting. The similar research findings were reported by Girapu and Kumar (2006) [9] on cape gooseberry and Pawar and Karale (1997) [16] on tomatoes.

The maximum number of flower (96.33) was recorded for T_3(Nitrogen @ 110 kg/ha) while the minimum number of flowers (75.83) was recorded in T_9 (Nitrogen @ 80 Kg/ha). The probable reason for this might be due to increased photosynthetic efficiency and rate of assimilation due to nitrogen and phosphorus application which reflects on vigorous growth of plant and ultimately remitting profuse flowering. Similar results were also found by Prasad *et al.*, (1985) [17] in cape gooseberry.

3.3 Quality parameters

The total soluble solids of fruit varied significantly due to different doses of nitrogen application. The highest TSS (12.03 ^{0}B) was observed in T_3 (Nitrogen @ 110 Kg/ha) followed by T_2 (11.66 ^{0}B) that is Nitrogen @ 115 Kg/ha while the lowest TSS (8.5 ^{0}B) was recorded in T_9 (Nitrogen @ 80 Kg/ha).The increase in total soluble solids with increasing nitrogen concentration in fruits due to NPK application might be due to fact that these nutrients are related to carbohydrates synthesis., when adequate supply of nutrients is available, the synthesized carbohydrates translocated to the fruits, which ultimately increased the total soluble solids of fruit. The similar results were also obtained by Singh *et al.* (1977) [18] and Prasad *et al.* (1985) [17]. The highest acidity 1.33% was observed in T_1 (Nitrogen @ 120 Kg/ha) followed by T_2 and T_3 (Nitrogen @ 115 Kg/ha, Nitrogen @ 110 Kg/ha with 1.28% and 1.26%. The probable reason for the increase in acidity was the plants grown with luxuriant supply of nitrogen and phosphorous prolonged their bio-chemical process and exhibited high acidity and content in fruit juice. Similar findings have been reported by Chahal and Bal (2006) [4] the increase in nitrogen from 5g/plant to 10g/plant increased the acidity the further increase in nitrogen content to 15 g/plant resulted in increase in acidity content of cape gooseberry.

The ascorbic acid of fruit varied significantly due to different doses of nitrogen application. The highest ascorbic acid content was observed in T_3 (Nitrogen @ 110 Kg/ha) with 47.1 mg followed by T_2 (Nitrogen @ 115 Kg/ha) at 45.13 mg, whereas the minimum value was recorded in treatment T9 (Nitrogen @ 80 Kg/ha) at 19.53 mg. The plants grown with luxuriant supply nitrogen and phosphorus, prolonged their bio-chemical process and exhibited high ascorbic acid content in fruit juice. The ascorbic acid was significantly influenced by different levels of nitrogen treatment. Similar findings have been reported by Ali and Singh (2015) [1].

Table 2: Study on Response of different doses of nitrogen on vegetative growth of Cape gooseberry

Treatment Symbols	Treatment combinations (Kg/ha)	Plant height (cm)			No of leaves/plant			Leaf area (cm^2)			No of branches	
		20 Days	40 days	60 days	20 days	40 days	60 days	20 Days	40 days	60 days	40 days	60 Days
T_1	N:P:K (120:60:60)	27.80	43.14	74.51	8.67	44.87	91.58	24.25	52.01	70.86	5.67	10.5
T_2	N:P:K (115:60:60)	30.35	44.37	70.69	9.17	41.35	85.73	24.14	48.72	70.77	5.5	10.83
T_3	N:P:K (110:60:60)	26.33	48.76	63.46	8.16	39.36	80.11	25.32	49.1	68.83	5.33	11.5
T_4	N:P:K (105:60:60)	24.72	42.28	64.74	8.33	36.48	81.17	24.89	49.67	66.18	4.67	10
T_5	N:P:K (100:60:60)	22.25	37.10	63.29	7.17	40.70	74.09	23.95	45.59	66.67	4.67	9.16
T_6	N:P:K (95:60:60)	23.08	39.75	58.88	6.83	34.58	76.41	22.34	45.8	64.58	4.16	8
T_7	N:P:K (90:60:60)	20.38	35.61	59.23	6.17	34.73	65.96	23.23	42.11	62.29	3.33	7.67
T_8	N:P:K (85:60:60)	21.01	36.62	56.51	7	32.81	65.51	23.62	42.75	52.48	3.16	6.67
T_9	N:P:K (80:60:60)	15.44	31.60	53.78	5.83	29.44	49.22	22.29	38.46	51.88	2.83	6.33

Table 3: Study on Response of different doses of nitrogen on flowering and fruiting of Cape gooseberry

Treatment Symbols	Treatment combinations (Kg/ha)	Days taken to first flowering	No. of flower/plant	Days taken to first fruiting
T_1	N:P:K (120:60:60)	64.67	91.67	73
T_2	N:P:K (115:60:60)	62	93.67	71.67
T_3	N:P:K (110:60:60)	61	96.33	70.67
T_4	N:P:K (105:60:60)	59.67	81.67	69
T_5	N:P:K (100:60:60)	58.33	79.33	67.67
T_6	N:P:K (95:60:60)	56.33	78	65.33
T_7	N:P:K (90:60:60)	53	77	62.33
T_8	N:P:K (85:60:60)	50.66	76.67	60.67
T_9	N:P:K (80:60:60)	47.33	75.83	56.67

Table 4: Study on Response of different doses of nitrogen on fruit quality of Cape gooseberry

Treatment Symbol	Treatment combinations (Kg/ha)	Total Soluble Solids (Brix^0)	Acidity (%)	Ascorbic acid (mg/100g)
T_1	N:P:K (120:60:60)	11.13	1.33	44.45
T_2	N:P:K (115:60:60)	11.67	1.28	45.13

T_3	N:P:K (110:60:60)	12.03	1.26	47.1
T_4	N:P:K (105:60:60)	10.77	1.21	44.38
T_5	N:P:K (100:60:60)	10.3	1.18	42.81
T_6	N:P:K (95:60:60)	10	1.12	41.07
T_7	N:P:K (90:60:60)	9.63	1.07	40.14
T_8	N:P:K (85:60:60)	9	0.98	37.43
T_9	N:P:K (80:60:60)	8.5	0.97	19.53

4. Conclusion

On the basis of present investigation, it is concluded that the treatment T_1 (Nitrogen @ 120 Kg/ha) was found best in respect to vegetative parameters like plant height, number of leaves and leaf area but flowering and fruit initiation was delayed whereas for number of branches, TSS and ascorbic acid T_3 (Nitrogen @ 110 Kg/ha) was found to be the best treatment. The acidity of fruit was recorded highest in treatment T_1 (Nitrogen @ 120 Kg/ha). The treatment combination T_3 (N @ 110kg/ha: P @ 60 Kg/ha: K @60 Kg/ha) was found suitable and best treatment under Prayagraj agro-climatic conditions.

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6. Conflict of Interest

As a corresponding Author, I Juhi Chandra, confirms that none of the others have any conflicts of interest associated with this publication.

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