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BN Hindalekar
Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

PC Haldavanekar
Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

SV Bhavar
Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

Correspondence
BN Hindalekar
Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

Comparative performance of f_1 hybrids under different growing conditions on vegetative growth parameters of okra (*Abelmoschus esculentus* L. Moench)

BN Hindalekar, PC Haldavanekar and SV Bhavar

Abstract
The present investigation entitled "Comparative performance of F_1 hybrids under different growing conditions on vegetative growth parameters of okra (*Abelmoschus esculentus* L. Moench)" was carried during summer season of 2014-2015, at Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (M.S.), with an objective "To study the vegetative growth of F_1 hybrids of okra under different growing conditions in Konkan region".
The highest plant height (2.00 m), number of nodes (22.36), leaf area (221.97 cm^2) and lowest days to seed germination (6.13), days to initiation of first flower (42.87), days to first fruit harvest (45.88) were observed in GC_1. However, the highest girth at collar region (51.12 mm) and lowest internodal length (7.62 cm) was recorded in GC_3. The lowest nodal position of first flower (3.99) was observed in GC_2. With regard to variation in F_1 hybrids, significantly the highest plant height at last harvest (1.66 m), lowest days to initiation of first flower (44.67), highest number of nodes (21.79) in V_1. While, lowest internodal length (7.71) reported in V_5. Number of nodes was significantly highest (21.79) and lowest days to seed germination in V_1. The highest leaf area (214.16 cm^2) was recorded in V_3. The hybrid V_3 showed the lowest days for first harvest (48.46) while, the effect of interaction between growing conditions and F_1 hybrids were recorded the highest number of nodes (24.33) in GC_1V_1 and GC_1V_2. Treatment combination GC_1V_3 produced the highest leaf area (245.86 cm^2) while, GC_1V_5 took the lowest days to appearance of first flower (42.67).
Growing condition GC_3 shows, the highest fruit yield per plant (0.25 Kg), fruit yield per m^2 (1.88 Kg) and yield per hectare (15.37 t). The highest fruit yield per plant (0.20 Kg), fruit yield per m^2 (1.51 Kg) and yield per hectare (9.60 t) were noticed in V_3. Among the interaction effects, the treatment combination GC_3V_3 produced the highest fruit yield per plant (0.28 Kg), fruit yield per m^2 (2.08 Kg) and fruit yield per hectare (16.47 t).

Keywords: Comparative performance, okra, f_1 hybrids, polyhouse, Shadenet house, open field

Introduction
Okra (*Abelmoschus esculentus* L. Moench) popularly known as 'Bhendi' or 'Lady's finger'. Okra is a member of the family malvaceae and is said to be native of Africa possibly Ethiopia (Singh and Bhagchandani, 1967) [12]. In India, okra is grown over an area of 0.231 million hectares with a production of 63.5 lakh Metric tonnes and productivity is 27.5 Metric tonnes/ha. In Maharashtra, area under this crop is 22 thousand hectares with an annual production of 3.28 lakh metric and productivity of 14.9 metric tonnes/ha, in the year 2012-13 (Anon, 2013) [2]. Okra is widely cultivated as a summer season crop in North India and as a *kharif* and summer season crop in Gujarat, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu. It grows well in the areas, where day temperatures remain between 25 ^{0}C to 40 ^{0}C.
Polyhouse and shadenet house can modify environmental conditions, So as to reduce biotic and abiotic stress for maximization of yield. Protected cultivation could possibly extend the growing season as well as overcome the problem of low productivity during extreme weather conditions. However, profitability in protected cultivation depends upon the choice of structure, selection of crop, selection of varieties, production technology and market price.
Now a days vegetable growers are using F_1 hybrids of vegetables for maximization of yield. Further, protected cultivation of vegetables could be used to improve yield quantity and quality (Ganesan, 2004) [4].

By taking into consideration the all year round demand for quality okra it is necessary to access possibility of growing okra F_1 hybrids under different growing conditions, to study their comparative performance with respect to growth and yield contributing characters. For assessing this possibility growing okra under various growing conditions can help to study their comparative performance with respect to growth and yield attributing characters needs to be studied. Hence, present study on, "Comparative performance of F_1 hybrids of okra (*Abelmoschus esculentus* L. Moench) under naturally ventilated polyhouse, shadenet house and open field conditions" has been planned.

Material and Methods

The present investigation was carried out during summer season of 2014 - 2015, at Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri (M.S.). The experiment was conducted in Split Plot Design consisting of three main treatments i.e. growing conditions viz. naturally ventilated polyhouse (GC_1), shadenet house (GC_2) and open field condition (GC_3) and five sub-treatments *i.e.* F_1 hybrids of okra viz. OH-152 (V_1), Bhendi NS-851 (V_2), Bhendi No-10 (V_3), NOH-1258 (V_4) with control as Varsha Uphar (V_5) variety. Thus, in all 15 treatment combinations replicated thrice with a plot size 2.7 m x 3 m per treatment and spacing maintained 45 cm × 30 cm. The plots were kept free from weeds by hand weeding and recommended fertilizer dose was given. The tender marketable pods (fruits) were harvested at two days interval by manually up to last harvest. In order to evaluate the effect of different treatments on growth and yield of crop, necessary periodical observations were recorded and the generated data was statistically analyzed by 'Analysis of Variance' method described by Panse and Sukhatme (1995) [9].

Treatment combinations

S. No	Treatments	Treatment details
1	GC_1 V_1	Naturally ventilated polyhouse + OH-152
2	GC_1 V_2	Naturally ventilated polyhouse + Bhendi NS-851
3	GC_1 V_3	Naturally ventilated polyhouse + Bhendi No-10
4	GC_1 V_4	Naturally ventilated polyhouse + NOH-1258
5	GC_1 V_5	Naturally ventilated polyhouse + Varsha Uphar
6	GC_2 V_1	Shadenet house + OH-152
7	GC_2 V_2	Shadenet house + Bhendi NS-851
8	GC_2 V_3	Shadenet house + Bhendi No-10
9	GC_2 V_4	Shadenet house + NOH-1258
10	GC_2 V_5	Shadenet house + Varsha Uphar
11	GC_3 V_1	Open field condition + OH-152
12	GC_3 V_2	Open field condition + Bhendi NS-851
13	GC_3 V_3	Open field condition + Bhendi No-10
14	GC_3 V_4	Open field condition + NOH-1258
15	GC_3 V_5	Open field condition + Varsha Uphar

Results and Discussions

i) Days to seed germination

It was observed from the data pertaining to Table 1 that, the days required for seed germination of okra under different growing conditions, F_1 hybrids and interaction effect reported non-significant variation. The non-significant variation in days required for seed germination might be due to interaction effect in between soil temperature, humidity and light under different growing conditions and genetic makeup of hybrids. Similar results were also reported by Mishra *et al.*, (2009) [6] in okra.

ii) Height of plant (m)

The data regarding plant height is presented in Tables 1, at last harvest, significantly the highest plant height (2.00 m) was observed under GC_1 and the lowest (1.22 m) in GC_3 and was found to be at par with GC_2. Same trend was observed during entire crop duration. At last harvest significantly the highest plant height (1.66 m) was found in V_1 and was at par with V_2 and V_3. While, the lowest plant height (1.31 m) was recorded in V_5 i.e. control. At last harvest the treatment combination GC_1V_2 showed the highest plant height (2.24 m), while the lowest (0.80 m) in GC_3V_4. The highest plant height under GC_1 might be due to the stimulation of cellular expansion and cell division due to diffused light and congenial relative humidity and temperature in protected structures. However in the open field biotic and abiotic stresses might be responsible for low plant height. These findings are in close conformity with Mishra *et al.*, (2009) [6], Rahman *et al.*, (2012) [10], Dash *et al.*, (2013) [3] in okra.

iii) Internodal length (cm)

From the data presented in Table 1, showed that, significantly the lowest internodal length (7.62 cm) was recorded under GC_3. While, the highest internodal length (8.97 cm) was recorded under GC_1 which was at par with GC_2.

It was evident that internodal length had significantly varied among different F_1 hybrids of okra. The lowest intermodal length (7.71 cm) was recorded in V_5 while, the highest internodal length (9.09 cm) was recorded in V_3 which was at par with V_1.

The internodal length among different F_1 hybrids of okra under different growing conditions showed non-significant variation. This might be due to enhanced photosynthesis, respiration and the favorable micro-climatic conditions in the protected cultivation. Similar results were also reported by Rajasekar *et al.*, (2013) [11] in okra.

iv) Number of nodes

The data pertaining to the number of nodes per plant in different F_1 hybrids of okra under different growing conditions are presented in Table 2 that, the significantly highest (22.36) number of nodes per plant were recorded under GC_1 and the lowest (15.68) under GC_2. This significant variation in number of nodes per plant under different growing conditions might be due to more vegetative growth under GC_1.

It was evident from the data presented that, the number of nodes per plant in F_1 hybrids had significantly the highest number of nodes (21.79) per plant in V_1 while, the lowest (18) in V_4. Variation in hybrids might be due to the difference in genetic makeup and its interaction with growing environmental conditions.

Interaction effect of growing conditions and hybrids on number of nodes per plant showed significantly, the highest number of nodes (24.33) in GC_1V_1 and GC_1V_2 and was at par with GC_3V_1, while the lowest (14.60) was recorded in GC_2V_5. This variation in number of nodes per plant might be due to the specific genetic makeup of different hybrids, inherent characteristics, hormonal factor and also due to the different growing conditions. The result was analogous to the findings of Akotkar *et al.*, (2010) [1] and Sharma *et al.*, (2014) [14] in okra.

v) Girth at Collar region (mm)

The data pertaining to the girth at collar region in different F_1 hybrids of okra under different growing conditions are presented in Table 2. The girth at collar region of okra plant was the highest (51.12 mm) at GC_3 while, lowest (33.74 mm) girth was observed at GC_2. Same trend was observed during entire crop duration. The rate of increase in girth at collar region of okra was found slow at initial days and then it increases rapidly upto 75 days later on it was increased at slower rate and showed non-significant variation. Significantly the highest girth at collar region of okra plant under GC_3 was might be due to favorable soil and climatic conditions than GC_1 and GC_2. However, at last harvest non-significant results were observed among different okra

hybrids and interaction effect. The result was contrasting to the findings of Thapa *et al.*, (2013) [15] in sprouting broccoli.

vi) Leaf area (cm^2)

As per Table 2, it is clear that leaf area varied significantly among all the growing conditions. The growing condition GC_1 showed the highest leaf area (221.97 cm^2) while, the lowest leaf area (184.76 cm^2) was reported in GC_3. The different hybrids also influenced the leaf area significantly. The highest leaf area (214.16 cm^2) was observed in V_3 whereas, the lowest (187.27 cm^2) was observed in V_2.

However, the interaction between different growing conditions as well as hybrids, a treatment combination GC_1V_3 produced significantly the highest leaf area (245.86 cm^2) while, the lowest (167.35 cm^2) was produced in GC_3V_4. The highest leaf area in protected structure might be due to congineal condition for vegetative growth characters in terms of leaf area and photosynthesis. The results are in line with Rajasekar *et al.*, (2013) [11] in okra and by Thapa *et al.*, (2013) [15] in sprouting broccoli

vii) Days to initiation of firs flower

From the data pertaining Table 3, revealed that significantly, the lowest days for initiation of first flower (42.87) were recorded under GC_1 while, the highest (46.43) days in GC_2. However days to initiation of first flower had non-significant variation among different hybrids.

Among the interaction between growing conditions and varieties, a treatment combination GC_1V_5 took the lowest days to appearance of first flower (42.67) and was found

Table 1: Effect of growing conditions, hybrids and their interactions on days to germination, plant height (m) and internodal length (cm).

F_1 Hybrid	Days to seed germination				Plant height at last harvest (m)				Internodal length (cm)			
	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean
V_1	6.00	6.00	6.33	6.11	2.17	1.53	1.27	1.66	9.16	9.01	8.52	8.90
V_2	6.33	6.67	6.33	6.44	2.24	1.46	1.26	1.65	9.21	9.08	7.17	8.48
V_3	6.33	7.33	7.00	6.89	1.97	1.31	1.56	1.61	9.32	9.17	8.77	9.09
V_4	6.00	6.67	6.00	6.22	1.93	1.23	0.80	1.32	8.86	8.07	6.69	7.87
V_5	6.00	6.67	6.67	6.44	1.66	1.05	1.22	1.31	8.32	7.87	6.95	7.71
Mean	6.13	6.67	6.47	6.42	2.00	1.32	1.22	1.51	8.97	8.64	7.62	8.41
	'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %	
GC	NS	0.22	-		SIG	0.07	0.26		SIG	0.22	0.87	
V	NS	0.19	-		SIG	0.09	0.27		SIG	0.18	0.53	
Interaction	NS	0.32	-		NS	0.16	-		NS	0.31	-	

Table 2: Effect of growing conditions, hybrids and their interactions on number of nodes, girth at collar region (mm) and leaf are (cm^2).

F_1 Hybrid	Number of nodes				Girth at collar region (mm)				Leaf area (cm^2)			
	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean
V_1	24.33	17.07	23.97	21.79	49.51	37.49	52.14	46.38	230.00	201.27	211.05	214.11
V_2	24.33	15.37	20.70	20.13	49.39	32.88	53.85	45.38	190.44	187.63	183.73	187.27
V_3	21.13	16.10	20.17	19.13	50.04	32.89	51.85	44.93	245.86	209.60	187.02	214.16
V_4	21.97	15.27	16.77	18.00	49.48	31.07	41.19	40.58	233.11	189.73	167.35	196.73
V_5	20.03	14.60	21.10	18.58	51.32	34.39	56.58	47.43	210.41	207.27	174.66	197.45
Mean	22.36	15.68	20.54	19.53	49.95	33.74	51.12	44.94	221.97	199.10	184.76	201.94
	'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %	
GC	SIG	0.22	0.86		SIG	1.00	3.93		SIG	2.70	10.60	
V	SIG	0.26	0.77		NS	1.67	-		SIG	2.33	6.80	
Interaction	SIG	0.46	1.34		NS	2.88	-		SIG	4.04	11.97	

Table 3: Effect of growing conditions, hybrids and their interactions on days to initiation of first flower, nodal position of first flower and days to first fruit harvest

F_1 Hybrid	Days to initiation of first flower				Nodal position of first flower				Days to first fruit harvest			
	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean
V_1	42.88	46.40	44.73	44.67	4.03	4.00	4.00	4.01	45.93	51.00	48.73	48.56
V_2	43.37	46.93	44.43	44.91	4.03	4.00	4.00	4.01	46.10	51.17	50.67	49.31
V_3	42.67	46.70	44.90	44.76	4.03	4.00	4.00	4.01	45.67	50.97	48.73	48.46
V_4	42.75	46.10	45.33	44.73	4.00	4.00	4.03	4.01	46.17	51.03	50.60	49.27
V_5	42.67	46.00	46.10	44.92	4.00	3.97	4.03	4.00	45.53	50.17	50.43	48.71
Mean	42.87	46.43	45.10	44.80	4.02	3.99	4.01	4.01	45.88	50.87	49.83	48.86
	'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %	
GC	SIG	0.10	0.40		SIG	0.00	0.02		SIG	0.20	0.77	
V	NS	0.17	-		NS	0.01	-		SIG	0.24	0.70	
Interaction	SIG	0.30	0.88		NS	0.02	-		NS	0.41	-	

Table 4: Effect of growing conditions, hybrids and their interactions on fruit yield per plant (Kg), fruit yield per m^2 (Kg) and yield per hectare (t)

F_1 Hybrid	Fruit yield per plant (Kg)				Fruit yield per m^2 (Kg)				Yield per hectare (t)			
	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean	GC_1	GC_2	GC_3	Mean
V_1	0.23	0.09	0.23	0.18	1.68	0.64	1.68	1.33	8.26	3.13	16.46	9.29
V_2	0.17	0.09	0.26	0.18	1.28	0.67	1.95	1.30	8.48	2.23	16.43	9.05
V_3	0.22	0.11	0.28	0.20	1.65	0.79	2.08	1.51	8.77	3.55	16.47	9.60
V_4	0.21	0.05	0.22	0.16	1.56	0.37	1.65	1.19	8.41	2.14	14.04	8.20

V_5	0.17	0.04	0.28	0.16	1.26	0.32	2.05	1.21	8.13	1.35	13.44	7.64
Mean	0.20	0.08	0.25	0.18	1.49	0.56	1.88	1.31	8.41	2.48	15.37	8.75
	'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %		'F' test	SE(m)±	CD @ 5 %	
GC	SIG	0.00	0.01		SIG	0.01	0.05		SIG	0.08	0.30	
V	SIG	0.00	0.01		SIG	0.01	0.04		SIG	0.08	0.25	
Interaction	SIG	0.00	0.01		SIG	0.03	0.07		SIG	0.15	0.43	

at par with GC_1V_5, GC_1V_4, GC_1V_1 and GC_1V_2. Whereas, treatment combination GC_2V_2 taken the highest days to appearance of first flower (46.93). These variation reported on days for initiation of first flower may be attributed to genetic makeup of hybrid, and congenial atmosphere prevailed on protective structures which encouraged the plants for more vegetative growth. These results are in agreement with the research finding with Rahman *et al*., (2012) [10], Dash *et al*., (2013) [3] and Shaikh *et al*., (2013) [13] in okra.

viii) Nodal position of first flower

It was observed from the Table 3, in respect of nodal position of first flower varied significantly among all the growing conditions. The growing condition GC_1 showed the highest nodal position of first flower (4.02) while, the lowest (3.99) in GC_2.

However, non-significant variation showed by different hybrids and also, non-significant interaction between different growing conditions and F_1 hybrids to nodal position of first flower. These results are in agreement with the research finding with Oppong-Sekyere *et al.*, (2012) [8], Dash *et al.*, (2013) [3] and Sharma *et al.*, (2014) [14] in okra.

ix) Days to first fruit harvest

The data pertaining days required to first fruit harvest in Table 3, reported that, the effect of growing conditions on number of days required from sowing to first harvest was found to be significant. The lowest days required to first harvest (45.88) were found in GC_1 while, the highest (50.87) in GC_2.

Significantly, the hybrid V_3 showed the lowest days for first harvest (48.46) which was found at par with V_1 and V_5 while, the highest days required for first harvest (49.31) was observed in V_2.

Interaction between growing conditions and hybrids was found non-significant with respect to days to first harvest. Similar results were also found by the scientists, Kumar and Arumugam (2010) [5], Rahman *et al.*, (2012) [10], Dash *et al.*, (2013) [3] in okra.

x) Fruit yield per plant (Kg)

It was observed from the Table 4, in respect of the different growing conditions influenced the fruit yield per plant significantly. The highest fruit yield per plant (0.25 Kg) was observed in GC_3. Whereas, the lowest fruit yield per plant (0.08 Kg) was observed under GC_2. It may be due to due to congenial environmental conditions in relation to sunlight, temperature, and atmospheric humidity in open field condition.

However, it is clear that, the fruit yield per plant varied significantly among all the hybrids. The hybrid V_3 showed the highest fruit yield per plant (0.20 Kg) over rest of the hybrids while, the lowest fruit yield per plant (0.16 Kg) was produced in variety V_5 which was at par with V_4.

Among the interaction effects, the treatment combination GC_3V_3 produced significantly the highest fruit yield per plant (0.28 Kg) and was at par with treatment combination of GC_3V_5 while, the lowest fruit yield per plant (0.04 Kg) was found in the treatment combination of GC_2V_5. Shaikh *et al.*, (2013) [13] reported the same result in okra.

xi) Fruit yield per m^2

The data pertaining Table 4 that, the different growing conditions influenced the fruit yield per m^2 significantly. The highest fruit yield per m^2 (1.88 Kg) was observed in GC_3 whereas, the lowest fruit yield per m^2 (0.56 Kg) was observed under GC_2. Further, it was observed that the treatment GC_3 was found significantly superior over rest of the treatments. It was due to congenial environmental conditions in relation to sunlight, temperature, and atmospheric humidity in open field condition.

As per Table 4, it is clear that fruit yield per m^2 varied significantly among all the hybrids. The hybrid V_3 showed significantly the highest fruit yield per m^2 (1.51 Kg) over rest of the hybrids while, the lowest fruit yield per m^2 (1.19 Kg) was produced in variety V_4 which was at par with V_5.

Similarly, the interaction effect of growing conditions and okra hybrids on fruit yield per m^2 was also found to be significant. The treatment combination GC_3V_3 reported highest fruit yield per m^2 (2.08 Kg) and was at par with treatment combination of GC_3V_5 while, the lowest fruit yield per m^2 (0.32 Kg) was found in GC_2V_5. This results are confined with result of Mishra *et al*., (2011) [7] in okra.

xii) Fruit yield per hectare (t)

The data pertaining Table 4, that the different growing conditions reported significantly, the highest fruit yield per hectare (15.37 t) when hybrids were grown in GC_3 whereas, the lowest (2.48 t) was observed under GC_2. Further, it was observed that the treatment GC_3 was significantly superior over rest of the treatments. It is because of favorable climatic conditions like light intensity, temperature and humidity.

Significant variation in fruit yield per hectare was also observed among all F_1 hybrids. Significantly, the highest fruit yield per hectare (9.60 t) was recorded in okra hybrid V_3, while the lowest (7.64 t) was observed in V_5.

Similarly, the effect of interaction between different growing conditions and F_1 hybrids was also found to be significant. A treatment combination GC_3V_3 produced the highest fruit yield per hectare (16.47 t) and was at par with GC_3V_1 and GC_3V_2 while, the treatment combination GC_2V_5 showed the lowest fruit yield per hectare (1.35 t).

This variation in yield per hectare under different growing conditions among different hybrids might be due to appropriate light compensation for higher photosynthesis, the fruit set percentage, fruit length, number of fruits per plant, fruit weight, fruit diameter, genetic makeup, growing conditions and vigour of the crop, also the required. Rahman *et al.*, (2012) [10] observed the highest yield (9.90 t/ha) in okra. Dash *et al.*, (2013) [3] observed the highest (9.11 t) and the lowest (4.60 t) pod yield per hectare in okra.

Conclusion

From the one year experimentation, it could be concluded that, the growth parameter of different F_1 hybrids, such as days to seed germination, plant height, internodal length,

number of nodes, girth at collar region leaf area, days to initiation of first flower, nodal position of first flower and days to first fruit harvest were shows significant effect with varying growing conditions. Similarly, the yield parameter of different F_1 hybrids was also shows significant difference with varying growing conditions. Thus, F_1 hybrid Bhendi No-10 grown under open field condition noticed maximum yield under Konkan agro-climatic condition. However, it needs confirmation by conducting the same investigation.

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