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Effect of Organic, Inorganic and Biofertilizer on Growth, Yield and Quality of Bottle Gourd (*Lagenaria siceraria* Mol.)

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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 investigation was carried out at Research Farm, Department of Horticulture, Naini Agricultural Institute, SHUATS, Naini, Prayagraj, Uttar Pradesh during the Kharif- 2023 with a view to identify the effects of different combinations of organic and inorganic fertilizers and its role in growth, yield and quality of bottle gourd variety Sharada. The experiment was laid in Randomized block design with 13 treatments and 3 replications with different combination in RDF and

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application of organic manures and bio fertilizers. In this experiment we found that the treatment T9 (50% RDF + 50% Vermicompost + Azospirillum @ 1 Kg ha-1) was found to be best in the terms of growth parameters viz., vine length observed at 60 DAS (166.65 cm), number of branches per plant (5.63 branches), yield parameters like number of fruits per plant (17.41 fruits), fruit length (40.11 cm), fruit diameter (7.51 cm) and fruit weight (916.97 grams) along with better yield (79.84 q/ha) and quality TSS and Vitamin C content of bottle gourd. The highest net return was found in the T9 (50% RDF + 50% Vermicompost + Azospirillum @ 1 Kg ha-1) with Rs 1,81,473/ha) and the highest B:C ratio was found in the same with 2.32.

Keywords: Bottle gourd; FYM; azospirillum; benefit cost ratio.

1. INTRODUCTION

"Bottle gourd, scientifically known as *Lagenaria siceraria* (Mol.) Standl., fruits have a variety of shapes: they can be huge and rounded, small and bottle-shaped, or slim and serpentine, and they can grow to be over a metre long. Rounder varieties are typically called calabash gourds. The gourd was one of the world's first cultivated plants grown not primarily for food, but for use as containers. The bottle gourd may have been carried from Asia to Africa, Europe, and the Americas during human migration, or by seeds floating across the oceans inside the gourd". Erickson et al [1] It has been proven to have been globally domesticated (and existed in the New World) during the Pre-Columbian era.

"Bottle gourd are horticulture crop belongs to the family *Cucurbitaceae* bearing chromosome number 2n=22" [2]. "Bottle gourd is a diploid of parentage. The bottle gourd is a commonly cultivated plant in tropical and subtropical areas of the world and was eventually domesticated in southern Africa. Stands of *L. siceraria*, which may be source plants and not merely domesticated stands, were reported in Zimbabwe" [3]. "Bottle gourds are grown by direct sowing of seeds or transplanting 15- to 20-day-old seedlings. The plant prefers well-drained, moist, organic rich soil. It requires plenty of moisture in the growing season and a warm, sunny position, sheltered from the wind" [4-6]. "It can be cultivated in small places such as in a pot and allowed to spread on a trellis or roof. In rural areas, many houses with thatched roofs are covered with the gourd vines. Bottle gourds grow very rapidly, and their stems can reach a length of 9 m in the summer, so they need a solid support along the stem if they are to climb a pole or trellis. If planted under a tall tree, the vine may grow up to the top of the tree. To obtain more fruit, farmers sometimes cut off the tip of the vine when it has grown to 6–8 feet in length". Decker et al. [3].

"Raw Bottle gourd is 96.1% water, 0.2% protein, 2.5% carbohydrates and contains negligible fat. In a 100-gram reference amount, raw bottle gourd is a source vitamin C (6 mg) with moderate contents of thiamine (0.23 mg), Nicotinic acid (0.20 mg) and magnesium (5 mg), Calcium (20 mg), Phosphorous (10 mg), Potassium (87 mg). Bottle gourd has valuable anti-cholesterol property. Bottle gourd is an important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia, Cyprus, and the Southern United States. In India area under Bottle gourd production in India accounts to 1.58 million hectares with production of 31.42 metric tonnes in year 2021-22. Bihar ranks first in area and production of Bottle gourd in year 2021-22 followed by Uttar Pradesh and Madhya Pradesh. In Uttar Pradesh area under production is 2.38 thousand hectares while production is estimated to be 5.09 million tonnes for year 2021-22". (Source: NHB, Ministry of Agriculture & Farmers Welfare, Government of India, [7].

"Farm manure is primarily made from cow dung, cow urine, straw, and other milk waste. A small amount of Nitrogen (N) is directly available to plants, but more N becomes available as FYM degrades. Mixing cow dung with urine gives plants a balanced diet. The availability of potassium and phosphorus from FYM is like that from inorganic sources. Applying FYM improves soil fertility. On an average well decomposed farmyard manure contains 0.5 per cent Nitrogen (N), 0.2 per cent Phosphate (P_2O_5) and .0.5 per cent Potassium (K_2O). FYM also increases the availability of soil phosphorus. In addition to the effect of FYM on soil P content, the application of FYM in presence of fertilizer phosphorus may also affect the solubility and hence the potential availability of applied P. It is widely recognized that neither use of organic manure alone nor chemical fertilizers can achieve the yield sustainability under the modern intensive farming" [8].

When applied to seeds, plant surfaces, or soil, a biofertilizer contains living microorganisms that colonise the rhizosphere or inside of the plant to stimulate growth by increasing the supply or availability of primary nutrients to the host plant. Natural processes such as nitrogen fixation, phosphorus solubilization, and plant growth-stimulating hormone synthesis are used by biofertilizers to add nutrients. The microorganisms in biofertilizers rebuild the soil's organic matter and nutrition cycle. Healthy plants can be cultivated with biofertilizers, improving soil health and sustainability. Although they are not yet able to completely replace the use of synthetic fertilisers and pesticides, biofertilizers can be expected to minimise their consumption. In this sense, inoculation and application of plant growth-promoting bacteria (PGPB) especially *Azospirillum brasilense* is an important strategy in cereal cultivation. Research about *A. brasilense* report enhanced plant growth by a number of mechanisms, including but not limited to the synthesis and secretion of hormones that increase the root system. Greater accumulation and availability of nutrients Galindo et al*.,* 2016; Rosa et al*.* [9] and greater tolerance to stresses (such as drought, salinity), plant vigour [10], chlorophyll content, and stomatal conductance (Bulegon et al*.,* 2017), as well as increases in grain productivity Munareto, 2016; Galindo et al*.* [11], were also reported.

Vermicompost, a product of earthworm activity, boasts a nutrient profile abundant in NPK (nitrogen at 2-3%, phosphorus at 1.55-2.25%, and potassium at 1.85-2.25%), alongside micronutrients and beneficial soil microbes. This organic by-product not only contains a wealth of macro and micronutrients but also houses vitamins, growth hormones, and an array of enzymes like proteases, amylases, lipase, cellulase, and chitinase. Remarkably, these enzymes persist in breaking down organic matter even after being expelled by the worms. Vermicomposting represents an innovative biotechnology, transforming agro-industrial waste into high-value products. Its utilization serves to enhance soil structure and fertility in the realm of organic farming. Studies by Garg and Gupta in [12] and Barik et al., in 2011 underscore the richness and ongoing efficacy of vermicompost in fostering agricultural vitality.

The study aimed to find out the effect of Organic and inorganic fertilizers and bio inoculants on growth, yield and fruit quality of Bottle gourd To work out the Economics of different treatments.

2. MATERIALS AND METHODS

2.1 Geographical Location of the Experimental Site

The experimental site is located at a latitude of 25.41º North and longitude of 81.84 º East, with an altitude of 98 meters above the mean sea level (MSL).

2.2 Climatic Conditions of the Experimental Area

The area of Prayagraj comes under humid sub-tropical climate, which experiences warm humid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1ºC while monthly mean temperatures are 18-29ºC. The daily average maximum temperature is about 22ºC and the minimum temperature is 9ºC. The average annual rainfall received is 1042.2 mm. At this location, the temperature reaches upto 46ºC-48ºC and the minimum temperature recorded is 4ºC-5ºC. The relative humidity ranges in this location ranges between 20-94%.

2.3 Characters Studied and Observations Recorded

2.3.1 Growth parameters

2.3.1.1 Vine length (cm) [30, 40, 60, DAS]

Using a metre scale, the height of five randomly chosen grafted plants from each plot was measured in centimetres at 30, 40, and 60 days after sowing, starting from the ground and ending at the tip of the shoot. Every replication's average vine length was noted and then statistically examined.

2.3.1.2 Number of branches per plant

At maturity, the number of branches on randomly chosen plants from each plot was counted. Each replication's average number of branches per plant was noted and then statistically examined.

Table 1. Treatment details

Treatment	Treatment Combination
T_1	100% RDF [NPK-200:100:100 kg/ha]
T_2	100% Farmyard manure [20 t ha^{-1}]
T_3	100% Vermicompost [10 t ha^{-1}]
T_4	100% Poultry manure [5 t ha^{-1}]
T_5	75% RDF [NPK-150:75:75] + 25% Farmyard manure [5 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_6	75% RDF [NPK-150:75:75] + 25% Vermicompost [2.5 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_7	75% RDF [NPK-150:75:75] + 25% Poultry manure [1.5 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_8	50% RDF [NPK-100:50:50] + 50% Farmyard manure [10 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_9	50% RDF [NPK-100:50:50] + 50% Vermicompost [5 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_{10}	50% RDF [NPK-100:50:50] + 50% Poultry manure [2.5 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_{11}	25% RDF[NPK-50:25:25] + 75% Farmyard manure [15 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_{12}	25% RDF [NPK-50:25:25] + 75% Vermicompost [7.5 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}
T_{13}	25% RDF [NPK-50:25:25] + 75% Poultry manure [3.75 t ha^{-1}] + Azospirillum @ 1 Kg ha^{-1}

2.3.2 Earliness parameters

2.3.2.1 Days to first male flowering

The number of days taken from sowing to days to first male flower appearance in experimental plots was observed as days to first male flowering. The data were recorded, averaged, and analyzed for all replications.

2.3.2.2 Days to first female flowering

Days to first female flowering in experimental plots was measured as the number of days from seeding to the first appearance of a female flower. For each replication, the data were collected, averaged, and analyzed.

2.3.2.3 Days to first fruit picking

The number of days taken from sowing to days to first picking of fruits post maturity in experimental plots was observed as days to first fruit picking. The data were recorded, averaged, and analyzed for all replications.

2.3.2.4 Number of fruits per plant

Number of fruits that set-in plant was counted and recorded as number of fruits per plant for each treatment and replication. The data recorded was subjected for analysis.

2.4 Yield Parameters

2.4.1 Fruit length (cm)

After being harvested, the fresh fruit from five randomly chosen plants was measured for length on an individual, treatment, and replication basis. The measurements were then computed, averaged, and analysed.

2.4.2 Fruit width (cm)

After being picked at random from five randomly chosen plants, the fresh fruit was measured for width both individually and in terms of replication and treatment. The measurements were then computed, averaged, and analysed.

2.4.3 Average fruit weight (g)

Five fruits were harvested at random from each plant, and they were weighed both replication- and treatment-wise. This was carried out for five randomly chosen plants in order to record data.

2.4.4 Fruit yield per plant (kg/plant)

To determine the fruit yield per plant treatment- and replication-wise, the harvested fruits of each randomly chosen and tagged plant were collected, weighed, and averaged before being subjected to analysis.

2.4.5 Fruit yield per hectare (q/ha)

The yield was calculated by weighing the total fruit yield per plot. The readings for all the harvest per plot were recorded.

3. RESULTS AND DISCUSSION

There was significant difference present among the treatments applied. It was also found that T_9 had lengthiest vine (166.65 cm) observed at 60 DAS among different treatment combination applied in bottle gourd whereas the minimum length of vine was found in treatment T_2 with 106.27 cm observed at 60 DAS. It was found that T_9 had highest number of primary branches (5.63 branches) among different treatment combination applied in bottle gourd at par with T_6 having 5.53 branches whereas the minimum number of primary branches was found in treatment T_2 with 3.43 branches. Among the various treatment combinations applied to bottle gourds, T_9 recorded the minimum days to first male flowering (33.92 days) and treatment T_2 with 42.37 days. Among the various treatment combinations applied to bottle gourds, T_9 recorded the minimum days to first female flowering (42.12 days) and treatment T_2 with 50.81 days recorded the maximum days to first female flowering. Significant difference was present among the treatments applied. T_9 recorded minimum days to first fruit picking (73.76 days) whereas the maximum days to first fruit picking was found in treatment T_2 with 82.94 days and Significant difference was present among the treatments applied. Maximum number of fruits was observed in T_9 with 17.41 fruits among different treatment combination applied in bottle gourd whereas the minimum number of fruits per plant was found in treatment T_2 with 9.26 fruits.

The superior Vegetative, flowering and yield growth per plant observed in the treatment combination of 50% RDF (Recommended Dose of Fertilizers) + 50% Vermicompost + Azospirillum @ 1 Kg/ha at 20, 40, and 60 days after sowing (DAS) in bottle gourd can be attributed to multiple factors. Vermicompost supplements the soil with essential nutrients and improves soil structure, facilitating better root development and nutrient uptake. Azospirillum, being a nitrogen-fixing bacterium, enhances nitrogen availability to plants, promoting vigorous growth. The balanced combination of organic (vermicompost), inorganic (RDF), and biofertilizer (Azospirillum) components ensures a synergistic effect, providing optimal nutrition and fostering robust plant growth, resulting in longer vines compared to other treatments with singular or less balanced nutrient sources. Similar findings were reported by Das et al. [13], Chaudhary et al. [14], Kishor and Sarvanan [15], Pravallika and Deepanshu [16], Nadoda et al. [17], Pathak et al. [18] in bottle gourd.

From the Table 3., the bottle gourd treatment combination T_9 had the longest fruit length (40.11 cm), and treatment T_2 with the shortest fruit length (20.98 cm). Maximum fruit width was observed in T_9 with 7.51 cm among different treatment combination applied in bottle gourd whereas the lowest fruit width was found in treatment T_2 with 5.52 cm. Maximum fruit weight was observed in T_9 with 916.97 gram among different treatment combination applied in bottle gourd whereas the minimum fruit weight was found in treatment T_2 with 807.61 gram. Out of all the treatment combinations applied to bottle gourds, T_9 had the highest fruit yield per plant, weighing 15.97 kg/plant and Treatment T_2 had the lowest fruit yield per plant, weighing 7.48 kg/plant. Out of all the treatment combinations applied to bottle gourds, T_9 had the highest fruit yield per hectare, yielding 79.84 q/ha and Treatment T_2 had the lowest fruit yield per hectare, yielding 37.41 q/ha. All the treatment combinations applied to bottle gourds, T_9 had the highest Total Soluble Solids, with 6.03 °Brix and Treatment T_2 had the lowest Total Soluble Solids, with 3.89 °Brix. Out of all the treatment combinations applied to bottle gourds, T_9 had the highest Vitamin C content, with 4.72 mg/100g and Treatment T_2 had the lowest Vitamin C content, with 3.40 mg/100g.

The enhanced fruit yield attributes and fruit quality observed in the treatment combination of 50% RDF + 50% Vermicompost + Azospirillum @ 1 Kg/ha compared to other treatments can be attributed to the synergistic effects of the fertilizers utilized. Vermicompost enriches the soil with organic matter, micronutrients, and beneficial microbes, which contribute to improved fruit development. Azospirillum, a nitrogen-fixing bacterium, enhances nitrogen uptake, crucial for fruit growth and elongation. The balanced combination of organic (vermicompost), inorganic (RDF), and biofertilizer (Azospirillum) ensures optimal nutrient availability throughout the fruiting stage, promoting cell division and elongation, resulting in longer fruits. This comprehensive nutrient approach outperforms other treatments with less balanced nutrient compositions, leading to the observed enhancement in fruit length. Similar findings were reported by Das et al. [13], Chaudhary et al. [14], Patle et al. [19], Prasad et al. [20], Rabari et al. [21], Mandloi et al. [22], Pathak et al. (2022) in bottle gourd.

Table 2. Effect of organic, inorganic and bio fertilizer on Vegetative and flowering growth of bottle gourd

Treatment	Vine Length (cm) at 60 DAS	No of Primary Branches Per Plant	Days to First Male Flowering	Days to First Female Flowering	Days to First Fruit Picking	Number of Fruits Per Plant
T_1	119.07	4.57	41.08	45.10	77.39	9.65
T_2	106.27	3.43	42.37	50.81	82.94	9.26
T_3	132.03	4.91	37.30	46.46	78.71	9.91
T_4	155.00	4.47	37.74	46.19	78.43	10.35
T_5	127.36	4.63	39.72	47.22	78.88	12.21
T_6	161.75	5.53	35.26	42.83	75.15	15.42
T_7	138.09	5.07	36.69	44.89	76.62	12.37
T_8	145.52	4.67	38.89	49.16	74.92	12.10
T_9	166.65	5.63	33.92	42.12	73.76	17.41
T_{10}	133.74	4.99	40.19	46.16	79.85	14.07
T_{11}	129.73	5.07	38.19	44.93	80.10	13.28
T_{12}	130.86	4.68	36.27	44.19	76.89	14.57
T_{13}	123.10	4.54	39.12	48.97	77.79	13.42
‘F’ Test	S	S	S	S	S	S
CV.	0.6	4.69	1.05	0.55	0.72	5.3
SE. m (±)	0.34	0.09	0.17	0.11	0.23	0.28
CD. at 5%	1	0.27	0.49	0.31	0.69	0.81

Table 3. Effect of organic, inorganic and bio fertilizer on yield attributes and quality of fruit of bottle gourd

Treatment	Fruit Length (cm)	Fruit Width (cm)	Fruit Weight (grams)	Fruit Yield Per Plant (kg/plant)	Fruit Yield Per Hectare (q/ha)	Total Soluble Solids (°Brix)	Vitamin C Content (mg/100g)
T_1	24.04	6.73	883.88	8.53	42.64	4.38	4.10
T_2	20.98	5.52	807.61	7.48	37.41	3.89	3.40
T_3	26.98	7.19	879.95	8.72	43.59	3.75	4.06
T_4	34.30	6.88	893.72	9.25	46.24	5.17	4.40
T_5	29.87	7.12	856.72	10.46	52.30	4.42	4.40
T_6	36.37	7.21	904.56	13.95	69.74	5.89	4.60
T_7	36.28	7.07	839.81	10.39	51.96	5.41	4.49
T_8	24.89	6.41	833.70	10.09	50.44	4.99	3.96
T_9	40.11	7.51	916.97	15.97	79.84	6.03	4.72
T_{10}	32.55	6.89	894.06	12.58	62.90	4.58	3.96
T_{11}	34.26	6.42	889.07	11.80	59.02	5.12	3.66
T_{12}	35.37	6.84	866.08	12.62	63.11	5.11	3.95
T_{13}	31.52	6.77	880.37	11.82	59.09	4.41	4.40
‘F’ Test	S	S	S	S	S	S	S
CV.	1.22	3.21	0.17	5.17	5.17	2.01	4.90
SE. m (±)	0.16	0.09	0.61	0.24	1.19	0.04	0.09
CD. at 5%	0.47	0.27	1.79	0.70	3.48	0.12	0.25

Table 4. Effect of organic, inorganic and bio fertilizer on economics of bottle gourd

Treatment Symbols	Fruit Yield Per Hectare (q/ha)	Cost of Cultivation [INR]	Gross Return [INR]	Net Return [INR]	BC Ratio
T_1	42.64	1,37,119	170560	33,441	1.24
T_2	37.41	1,38,200	149640	11,440	1.08
T_3	43.59	1,38,200	174360	36,160	1.26
T_4	46.24	1,34,200	184960	50,760	1.38
T_5	52.3	1,37,616	209200	71,584	1.52
T_6	69.74	1,37,616	278960	1,41,344	2.03
T_7	51.96	1,37,016	207840	70,824	1.52
T_8	50.44	1,37,887	201760	63,873	1.46
T_9	79.84	1,37,887	319360	1,81,473	2.32
T_{10}	62.9	1,35,887	251600	1,15,713	1.85
T_{11}	59.02	1,38,157	236080	97,923	1.71
T_{12}	63.11	1,38,157	252440	1,14,283	1.83
T_{13}	59.09	1,35,157	236360	1,01,203	1.75
Selling price of bottle gourd Rs 40/kg					

The farmers must consider economics when making decisions about the application of scientific knowledge and techniques, T_9 (50% RDF + 50% Vermicompost + Azospirillum @ 1 Kg ha^{-1}) produced one of the highest gross returns, net returns, and cost benefits because of its higher yield quality and productivity, which raises the fruit's market value [23-25].

4. CONCLUSION

From the above experimental finding it is concluded that the treatment T_9 (50% RDF + 50% Vermicompost + Azospirillum @ 1 Kg ha^{-1}) was found to be best in the terms of growth, yield and quality of bottle gourd. The highest net return was found in the T_9 (50% RDF + 50% Vermicompost + Azospirillum @ 1 Kg ha^{-1}) with Rs 1,81,473/ha) and the highest B:C ratio was found in the same with 2.32.

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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