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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

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

Velamala Sravani
Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

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

Growth and tuber yield performance of two greater yam (*Dioscorea alata* L.) varities under different growing conditions

JM Vashi, SN Saravaiya, KD Desai, AI Patel and Velamala Sravani

Abstract
An 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 indicated that **s**ignificantly higher amount of growth attributes were recorded with V_2 (Long type) in growth and yield parameters like total number of tillers (6.68), vine length (7.26 m), fresh weight of tuber (1351.19 g), tuber length (25.48 cm), tuber yield vine $^{-1}$ (1.36 kg) and maximum tuber yield 1000 m^{-2} (2810.79 kg)as compared to V_2 (Round type).

Keywords: Greater yam, long type, round type, naturally ventilated poly house

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 dioceious 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) [2].

Plant population is defined as the total number of plants present at unit area of land, while plant spacing is the arrangement of plants on an area. The yield of crop is directly influenced by population of plant. It is always good to follow the recommended crop spacing guidelines. Overcrowding of crops may reduce yields and it may also lower quality of the yield produced because of competition for light and soil nutrients.

As far as concern to protected cultivation plant spacing is one of the key factor for achieving the good crop yield. Plant spacing greatly affected leaf area and canopy photosynthesis because vertically grown crops requires good plant architecture for good canopy development which is the key for better utilization of photosynthetic photon flux density. Recently many progressive farmers of Gujarat have started the cultivation of greater yam under protected conditions like (Poly house, Net house etc. but it was observed (on the basis of survey) that they were in need of some recognize technical information regarding planting density (spacing) for achieving higher marketable tuber yield from unit area. 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, $G_1D_1V_1$; $G_1D_1V_2$; $G_1D_2V_1$; $G_1D_2V_2$; $G_1D_3V_1$; $G_1D_3V_2$; $G_2D_1V_1$; $G_2D_1V_2$; $G_2D_2V_1$; $G_2D_2V_2$; $G_2D_3V_1$; $G_2D_3V_2$; $G_3D_1V_1$; $G_3D_1V_2$; $G_3D_2V_1$; $G_3D_2V_2$; $G_3D_3V_1$ and $G_3D_3V_2$. 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 maintain 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. Total number of tillers was recorded by counting the total number of tillers at harvest.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 and tuber yield per vine 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) [4].

Results and Discussion

Effect of variety on total number of tillers at harvest did not affect significantly during first year of experimentation. During second year of experimentation and in pooled analysis V_2 (Long type) variety produced significantly higher total number of tillers (6.04 and 6.68; respectively). On the other hand, lower total number of tillers at harvest (5.66 and 6.30; respectively) was observed with V_1 (Round type) variety.

Different varieties were significantly affected vine length (m) during consecutive years of experimentation and in pooled analysis. Long type (V_2) recorded significantly higher vine length during 2015-16 (7.67 m), 2016-17 (6.85 m) and in pooled analysis (7.26 m), as compared to Round type (V_1) during both the years of experimentation and in pooled analysis (7.21 m, 6.37 m and 6.79 m; respectively).

Fresh weight of tuber (g) was significantly affected by two varieties during 2015 - 16, 2016 - 17 and in pooled analysis. V_2 (Long type) variety produced significantly higher fresh weight of tuber during 2015-16 (1382.03 g), 2016-17 (1320.35 g) and in pooled analysis (1351.19 g). Significantly lower fresh weight of tuber at harvest was observed with V_1 (Round type) during individual years of experimentation and in pooled analysis (1293.67 g, 1239.44 g and 1266.56 g; respectively).

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.

V_2 (Long type) produced significantly higher tuber length during 2015 - 16, 2016 - 17 and in pooled analysis. (25.57 cm, 25.39 cm and 25.48 cm; respectively).While, significantly lower tuber length was produced in V_1 (Round type) during individual years of experimentation and in pooled analysis(11.84 cm, 11.88 cm and 11.86 cm; respectively).

During both years of experimentation and in pooled analysis. V_2 (Long type) produced significantly higher tuber yield vine^{-1} (1.29 kg, 1.43 kg and 1.36 kg; respectively). While, significantly lower tuber yield vine^{-1} was found in V_1 (Round type) during 2105 – 16, 2016 – 17 and in pooled analysis (1.19 kg, 1.33 kg and 1.26 kg; respectively).

Significantly higher yield 1000 m^{-2} during 2015 – 16 and 2016 - 17 (2793.27 kg and 2429.27 kg; respectively). While, V_1 (Round type) recorded significantly lower yield 1000 m^{-2} during 2015 – 16 (1753.64 kg) and 2016 – 17 (1587.74 kg). In pooled analysis it was remained non significant.

Yield attributing 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, resulting in the increased tuber weight and volume in Long type variety of greater yam. Similar findings were recorded by Buitelaar and Janse (1987) [1] in tomato and Mohomedien *et al*. (1991) [3] in cucumber.

Table 1: Response of different treatments on total number of tillers at harvest

Treatments	Total number of tillers at harvest		
Growing conditions (G)	**2015-16**	**2016-17**	**Pooled**
G_1 (Poly house)	8.77	7.51	8.14
G_2 (Net house)	7.34	6.06	6.70
G_3 (Open field)	5.29	3.98	4.63
S.Em. ± (G)	0.20	0.15	0.12
C.D.at 5 % (G)	0.57	0.42	0.34
Planting distance (D)			
D_1 (60 cm x 60 cm)	6.37	5.07	5.72
D_2 (60 cm x 45 cm)	7.96	6.68	7.32
D_3 (90 cm x 90 cm)	7.08	5.80	6.44
S.Em. ± (D)	0.20	0.15	0.12
C.D. at 5 % (D)	0.57	0.42	0.34
Variety (V)			
V_1 (Round type)	6.95	5.66	6.30
V_2 (Long type)	7.32	6.04	6.68
S.Em. ± (V)	0.16	0.12	0.10
C.D. at 5 % (V)	NS	0.34	0.28

C.D. at 5 % (GD)	NS	NS	NS
C.D.at 5 % (GV)	NS	NS	NS
C.D.at 5 % (DV)	NS	NS	NS
C.D. at 5 % (GDV)	NS	NS	NS
S.Em. ± (YG)			0.17
C.D. at 5 %			NS
S.Em. ± (YD)			0.17
C.D. at 5 %			NS
S.Em. ± (YGD)			0.30
C.D. at 5 %			NS
S.Em. ± (YV)			0.14
C.D. at 5 %			NS
S.Em. ± (YGV)			0.25
C.D. at 5 %			NS
S.Em. ± (YDV)			0.25
C.D. at 5 %			NS
S.Em. ± (YGDV)			0.43
C.D. at 5 %			NS
C.V. %	11.76	10.63	11.38

Table 2: Response of different treatments on vine length (m) at harvest

Treatments	Vine length (m) at harvest		
Growing conditions (G)	**2015-16**	**2016-17**	**Pooled**
G_1 (Poly house)	9.44	8.66	9.05
G_2 (Net house)	7.69	6.87	7.28
G_3 (Open field)	5.20	4.30	4.75
S.Em. ± (G)	0.18	0.15	0.12
C.D.at 5 % (G)	0.52	0.42	0.33
Planting distance (D)			
D_1 (60 cm x 60 cm)	6.50	5.65	6.08
D_2 (60 cm x 45 cm)	8.44	7.64	8.04
D_3 (90 cm x 90 cm)	7.38	6.55	6.96
S.Em. ± (D)	0.18	0.15	0.12
C.D. at 5 % (D)	0.52	0.42	0.33
Variety (V)			
V_1 (Round type)	7.21	6.37	6.79
V_2 (Long type)	7.67	6.85	7.26
S.Em. ± (V)	0.15	0.12	0.13
C.D. at 5 % (V)	0.43	0.34	0.39
C.D. at 5 % (GD)	NS	NS	0.56
C.D.at 5 % (GV)	NS	NS	NS
C.D.at 5 % (DV)	NS	NS	NS
C.D. at 5 % (GDV)	NS	NS	NS
S.Em. ± (YG)			0.17
C.D. at 5 %			NS
S.Em. ± (YD)			0.17
C.D. at 5 %			NS
S.Em. ± (YGD)			0.28
C.D. at 5 %			NS
S.Em. ± (YV)			0.14
C.D. at 5 %			NS
S.Em. ± (YGV)			0.23
C.D. at 5 %			NS
S.Em. ± (YDV)			0.23
C.D. at 5 %			NS
S.Em. ± (YGDV)			0.41
C.D. at 5 %			NS
C.V. %	10.40	9.44	10.01

Table 3: Response of different treatments on average fresh weight of tuber (g)

Treatments	Fresh weight of tuber (g)		
Growing conditions (G)	**2015-16**	**2016-17**	**Pooled**
G_1 (Poly house)	1723.45	1632.97	1678.21
G_2 (Net house)	1386.05	1324.03	1355.04
G_3 (Open field)	904.05	882.70	893.37
S.Em. ± (G)	32.37	30.57	22.14

C.D.at 5 % (G)	92.90	87.74	62.49
Planting distance (D)			
D_1 (60 cm x 60 cm)	1157.10	1114.40	1135.75
D_2 (60 cm x 45 cm)	1530.65	1456.43	1493.54
D_3 (90 cm x 90 cm)	1325.80	1268.87	1297.33
S.Em. ±(D)	32.37	30.57	22.00
C.D. at 5 % (D)	92.90	87.74	62.08
Variety (V)			
V_1 (Round type)	1293.67	1239.44	1266.56
V_2 (Long type)	1382.03	1320.35	1351.19
S.Em. ± (V)	26.43	24.96	18.05
C.D. at 5 % (V)	75.85	71.64	50.96
C.D. at 5 % (GD)	NS	NS	105.89
C.D.at 5 % (GV)	NS	NS	NS
C.D.at 5 % (DV)	NS	NS	NS
C.D. at 5 % (GDV)	NS	NS	NS
S.Em. ± (YG)			31.48
C.D. at 5 %			NS
S.Em. ± (YD)			31.48
C.D. at 5 %			NS
S.Em. ± (YGD)			54.53
C.D. at 5 %			NS
S.Em. ± (YV)			25.71
C.D. at 5 %			NS
S.Em. ± (YGV)			44.52
C.D. at 5 %			NS
S.Em. ± (YDV)			44.52
C.D. at 5 %			NS
S.Em. ± (YGDV)			77.11
C.D. at 5 %			NS
C.V. %	10.27	10.13	10.21

Table 4: Response different treatments on tuber length (cm)

Treatments	**Tuber length (cm)**		
Growing conditions (G)	**2015-16**	**2016-17**	**Pooled**
G_1 (Poly house)	21.98	22.06	22.02
G_2 (Net house)	17.24	17.00	17.12
G_3 (Open field)	16.89	16.85	16.87
S.Em. ± (G)	0.54	0.69	0.43
C.D.at 5 % (G)	1.55	1.98	1.22
Planting distance (D)			
D_1 (60 cm x 60 cm)	18.22	18.29	18.26
D_2 (60 cm x 45 cm)	18.42	17.81	18.11
D_3 (90 cm x 90 cm)	19.48	19.82	19.65
S.Em. ± (D)	0.54	0.69	0.43
C.D. at 5 % (D)	NS	NS	1.22
Variety (V)			
V_1 (Round type)	11.84	11.88	11.86
V_2 (Long type)	25.57	25.39	25.48
S.Em. ± (V)	0.44	0.56	0.36
C.D. at 5 % (V)	1.26	1.62	1.00
C.D. at 5 % (GD)	NS	NS	NS
C.D.at 5 % (GV)	2.19	2.80	1.73
C.D.at 5 % (DV)	NS	NS	1.74
C.D. at 5 % (GDV)	NS	NS	2.97
S.Em. ± (YG)			0.62
C.D. at 5 %			NS
S.Em. ± (YD)			0.62
C.D. at 5 %			NS
S.Em. ± (YGD)			1.07
C.D. at 5 %			NS
S.Em. ± (YV)			0.50
C.D. at 5 %			NS
S.Em. ± (YGV)			0.88
C.D. at 5 %			NS
S.Em. ± (YDV)			0.88
C.D. at 5 %			NS

S.Em. ± (YGDV)			1.52
C.D. at 5 %			NS
C.V. %	12.24	15.72	14.08

Table 5: Response of different treatments on tuber yield vine^{-1} (kg)

Treatments	Tuber yield per vine $^{-1}$ (kg)		
	2015-16	2016-17	Pooled
Growing conditions (G)			
G_1 (Poly house)	1.69	1.85	1.77
G_2 (Net house)	1.30	1.44	1.37
G_3 (Open field)	0.74	0.85	0.79
S.Em. ± (G)	0.03	0.03	0.02
C.D.at 5 % (G)	0.09	0.09	0.06
Planting distance (D)			
D_1 (60 cm x 60 cm)	1.03	1.16	1.10
D_2 (60 cm x 45 cm)	1.46	1.62	1.54
D_3 (90 cm x 90 cm)	1.23	1.37	1.30
S.Em. ± (D)	0.03	0.03	0.02
C.D. at 5 % (D)	0.09	0.09	0.06
Variety (V)			
V_1 (Round type)	1.19	1.33	1.26
V_2 (Long type)	1.29	1.43	1.36
S.Em. ± (V)	0.03	0.03	0.02
C.D. at 5 % (V)	0.07	0.08	0.05
C.D. at 5 % (GD)	NS	NS	0.11
C.D.at 5 % (GV)	NS	NS	NS
C.D.at 5 % (DV)	NS	NS	NS
C.D. at 5 % (GDV)	NS	NS	NS
S.Em. ± (YG)			0.03
C.D. at 5 %			NS
S.Em. ± (YD)			0.03
C.D. at 5 %			NS
S.Em. ± (YGD)			0.05
C.D. at 5 %			NS
S.Em. ± (YV)			0.03
C.D. at 5 %			NS
S.Em. ± (YGV)			0.04
C.D. at 5 %			NS
S.Em. ± (YDV)			0.04
C.D. at 5 %			NS
S.Em. ± (YGDV)			0.07
C.D. at 5 %			NS
C.V. %	10.54	10.09	10.31

Table 6: Response of different treatments on tuber yield 1000 m^{-2} (kg)

Treatments	Tuber yield 1000 m^{-2} (kg)		
	2015-16	2016-17	Pooled
Growing conditions (G)			
G_1 (Poly house)	2699.42	2408.34	2553.88
G_2 (Net house)	2351.89	2075.65	2213.77
G_3 (Open field)	1769.06	1541.53	1655.29
S.Em. ± (G)	45.63	38.92	29.71
C.D.at 5 % (G)	130.97	111.71	83.83
Planting distance (D)			
D_1 (60 cm x 60 cm)	2254.02	1987.29	2120.66
D_2 (60 cm x 45 cm)	2966.51	2655.07	2810.79
D_3 (90 cm x 90 cm)	1599.83	1383.16	1491.50
S.Em. ± (D)	45.63	38.92	29.84
C.D. at 5 % (D)	130.97	111.71	84.20
Variety (V)			
V_1 (Round type)	1753.64	1587.74	1670.69
V_2 (Long type)	2793.27	2429.27	2611.27
S.Em. ± (V)	37.26	31.78	70.03
C.D. at 5 % (V)	106.93	91.21	NS
C.D. at 5 % (GD)	226.84	193.49	142.77
C.D.at 5 % (GV)	185.21	157.99	118.54
C.D.at 5 % (DV)	185.21	157.99	119.26

C.D. at 5 % (GDV)	320.80	273.64	201.84
S.Em. ± (YG)			42.41
C.D. at 5 %			NS
S.Em. ± (YD)			42.41
C.D. at 5 %			NS
S.Em. ± (YGD)			73.46
C.D. at 5 %			NS
S.Em. ± (YV)			34.63
C.D. at 5 %			97.75
S.Em. ± (YGV)			59.98
C.D. at 5 %			NS
S.Em. ± (YDV)			59.98
C.D. at 5 %			NS
S.Em. ± (YGDV)			103.89
C.D. at 5 %			NS
C.V. %	8.52	8.22	8.40

Conclusion

Apart from the research results of two years of experiment, it was concluded that higher growth and yield attributes of greater yam was recorded with V_2 (Long type) variety.

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