



Effect of Organic Manure and Plant Growth Promoting Rhizobacteria Enriched Biocapsules on Growth Yield and Quality of Cape Gooseberry (*Physalis Peruviana* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present experiment was conducted at Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. Prayagraj during the session 2023 - 2024. The experiment was laid out in randomized block design with three

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replications, and the study consists of ten treatment combinations including control by using different Effect of organic manure and plant growth promoting rhizobacteria enriched biocapsules on growth yield and quality of cape gooseberry. The best treatment was T8 (Poultry manure @0.56 kg + 500 PPM Biocapsule) & T7 (Green manure @1.12 kg + 500 PPM Biocapsule) which shows highest values in all the parameters viz., plant height (85.80 cm), number of leaf/plant (71.76), Leaf area (cm²) (64.62 cm²), Days to anthesis of 1st flower after planting (35.75), Flowering duration (138.36), flower/plant (118.86), Fruit setting after flowering (8.91), fruit set to maturity (50.10), 1st fruit harvesting (101.16), fruit/plant(84.00) fruit weight (10.77 g), fruit yield/plant (400.68 kg), TSS (17.68 %), Ascorbic acid (61.22 mg/100g), Acidity (0.49 %), total sugar (12.39 %). All the treatments were significantly superior in their growth, flowering, fruit yield and quality of cape gooseberry over control (T0) and (T9).

Keywords: Cape gooseberry; organic; biocapsule; growth; yield; quality.

1. INTRODUCTION

“Cape-gooseberry (*Physalis peruviana* L.) is a plant in the nightshade family (Solanaceae), native to warm temperate and subtropical regions throughout the world. *Physalis peruviana* was derived from the Greek word *physa* meaning bladder, for the calyx covering the fruit and *peruviana* meaning of Peru. It is commonly known as Goldenberry, Husk Cherry, Peruvian Ground Cherry, Poha Berry, Rasbhari, Makoi etc. The cape gooseberry is an annual in temperate regions and a perennial in the tropics. 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” [1]. “The cape gooseberry is known as goldenberry in European countries, uchuva in Colombia, uvilla in Ecuador, aguaymanto in Peru and topotopo in Venezuela” [2]. Three types of cape gooseberry indigenous to Colombia, Kenya and South Africa are cultivated worldwide. Colombia is the world’s largest producer of cape gooseberry followed by South Africa.

“The organic manures such as FYM, vermicompost and press mud influence the physical chemical as well as biological properties of the soil which improve soil fertility, structure, porosity, aeration, drainage and water relation capacity. FYM supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. Improvement in the soil structure due to FYM application leads to a better environment for root development. FYM also improves soil water holding capacity” [3].

“Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. In contrast to chemical fertilizer, it adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration” [4].

Biocapsule, a bio-fertilizer technology developed by the IISR (Indian Institute of Spices Research). The reason biocapsules are significant is that they allow for the encapsulation of targeted microorganisms in a gelatin capsule, which is then transferred to the crops to improve soil nutrient solubilization, growth, and yield. Because a single gramme of capsules has the same amount of microorganisms as a kilogramme box of powdered biofertilizer or a litre bottle, they are incredibly effective. Additionally, unlike many liquid-based bio formulations, these microbial strains are not at risk of viability loss at room temperature since they are maintained in the dormant condition. It is made out of a carrier medium that is abundant in live microorganisms. Applied to seed, soil, or growing plants, it either boosts or organically releases the nutrients from the earth.

2. MATERIALS AND METHODS

This experiment was laid out during the August 2023 to March 2024 at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The horticulture research farm is situated at 25° 39' 42" N latitude, 81° 67' 56" E longitude and at an altitude of 98 m above mean sea level. The treatment consisted of T₀- Control, T₁ - FYM @ 1.68 kg, T₂ - Vermicompost @ 0.56 kg, T₃ - Green Manure @ 1.12 kg, T₄ - Poultry Manure

@ 0.56 kg, T₅ - FYM @ 1.68 Kg + 500 ppm Biocapsule, T₆- Vermicompost @ 0.56 kg + 500 ppm Biocapsule, T₇- Green Manure @ 1.12 kg + 500 ppm Biocapsule, T₈ - Poultry Manure @ 0.56 kg + 500 ppm Biocapsule. The experiment was laid out in a Randomized Block Design with 9 treatments and replicated thrice. Data recorded on different aspects of fruit crop, viz., growth, yield were subjected to statistically analysis by analysis of variance method. Gomez and Gomez, [5] and economic data analysis mathematical method.

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth of Cape Gooseberry

The data pertaining to Vegetative growth of cape gooseberry in different treatment combinations was recorded and are presented in Table 1.

3.2 Plant Height (cm)

At 120 DAT, significantly and maximum plant height (85.80 cm) was recorded in T₈ [Poultry Manure + 500 ppm Biocapsule] followed by the T₇ [Green Manure + 500 ppm Biocapsule] (84.97 cm), whereas minimum plant height of (75.33 cm) was recorded in T₀ [Control].

Biocapsule increases the nutrient fixation in the root and nanozeolite played an important role to make availability of nutrient in the soil. These results are in support with Bandana and Chandel [6] and Padhan et al. [7]. It might be due to the more availability of nutrients by poultry manure throughout the growing season. Nitrogen increases photosynthetic activity and helps in maintaining higher auxin level which might have resulted in better plant height Verma et al., [8].

3.3 Number of Leaf Per Plant

At 120 DAT, significantly and maximum number of leaf per plant (71.76) was recorded in T₈ [Poultry Manure + 500 ppm Biocapsule] followed by the T₇ [Green Manure + 500 ppm Biocapsule] (69.20), whereas minimum number of leaf per plant of (62.47) was recorded in T₀ [Control].

The significant and maximum number of leaf/plant was with application of poultry manure might be due to with increased levels of NPK function in most of the physiological and metabolic processes resulting in increased

growth and development, resulting in maximum leaf/plant. Similar result was also reported by Verma et al., [8]. Further The significant and maximum leaf/plant was with application of biocapsule might be due to involvement of stimulation of cell division, photosynthetic process as well as formation of chlorophyll Singh et al., [9].

3.4 Leaf Area (cm²)

At 120 DAT, significantly and maximum leaf area (64.62 cm²) was recorded in T₈ [Poultry Manure + 500 ppm Biocapsule] followed by the T₇ [Green Manure + 500 ppm Biocapsule] (63.01 cm²), whereas minimum leaf area of (55.50 cm²) was recorded in T₀ [Control].

The significant and maximum leaf area cm² was with application of poultry manure might be due to with increased levels of NPK function in most of the physiological and metabolic processes resulting in increased growth and development, resulting in maximum leaf are cm². Similar result was also reported by Verma et al., [8].Further The significant and maximum leaf/plant was with application of biocapsule might be due to involvement of stimulation of cell division, photosynthetic process as well as formation of chlorophyll [9].

3.5 Reproductive Growth of Cape Gooseberry

The data pertaining to reproductive growth of cape gooseberry after planting in different treatment combinations was recorded and are presented in Table 2.

3.6 Days to Anthesis of 1st Flower after Planting

Significantly the minimum days to anthesis of 1st flower after planting of 35.75 days after planting was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 37.60 days, whereas minimum days to anthesis of 1st flower after planting of 44.57 days was recorded in T₀ [Control].

The minimum in number of days to anthesis of cape gooseberry due to treatment might be due to fact that poultry manure regulate the growth by causing cell division and cell elongation in plant system. These results are in conformity with Deepa et al., [10].

3.7 Flowering Duration

Significantly the maximum flowering duration of 138.36 days after planting was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 134.60 days, whereas minimum days to anthesis of 1st flower after planting of 116.33 days was recorded in T₀ [Control].

The results of present findings indicated that the sole application of organic manure did not have any significant effect on the flowering and fruiting but their combination of biocapsule showed better results. The earliness in flowering coupled with higher number of flowers after application of FYM, poultry manure and vermicompost might be due to enhanced level of nitrogen and phosphorus. They were proved to be better for synthesis of growth promoters and increased photosynthate production. These findings are in accordance with Arancon et al. [11] in strawberry and Yadav et al. [12] in papaya.

3.8 Total Number of Flowers Plant⁻¹

Significantly the maximum total number of flowers plant⁻¹ 118.86 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 116.98, whereas minimum total number of flowers plant⁻¹ of 101.85 was recorded in T₀ [Control].

The increase in number of flowers might be due to organic fertilizers that produced significant increase in vegetative growth which in turn produced more photosynthates which were probably diverted towards the more flower production. The findings are in accordance with the results obtained by Mohamed and El-Sehrawy [13] in mango and El-Miniawy et al. [14] in strawberry.

3.9 Yield and Yield Attributes

The data pertaining to yield and yield attributes in different treatment combinations was recorded and are presented in Table 3

3.9.1 Total fruit number plant⁻¹

Significantly the maximum number of fruits per plant 84.00 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 82.33,

whereas minimum number of fruits per plant 71.33 was recorded in T₀ [Control].

It may possibly be due to fact that INM application accelerated the development of fruits which are positively correlated with the number of fruits in the following spring. Increased number of fruits might have also resulted because of increase in number of flowers per plant. Similar observations were also reported by Tripathi et al. [15] in strawberry.

3.9.2 Average fruit weight (g)

Significantly the maximum average fruit weight 10.77 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 9.10, whereas minimum average fruit weight 6.98 was recorded in T₀ [Control].

The higher fruit weight of kiwi fruit in the combined application organic manures and inorganic fertilizers may be attributed to the relative increase in availability of nutrients and better solute uptake by plants [16]. These findings are in close conformity with Ray et al. [17] in papaya and Gautam et al. [18] in Mango.

3.9.3 Fruit yield plant⁻¹(g)

Significantly the maximum fruit yield per plant 918.97 g was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 699.86 g, whereas minimum fruit yield per plant 497.84 g was recorded in T₀ [Control].

Further, the higher yield obtained with combined application of inorganic fertilizer and organic manure might be attributed to conducive physical and biological environment of soil which lead to higher and balanced nutrients uptake [19].

3.10 Quality Parameters

The data pertaining to quality parameters in different treatment combinations was recorded and are presented in Table 4

3.10.1 Total soluble solids (%)

Significantly the total soluble solids 17.68 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 16.98, whereas minimum total soluble solids 13.26 was recorded in T₀ [Control].

Table 1. Effect of organic manure and plant growth promoting rhizobacteria enriched biocapsule vegetative growth of cape gooseberry

Treatment Symbol	Treatment Combination	Plant height (cm) 120 DAT	Number of leaf/plant 120 DAT	Leaf area (cm²) 120 DAT
T ₀	CONTROL	75.33	62.47	55.50
T ₁	FYM @ 1.68 kg	78.47	64.09	57.50
T ₂	VERMICOMPOST @ 0.56 kg	76.56	63.33	56.88
T ₃	GREEN MANURE @ 1.12 kg	81.60	67.89	60.15
T ₄	POULTRY MANURE @ 0.56 kg	79.09	65.47	59.61
T ₅	FYM @1.68 kg + 500 PPM BIOCAPSULE	82.94	68.10	61.99
T ₆	VERMICOMPOST @0.56 kg + 500 PPM BIOCAPSULE	83.90	68.79	62.89
T ₇	GREEN MANURE @1.12 kg + 500 PPM BIOCAPSULE	84.97	69.20	63.01
T ₈	POULTRY MANURE @0.56 kg +500 PPM BIOCAPSULE	85.80	71.76	64.62
	F-test	S	S	S
	SEm(±)	2.33	1.92	1.83
	CD (p=0.05)	6.98	6.77	5.47

Table 2. Effect of organic manure and plant growth promoting rhizobacteria enriched biocapsule reproductive growth of cape gooseberry

Treatment Symbol	Treatment Combination	Day to Anthesis of 1 st Flower after Planting	Flowering duration	Total number of flowers plant ⁻¹
T ₀	CONTROL	44.57	116.33	101.85
T ₁	FYM @ 1.68 kg	43.04	125.33	106.34
T ₂	VERMICOMPOST @ 0.56 kg	42.72	124.88	103.67
T ₃	GREEN MANURE @ 1.12 kg	41.46	126.11	110.89
T ₄	POULTRY MANURE @ 0.56 kg	38.58	125.98	107.98
T ₅	FYM @1.68 kg + 500 PPM BIOCAPSULE	40.35	133.73	111.29
T ₆	VERMICOMPOST @0.56 kg + 500 PPM BIOCAPSULE	37.60	132.96	114.79
T ₇	GREEN MANURE @1.12 kg + 500 PPM BIOCAPSULE	36.50	134.60	116.98
T ₈	POULTRY MANURE @0.56 kg +500 PPM BIOCAPSULE	35.75	138.36	118.86
	F-test	S	S	S
	SEm(±)	1.57	4.06	3.30
	CD (p=0.05)	4.66	12.18	9.88

Table 3. Effect of organic manure and plant growth promoting rhizobacteria enriched biocapsule yield of cape gooseberry

Treatment Symbol	Treatment Combination	Number of fruit plant ⁻¹	Average fruit weight (g)	Fruit yield plant ⁻¹ (g)
T ₀	CONTROL	71.33	6.98	497.84
T ₁	FYM @ 1.68 kg	75.00	7.97	597.70
T ₂	VERMICOMPOST @ 0.56 kg	73.33	7.35	538.93
T ₃	GREEN MANURE @ 1.12 kg	78.00	8.90	694.32
T ₄	POULTRY MANURE @ 0.56 kg	75.67	8.65	654.24
T ₅	FYM @1.68 kg + 500 PPM BIOCAPSULE	78.67	8.50	711.91
T ₆	VERMICOMPOST @0.56 kg + 500 PPM BIOCAPSULE	80.00	9.05	727.78
T ₇	GREEN MANURE @1.12 kg + 500 PPM BIOCAPSULE	82.33	9.10	699.86
T ₈	POULTRY MANURE @0.56 kg +500 PPM BIOCAPSULE	84.00	10.77	918.97
	F-test	S	S	S
	SEm(±)	2.33	0.39	14.32
	CD (p=0.05)	6.98	1.18	42.93

Table 4. Effect of organic manure and plant growth promoting rhizobacteria enriched bio capsules quality of cape gooseberry

Treatment Symbol	Treatment Combination	Total soluble solids (%)	Ascorbic acid (mg/100g)	Acidity (%)	Total sugar (%)
T ₀	CONTROL	13.26	50.24	0.75	8.98
T ₁	FYM @ 1.68 kg	13.98	57.79	0.68	9.91
T ₂	VERMICOMPOST @ 0.56 kg	13.50	57.12	0.72	9.66
T ₃	GREEN MANURE @ 1.12 kg	14.88	58.99	0.61	10.44
T ₄	POULTRY MANURE @ 0.56 kg	14.30	58.33	0.65	10.10
T ₅	FYM @ 1.68+ 500 PPM BIOCAPSULE	15.67	59.66	0.59	10.77
T ₆	VERMICOMPOST @ 0.56 kg + 500 PPM BIOCAPSULE	16.55	60.44	0.55	11.50
T ₇	GREEN MANURE @ 1.12 kg + 500 PPM BIOCAPSULE	16.98	60.96	0.52	11.98
T ₈	POULTRY MANURE @ 0.56 kg +500 PPM BIOCAPSULE	17.68	61.22	0.49	12.39
	F-test	S	S	S	S
	SEm(±)	0.67	1.77	0.02	0.02
	CD (p=0.05)	2.00	5.29	0.06	0.06

Table 5. Effect of organic manure and plant growth promoting rhizobacteria enriched bio capsules economics of cape gooseberry

Treatment Symbol	Treatment Combination	Cost of cultivation/ha	Gross Return/ha	Net Return/ha	B:C Ratio
T ₀	CONTROL	90000	191860	101860	1.13
T ₁	FYM @ 1.68 kg	101000	230346	129346	1.28
T ₂	VERMICOMPOST @ 0.56 kg	100000	207696	107696	1.08
T ₃	GREEN MANURE @ 1.12 kg	99000	267582	168582	1.70
T ₄	POULTRY MANURE @ 0.56 kg	96000	252134	156134	1.63
T ₅	FYM @ 1.68+ 500 PPM BIOCAPSULE	105000	274361	169361	1.61
T ₆	VERMICOMPOST @ 0.56 kg + 500 PPM BIOCAPSULE	103000	280476	177476	1.72
T ₇	GREEN MANURE @ 1.12 kg + 500 PPM BIOCAPSULE	102000	269715	167715	1.64
T ₈	POULTRY MANURE @ 0.56 kg +500 PPM BIOCAPSULE	101000	354156	253156	2.51

Generally, addition of organic manures for nutrients, moisture and growth promoting substances enhance the metabolic and hormonal activity of the plant. This promotes production of more photosynthates to be stored in fruits in the form of starch and carbohydrates. It is an established fact that the transformation of mature fruit into ripe form i.e. during the process of ripening in storage, the fruit undergoes physical, physiological and bio-chemical changes. The increase in Total Soluble Solids (TSS) may be attributed to the conversion of reserved starch and other insoluble carbohydrates into soluble sugars. These results elucidate the findings of Prasanna and Rajan [20] and Yadav et al. [12].

3.10.2 Ascorbic acid (mg/100g)

Significantly the ascorbic acid 61.22 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 60.96, whereas minimum ascorbic acid 50.24 was recorded in T₀ [Control].

The ascorbic acid content was found higher with the application of organic supplements than the inorganic fertilizers. The negative relationship between nitrogen levels and vitamin-C content can be seen. This might be due to the exposure of plant with more of nitrogen, which increased protein production but reduce the carbohydrates. Similar findings have been reported by Worthington, [21], Bahadur et al. [22] and Citak and Sonmez, [23]. Ascorbic acid is vulnerable to loss as it is easily oxidizes in the presence of light, oxygen and heat.

3.10.3 Acidity (%)

Significantly the acidity 0.49 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule] followed by T₇[Green manure + 500 ppm Biocapsule] of 0.52, whereas minimum acidity 0.75 was recorded in T₀ [Control].

The decrease in acidity might be due to the degradation of organic acids. A gradual declining trend in the acidity content of fruit in all the treatment was observed with the advancement of storage period. Similar results were observed by Rawat [24]. These results are also in agreement with the findings of Sivakumar et al. [25] in Litchi.

3.10.4 Total sugar (%)

Significantly the total sugar 12.39 was recorded at T₈ [Poultry Manure + 500 ppm Biocapsule]

followed by T₇[Green manure + 500 ppm Biocapsule] of 0.52, whereas minimum total sugar 8.98 was recorded in T₀ [Control].

Generally, addition of organic manures for nutrients, moisture and growth promoting substances enhance the metabolic and hormonal activity of the plant. This promotes production of more photosynthates to be stored in fruits in the form of starch and carbohydrates. It is an established fact that the transformation of mature fruit into ripe form i.e. during the process of ripening in storage, the fruit undergoes physical, physiological and bio-chemical changes. The increase in total sugars (TS) may be attributed to the conversion of reserved starch and other insoluble carbohydrates into soluble sugars. These results elucidate the findings of Prasanna and Rajan [20] and Yadav et al. [12].

3.11 Economic Parameter of Cape Gooseberry

The calculations regarding the gross return, net return and benefit cost ratio of the cape gooseberry was recorded, tabulated and analyzed. Benefit cost ratio were found significantly higher in different treatments and is clear from the Table 5

3.11.1 Cost of cultivation (Rs. /ha)

The maximum cost of cultivation (Rs. 105000) was observed in T₅ (Fym @ 1.68+ 500 ppm Biocapsule) followed by (Rs. 103000) was observed in T₆ (Vermicompost @ 0.56 Kg + 500 ppm Biocapsule) while the minimum cost of cultivation (Rs.90000) was observed in T₀ (Control).

3.11.2 Gross return (Rs. /ha)

The maximum gross return (Rs. 354156) was observed in T₈ (Poultry Manure + 500 ppm Biocapsule) followed by (Rs. 280476) was observed in T₆ (Vermicompost @ 0.56 Kg + 500 ppm Biocapsule) while the minimum gross return (Rs.191860) was observed in T₀ (Control).

3.11.3 Net return (Rs. /ha)

The maximum net return (Rs. 243156) was observed in T₈ (Poultry Manure + 500 ppm Biocapsule) followed by (Rs. 177476) was observed in T₆ (Vermicompost @ 0.56 Kg + 500 ppm Biocapsule) while the minimum cost of net return (Rs.101860) was observed in T₀ (Control).

3.11.4 Benefit cost ratio (B:C)

The maximum benefit cost ratio (2.51) was observed in T₈ (Poultry Manure + 500 ppm Biocapsule) followed by (1.72) was observed in T₆ (Vermicompost @0.56 Kg + 500 ppm Biocapsule) while the minimum cost of cultivation (1.08) was observed in T₂ (Vermicompost @ 0.56 kg).

4. CONCLUSION

Based on the results of the present study:

It is concluded that, overall treatment T₈ (Poultry Manure + 500 ppm Biocapsule) performed best in terms vegetative as well as reproductive growth of cape gooseberry, yield, yield attributes and Economics of cape gooseberry was also obtained from this treatment.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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