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Genetic evaluation of sprouting broccoli [*Brassica oleracea* (L.) var. *italica* (Plenck.)] under mid hill conditions of Himachal Pradesh

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Abstract

Sixteen genotypes of sprouting broccoli [*Brassica oleracea* (L.) var. *italica* (Plenck.)] were evaluated for fourteen horticultural traits *viz.*, marketable yield per plant, days to first harvest, terminal head weight per plant, gross weight per plant, number of spears per plant, head size index, plant frame, leaf size with leaf stalk, leaf size without leaf stalk, plant height up to longest leaf, plant height up to head, stalk length, weight of spears per plant and harvest index at the Experimental Farm of the Department of Vegetable Science and Floriculture during 2010-11 and 2011-12. The analysis of variance revealed the presence of sufficient genetic variability for all the characters under study. Based on mean performance, the genotype 'Altar' was found promising for marketable yield per plant and other related characters like terminal head weight per plant, gross weight per plant and harvest index in both the years. The genotype 'CBH-1' took minimum number of days to first harvest in 2010-11 (98.33 days) and 2011-12 (88.00 days) and appeared as an early maturing genotype.

Key words: Sprouting broccoli, mean performance, horticultural traits.

Introduction

Broccoli [*Brassica oleracea* (L.) var. *italica* (Plenck.)], a member of family Brassicaceae, is one of the most nutritious cole crops. The name broccoli has been derived from an Italian word 'brocco' meaning, the young shoots. It is native to Southern Europe and Mediterranean region, whereas, Italy is thought to be primary centre of origin. Broccoli is known for its taste, flavour, medicinal and nutritive value, especially with respect to vitamin A (2500 IU), vitamin C (113 IU), calcium (103 mg) and potassium (382 mg) per 100 g of edible portion (Tiwari, 2010). It also contains the compound glucoraphanin, which can be processed into an anti-cancer compound sulphoraphane (Aires *et al.*, 2006).

In India, broccoli and cauliflower are cultivated over an area of 3,14,900 hectares with the production of 59,88,500 metric tonnes (Anonymous, 2011). Broccoli is a cool season vegetable but its off season cultivation fetches lucrative remuneration to the growers during summer season in hills when it cannot be grown in plains due to prevailing high temperature. These days, broccoli is highly preferred on an account of its nutritive value, and the crop is being sold at higher prices in comparison to other cole crops *viz.*, cabbage, cauliflower, knol-khol, kale and Brussels sprout. Furthermore, hill farmers with small land holdings are benefited with sprouting type of broccoli as two to three harvestings can be taken. These days, lots of varieties are made available to the farmers by various public and private concerns owing to earliness and higher yield. However, many of these varieties do not form proper heads which inturn lead to huge losses to the growers. Therefore, the present investigation was carried out in sprouting broccoli for obtaining the first hand information, so as to select suitable genotypes for direct and indirect use in broccoli improvement program.

Materials and Methods

The present investigation was carried out at the

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Experimental Farm of the Department of Vegetable Science and Floriculture, CSK HPKV, Palampur during 2010-11 and 2011-12. The experimental material comprised of 16 genotypes of sprouting broccoli. There were 16 plants in each plot having 4.5 m^2 area planted at 60 cm distance between rows and 45 cm within row in a Randomized Complete Block Design, with three replications. Observations were recorded on five randomly selected competitive plants per replication for fourteen characters *viz.*, marketable yield per plant (g), days to first harvest, terminal head weight per plant (g), gross weight per plant (g), number of spears per plant, head size index (cm^2), plant frame (cm^2), leaf size with leaf stalk (cm^2), leaf size without leaf stalk (cm^2), plant height up to longest leaf (cm), plant height up to head (cm), stalk length (cm), weight of spears per plant (g) and harvest index (%). The data regarding above mentioned characters were averaged and subjected to analysis of variance (Panse and Sukhatme, 1985).

Results and Discussion

Mean performance of genotypes for different horticultural traits is given in Tables 1 and Table 2 for environment I and environment II, respectively. The estimation of mean values in environment I revealed that the marketable yield per plant varied from 126.33 to 536.66 g. The highest marketable yield per plant was found in genotype Altar (536.66 g) followed by Green Magic (399.33 g) which were significantly superior to the best check Palam Haritika (331.33 g). In environment II, the marketable yield per plant of various genotypes ranged between 155.00 and 546.00 g. The genotype Altar (546.00 g) recorded the highest marketable yield per plant and appeared to be significantly superior to the best check Palam Haritika (382.00 g). Days taken to first harvest varied from 97.67 to 125.66 in environment I. Genotype Indica (97.67 days) took minimum number of days to first harvest followed by CBH-1 (98.33 days) and both were found to be significantly superior to the early maturing recommended check Palam Samridhi (105.53 days). In environment II, the ranges for this character varied from 88.00 to 132.33 days. Only one genotype, *i.e.*, CBH-1 (88.00 days) took minimum number of days to first harvest and was significantly superior to the best (early maturing) check Palam Samridhi (96.66 days). Terminal head weight per plant was found to be maximum (523.33 and 527.66 g) in Altar and minimum (71.33 and 126.66 g) in Indica in environment I and II, respectively. Among all the genotypes studied in environment I, the highest terminal head weight per plant was recorded in Altar (523.33 g) followed by Green Magic (384.66 g), BR-70 (346.00 g), Lucky (345.66 g) and Supreme (342.66 g) which were significantly superior to the best check Palam Haritika (298.00 g). In environment II, the genotype Altar (527.66 g) recorded the highest terminal head weight per plant and was found to be significantly superior to the best check Palam Haritika (326.66 g).

A maximum (1041.66 g) gross weight per plant was found in Green Magic and minimum (658.33 g) in Palam Samridhi in environment I. The highest gross weight per plant was recorded in genotype Green Magic (1041.66 g) followed by Altar (1005.00 g), Fiesta (960.00 g), BR-70 (913.33 g) and Supreme (891.66 g), which were found to be significantly superior to the best check Palam Haritika (731.66 g). In environment II, the maximum (1237.33 g) gross weight per plant was found in Altar and minimum (703.00 g) in Palam Samridhi. Only one genotype, *i.e.*, Altar (1237.33 g) recorded the significantly high gross weight per plant to the best check Palam Haritika (984.33 g). Wide range of variability observed for these characters in different genotypes of broccoli is in broad conformity with the findings of Kalia and Shakuntla (2002) and Gautam *et al.* (2004). The number of spears per plant was found in the range of 1.33-9.73 in environment I. The maximum number of spears per plant was produced by genotype Kendi (9.73) most closely followed by Indica (9.26), and both of them were found to be significantly superior to the best check Palam Samridhi (5.46). In environment II, the range for this character varied from 1.50 to 10.66. The genotype Indica (10.66) recorded the maximum number of spears per plant, and it was found to be significantly superior to best check Palam Samridhi

Table 1. Estimation of mean values for marketable yield per plant and other characters of broccoli in environment I

Characters / Genotypes	Days to first harvest	Marketable yield/ plant (g)	Terminal head weight/ plant (g)	Gross weight/ plant (g)	Number of spears/ plant	Head size index (cm^2)	Plant frame (cm^2)	Leaf size with leaf stalk (cm^2)	Leaf size without leaf stalk (cm^2)	Plant height up to longest leaf (cm)	Plant height up to head (cm)	Stalk length (cm)	Weight of spears/ plant (g)	Harvest index (%)
Lucky	113.60	364.00	345.66	846.66	2.48	220.51	4140.93	438.89	249.70	43.33	24.73	2.60	42.66	42.72
Fiesta	119.80	371.33	328.66	960.00	1.78	244.76	4222.33	537.69	306.74	44.60	24.53	2.08	52.00	40.42
Kendi	113.20	340.66	325.33	836.66	9.73	250.86	3393.26	475.54	312.92	41.60	30.33	2.32	156.00	41.66
Indica	97.67	126.33	71.33	668.33	9.26	140.24	3386.46	540.98	313.40	48.26	40.36	3.25	173.00	19.90
Green Magic	113.20	399.33	384.66	1041.66	4.80	257.76	2936.46	560.09	383.93	47.13	28.80	2.36	131.33	38.24
BR-70	114.06	370.66	346.00	913.33	5.46	288.81	3445.80	679.90	452.82	47.53	24.66	2.23	107.33	40.24
BR-60	112.53	264.00	292.00	825.00	4.40	250.30	3555.13	689.58	391.48	47.26	27.26	2.44	104.66	32.64
Altar	121.60	536.66	523.33	1005.00	1.33	232.66	4434.57	771.21	445.47	52.80	25.60	2.41	15.00	51.77
CBH-1	98.33	336.33	299.00	865.00	5.93	264.14	3209.86	609.85	330.11	46.10	32.46	2.57	80.66	32.53
Pluto	111.93	295.33	251.33	855.00	5.00	234.41	4799.73	686.10	346.82	50.86	29.53	2.50	78.00	35.52
Green Beauty	110.80	142.66	123.66	820.00	4.55	163.56	4409.53	540.75	372.40	44.20	30.13	2.51	59.33	18.37
Supreme	112.73	307.66	342.66	891.66	4.60	185.54	3626.93	614.86	346.48	45.26	28.73	2.48	102.66	41.61
Packman	109.53	280.33	251.33	718.33	5.26	241.00	3392.13	354.95	349.12	43.80	30.40	2.73	95.33	34.31
Tiltest	113.53	270.33	253.00	723.33	5.00	209.31	3347.33	635.82	358.31	48.23	31.62	2.27	100.66	36.22
Palam Haritika (c)	125.66	331.33	298.00	731.66	3.71	228.10	3747.26	716.85	377.22	54.93	31.96	2.46	110.66	43.25
Palam Samridhi (c)	105.53	258.66	233.33	658.33	5.46	217.36	2857.06	492.06	288.50	43.20	27.93	2.53	94.00	37.03
Grand Mean (X)	**112.10**	**312.22**	**291.83**	**835.00**	**4.92**	**223.08**	**3681.55**	**584.07**	**351.59**	**46.82**	**29.31**	**2.48**	**93.95**	**36.65**
S.E (d)±	**2.10**	**17.07**	**15.32**	**48.56**	**0.30**	**17.40**	**266.91**	**31.46**	**21.13**	**1.99**	**1.70**	**0.08**	**8.17**	**2.12**
CD (P=0.05)	**6.06**	**49.30**	**44.24**	**140.26**	**0.88**	**50.26**	**770.89**	**90.86**	**61.04**	**5.76**	**4.91**	**0.23**	**23.60**	**6.14**
CV (%)	**3.24**	**9.47**	**9.09**	**10.07**	**10.77**	**13.51**	**12.55**	**9.32**	**10.41**	**7.37**	**10.05**	**5.71**	**15.06**	**10.05**
Range	**97.67-125.66**	**126.33-536.66**	**71.33-523.33**	**658.33-1041.66**	**1.33-9.73**	**140.24-288.81**	**2857.06-4799.73**	**354.95-771.21**	**249.70-452.82**	**41.60-54.93**	**24.53-40.36**	**2.08-3.25**	**15.00-173.00**	**18.37-51.77**

(c): Check

Table 2. Estimation of mean values for marketable yield per plant and other characters of broccoli in environment II

Characters / Genotypes	Days to first harvest	Marketable yield/ plant (g)	Terminal head weight/ plant (g)	Gross weight/ plant (g)	Number of spears/ plant	Head size index (cm^2)	Plant frame (cm^2)	Leaf size with leaf stalk (cm^2)	Leaf size without leaf stalk (cm^2)	Plant height up to longest leaf (cm)	Plant height up to head (cm)	Stalk length (cm)	Weight of spears/ plant (g)	Harvest index (%)
Lucky	118.33	372.00	352.00	1046.66	2.33	224.98	4057.26	551.96	358.16	48.23	30.00	2.56	48.33	36.97
Fiesta	125.33	376.00	359.33	980.00	4.73	270.00	4044.06	595.12	396.81	48.00	34.53	2.12	55.83	40.93
Kendi	107.00	369.00	358.00	1078.33	7.00	245.53	4089.06	609.86	349.72	47.56	36.20	2.54	144.80	33.83
Indica	102.00	155.00	126.66	724.33	10.66	122.10	4219.60	594.43	346.41	57.63	45.56	3.17	140.33	19.19
Green Magic	107.20	378.66	354.66	1054.33	5.20	231.40	3874.13	712.09	411.61	51.53	30.13	2.62	117.33	35.89
BR-70	101.53	359.66	344.66	1075.66	5.73	243.13	3725.60	792.01	407.28	55.46	32.73	2.38	113.00	32.71
BR-60	99.93	306.00	279.33	858.33	6.06	242.06	3716.46	724.37	383.26	55.26	31.53	2.34	113.46	36.62
Altar	116.86	546.00	527.66	1237.33	1.50	240.80	5239.86	825.56	454.19	53.86	31.66	2.38	26.66	46.70
CBH-1	88.00	329.33	315.33	917.00	6.00	193.53	3168.86	590.79	412.01	49.06	31.06	2.51	123.33	35.38
Pluto	99.13	305.00	263.00	905.66	6.86	228.61	4507.73	773.96	470.31	55.46	34.26	2.52	157.00	35.64
Green Beauty	104.93	210.00	193.33	890.66	2.70	193.63	4439.86	556.13	332.65	47.73	34.53	2.42	76.66	23.80
Supreme	112.40	303.00	290.33	986.00	5.96	216.51	4202.60	636.52	304.04	52.40	31.53	2.34	120.66	39.34
Packman	91.33	238.00	229.33	740.00	5.66	231.23	3410.53	598.38	345.43	47.00	33.80	2.58	118.80	31.98
Tiltest	101.06	263.00	250.66	780.00	5.00	238.73	3831.20	717.57	412.57	59.00	32.26	2.65	153.33	32.89
Palam Haritika (c)	132.33	382.00	326.66	984.33	5.50	276.73	4119.20	806.98	429.89	51.36	36.86	2.34	127.33	38.99
Palam Samridhi (c)	96.66	248.00	235.33	703.00	6.73	249.73	2698.26	543.12	305.70	45.26	34.26	2.59	122.50	31.81
Grand Mean (X)	**106.54**	**321.29**	**300.39**	**935.10**	**5.47**	**228.04**	**3959.02**	**664.30**	**382.50**	**51.55**	**33.81**	**2.50**	**109.96**	**34.54**
S.E (d)±	**2.99**	**18.40**	**17.71**	**57.37**	**0.35**	**18.63**	**268.60**	**39.14**	**25.60**	**2.19**	**2.30**	**0.08**	**9.51**	**1.94**
CD (P=0.05)	**8.64**	**53.17**	**51.15**	**165.71**	**1.03**	**53.81**	**775.77**	**113.05**	**73.93**	**6.33**	**6.65**	**0.25**	**27.47**	**5.61**
CV (%)	**4.86**	**9.92**	**10.21**	**10.62**	**11.32**	**14.15**	**11.75**	**10.20**	**11.04**	**7.36**	**11.80**	**6.12**	**14.98**	**9.75**
Range	**88.00-132.33**	**155.00-546.00**	**126.66-527.66**	**703.00-1237.33**	**1.50-10.66**	**122.10-276.73**	**2698.26-5239.86**	**543.12-825.56**	**304.04-470.31**	**45.26-59.00**	**30.00-45.56**	**2.12-3.17**	**26.66-157.00**	**19.19-46.70**

(c): Check

(6.73). Head size index of different genotypes in environment I varied between 140.24 and 288.81 cm^2. Only one genotype, *i.e.*, BR-70 (288.81 cm^2) recorded high head size index and found to be significantly superior to the best check Palam Haritika (228.10 cm^2). In environment II, the range varied for this character between 122.10 and 276.73 cm^2 and none of the genotypes in the present investigation recorded significantly higher head size index than the best check Palam Haritika (276.73 cm^2). However, the genotype Fiesta (270.00 cm^2) followed by Kendi (245.53 cm^2), BR-70 (243.13 cm^2), BR-60 (242.06 cm^2), Altar (240.80 cm^2), Tiltest (238.73 cm^2), Green Magic (231.40 cm^2), Packman (231.23 cm^2), Pluto (228.61 cm^2) and Lucky (224.98 cm^2) was statistically at par with the best check Palam Haritika (276.73 cm^2).

The plant frame of different genotypes varied between 2857.06 and 4799.73 cm^2 and 2698.26 and 5239.86 cm^2 in environment I and environment II, respectively. The genotypes Pluto (4799.73 cm^2) and Altar (5239.86 cm^2) showed the highest plant frame and appeared to be significantly superior to the best check Palam Haritika (3747.26 and 4119.20 cm^2) in environment I and II, respectively. In environment I, the leaf size with leaf stalk of different genotypes varied from 354.95 and 771.21 cm^2. None of the genotypes had significantly higher leaf size with leaf stalk in comparison to the best check Palam Haritika (716.85 cm^2). However, five genotypes *viz.*, Altar (771.21 cm^2), BR-60 (689.58 cm^2), Pluto (686.10 cm^2), BR-70 (679.90 cm^2) and Tiltest (635.82 cm^2) were at par with the best check Palam Haritika (716.85 cm^2). In environment II, the range for this character varied between 543.12 and 825.56 cm^2. The genotype Altar (825.56 cm^2) followed by BR-70 (792.01 cm^2), Pluto (773.96 cm^2), BR-60 (724.37 cm^2), Tiltest (717.57 cm^2) and Green Magic (712.09 cm^2) was found to be statistically at par with the best check Palam Haritika (806.98 cm^2). The leaf size without leaf stalk of various genotypes ranged between 249.70 and 452.82 cm^2 in environment I. The two genotypes namely, BR-70 (452.82 cm^2) and Altar (445.47 cm^2) showed the maximum leaf size without leaf stalk and they appeared to be significantly superior to the best check Palam Haritika (377.22 cm^2). The range for this character in environment II varied from 304.04 to 470.31 cm^2. Nine genotypes *viz.*, Pluto (470.31 cm^2), Altar (454.19 cm^2), Tiltest (412.57 cm^2), CBH-1 (412.01 cm^2), Green Magic (411.61 cm^2), BR-70 (407.28 cm^2), Fiesta (396.81 cm^2), BR-60 (383.26 cm^2) and Lucky (358.16 cm^2) were found to be statistically at par with the best check Palam Haritika (429.89 cm^2).

The plant height up to the longest leaf of various genotypes in environment I ranged from 41.60 to 54.93 cm. The genotypes Altar (52.80 cm) and Pluto (50.86 cm) were statistically at par with best check Palam Haritika (54.93 cm). In environment II, the range for this character varied between 45.26 and 59.00 cm. The genotype Tiltest (59.00 cm) appeared to be significantly tallest in comparison to the best check Palam Haritika (51.36 cm). Plant height up to head in environment I was found to be the maximum (40.36 cm) in Indica and minimum (24.53cm) in Fiesta. In environment II, it was maximum (45.56 cm) in Indica and minimum (30.00 cm) in Lucky. The genotype Indica (40.36 and 45.56 cm) exhibited significantly maximum plant height up to head in comparison to the best check Palam Haritika (31.96 and 36.86 cm) in environment I and II, respectively. A maximum (3.25 and 3.17 cm) stalk length was found in genotype Indica and minimum (2.08 and 2.12 cm) in Fiesta in environment I and II, respectively. The genotype Indica (3.25 and 3.17 cm) recorded significantly the maximum stalk length to the best check Palam Samridhi (2.53 cm, 2.59 cm) in environment I and environment II, respectively. Weight of spears per plant of different genotypes in environment I varied between 15.00 and 173.00 g. The two genotypes *viz.*, Indica (173.00 g) and Kendi (156.00 g) recorded the highest weight of spears per plant and both appeared to be significantly superior to the best check Palam Haritika (110.66 g). In environment II, the range for this character varied between 26.66 and 157.00 g. Only one genotype, *i.e.*, Pluto (157.00 g) was found to be significantly superior

to the best check Palam Haritika (127.33 g). Similar variations in weight of spears per plant in broccoli were also reported by Kalia and Shakuntla (2002). In environment I, the harvest index of various genotypes ranged between 18.37 and 51.77%. On the other hand, in environment II, the range for this character varied from 19.19 to 46.70%. The genotype Altar (51.77 and 46.70%) recorded significantly the highest harvest index to the best check Palam Haritika (43.25 and 38.99%) in environment I and environment II, respectively.

In the present investigation amongst sixteen broccoli genotypes, the genotype Altar showed high yield potential and other desirable economic traits in both the environments. Therefore, it needs to be further tested extensively at different locations of Himachal Pradesh to know its stability. Earliness is one of the desirable traits as the market prices are invariably high in the early season. Results of the present study revealed that genotype CBH-1 was early maturing and took minimum days to first harvest in both the environments.

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