emergent
Life Sciences Research

Research Article

Influence of planting time and spacing on quality of Zucchini (*Cucurbita pepo*) under naturally ventilated polyhouse

Dhiraj Bhattacharjee, Deepa Borbora Phookan, Suchibrata Chamuah, Mausum Kumar Nath, Sailen Gogoi, Sangita Das, Palash Debnath

Abstract

An experiment was carried out during 2021-2022 to examine the influence of planting time and spacing on the growth, yield, and quality of Zucchini (*Cucurbita pepo*. L) under a naturally ventilated polyhouse in the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat. Factorial Randomized Block Design was used to set up the experiment with 4 different times of planting (10th November 2021, 1st December 2021, 20th December 2021 and 10th January 2022), and 3 spacings (45cm x 60cm, 60cm x 60cm, and 75cm x 60cm) with 3 replications. Moisture content of fruit (96.24% & 95.31%) was highest in P_4 and S_3 spacing whereas ascorbic acid content (38.46mg/100g & 36.82 mg/100g) was highest in P_2 and S_3 spacing. The protein content of fruit (6.52 % & 6.42 %), total carotenoid content (8.37 µg/g), fiber content (0.91 %), ash content (0.65 % & 0.59 %) was recorded highest in the P_3 planting and S_3 spacing. Total soluble solids content (4.15 brix & 3.95 brix) was highest in P_3. Fat content (0.66 mg & 0.67 mg) was highest in P_4 planting and S_3 spacing. Fiber content (0.90 %) in S_2 spacing was found to be significantly different from other spacing. The outcome of the study showed that under naturally ventilated polyhouse conditions planting on 20th December along with a moderate planting distance of 60cm x 60cm induces maximum advantage in plant's quality parameters.

Keywords ash, carotenoid, fiber, polyhouse, zucchini

Received: 20 May 2023
Accepted: 07 August 2023
Online: 11 August 2023

Authors:
D. Bhattacharjee ✉, D. B. Phookan, S. Chamuah, M. K. Nath
Department of Horticulture, Assam Agricultural University, Jorhat-13, Assam, India

S. Das
Department of Crop Physiology, Assam Agricultural University, Jorhat-13, Assam, India

S. Gogoi
AICRP on Vegetable Crops, Assam Agricultural University, Jorhat-13, Assam, India

P. Debnath
Department of Plant Pathology, Assam Agricultural University, Jorhat-13, Assam, India

✉ dhirajbhattacharjee99@gmail.com

Emer Life Sci Res (2023) 9(2): 43-50

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2023.924350

Introduction

Zucchini (*Cucurbita pepo*. L.) is an exotic vegetable that belongs to the Cucurbitaceae family. In some parts of the world, it is also known as a field pumpkin or vegetable marrow. Zucchini is a fast-growing, high-yielding squash. It is believed to be the only annual bush-type cucurbit that can be consumed by humans and is native to North America and North-eastern Mexico. The plant can set fruit in close succession and has trailing habits and short internodes. Pepo is a botanical type of fruit, which can be harvested 50–60 days after sowing. Its sex form is monoecious in nature but nowadays androecious forms are also seen [1]. Zucchini holds tremendous medicinal value and possesses several health advantages [2]. Zucchini is regarded as one of the low-calorie vegetables (17 Kcal per 100 gm) that don't contain saturated fats or cholesterol. Its peel is regarded as an excellent source of fiber that prevents colon cancers, manages diabetes symptoms and safeguards heart health, in addition to preventing inflammatory conditions [3]. It contains considerable amounts of vitamin C, E, B6, niacin and thiamine as well as minerals like potassium, magnesium, phosphorus, calcium, iron and manganese. Fresh zucchini also provides vitamin A up to 200 IU per 100g [4]. Golden skin types are rich in flavonoids and antioxidants such as carotenes, lutein and zeaxanthins. The rich and fertile soil of the Barak and Brahmaputra valleys in Assam are highly potential areas for vegetable cultivation in Assam. Here, the total area under vegetables is 2.96 lakh hectares along with an output of 51.63 million tons and productivity of 184.57 q/ha [5]. The cropping intensity of Assam is only 145 per cent in vegetable shares about 8.10 per cent. In 2021, Assam's vegetable area was estimated to be 334.50 thousand hectares. This is an increase from the previous year's total production of 312.970 thousand hectares in 2020. There is a vast scope for increasing vegetable cultivation in Assam. A polyhouse is defined as a framed or flexible building coated in a transparent or translucent material that is big enough to carry out cultural activities along with the cultivation of crops under controlled conditions [6-7].

Protected cultivation inside polyhouses offers plants a regulated environment for developing in the best possible way for boosting crop yield. The microclimate inside the polyhouse is impacted by variables viz. light, temperature, humidity, and carbon dioxide concentration. Numerous studies have looked into how these environmental elements affect the development, growth, and yield of crops. Santosh and Maitra [7] revealed that light is the primary indicator of crop development and plant responses to environmental conditions, which can significantly alter crop timing and yield [6]. According to Stoffella and Bryan, [8] plant density has a significant role in influencing plant development, growth and marketable yield of many crops. Optimizing light absorption by adjusting plant spacing has a direct impact on the physiology, growth, and yield of the plant. Providing the best conditions for growth and development that leads to improvement of yield qualities and optimal plant spacing is one of the key agronomic components in achieving a crop's potential yield [9].

Low-cost polyhouses can be easily constructed by the small and marginal farmer’s in Assam. Previous studies have reported higher production of zucchini inside the polyhouse as compared to the outside environment. Keeping these facts in mind, an experiment was done to determine the effects of planting time and spacing on quality of zucchini inside a naturally ventilated polyhouse.

Methodology

The current research was carried out in the naturally ventilated polyhouse in Horticultural Experimental Farm, Assam Agricultural University located in Jorhat from November; 2021 to March 2022. The location of the experimental plot was at 26° 48’N latitude and 94° 13’E longitude and at an elevation of 86.89 m above mean sea level. Meteorological observations were recorded inside the naturally ventilated polyhouse by using the wet bulb and dry bulb thermometers.

A factorial randomized block design was used to set up the experiment with 4 different times of planting (10th November 2021, 1st December 2021, 20th December 2021 and 10th January 2022), and 3spacings (45cm x 60cm, 60cm x 60cm, and 75cm x 60cm) with 3 replications. Freshly harvested fruits were taken from the field for studying the various quality parameters like moisture percentage, fiber content, ascorbic acid, total soluble solids content, ash content, fat content, protein content and total carotenoid content.

Moisture percentage

Yellow fruit samples from each treatment were freshly chopped and placed in a dryer to reach a constant weight as directed by Ranganna [10]. Using the formula below, the moisture content was determined.

$$Moisture\ Percentage = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}}\ X\ 100$$

Ascorbic acid content

According to Ranganna's method [10], by reducing 2, 6-dichlorophenol indophenol (dye) with ascorbic acid, the ascorbic acid level was measured. A 3% metaphosphoric acid (HPO_3) solution was added to 10 ml of the extracted juice to bring the volume up to 100 ml. To titrate this solution against the dye (2, 6-

dichlorophenol-indophenol), 10 ml of it was employed until the pink colour was visible (endpoint). Calculations were made after recording the titre value. The following formula was used to compute ascorbic acid and convert it to mg per 100g of pulp.

$$Ascorbic\ acid = \frac{mg}{100\ \text{pulp}} = \frac{Title\ X\ Dye\ factor\ X\ volume\ given\ multiplied\ by\ 100}{\text{Aliquot used in the estimation X Quantity of samples used for Estimation}}$$

Total soluble solids

Using a digital hand refractometer, the total soluble solids present in the fruit pulp were measured at room temperature and the readings were stated in terms of Brix.

Protein content in fruit

Using auto analyzers, the total nitrogen of dried fruit samples was calculated using the Micro-Kjeldahl method (Kelphus pelican model). After digestion, a 50ml aliquot of the fruit sample (0.5g) was made using concentrated H_2SO_4 (15ml) and H_2O_2 (5ml). The Kelphus pelican model was used to take an exact amount of aliquot for nitrogen distillation. The sample's % protein content was calculated using the following.

$$\text{Protein (\%)=Nitrogen (\%)X6.25}$$

Fiber percentage

Ranganna's [10] approach was used to assess the fibre content of a sample of dried fruits that had no fat. Petroleum ether was used to extract 2 g of the crushed material. 200 cc of H_2SO_4 and 2 g of dry material were heated for 30 minutes. After filtering it through a cotton cloth and rinsing it in boiling water, the acid was finally eliminated. After that, it was boiled in the beaker for 30 minutes with NaOH solution. It was then cleaned with 25 ml of boiling 1.25 % H_2SO_4, followed by 50 ml of water and 25 ml of alcohol. It was then filtered once more using a muslin towel. The remaining material was then removed and added to the crucible. At 130°C, the residue was dried for 24 hours. The desiccators' crucible was cooled before being weighed. Afterwards, it was fired for 30 minutes in a muffle furnace. The desiccators were cooled and weighed once more. The following formula was used to calculate the fiber content.

$$Fiber\ percentage = \frac{\text{Loss in weight}}{\text{Weight of sample}}\ X\ 100$$

Ash percentage

After the measurement of the fiber, the weight of the crucible was taken. Then, 2 g of the oven-dried sample, which had been weighed in a silica dish, was taken and heated on a burner until it was red hot before being placed in the muffle furnace at 600°C for full ignition. When the temperature dropped to 70°C, the crucible was taken out of the furnace and placed in a desiccator, where it was held until cooled. The formula below was employed.

$$Ash\ percentage = \frac{(Final\ crucible\ weight) - \text{(Initial crucible weight)}}{\text{Weight of sample}}\ X\ 100$$

Fat content

The ether extract was used to remove the fat from the dry material. A thimble was used to hold the 2g accurate dry sample weight, and cotton was used as the plug. The system was loaded with petroleum ether after being poured into a beaker. Set the thermostat at 90 °C for 50 minutes. Later, the temperature was elevated for 30 minutes to 170 °C. Only the ether that was still present in the flask residue was evaporated. The Beaker and residue were dried in an oven set to 100 °C, then cooled and weighed Ranganna's [10].

$$Fat\ percentage = \frac{Q\ (wt)\ \text{of ether}}{\text{Q}\ (wt)\ \text{of the sample}}\ X\ 100$$

Total carotenoid

With the help of acid-and alkali-washed pestle and mortar, a sample of 5g of fresh skin was taken and crushed in 10 ml of acetone. Until the residue is colourless, the supernatant is decanted into a conical flask and the procedure is repeated. After that, the combined supernatant is sent to a separating funnel where 10 ml of petroleum ether is added and properly mixed. Then, 25 ml of 5 % anhydrous sodium sulphate solution is added, and after vigorously shaking, the mixture is left standing until the two layers have separated. After removing the bottom, colourless layer, the higher, coloured layer was kept; and petroleum ether (10ml) was added again. Up until the colour was transferred into the petroleum ether layer, petroleum ether (10ml) was continuously added to the acetone layer containing Na2SO4. The upper, pigment-containing layer was gathered in a 25 ml flask, the lower, colourless layer was discarded and petroleum ether was added to get the final volume to 25 ml. Petroleum ether was used as a blank to capture the 452 nm optical density. The total carotenoid content was calculated using the formula below:

$$Total\ carotenoid\ (mg\ per\ 100g\ pulp) = \frac{3.857\ X\ O.D.X\ Volume\ made\ up\ X\ Dilution\ X\ 100}{\text{Weight of the sample X 1000}}$$

Analysis of statistics

Fisher's method of analysis of variance was utilized in this study and a randomized block design with two factors was used to statistically assess the experimental data gathered from multiple observations [11]. Calculating the corresponding "F" values allows one to determine whether the variance caused by the effects of the different treatments is significant. Utilizing the formula, calculated the standard error of the differences.

$$S.ED = \frac{\sqrt{2EMS}}{\text{r}}$$

The critical difference (C.D.) at a % probability level is calculated to estimate the mean difference between the treatments. The following phrase is used to calculate CD.

CD= S.Ed x t_5% for error d.f

Where,

t = tabular value of t considering an appropriate degree of freedom at a 5% probability level

Results and Discussion

This study examined how planting time and spacing affected the quality of zucchini fruits by considering the quality viz. moisture content, protein content, ash content, fat content, fibre content, TSS and ascorbic acid.

Moisture content

The influence of planting time, spacing, and their interaction effect had a significant impact on the moisture content (Table 1). P_4 fruits had the highest moisture level (96.241 %), whereas P_2 fruits had the lowest moisture content (93.340 %). S_3 spacing had the highest moisture content (95.313%), and S_1 spacing had the lowest moisture content (94.874%). It might be because fruits on plants with a close spacing are shielded from direct sunlight by foliage as compared to plants with a wider spacing. Similar results were found by different researchers [12-13] in cabbage and Pandey et al., [14] in chilli. The interactions between planting time and spacing resulted in the highest moisture content in P_4S_3 (96.899%) fruits. The minimum moisture content in fruits was observed in P_2S_2 (93.190%) (Table 2).

Table 1. Influence of planting time and spacing on quality of Zucchini

Treatments	Moisture Content (%)	Protein Content (%)	Total Carotenoid Content (µg/g)	Fat Percentage (%)	Fiber Percentage (%)	Ash Content (%)	TSS content (brix)	Ascorbic Acid Content (mg/100g)
P_1	94.81	6.32	7.26	0.65	0.84	0.58	3.50	34.84
P_2	93.34	6.23	6.58	0.64	0.85	0.51	3.46	38.46
P_3	95.91	6.52	8.37	0.66	0.91	0.65	4.15	32.41
P_4	96.24	6.43	7.68	0.66	0.86	0.59	4.05	35.81
S.Ed(±)	**0.04**	**0.02**	**0.54**	**0.006**	**0.009**	**0.006**	**0.07**	**0.26**
CDat5%	**0.08**	**0.06**	**0.26**	**0.012**	**0.018**	**0.013**	**0.16**	**0.55**
S_1	94.87	6.35	7.26	0.64	0.83	0.57	3.66	35.48
S_2	95.04	6.35	7.68	0.66	0.90	0.59	3.77	33.83
S_3	95.31	6.42	7.48	0.67	0.86	0.59	3.95	36.82
S.Ed(±)	**0.03**	**0.02**	**0.22**	**0.005**	**0.007**	**0.005**	**0.06**	**0.23**
CD at 5%	**0.07**	**0.05**	**NS**	**0.011**	**0.015**	**0.011**	**0.14**	**0.48**
Interaction (P x S)	**SIG**	**NS**	**NS**	**SIG**	**SIG**	**SIG**	**SIG**	**SIG**

Protein content

Data on the effect of planting and spacing on quality parameters are presented in Table 1, revealing that P_3 fruits had the significantly highest (6.521%) protein content and P_2 fruits had the lowest protein content (6.239%). S_3 spacing fruits had the highest protein content (6.426%), whereas S_2 spacing fruits had the lowest (6.352%). According to meteorological data, the months of November to January had high temperatures, which caused the nitrogen content of late-sown crops to be higher inside poly-house environments. Since the plant's nitrogen content and protein content are positively connected, the protein content increased as nitrogen metabolism increased. According to Skjelvag [15], the nitrogen concentration of vegetables increased as the temperature goes up which is related to meteorological data during the growing season. Similar results were found in Mohanty et al., [12] in zucchini. Interactions were found to be non-significant (Table 2)

Total carotenoid content

Planting time had a significant impact on the total carotenoid content (Table 1). P_3 fruits had the significantly highest (8.374mg) total carotenoid content and P2 fruits had the lowest total carotenoid content (6.585mg). Among the spacing, the highest total carotenoid content was found in S_2 fruits (7.684mg) and S_1 (7.265mg) spacing fruits had the lowest total carotenoid content. The influence of light played an important role in determining the yellow colour and the total carotenoid content of fruits [16]. The influence of temperature, light intensity and harvesting time is responsible for the response of carotenoid bio-synthesis-related genes and thus resulted in differences in levels of carotenoid accumulation. Similar results were found in Mohanty et al., [12] and Narke et al., [17] in zucchini. Interactions were found to be non-significant (Table 2).

Fat content

The combined effect of planting time and spacing had a significant impact on the fat content (Table 1). P_3 fruits had the highest (0.669%) fat content and P_2 fruits had the lowest fat content (0.640%). The highest fat content was recorded at spacing S_3 (0.672%) and S_1 (0.643%) spacing had the lowest fat content. Fat content is directly proportional to the water content of the fruit and a decrease in water content that occurs at high temperatures leads to an increase in the percentage of fat content. Similar results were found in Narke et al., [17] and Lata et al., [18] in zucchini. Interactions were found to be significant with planting time and spacing and P_4S_3 (0.687%) fruits recorded the highest fat content whereas the lowest fat content was recorded in P_2S_1 (0.630%) fruits (Table 2).

Table 2. Interaction table of planting time and spacing on quality of Zucchini

Treatments	Moisture Content (%)	Protein Content (%)	Total Carotenoid Content (µg/g)	Fat Percentage (%)	Fiber Percentage (%)	Ash Content (%)	TSS content (brix)	Ascorbic Acid Content (mg/100g)
P_1S_1	94.76	6.31	7.41	0.65	0.81	0.58	3.14	35.19
P_2S_1	93.30	6.18	6.26	0.63	0.79	0.51	3.41	38.20
P_3S_1	95.24	6.48	8.12	0.63	0.89	0.63	4.00	32.84
P_4S_1	96.19	6.45	7.26	0.65	0.84	0.57	4.08	35.71
P_1S_2	94.76	6.26	7.29	0.65	0.87	0.58	3.52	33.25
P_2S_2	93.19	6.21	6.89	0.64	0.83	0.52	3.50	37.23
P_3S_2	96.57	6.53	8.66	0.68	0.96	0.64	4.10	31.34
P_4S_2	95.63	6.39	7.88	0.66	0.93	0.61	3.94	33.52
P_1S_3	94.91	6.39	7.09	0.66	0.83	0.59	3.84	36.09
P_2S_3	93.52	6.31	6.60	0.65	0.92	0.51	3.47	39.95
P_3S_3	95.91	6.54	8.34	0.68	0.88	0.68	4.36	33.06
P_4S_3	96.89	6.43	7.91	0.68	0.80	0.60	4.14	38.20
S.Ed(±)	**0.06**	**0.05**	**0.45**	**0.010**	**0.015**	**0.010**	**0.13**	**0.46**
CD at 5%	**0.14**	**NS**	**NS**	**0.021**	**0.031**	**0.022**	**0.28**	**0.96**

Fiber content

The influence of planting time and spacing had a significant impact on the fiber content (Table 1). P_3 fruits had the maximum (0.917%) fiber content and P_1 plants had the lowest fiber content (0.841%). The highest fiber content was measured at spacing S_2 (0.903%) and S_1 (0.839%) spacing had the lowest fiber content. By creating dry matter and other energy-dense compounds, it is responsible for regulating photosynthesis, carbon adsorption, and plant development as a result of increased nutrient intake. Interactions were found to be significant with P_3S_2 (0.968%) fruits recorded the highest whereas the lowest fiber content was observed in P_2S_1 (0.796%). Similar results were found in Narke et al., [17] in zucchini and Bake et al., [19] in okra (Table 2).

Ash content

From the experiment (Table 1) we observed that P_3 recorded the highest (0.654%) ash content of fruits whereas P_2 fruits recorded the lowest ash content (0.519%). The highest ash content was measured at spacing S_3 (0.599%) fruits whereas S1 (0.577%) spacing fruits recorded the lowest ash content. Increased fruit size in comparison to other fruits and improved nutrient use for reproduction capacity may be the causes of the rise in dry matter content. Similar results were found in Osadebe et al., [20] in fluted pumpkin and Lata et al., [18] in zucchini. Interactions were found to be significant as P_3S_3 (0.684%) fruits recorded the highest ash content whereas the lowest ash content was observed in P_2S_3 (0.513%) fruits (Table 2).

Total soluble solids content

Data revealed that the influence of planting time and spacing on total soluble solids content was found significant (Table 1). P_3 fruits had the maximum (4.156 bix) total soluble solids and P_2 fruits had the lowest total soluble solids (3.463 bix). The highest total soluble solid was measured at spacing S_3 (3.955 bix) and S_1 (3.660 bix) spacing recorded the lowest TSS content. TSS depends on the date and time of harvest, and also on the room temperature at which the refractometer is being used. S_3 plant spacing may have aided in the efficient use of soil nutrients, moisture, and sun radiation, which produced fruits of high quality. These outcomes were consistent with those of Watanabe et al., [21] who studied watermelon. Similar results were found in Kirimi et al., [22] in tomato. Interactions were found to be significant with P_3S_3 (4.361 bix) fruits showing the highest total soluble solids and the lowest total soluble solids were recorded in P_1S_1 (3.146 bix) fruits (Table 2).

Ascorbic acid

Data showed that the influence of planting time and spacing had a significant impact on the ascorbic acid content (Table 1). P_3 fruits recorded the maximum (38.462mg) ascorbic acid and P_2 fruits recorded the lowest ascorbic acid (32.416mg). The highest ascorbic acid was measured at spacing S_3 (36.828mg) and S_1 (33.839mg) spacing had the lowest ascorbic acid. The data clearly showed that planting in December and with greater spacing had higher ascorbic acid contents. S_3 spacing may have helped to improve quality attributes like ascorbic acid. There is a positive relationship between light and ascorbic acid levels in the plants which was also stated by Lee and Kader [9] and Acikgoz [23-24]. Interactions were found to be significant with P_3S_3 (39.952mg) fruits showing the highest ascorbic acid and the lowest ascorbic acid was observed in P_1S_1 (31.346mg) (Table 2).

Conclusion

From the experiment, it was observed that the maximum moisture content of fruits (96.24 % and 95.31 %) was highest in P_4 (10th January) and S_3 (75 cm x 60cm) spacing. The maximum protein content of fruit (6.52% & 6.42%), total carotenoid content of fruit (8.37 μg/g), fiber content (0.91 %) and ash content (0.65 % & 0.59 %) was recorded highest in the P_3 (20th December) planting time and S3 (75cm x 60cm) spacing. The similarly highest total soluble solids content of fruits (4.15 brix and 3.95 brix) was recorded in P_3 (20th December) and S_3 (75 cm x 60 cm) spacing. Fat content (0.66 mg and 0.67 mg) was highest in P_4 planting and S_3 (75 cm x 60 cm) spacing fruits. Fiber content (0.90 %) in S_2 (60 cm x 60 cm) spacing was found to be significantly highest among the other spacing whereas maximum ascorbic acid content of fruit (38.46 mg/100g & 36.82 mg/100g) was recorded in P_2 (1st December) and S_3 (75cm x 60 cm) spacing.

The findings of the current research showed that under naturally ventilated polyhouse conditions planting on 20th December along with a moderate planting distance of 60cm x 60 cm induces maximum advantage in plant quality parameters. More research on the impact of different mulching materials on zucchini growth, yield, and quality will also assist farmers in lowering their production costs. Farmers would benefit from studies on insect-pest incidence and organic farming as they work to cut back on biotic stress losses. Additionally, as zucchini is a highly valued crop, including it in sequence cropping will improve farmers' profits.

References

[1] D. Bhattacharjee **(2022)**. Zucchini (*Cucurbita pepo* L.) cultivation in India: A review. Bhartiya Krishi Anusandhan Patr., **37:** 88-90. doi: 10.18805/BKAP359.

[2] M. Bannayan, E. E. Revaei and A. Alizadeh **(2011)**. Climatic suitability of growing summer squash (*Cucurbita pepo* L.) as a medicinal plant in Iran. Not. Sci. Biol., **3:** 39-46

[3] M. A. A. Alla, A. A. Mohsen and H. A. El Tanbashawy **(2013)**. Effect of grafting Nubian watermelon on its growth, flowering, yield and fruit quality. Proc. 7th Int. Con. Biol. Sci. (Bot.) pp7-13.

[4] T. K. Bose and M. G. Som **(1986)**. Vegetable crops in India. Naya Prokash, Calcutta, Bib ID: 921234.

[5] F. Welfare **(2018)**. Horticultural statistics at a glance. OUP Catalogue.

[6] S. Maitra, T. Shankar, J.B. Palai, M. Sairam, A. Pal and D.J. Gaikwad (2020). Cultivation of Gerbera in polyhouse, *In*: Protected Cultivation and Smart Agriculture, New Delhi Publishers, India, pp219-226. doi: 10.30954/NDP-PCSA.2020.23.

[7] D. T. Santosh, and S. Maitra **(2021)**. Estimation of irrigation water requirement of Zucchini squash (*Cucurbita pepo* L.) Under protected cultivation structures and in open field conditions. Indian J. Nat. Sci., **12:** 37380-37385.

[8] P. J. Stoffella and H. H. Bryan **(1988)**. Plant population influences growth and yield of bell pepper. J. Amer. Soc. Horti. Sci., **113:** 835-839.

[9] D. Singh, S. Kaur, T. S. Dhillon, P. Singh, J. S. Hundal and G. J. Singh **(2004)**. Protected cultivation of sweet pepper hybrids under net-house in Indian conditions. Acta Hort., **659:** 515-521.

[10] S. Ranganna **(1986)**. Handbook of analysis and quality control for fruits and vegetable products. Tata-McGraw Hill Publishing Co. Ltd. New Delhi.

[11] V. G. Panse and P. V. Sukhatme **(1995)**. Randomized design and square and factorial experiment in statistical methods of agricultural workers. (2nd Edn.) ICAR, NewDelhi.

[12] M. Mohanty, M. Kachari, D.B. Phookan, N. Borah and S. Baruah **(2023)**. Quality of zucchini (*Cucurbita pepo*) influence by planting time and fertilizers. Pharma Innov. J., **12:** 3888-3891.

[13] A. Ullah, M. N. Islam, M. I. Hossain, M. D. Sarkar and M. Moniruzzaman **(2013)**. Effect of planting time and spacing on growth and yield of cabbage. Int. J. Bioresour. Stress Manag., **4:** 182-186.

[14] A. K. Pandey, A. K. Singh, A. Kumar and S. K. Singh **(2013)**. Effect of Drip irrigation, spacing and nitrogen fertigation on productivity of chilli (*Capsicum annuum* L.). Environ. Ecol., **31:** 139-142.

[15] A. O. Skjelvag **(1981)**. Effects of climatic factors on the growth and development of the field bean (*Vicia faba* L. var. minor) I. Phenology, Height Growth and Yield in a Phytotrone Experiment. Acta Agric. Scand., **31:** 358-371.

[16] J. Lado, E. Alós, M. Manzi, P. J. R. Cronje, A. Gómez-Cadenas, M. J. Rodrigo and L. Zacarías **(2019)**. Light regulation of carotenoid biosynthesis in the peel of mandarin and sweet orange fruits. Front. Plant Sci., **10:** 1288. doi: 10.3389/fpls.2019.01288.

[17] S. R. Narke, Y. R. Parulekar, P. C. Haldavanekar, P. M. Haldankar, R. V. Dhopawkar and S. S. Hinge **(2015)**. Effect of spacing and fertilizer levels on growth and yield of zucchini under Konkan agro-climatic conditions. J. Indian Soc. Coastal Agric. Res., **33:** 22-27.

[18] H. Lata, R. G. Khandenkar, D. C. Haldavanekar, V. G. Salvi and B. R. Salvi **(2017)**. Effect of spacing and fertilizer levels on growth and yield of zucchini (*Cucurbita pepo* L.). J. Indian Soc. Coastal Agric. Res., **35:** 25-29.

[19] I. D. Bake, B. K. Singh, A. K. Singh,D. P.Moharana and A.K. Maurya **(2017)**. Effect of sowing dates and planting distances on quantitative attributes of okra [*Abelmoschus esculentus* (L.) Moench] cv. Kashi Pragati. Pharm Innov., **6:** 142-148.

[20] V. O. Osadebe, B. C. Echezona and S. O. Bakare **(2014)**. Effect of weed management and cutting frequency on the leaf yield and proximate composition of fluted pumpkin (*Telfairia occidentalis* Hook F.). Am.-Eurasian J. Agric. Environ. Sci., **14:** 664-673.

[21] S. Watanabe, Y. Nakano and K. Okano **(2003)**. Effect of planting density on fruit size, light-interception and photosynthetic activity of vertically trained watermelon (*Citrullus lanatus* (Thunb.) Matsum. et Nakai) plants. J. Japn. Soc. Hortic. Sci., **72:** 497-503.

[22] J. K. Kirimi, F. M. Itulya and V. N. Mwaja **(2011)**. Effects of nitrogen and spacing on fruit yield of tomato. Afr. J. Hort. Sci., **5:** 50-60.

[23] S. K. Lee and A. A. Kader **(2000)**. Preharvest and postharvest factors influencing Vitamin C content of horticultural crops. Postharvest Biol. Technol., **20:** 207-220.

[24] F. E. Acikgoz **(2012)**. Determination of yield and some plant characteristics with vitamin C, protein and mineral material content in mibuna (*Brassica rapa* var. N*ipposinica*) and mizuna (*Brassica rapa* var. *Japonica*) grown in fall and spring sowing times. J. Tekirdag Agric. Fac., **9:** 64-70.