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Growth, Yield and Fruit Quality of Capsicum Hybrids *(Capsicum annuum)* as Affected by Integration of Inorganic Fertilizers and Organic Manures (FYM) in Protected Condition

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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

A trial was conducted at Horticulture Research Farm, Department of Horticulture, during the year 2023-24. Five Capsicum varieties Names Nemalite, Cebrail, Bungi, Volante and Shehzadi. were evaluated at SHUATS, Prayagraj in randomized block design with three replications during Jan-April 2023-24 to evaluate the best performing variety in terms of growth, yield and quality. The variety Cebrail performed best in terms of plant height (68.97 cm), number of branches (5.65), days to first flower initiation (42.89), chlorophyll content (SPAD Value) (45.71 cm), number of fruits per plant (8.53), fruit length (9.2 cm), individual fruit weight (160.44 g), fruit yield per plant (1.09 kg), maximum fruit yield per plot (6.56 kg). The highest benefit cost ratio was found at 3.15 in the same variety.

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Keywords: Capsicum; performance; varieties; fruit yield; financial significance; polyhouse; plant height; vegetables.

1. INTRODUCTION

"Capsicum (*Capsicum annuum L*.) moreover called Simla Mirch in India is one of the most important vegetables grown in open situations further to beneath managed situations. Its financial significance as a excessive-fee vegetable crop both in home and remote places markets. due to more consumer alternatives and use in diverse culinary products, satisfactory production of capsicum is the need of the day" [1].

1.1 Why Integrated Nutrient Management?

It is the process of making crops by using both chemical and organic fertilizers in combination. Ecologically, socially, and commercially, it is quite doable. It will boost crop productivity and quality, reduce the amount of artificial and natural fertilizers you need to use, Ammonia emissions are decreased, human health is improved, and air quality is improved. It reduces greenhouse gas emissions and helps mitigate the effects of climate change. It also lessens harm to vulnerable habitats caused by excess nutrients delivered in the air or by water.

1.2 Importance of Integrated Nutrient Management

- Nutrient management helps to reduce the contamination of waterways by plant nutrients.
- Improve soil fertility.
- Enhance plant productivity.
- Reduce the cost of chemical fertilizers.
- Providing balanced nutrition to crops.
- Promotes carbon sequestration and prevents the deterioration of soil, water, ecology, and also leaching of nutrients from the soil.
- Help to check the emerging deficiency of nutrients other than NPK.
- It brings economy and efficiency to fertilizer use and favourably affects the physical, chemical and biological environment of soil.

2. MATERIALS AND METHODS

This experiment was carried out during in 2023 at Horticulture Research Farm, SHUATS, Prayagraj, Uttar Pradesh,India which is located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Prayagraj Rewa Road about 5 km away from Prayagraj, city. The experiment was done in the polyhouse. The highest O2 and CO2 concentration was 20.2%. and 480 ppm respectively. In the polyhouse the maximum temperature was 34.7 °C. The maximum light intensity inside and outside the polyhouse was 63600 lux and 110600 lux.

The temperature reached up to 48oC in summer and in winter it goes down to as low as 2-3 ^{o}C. The experiment was laid out in a randomized block design with 9 treatments and three replications. The crop was grown in a naturally ventilated polyhouse. 30 days old seedlings were used for transplanting. November was the first week that transplants were performed at 60 cm × 45 cm spacing on the raised bed. The plants were trained along a plastic thread tied to GI wire stretched over beds. The necessary recommended cultural practices like fertilizer application, irrigation and weeding.

Treatment Combinations:

Treatment	Combination
T0(Nemalite)	100% NPK+15t FYM
T1(Nemalite)	100% NPK + 15t FYM + AZOTOBACTER (10 g)
T2(Cebrail)	100% NPK+15t FYM
T3(Cebrail)	100% NPK + 15t FYM + AZOTOBACTER (10 g)
T4(Bungi)	100% NPK+15t FYM
T5(Bungi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)
T6(Volante)	100% NPK+15t FYM
T7(Volante)	100% NPK + 15t FYM + AZOTOBACTER (10 g)
T8(Sehezadi)	100% NPK+15t FYM
T9(Sehezadi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)

2.1 Statistical Analysis

The data recorded during the course of the investigation were subjected to statistical analysis as per the method of analysis of variance [2]. This investigation was done in the RBD statistical method. The significance and non-significance of the treatment effect were judged with the help of 'f' value (variance ratio) and compared with the table value at a 5% level of significance. If the calculated value exceeds then the value, the effect of considered to be significant. The significant difference between the means was tested against the critical difference at a 5% level of significance.

3. RESULTS AND DISCUSSION

Observations were recorded for growth parameters which are Plant height (cm), Number of primary branches, Days taken for flower initiation and chlorophyll content. In yield parameters are number of fruits per plant, fruit length (cm), fruit diameter (cm), average fruit weight (g), fruit yield (kg plant^{-1}), individual fruit Weight(gm), fruit yield (200sq. m). In quality parameters are total soluble solids (°Brix), vitamin-C (mg/100g). In economics parameters are cost of cultivation (Rs/200sq. m), Gross Return (Rs/200sq. m), Net Return (Rs/200sq. m) and Benefit Cost Ratio (Rs/200sq. m).

3.1 Growth Parameter

3.1.1 Plant height (cm)

The Maximum plant height at 90 DAP was recorded in the Variety Capsicum Cebrail (T2) (68.97 cm) given in (Table 1). This might be due to the genetic constitution of the varieties. The differential response of vegetative growth of the different may be due to differences in genetic constituents of the varieties [3].

3.1.2 Number of primary branches

The Maximum Number of branches was recorded in the Variety Capsicum Cebrail (T2) (5.65) given in (Table 1). It is due to the organic treatment of cebril (T2) was good consumption for those capsicum plants. The temperature can be controlled and regulated under protected condition, therefore healthy and better growth of plants can be expected under protected condition. The differential response of vegetative growth of the different varieties may be due to differences in genetic constituents of the varieties and microclimate condition.

3.1.3 Days taken for flower initiation

The Early days to first flower initiation were recorded in the Variety Capsicum Cebrail (T2) (42.89) given in (Table 1). This may be due occurrence of early flowering is basically a genetic character of each variety. However, favourable temperature regime in protected conditions for a longer period showed a great impact on the genetic constitution of plant to express its full genetic potential. Better environmental conditions and available nutrients seems to have brought quick changes in plant growth and development.

3.2 Yield Parameters

3.2.1 Number of Fruits Per Plant

The Maximum Number of fruits per plant was recorded in the Variety Capsicum Cebrail (T2) (8.53) given in (Table 2). This might be due to the favourable climatic conditions and sufficient accumulation of photosynthesis in the polyhouse condition [4].

3.2.2 Fruit length (cm)

The Maximum Fruit length (cm) was recorded in the Variety Capsicum Cebrail (T2) (9.2 cm) given in (Table 2). Increased fruit size in different hybrids, might be due to enhanced photosynthesis accumulation of carbohydrates and favourable effect on vegetative growth which increased the fruit variety besides increasing fruit size [5].

3.2.3 Fruit diameter (cm)

The Maximum Fruit diameter was recorded in the Variety Capsicum Volante (T6) (8.04 cm) given in (Table 2). It might be increased fruit size attributed in different hybrids might be due to enhanced photosynthesis, accumulation of carbohydrates and favourable effect on vegetative growth which increased the fruit variety besides increasing the fruit size[6].

3.2.4 Individual fruit weight (g)

The Maximum individual fruit weight was recorded in the Variety Capsicum Cebrail (T2) (160.44 g) given in (Table 2). Due to increased fruit weight may be attributed to the favourable microclimate that prevailed in the polyhouse compared to other structures [7,8].

Table 1. Height of Plant (cm), number of primary branches, days taken for flower initiation and chlorophyll as affected by inorganic fertilizers and Organic manures in Capsicum varieties in protected conditio

Treatment	Treatment Combination	Plant height (cm)	Number of Branches	Days to First Flower Initiation
T0(Nemalite)	100% NPK+15t FYM	67.76	5.03	43.56
T1(Nemalite)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	65.86	5.06	43.44
T2(Cebrail)	100% NPK+15t FYM	68.97	5.65	42.89
T3(Cebrail)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	67.91	5.61	43.33
T4(Bungi)	100% NPK+15t FYM	61.34	4.01	48.56
T5(Bungi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	61.30	4.01	48.67
T6(Volante)	100% NPK+15t FYM	62.78	4.03	46.67
T7(Volante)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	62.67	4.04	47.00
T8(Sehezadi)	100% NPK+15t FYM	63.00	4.35	49.22
T9(Sehezadi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	63.18	4.36	49.00
F test		S	S	S
S.E (d) (±)		0.89	0.03	1.21
CD 0.05		1.87	0.07	2.55
C.V		1.69	0.84	3.21

Table 2. Number of Fruits Per Plant, Fruit Length (cm), Fruit Diameter (cm), Individual Fruit Weight (gm), Fruit Yield Per Plant (kg) and Fruit yield per plot (kg/m2) as affected by inorganic fertilizers and Organic manures in Capsicum varieties in protected condition

Treatment	Treatment Combination	Number of Fruits Per Plant	Fruit Length (cm)	Fruit Diameter (cm)	Individual Fruit Weight (gm)	Fruit Yield Per Plant in(kg)	Fruit yield per plot (kg/m2)
T0(Nemalite)	100% NPK+15t FYM	7.34	8.7	7.03	141.56	1.03	6.18
T1(Nemalite)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	7.31	8.7	7.04	144.44	0.99	5.96
T2(Cebrail)	100% NPK+15t FYM	8.53	9.2	6.98	160.44	1.09	6.56
T3(Cebrail)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	8.43	8.9	7.00	158.56	0.99	5.96
T4(Bungi)	100% NPK+15t FYM	7.22	6.3	5.97	102.11	0.84	5.06
T5(Bungi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	7.90	6.2	6.26	99.00	1.07	6.44
T6(Volante)	100% NPK+15t FYM	7.42	8.8	8.04	139.00	0.96	5.74
T7(Volante)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	7.44	8.9	8.00	132.22	0.90	5.42
T8(Sehezadi)	100% NPK+15t FYM	7.93	5.6	5.38	85.67	0.53	3.20
T9(Sehezadi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	7.33	5.5	5.34	88.11	0.60	3.60
F test		S	S	S	S	S	S
S.E (d) (±)		0.29	0.14	0.35	3.34	0.01	0.09
CD 0.05		0.61	0.30	0.74	7.02	0.03	0.18
C.V		4.65	2.28	6.41	3.27	1.85	1.96

3.2.5 Fruit yield per plant (kg)

The Maximum fruit yield per plant was recorded in the Variety Capsicum Cebrail (T2) (1.09 kg) given in (Table 2). It might be due to the organic condition of Cebril (T2) was higher number of flowers per plant, fruits per plant, more pollination, lesser flower drop, maximum percent fruit set, maximum mean fruit weight and fruit volume [9].

3.2.6 Fruit yield (kg/m2)

The Maximum fruit yield per plot was recorded in the Variety Capsicum Cebrail (T2) (6.56 kg) given in (Table 2). The higher fruit yield under this condition may be attributed to the favourable climatic conditions that prevailed under polyhouse and also due to its protective ability against major biotic stress, which reduces the effect of the excess rainfall, water logging, and provides a controlled environment to the crop. similarly higher fruit yield was also reported [10-13].

3.3 Quality Parameters

3.3.1 TSS Content (°Brix)

The Maximum Tss (°Brix) was recorded in the Variety *Capsicum* Volante (T7) (9.34) is given in (Table 3). TSS is an important quality attribute of capsicum fruit. An increase in this parameter improves the flavour and increases the palatability. Since capsicum is used for salad making, fruits with high TSS are highly preferred. [14].

3.3.2 Vitamin C (mg/100g)

The Maximum Vitamin C content (mg/100g) was recorded in the Variety Capsicum Sehezadi (T8) (154.66) is given in (Table 3). Generally, the higher ascorbic acid content would increase the nutritive value of capsicum, which would help better retention of colour and flavour. Capsicum varieties and hybrids possessing high ascorbic acid content are in great demand in export markets which may be due to differences in genetic constituents of the varieties and microclimate condition.[9]

3.3.3 Chlorophyll (mg/cm^{-2})

The Maximum Chlorophyll content (mg/cm^{-2}) was recorded in the Variety Capsicum Cebrail (T2) given in (Table 3). This means that less photosynthesis would occur in the leaves of the plant, so less glucose is made as a result. Therefore there is less energy released for growth as glucose is needed for respiration.

Table 3. TSS (°Brix) & Vitamin C (mg/100g) content as affected by inorganic fertilizers and Organic manures in Capsicum varieties in protected condition

Treatment	Treatment Combination	Tss (°Brix)	Vitamin C (mg/100g)	Chlorophyll (mg m^{-2})
T0(Nemalite)	100% NPK+15t FYM	7.56	152.00	42.32
T1(Nemalite)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	9.26	153.22	43.03
T2(Cebrail)	100% NPK+15t FYM	8.70	152.03	45.71
T3(Cebrail)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	8.74	152.15	43.31
T4(Bungi)	100% NPK+15t FYM	9.00	152.56	45.20
T5(Bungi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	9.08	154.10	43.86
T6(Volante)	100% NPK+15t FYM	7.59	154.48	42.40
T7(Volante)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	9.34	152.56	44.39
T8(Sehezadi)	100% NPK+15t FYM	8.83	154.66	43.41
T9(Sehezadi)	100% NPK + 15t FYM + AZOTOBACTER (10 g)	8.68	154.05	43.07
F test		S	S	S
S.E (d) (±)		0.05	1.19	1.48
CD 0.05		0.12	2.50	3.11
C.V		0.77	0.95	4.16

Table 4. Cost of agronomical practices of cultivation as affected by inorganic fertilizers and Organic manures in Capsicum varieties in protected condition

S. No	Particular	Requirement	Rate/unit Rs.	Cost
(A)	Land preparation			
I.	Soil Pulverization	4 labours	350 Rs/labours	1,400
II.	Layout of field	2 labours	350 Rs/labours	700
III.	Mulching (30 Micron) Silver black			6,000
(B)	Planting	1 labour	350 Rs/labour	350
(C)	Manures and fertilizer			
I.	FYM	300kg	10 Rs/kg.	3,000
II.	Urea	60 Kg	10 Rs/Kg	600
III.	DAP	50 Kg	30 Rs/Kg	1,500
IV.	MOP	40 Kg	50 Rs/Kg	2,000
V.	Labour	1 labours X 3 time	350 Rs/labour	1,050
(D)	Irrigation	1 Labour X 3 time	350	1,050
(E)	Weed Management	1 labour X 3 time	350 Rs/labour	1,050
(F)	Harvesting	1 labours X 3 time	350 Rs/labour	1,050
	Total cost of cultivation			19,750

Table 5. Cost economics of growing different varieties of capsicum as affected by inorganic fertilizers and Organic manures in Capsicum varieties in protected condition

Treatments	Cost of cultivation (Rs/200sq. mt)	Total yield 200sq. mt	Selling Rate (Rs/q)	Gross return (Rs/200sq. mt)	Net return Rs./ 200sq. mt)	Benefit cost ratio
T0(Nemalite)	19,750	15.45	5000	77,250	57,500	2.91
T1(Nemalite)	19,750	14.90	5000	74,500	54,750	2.77
T2(Cebrail)	19,750	16.40	5000	82,000	62,250	3.15
T3(Cebrail)	19,750	14.90	5000	74,500	54,750	2.77
T4(Bungi)	19,750	12.65	5000	63,200	43,500	2.20
T5(Bungi)	19,750	16.10	5000	80,500	60,750	3.07
T6(Volante)	19,750	14.35	5000	71,750	52,000	2.63
T7(Volante)	19,750	13.55	5000	67,750	48,000	2.43
T8(Sehezadi)	19,750	8.00	5000	40,000	20,250	1.02
T9(Sehezadi)	19,750	9.00	5000	45,000	25,250	1.27

4. CONCLUSION

From the present investigation it is concluded that variety Cebrail (T2) performed best in terms of Growth parameters viz., plant height (68.97 cm), Number of branches (5.65), Days to first flower initiation (42.89), Chlorophyll content (45.71). In terms of Yield Parameter number of fruits per plant (8.53), Fruit length (9.2 cm), individual fruit (160.44 g), fruit yield per plant (1.09 kg), fruit yield per plot (6.56 kg). Also, in terms of Economics, Variety Cebrail (T2) recorded the highest Benefit cost ratio (3.15).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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