www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 2006-2011

www.thepharmajournal.com
Received: 11-06-2022
Accepted: 26-08-2022

JM Vashi
Department of Vegetable Science, ASPEE College of Horticulture and Forestry Navsari Agricultural University, Navsari, Gujarat, India

SN Saravaiya
Department of Vegetable Science, ASPEE College of Horticulture and Forestry Navsari Agricultural University, Navsari, Gujarat, India

KD Desai
Department of Vegetable Science, ASPEE College of Horticulture and Forestry Navsari Agricultural University, Navsari, Gujarat, India

Patel AI
Department of Vegetable Science, ASPEE College of Horticulture and Forestry Navsari Agricultural University, Navsari, Gujarat, India

Corresponding Author:
JM Vashi
Department of Vegetable Science, ASPEE College of Horticulture and Forestry Navsari Agricultural University, Navsari, Gujarat, India

Response of greater yam (*Dioscorea alata* L.) under different growing conditions for tuber growth, yield and quality

JM Vashi, SN Saravaiya, KD Desai and Patel AI

Abstract
A field experiment was carried out, with a view to study the Response of Greater Yam (*Dioscorea alata* L.) to different growing conditions at Vegetable Research Scheme, Regional Horticultural Research Station of the Navsari Agricultural University, Navsari, Gujarat, India during 2015-2016 and 2016-2017. The experiment was conducted in Large Plot; analysis as CRD with factorial concept (FCRD) with three repetitions which included three growing conditions (G_1: Naturally Ventilated Poly house, G_2: Net house and G_3: Open field), three planting distance (D_1: 60 cm x 60 cm, D_2: 60 cm x 45 cm and D_3: 90 cm x 90 cm) and two varieties (V_1: Round type and V_2: Long type). The results revealed that higher values for growth characters namely, vine length at harvest and fresh weight tuber, yield characters *viz*., tuber girth, tuber length and tuber yield and quality characters like carbohydrate, starch and protein were found significant in Naturally Ventilated Poly house, Closer spacing 60 cm x 45 cm and Long type variety (V_1). Among from different interaction treatments G x D were found significant in growth, yield and quality characters.

Keywords: Greater yam, naturally ventilated poly house, net house, open field condition, long type and round type variety

Introduction

Greater yam is primarily used for human consumption in the tropical and sub tropical regions. The yam tubers are rich source of carbohydrates, protein and amino acid. Normally tubers are consumed as boiled, baked or fried vegetables. It is also useful for making chips, flakes and flour. Greater yam is basically a dioecious twining herbaceous vine. Stems are 10 m or more in length and freely branching above. It possesses four wings on the thick stem, which twines to the right. The petiole has also wings. Leaves are ovate, cordate, bigger and opposite in phylotaxy. Tubers are variable in shape but mostly cylindrical. The skin of the tuber is black and brown, whereas flesh is white, yellowish, or purplish. Each plant may produce 1 to 3 tubers. Its cultivars rarely flower. Flowers are small, occasional, male and female arising from leaf axils on separate plants (*i.e.* dioecious species), male flowers having panicle which is 30 cm long, female flowers having smaller spikes. Fruit is botanically a 3 parted capsule and seeds are winged (Chadha, 2002) [8].

Protected cultivation practices can be defined as a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of crops grown during their period of growth. With the advancement in horticulture various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged. Among these protective cultivation practices, poly green house, net house, shade house, plastic tunnel *etc*. are very useful for India. This technology can be adopted by the rural youth for more income per unit of land. The improvement in economy of farmers with the decreasing land holding is also possible through the protected cultivation by increasing production per unit area. The glut of vegetable during a short period of harvesting is also the problem in the country which can be minimized with the protected cultivation as harvesting period of crops under protected structures is longer. Recently many progressive farmers of Gujarat have started the cultivation of greater yam under protected conditions like Poly house, Net house etc. Keeping in view of farmers survey, this research was set up to find out better growing condition for greater yam growth and yield.

Materials and Methods

The experiment was undertaken at the Vegetable Research Scheme, Regional Horticultural Research Station of the Navsari Agricultural University, Navsari, Gujarat, India during 2015 -16 and 2016-17. The experiment was conducted in Large Plot; analysis as CRD with factorial concept (FCRD) with three repetition which included three growing conditions (G_1: Naturally Ventillated Poly house, G_2: Net house and G_3: Open field), three planting distance (D_1: 60 cm x 60 cm, D_2: 60 cm x 45 cm and D_3: 90 cm x 90 cm) and two varities (V_1: Round type and V_2: Long type).The experiment was included 18 combinations namely, $G_1D_1V_1$; $G_1D_1V_2$; $G_1D_2V_1$; $G_1D_2V_2$; $G_1D_3V_1$; $G_1D_3V_2$; $G_2D_1V_1$; $G_2D_1V_2$; $G_2D0_2V_1$; $G_2D_2V_2$; $G_2D_3V_1$; $G_2D_3V_2$; $G_3D_1V_1$; $G_3D_1V_2$; $G_3D_2V_1$; $G_3D_2V_2$; $G_3D_3V_1$ and G_3D_3 V_2.. The experiment was conducted on same location without changing the randomization for the succesive year to access treatment effects.Tuber pieces of 200 g were used for planting material for both variety. The experimental growing conditions for all three locations were thoroughly prepared as our treatment includes different spacing treatments. The beds inside the poly house and net house were made symmetrical and levelling was done with the help of wooden plank. Cultural practices for three growing conditions (Naturally Ventilated Poly house, Net house and Open field) were maintained same for two seasons.

For recording different field observations, five plants of greater yam from each net plot area were selected randomly in the beginning and tagged with the labels. Vine length was measured from base of the plant to tip of the main shoot with the help of meter tape at final harvest and fresh weight of tuber recorded immediately after harvest. Tuber girth and length were measured with measuring tape. The collected data were subjected to statistical analysis as per Panse and Sukhatme (1967) [16].

Carboydrate and protein content was estimated using Lowry's method as described by Sadasivam and Manickam (1996) [25]. For measuring starch content 0.5 gram of yam tuber sample was chopped and ground finely in ice cold water. The filtrate was kept in icebath such that starch settles down. The filtrate was decanted and washings were given and the residue was washed with alcohol and ether to obtain pure residue of starch.

$$\text{Starch \%} = \frac{C \times V \times 100 \times 0.9}{1000 \times V_1 \times W}$$

Results and Discussion

Main Effect: Results of main effect is shown in table no 1.

Table 1: Effect of growing condition, spacing and variety on growth, yield and quality of greater yam.

Treatments	Character							
	Vine length (m) at harvest	Fresh weight of tuber (g)	Tuber girth (cm)	Tuber length (cm)	Tuber yield 1000 m^{-2} (kg)	Carbohydrate content (%)	Starch content (%)	Protein content (%)
Growing conditions (G)								
G_1 (Poly house)	9.05	1678.21	28.28	22.02	2553.88	19.63	33.50	1.37
G_2 (Net house)	7.28	1355.04	24.49	17.12	2213.77	17.22	30.94	1.25
G_3 (Open field)	4.75	893.37	20.56	16.87	1655.29	15.33	30.04	1.21
S.Em. ±	0.12	22.14	0.30	0.43	29.71	0.30	0.30	0.02
$C.D._{0.05}$ (G)	0.33	62.49	0.85	1.22	83.83	0.85	0.84	0.06
Planting distance (D)								
D_1 (60 cm x 60 cm)	6.08	1135.75	23.92	18.26	2120.66	17.80	31.64	1.21
D_2 (60 cm x 45 cm)	8.04	1493.54	21.47	18.11	2810.79	18.37	32.23	1.35
D_3 (90 cm x 90 cm)	6.96	1297.33	27.94	19.65	1491.50	16.02	30.60	1.27
S.Em. ±	0.12	22.00	0.30	0.43	29.83	0.30	0.30	0.02
$C.D._{0.05}$ (D)	0.33	62.08	0.86	1.22	84.20	0.85	0.84	0.06
Variety (V)								
V_1 (Round type)	6.79	1266.56	27.23	11.86	1670.69	15.73	30.22	1.20
V_2 (Long type)	7.26	1351.19	21.65	25.48	2611.27	19.05	32.76	1.35
S.Em. ±	0.13	18.05	0.25	0.36	70.03	0.25	0.25	0.02
$C.D._{0.05}$ (V)	0.39	50.96	0.69	1.00	NS	0.70	0.69	0.05

Effect of growing conditions

Different growing conditions were significantly influenced vine length (m). Significantly higher vine length (9.05 m) was noted with naturally ventilated poly house (G_1) while significantly lower vine length (4.75 m) was observed in open field condition (G_3). This might be due to the use of ultraviolet stabilized plastic film, which allowed filtered light inside the Naturally Ventilated Poly house as compared to other growing conditions. The reduction of vine length of greater yam under open field condition was might be due to non control of light radiation, such results of higher growth rate under greenhouse conditions have been reported by Nimje *et al.* (1990) [13], Bhatnagar *et al.* (1990) [4], Naik (2005) [12] and Bai and Sudha (2015) [3] in capsicum, where as Papadopoules and Ormrod (1991) [18] in tomato.

Effects of different growing conditions were significantly affected on fresh weight of tuber (g) at harvest. Significantly higher fresh weight of tuber (1678.21 g) was observed in G_1 (Naturally Ventilated Poly house). While, significantly lower fresh weight (893.37 g) of tuber was recorded in G_3 (Open field condition).This might be due to the greater yam had higher yield under Naturally Ventilated Poly house due to light compensation for higher photosynthesis and control solar injury by controlling ultraviolet radiation. This positively influenced the morpho-phenological and physiological events of greater yam plants. It was concluded that the better growth, development and yield of greater yam was achieved under Naturally Ventilated Poly house due to optimum utilization of solar energy. Similar results were reported by Naik (2005) [12] and Biradar *et al*. (2014) [5] in capsicum, Rajesekar *et al*. (2013) [21] and Rana *et al*., (2015) [23] in tomato.

Significantly higher tuber girth (28.28 cm) was found in G_1 (Naturally Ventilated Poly house) and significantly lower tuber girth (20.56 cm) was noted with treatment G_3 (Open field condition).Tuber length (22.02 cm) was also observed significantly higher with G_1 (Naturally Ventilated Poly house). While, significantly lower tuber length (16.87 cm) was noted with G_3 (Open field).Naturally Ventilated Poly house (G_1) recorded significantly higher tuber yield 1000 m^{-2} (2553.88 kg). Significantly lower yield 1000 m^{-2}(1655.29 kg) was observed with G_3 (Open field).

All these yield attributing parameters of greater yam were significantly higher with Naturally Ventilated Poly house as compared to Net house and Open field. This might be due to the translocation of more photosynthesis from source to sink and also favourable microclimate that prevailed in the Naturally Ventilated Poly house throughout the crop growth period. Greater yam had higher yield under Naturally Ventilated Poly house due to light compensation for higher photosynthesis and control solar injury due to filtered solar radiation. This positively influenced the morpho-phenological and physiological events of greater yam vines. It was concluded that the better growth, development and yield of greater yam was achieved under Naturally Ventilated Poly house due to optimum utilization of solar energy. The results corroborate with the findings of Naik (2005) [12] in capsicum, Parvej *et al*. (2010) [20] in tomato and Brahma *et al*. (2012) [6] in capsicum.

Quality parameters of greater yam *viz.*, carbohydrate (19.63%), starch (33.50%), and protein (1.37%) were recorded significantly higher in Naturally Ventilated Poly house followed by Net house compared to Open field, because solar radiation energy is one of the most important environmental factors required for plant quality. To develop biosynthetic pathway of secondary metabolism depends on any plants in given environment that achieving quality of wavelength, duration and quantity of solar radiation. Higher quality of greater yam tuber under protected structures might be due to better climatic condition and ultraviolet radiation impact under protected structures, similar results reported by Biradar *et al.* (2014) [5] in capsicum.

Effect of spacing

From different planting distances, significantly higher vine length (8.04 m) were recorded with closer spacing 60 cm x 45 cm (D_2) as compared to wider spacing 60 cm x 60 cm (D_1) and 90 cm x 90 cm (D_3). This might be due to the great competition for space and light thereby forcing the plants to grow taller. The short and stout plants were produced at wider spacing because of availability of more growth space where in plants were able to exploit more nutrients from the soil and light sources. Similar increase in growth rate at closer spacing were noticed and reported by Rajewar *et al.* (1981) [22] in tomato, Papadopoulos and Ormrod (1991) [18] in tomato, Narayan *et al.* (2017) [14] in cherry tomato and Stoffella and Bryan (1988) [29] in capsicum.

Significantly higher fresh weight of tuber (1493.54 g) were observed with closer spacing 60 cm x 45 cm (D_1). This could be due to increased uptake of more nutrients and build up of sufficient photosynthesis enabling the increase in size of tubers (length and width), ultimately resulted in the higher tuber weight. The results are in conformity with the findings of Sulikeri *et al*. (1973) [31] and Randhawa *et al*. (1975) [24] in tomato, Singh and Naik (1990) [28] in capsicum.

Significantly higher tuber girth and tuber length (27.94 cm and 19.65 cm) was observed with wider spacing D_3 (90 cm x 90 cm) while lowest tuber girth was observed with closer spacing D_2 (60 cm x 45 cm). Tuber yield 1000 m^{-2} (2810.79 kg) was found significantly higher in closer spacing 60 cm x 45 cm (D_1). This might be due to higher plant population per unit area, greater crop biomass and increased availability of total assimilates for distribution to tuber which intern helps to increase harvest index. Similar results were obtained by Sulikeri *et al.* (1973) [31], Randhawa *et al.* (1975) [24], Streck *et al.* (1996) [30], Papadopoulos and Pararajasingham (1997) [19], Sandri *et al.* (2002) [28], Ogbomo and Egharevba (2009) [15], Agarwal and Zakwan (2011) [1] in tomato, Ahmed (1984) [2], Granges and Leger (1989) [10], Singh and Naik (1990) [28], Savic *et al.*(1992) [27] as well as Choudhary and Singh (2006) [9] in capsicum.

Effect of variety: V_2 (Long type) was significant in vine length (7.26 m) and fresh weight of tuber (1351.19 g).Superiority of V_2 (Long type) over V_1(Round type) might be due to its greater genetic build up mechanism and capacity for accumulation of more photosynthesis that favoured higher growth attributes as compared to Round type variety.

Tuber girth (27.23 cm), tuber length (25.48 cm) and tuber yield 1000 m^{-2} (2611.27 kg) were significantly affected by two different varieties of greater yam. Significantly these all characters regarding greater yam were higher with Long type variety (V_2) as compared to Round type variety (V_1). This could be due to high uptake of nutrients and build up of sufficient photosynthesis enabling the increase in size of tuber (girth and length), resulting in the increased tuber weight and volume in Long type variety of greater yam. Similar findings were recorded by Buitelaar and Janse (1987) [7] in tomato and Mohomedien *et al*. (1991) [11] in cucumber.

Quality parameters *viz.*, carbohydrate (19.05%), starch (32.76%) and protein (1.35%) found significantly higher in Long type variety (V_2). Significantly higher quality of all these parameters are recorded in Long type variety (V_2) as compared to Round type variety (V_1) because of congeal effect, better environmental condition which turns achieving higher growth and yield under this variety which may also responsible for better quality.

Interaction Effect: Results of interaction effect is shown in table no 2.

Growth characters

Interaction effect due to G x D showed significant effect on vine length and fresh weight of tuber while interaction effect of G x V, D x V and G x D x V remained non significant.

Significantly higher vine length (m) and fresh weight of tuber (g) (10.06 and 1862.87 respectively) was recorded with G_1D_2 (Naturally Ventilated Poly house x 60 cm x 45 cm) and significantly lower vine length (m) and fresh weight of tuber(g) (4.18 and 789.50 respectively) was recorded with with G_3D_1 (Open field x 60 cm x 60 cm).This might be due to congenial climatic condition under naturally ventilated poly house, as well as great competition for space and light thereby forcing the plants to grow taller. Plant can effectively use light interception which ultimately increased photosynthetic rate, ultimately increased growth of plant. Similar results was obtained by Biradar *et al*. (2014) [5] in capsicum.

Yield Characters

Interaction between different treatments *viz.*, for tuber girth G x D, D x V and G x D x V while for tuber length, G x V, D x V and G x D xV and for tuber yield 1000 kg m^{-2} G x D, G x V, D x V and G x D x V interactions were found significant.

Treatment combination G_1D_3 (Naturally Ventilated Poly house x Planting distance 90 cm x 90 cm) D_3V_1 (Planting distance 90 cm x 90 cm x Round type) and $G_1D_3V_1$ (Naturally Ventilated Poly house x Planting distance 90 cm x 90 cm x Long type) was recorded significantly higher tuber girth (cm) (31.96, 31.57 and 36.99 cm; respectively).This may be due to wider spacing in naturally ventilated growing condition provide much more effective in longer type greater yam variety. Similar observations were recorded by Biradar *et al.* (2014) [5] in capsicum.

G_1V_2 (Naturally Ventilated Poly house x Long type) recorded significantly higher tuber length (cm), D_3V_2 (Planting distance 90 cm x 90 cm X Long type) and $G_1D_3V_2$ (Naturally Ventilated Poly house x Planting distance 90 cm x 90 cm x Long type) was found significantly higher tuber length in pooled analysis (30.52 cm, 27.29 cm and 34.15 cm; respectively). This may be attributed to the favourable climatic conditions that prevailed under naturally ventilated poly house, leading to higher vegetative growth and congenial climate for long type variety of greater yam and better space available in wider spacing.

Table 2: Interaction of growing condition, spacing and variety on growth, yield and quality of greater yam.

Treatments	Character							
	Vine length (m)at harvest	Fresh weight of tuber (g)	Tuber girth (cm)	Tuber length (cm)	Tuber yield 1000 m^{-2}	Carbohydrate content (%)	Starch content (%)	Protein content (%)
G_1D_1	7.78	1447.37	26.60	21.41	2632.81	19.95	33.39	1.23
G_1D_2	10.06	1862.87	26.28	21.29	3088.71	22.45	35.52	1.48
G_1D_3	9.30	1724.37	31.96	23.35	1940.12	16.51	31.59	1.40
G_2D_1	6.26	1170.37	24.34	17.03	2203.59	18.36	31.56	1.22
G_2D_2	8.54	1585.87	21.39	16.41	2944.74	17.15	31.02	1.33
G_2D_3	7.02	1308.87	27.72	17.93	1492.98	16.15	30.24	1.20
G_3D_1	4.18	789.50	20.81	16.32	1525.55	15.09	29.97	1.16
G_3D_2	5.50	1031.87	16.74	16.63	2398.91	15.51	30.17	1.25
G_3D_3	4.56	858.75	24.13	17.66	1041.41	15.39	29.98	1.21
S.Em. ±	0.20	37.54	0.52	0.74	73.21	0.61	0.51	0.03
$C.D._{0.05}$	0.56	105.89	1.46	NS	209.97	1.76	1.44	0.08
G_1V_1	8.86	1643.59	31.64	13.52	1946.65	18.24	32.06	1.27
G_1V_2	9.24	1712.83	24.92	30.52	3161.10	21.03	34.94	1.47
G_2V_1	7.09	1320.42	27.03	11.90	1721.63	15.48	29.89	1.19
G_2V_2	7.47	1389.67	21.93	23.13	2705.91	18.96	31.99	1.31
G_3V_1	4.43	835.66	23.02	10.95	1343.79	13.49	28.71	1.13
G_3V_2	5.06	951.08	18.09	22.79	1966.79	17.17	31.37	1.29
S.Em. ±	0.14	25.71	0.42	0.81	59.77	0.42	0.92	0.03
$C.D._{0.05}$	NS	NS	NS	2.33	171.44	NS	NS	NS
D_1V_1	5.82	1089.58	26.74	11.30	1672.60	15.81	29.69	1.15
D_1V_2	6.33	1181.92	21.10	25.21	2568.70	17.40	30.92	1.26
D_2V_1	7.85	1458.92	23.40	12.28	2088.55	14.00	30.05	1.26
D_2V_2	8.23	1528.17	19.55	23.94	3533.02	19.79	33.59	1.44
D_3V_1	6.71	1251.17	31.57	12.00	1250.93	19.34	33.55	1.18
D_3V_2	7.21	1343.50	24.30	27.29	1732.08	18.03	31.16	1.36
S.Em. ±	0.16	31.05	0.52	0.70	59.77	0.42	0.42	0.03
$C.D._{0.05}$	NS	NS	1.50	2.03	171.44	1.20	1.19	NS
$G_1D_1V_1$	7.59	1412.75	29.07	12.56	2106.89	18.01	31.06	1.19
$G_1D_1V_2$	7.97	1482.00	24.13	30.27	3158.72	21.87	35.71	1.28
$G_1D_2V_1$	9.87	1828.25	28.85	15.43	2140.30	21.65	33.62	1.34
$G_1D_2V_2$	10.25	1897.50	23.71	27.14	4037.12	23.25	37.42	1.62
$G_1D_3V_1$	9.11	1689.75	36.99	12.55	1592.77	15.03	31.50	1.28
$G_1D_3V_2$	9.49	1759.00	26.93	34.15	2287.47	17.97	31.67	1.52
$G_2D_1V_1$	6.07	1135.75	27.59	11.06	1772.31	16.14	29.54	1.19
$G_2D_1V_2$	6.46	1205.00	21.09	23.00	2634.88	20.58	33.57	1.25
$G_2D_2V_1$	8.35	1551.25	22.63	10.90	2123.91	15.60	30.09	1.26
$G_2D_2V_2$	8.73	1620.50	20.16	21.92	3765.56	18.70	31.97	1.40
$G_2D_3V_1$	6.83	1274.25	30.90	11.39	1268.68	14.71	30.06	1.13
$G_2D_3V_2$	7.21	1343.50	24.55	24.46	1717.28	17.59	30.42	1.27
$G_3D_1V_1$	3.80	720.25	23.54	10.27	1138.60	13.27	28.47	1.07
$G_3D_1V_2$	4.56	858.75	18.07	22.36	1912.51	16.91	31.48	1.26
$G_3D_2V_1$	5.32	997.25	18.71	10.50	2001.43	14.95	29.08	1.19
$G_3D_2V_2$	5.69	1066.50	14.78	22.76	2796.38	16.07	31.26	1.31
$G_3D_3V_1$	4.18	789.50	26.82	12.07	891.33	12.25	28.59	1.13
$G_3D_3V_2$	4.94	928.00	21.45	23.25	1191.49	18.53	31.38	1.29
S.Em. ±	0.28	53.07	0.75	1.05	103.53	0.73	0.72	0.04
$C.D._{0.05}$	NS	NS	2.11	2.97	296.94	NS	NS	NS

Tuber yield 1000 m^{-2} (kg) was found significant with G_1D_2 (Naturally Ventilated Poly house ***x*** Planting distance 60 cm x 45 cm), G_1V_2 (Naturally Ventilated Poly house ***x*** Long Variety), D_2V_2 (Planting distance 60 cm x 45 cm ***x*** Long type) and with $G_1D_2V_2$ (Naturally Ventilated Poly house x Planting distance 60 cm x 45 cm x Long type) obtained significantly higher yield 1000 m^{-2}(kg) (3088.71, 3161.10, 3533.02 and 4037.12 respectively). This might be due to better climatic condition in naturally ventilated poly house and higher plant population in closer spacing and genetic build up and suitability of long type variety. Similar finding was recorded by Papadopoulos and Ormrod (1988) [17] in tomato.

Quality Characters

Results on quality parameters of greater yam *viz*., carbohydrate (%), starch content (%) and protein content (%) were showed significant effect due to different interaction (G x D and D x V) where it shows non significant effect in G x V and G x D x V interaction. These significant effects were due to congeal effect of better climatic condition which turns into higher photosynthetic active radiation with respect to growing condition (Naturally Ventilated poly house), planting distance (60 cm x 45 cm) and variety (Long type).

Conclusion

Apart from the research results of two years of experiment, it was concluded that higher growth, yield attributes and quality of greater yam was recorded with Naturally Ventilated Poly house as compared to Net house and Open field.

References

1. Agarwal A, Ahmed Z. Influence of plant density and environment on productivity of tomato. Prog. Hort. 2011;43(2):307-311.
2. Ahmed MK. Optimum plant spacing and nitrogen fertilization of Sweet pepper in Sudan Gezira. Acta Horticulturae. 1984;143:305-310.
3. Bai G, Sudha B. Growth and yield of chilli as influenced by spacing under greenhouse condition. Int. J Agric. Sci. 2015;11(20):297-300.
4. Bhatnagar RR, Vedprakash RC, Srivastav RC. Production of vegetables in polythene greenhouse during winters in mid hills of Uttar Pradesh. Prog. Hort. 1990;22:97-100.
5. Biradar MS, Patil AA, Mantur SM, Mannikeri IM. Influence of growing environment and planting geometry on yield and yield attributes of capsicum (*Capsicum annuum* L. *var. Grossum Sendt.*) genotypes. Karnataka J Agric. Sci. 2014;27(2):202-207.
6. Brahma S, Phookan DB, Kachari M, Hazarika TK. Response of capsicum to different plant density under poly house and open conditions. Indian J Hort. 2012;69(2):292-294.
7. Buitelaar K, Janse M. Temperature for hot house tomatoes, internal and external quality better at a higher average temperature. Groenten en fruit. 1987;9:155-161.
8. Chadha KL. Handbook of Horticulture, Indian Council of Agricultural Research, New Delhi; c2002. p. 522-525.
9. Choudhary AS, Singh RL. Effect of spacing, nitrogen and phosphorus on growth and yield of capsicum hybrid. Haryana J Hort. Sci. 2006;35(1&2):124-125.
10. Granges A, Leger A. How to improve the yield of sweet pepper grown on short term crops under glass. Scientia Horticulturae. 1989;21(5):313-316.
11. Mohomedin SEA, Doweny HH, Hashem MM. Response of some cucumber hybrids to plasti culture under Egyptian environment conditions. Egyptian J Hort. 1991;18(1):63-71.
12. Naik RK. Influence of N-substitution levels through organic and inorganic sources on growth, yield and post-harvest quality of capsicum under protected condition. Thesis Ph.D., Univ. Agric. Sci., Dharwad, Karnataka, India; c2005.
13. Nimje PM, Wajnan OD, Shyam M. Greenhouse technology for vegetable crop production. Proc. of XI Int. Cong. on the use of Plastics in Agric; c1990. p. 83-90.
14. Narayan S, Makhdoomi MI, Nabi A, Khan SH, Mufti S, Afroza B, *et al*. Effect of plant spacing and pruning on growth and yield of cherry tomatoes under polyhouse conditions. The Bioscan. 2017;12(1):359-361.
15. Ogbomo KEL, Egharevba RKA. Effects of planting density and NPK fertilizer application on yield and yield components of tomato. World J Agric. Sci. 2009;5(2):152-158.
16. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers, Indian Council of Agricultural Research, New Delhi, India; c1967. p. 272-279.
17. Papadopoulous AP, Ormrod DP. Plant spacing effects on light interception by greenhouse tomatoes. Canadian J Pl. Sci. 1988;68:1197-1208.
18. Papadopoulous AP, Ormrod DP. Plant spacing effects on growth and development of the greenhouse tomato. Canadian J Pl. Sci. 1991;71:297-304.
19. Papadopoulos AP, Pararajasingham S. The influence of plant spacing on light interception and use in greenhouse tomato (*Lycopersicon esculentum* Mill.) Scientia Horticulturae. 1997;69:1-29.
20. Parvej MR, Khan MAH, Awal MA. Phenological development and production of tomato under polyhouse climate. J Agric. Sci. 2010;5(1):19-31.
21. Rajasekar M, Arumugam T, Kumar R. Influence of weather and growing environment on vegetable growth and yield. J Hort. and Forestry. 2013;5(10):160-167.
22. Rajewar SR, Patil VK, Santakke MD. Growt parameters of some important varieties of tomato (*Lycopersicon esculentum* Mill.) as influenced by spacing, pruning and staking. Andhra Agric. J. 1981;28(12):36-42.
23. Rana N, Kumar M, Walia A, Sharma S. Tomato Fruit Quality under Protected Environment and Open Field Conditions. Int. J Bio-resources and Strees Management. 2015;5(3):422-426.
24. Randhawa KS, Nandapuri KS, Singh D. Studies on optimum spacing requirements of four new varieties of tomato (*Lycopersiucon esculentum* Mill). Veg. Sci. 1975;2(1&2):31-34.
25. Sadasivam S, Manickam A. Biochemical Methods (2nd edn.), New Age International Publishers, New Delhi, India; c1996. pp. 1-256.
26. Sandri MA, Andriolo JL, Witter M, Ross T. High density of defoliated tomato plants in protected cultivate and its effects on development of trusses and fruits. Hort. Bras. 2002;20(3):485-489.
27. Savic V, Ziaijo O, Llic Z. The effect of spacing on capsicum (*Capsicum annuum* L.) yield. Uticaj. Vegetacionog Prostora Naprinos Paprika Savremena ljoprivreda. 1992;40(1-2):41-44.

28. Singh RV, Naik LB. Effect of nitrogen, phosphorus and plant spacing on sweet pepper (*Capsicum annuum* L.). Haryana J Hort. Sci. 1990;19(1-2):168-172.
29. Stoffella PJ, Bryan HH. Plant population influences growth and yields of bell pepper. J American Soc. Hort. Sci. 1988;113(6):835-839.
30. Streck NA, Burial GA, Schneider FM. Effect of plant density on yield of tomatoes cultivated in a plastic greenhouse. Pesquisa Agropecuria Brasileira. 1996;31(2):105-112.
31. Sulikeri GS, Bankapur VM, Rao MM. Effect of varying levels of fertilizers and spacing on the yield of Pusa Ruby tomato under Dharwad conditions. Curr. Res. 1973;4(11):190-191.