Original Research Article

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

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 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 T_8 (Poultry manure @0.56 kg + 500 PPM Biocapsule) &T_7(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 (cm^2) (64.62 cm^2), Days to anthesis of 1^{st} 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), 1^{st} 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 (T_0) and (T_9).

Key words:Cape gooseberry, organic, biocapsule, growth, yield, quality

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 **(Mayorga *et al.*, 2001**). The cape gooseberry is known as goldenberry in European countries, uchuva in Colombia, uvilla in Ecuador, aguaymanto in Peru and topotopo in Venezuela **(Puente *et al.*, 2011).** 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 **(Tadesse *et al.*, 2013).**

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 **(Deksissa*et al.*, 2008).**

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.

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 25^0 39" 42" N latitude, 81^0 67" 56" E longitude and at an altitude of 98 m above mean sea level.The treatment consisted of T_0 - Control, T_1- FYM @ 1.68 kg, T_2- Vermicompost @ 0.56 kg, T_3 - Green Manure @ 1.12 kg, T_4- Poultry Manure @ 0.56 kg, T_5 - FYM @ 1.68 Kg + 500 ppmBiocapsule, T_6 - Vermicompost @ 0.56 kg+ 500 ppmBiocapsule, T_7 - Green Manure @ 1.12 kg+ 500 ppmBiocapsule, T_8 - Poultry Manure @ 0.56 kg+ 500 ppmBiocapsule. TheexperimentwaslaidoutinaRandomizedBlockDesignwith9treatmentsand replicatedthrice.Datarecordedondifferentaspectsoffruit crop,*viz.*,growth,yieldwere subjected to statistically analysis by analysis of variance method. (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

RESULTANDDISCUSSION

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.

Plant height (cm)

At 120 DAT, significantly and maximum plant height (85.80 cm) was recorded in T_8 [Poultry Manure + 500 ppm Biocapsule] followed by the T_7 [Green Manure + 500 ppm Biocapsule] (84.97 cm), whereas minimum plant height of (75.33 cm) was recorded in T_0 [Control].

Biocapules 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 (2017)** and **Padhan *et al.* (2019).** 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.*, (2017b).**

Number of Leaf per plant

At 120 DAT, significantly and maximum number of leaf per plant (71.76) was recorded in T_8 [Poultry Manure + 500 ppm Biocapsule] followed by the T_7 [Green Manure + 500 ppm Biocapsule] (69.20), whereas minimum number of leaf per plant of (62.47) was recorded in T_0 [Control].

The significant and maximum number of leaf/plant was with application ofpoultry manuremight be due to with increased levels of NPK function in most of the physiological andmetabolic processes resulting in increased growth and development, resulting in maximum leaf/plant. Similar result wasalso reported by **Verma *et al.*, (2017b).** FurtherThe 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.*, (2023).**

Leaf area (cm^2)

At 120 DAT, significantly and maximum leaf area (64.62 cm^2) was recorded in T_8 [Poultry Manure + 500 ppm Biocapsule] followed by the T_7 [Green Manure + 500 ppm Biocapsule] (63.01 cm^2), whereas minimum leaf area of (55.50 cm^2) was recorded in T_0 [Control].

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Reproductive Growth of Cape Gooseberry

The data pertaining to reproductive growth of cape gooseberryafter planting in different treatment combinations was recorded and are presented in table 2

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 T_8 [Poultry Manure + 500 ppm Biocapsule] followed by

T_7[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 T_0 [Control].

The minimum in number of days to anthesis of cape gooseberry due to treatment might be due to fact that poultry manureregulate the growth by causing cell division and cell elongation in plant system. These results are in conformity with **Deepa *et al.*, (2014)**.

Flowering duration

Significantly the maximum flowering duration of 138.36 days after planting was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 134.60 days, whereas minimum days to anthesis of 1stflower after planting of 116.33 days was recorded in T_0 [Control].

The results of present findingsindicated that the sole application of organic manure didnot have any significanteffect ontheflowering and fruitingbut theircombination of biocapcule showed better results.The earliness in flowering coupled with higher number offlowersafter application of FYM, poultry manure and vermicompost might beduetoenhancedlevel of nitrogenandphosphorus.Theywereprovedto be better for synthesis of growthpromotersandincreasedphotosynthateproduction.Thesefindingsarein accordance with**Aranconе*tal*.(2004)**in strawberry and **Yadav*et al*.(2011)** in papaya.

Total number of flowers plant^{-1}

Significantly the maximum total number of flowers plant^{-1}118.86 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 116.98, whereas minimum total number of flowers plant^{-1} of 101.85 was recorded in T_0 [Control].

The increase in number offlowersmight 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 obtainedby **Mohamed and El-Sehrawy (2013)** in mangoand**El-Miniawy*et al*. (2014)** in strawberry.

YIELD AND YIELD ATTRIBUTES

The data pertaining to yield and yield attributesin different treatment combinations was recorded and are presented in table 3

Total fruit number plant^{-1}

Significantly the maximum number of fruits per plant 84.00 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 82.33, whereas minimum number of fruits per plant 71.33 was recorded in T_0 [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*. (2010)** in strawberry.

Average fruit weight (g)

Significantly the maximum average fruit weight 10.77 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 9.10, whereas minimum average fruit weight 6.98 was recorded in T_0 [Control].

The higher fruit weight of kiwifruit 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 **(Korwar*et al.,* 2006).** These findings are in close conformity with **Ray *et al*. (2008)** in papaya and **Gautam *et al*. (2012)** in Mango.

Fruit yield plant^{-1}(g)

Significantly the maximum fruit yield per plant 918.97 g was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 699.86 g, whereas minimum fruit yield per plant 497.84 g was recorded in T_0 [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 **(Deshpande and Senapathy,2010).**

QUALITY PARAMETERS:

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

Total soluble solids (%)

Significantly the total soluble solids17.68 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 16.98, whereas minimum total soluble solids13.26 was recorded in T_0 [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 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 (2001)** and **Yadav *et al.* (2011).**

Ascorbic acid (mg/100g)

Significantly the ascorbic acid61.22 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 60.96, whereas minimum ascorbic acid50.24 was recorded in T_0 [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, (2001)**; **Bahadur *et al*. (2006)** and **Citak and Sonmez, (2010)**.Ascorbic acid is vulnerable to loss as it is easily oxidizes in the presence of light, oxygen and heat.

Acidity (%)

Significantly the acidity 0.49 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 0.52, whereas minimum acidity 0.75 was recorded in T_0 [Control].

The decrease in acidity might be due to thedegradationof organic acids. A gradualdeclining trend in the acidity content of fruit in all thetreatment was observed with theadvancement of storage period. Similar results were observedby**Rawat (2001).** These resultsare also in agreement with thefindings of**Sivakumar *et al*. (2010)** in Litchi.

Total sugar (%)

Significantly the total sugar 12.39 was recorded at T_8 [Poultry Manure + 500 ppm Biocapsule] followed by T_7[Green manure + 500 ppm Biocapsule] of 0.52, whereas minimum total sugar 8.98 was recorded in T_0 [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 (2001)** and **Yadav *et al*. (2011).**

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

Cost of cultivation (Rs. /ha)

The maximum cost of cultivation (Rs. 105000) was observed in T_5 (Fym @ 1.68+ 500 ppm Biocapsule) followed by (Rs. 103000) was observed in T_6 (Vermicompost @ 0.56 Kg + 500 ppm Biocapsule)while the minimum cost of cultivation (Rs.90000) was observed in T_0 (Control).

Gross Return (Rs. /ha)

The maximum gross return (Rs. 354156) was observed in T_8 (Poultry Manure + 500 ppm Biocapsule) followed by (Rs. 280476) was observed in T_6 (Vermicompost @ 0.56 Kg + 500 ppm Biocapsule)while the minimum gross return (Rs.191860) was observed in T_0 (Control).

Net Return (Rs. /ha)

The maximum net return (Rs. 243156) was observed in T_8 (Poultry Manure + 500 ppm Biocapsule) followed by (Rs. 177476) was observed in T_6 (Vermicompost @ 0.56 Kg + 500 ppm Biocapsule)while the minimum cost of net return (Rs.101860) was observed in T_0 (Control).

Benefit Cost ratio (B:C)

The maximum benefit cost ratio (2.51) was observed in T_8 (Poultry Manure + 500 ppm Biocapsule) followed by (1.72) was observed in T_6 (Vermicompost @0.56 Kg + 500 ppm Biocapsule) while the minimum cost of cultivation (1.08) was observed in T_2 (Vermicompost @ 0.56 kg).

CONCLUSION

Based on the results of the present study:

It is concluded that, overall treatment T_8 (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.

Table 1 Effect ofOrganic Manure and Plant Growth Promoting RhizobacteriaEnriched Biocapsulevegetative growth of cape Gooseberry

Treatment Symbol	Treatment combinations	Plant height (cm) 120 DAT	Number of leaf/plant 120 DAT	Leaf area (cm^2)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 ofOrganic Manure &Plant Growth Promoting RhizobacteriaEnriched Biocapsulereproductive growth of cape

Treatment Symbol	Treatment combinations	Days to Anthesis of 1st 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

Gooseberry

Table 3 Effect ofOrganic Manure &Plant Growth Promoting RhizobacteriaEnriched Biocapsuleyield of cape Gooseberry

Treatment Symbol	Treatment combinations	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	Treatment Combination	Total soluble	Ascorbic acid	Acidity	Total sugar

Symbol		solids (%)	(mg/100g)	(%)	(%)
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

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