

ORIGINAL ARTICLES

Evaluation of Some Broccoli Cultivars Growth, Head Yield and Quality Under Different Planting Dates

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ABSTRACT

Field experiments were conducted in Nubaria Agricultural station of the National Research center in the winter seasons of 2010-2011 and 2011-2012. Treatments were the combinations of three planting dates (15th Sep. 1st Oct. and 15th Oct.) and five broccoli cultivars (Centauro, Snowball, Heraklion H., Calabrese and Sakura). Medium planting date recorded the tallest plants, the highest fresh weight and dry weight percentage of leaves and heads as well as the highest total head yield , yield increase and its percentage, followed by the early plantation. Head quality of the medium date expressed as height and diameter was the lowest. Late planting date recorded the lowest values of growth, yield and yield increase and its percentage with the best quality. Herklion H. cv. Plants were the tallest, denser leaves , higher fresh weight and dry weight percentage of heads and leaves as well as the highest head yield, yield increase and its percentage with the lowest quality (head height and diameter). On the contrary, the lowest values of growth, and head yield were recorded by sakura cv. but with high head quality. Other cultivars ranged inbetween. With respect to interactions, centauro cv. in the medium planting date was superior in total yield, yield increase and its percentage followed by heraklion in the medium planting date. Lower values of total head yield were obtained by other interactions. The lowest total head yield was obtained by snowball cv. when planted in the late planting date.

Key words: Broccoli, head, yield, cultivars, planting date

Introduction

Broccoli (Brassica Oleracea Var. Italica) is a winter season vegetable crop grown in many countries. Broccoli is a member of Brassicaceae Family as a wild form of this family which is found along the Mediterranean region (Decoteau, 2000). Broccoli is widely cultivated in many European and American countries. Broccoli is highly nutritious and has been deemed as anti-cancerous food by the American Cancer society. It is a good source of vit. A, calcium and Vit. B₂ (Sanders, 1996). Broccoli buds were found to be a rich source of most minerals especially of K.S.P.Mg and micro elements (Aboul-Nasr and Ragab, 2000).

In Egypt, broccoli still grown in a very limited scattered areas and the total cultivated area is not exactly known. However, the cultivation of broccoli started to spread lately where Egypt is ranking the fifteenth in the world production with a total production of 130.000 tons valuing more than 31 milion dollars. China is the top world producer of broccoli (FAO statistics, 2009). Growing broccoli in the newly reclaimed soils is faced by various problems, such as cultivars, fertilization, irrigation as well as poor hydrophilic, chemical and biological properties of the sandy soils. High yielding cultivars with high quality of heads might be introduced to the Egyptian farmers. In addition, the suitable planting dates might be studied for increasing broccoli production. So, many investigators dealt with planting dates under the Egyptian conditions (Diputado and Nichols, 1989; Sharma *et al.*, 1995; Damato *et al.*, 1996; Bianco *et al.*, 1996; Trotta and Damato, 2000; Damato and Trotta, 2000; Damato, 2000; Rozek, 2000; El-Hifny, *et al.*, 2002; Emam, 2005; E l-Hamd and Esmail, 2005; ABou El-Magd *et al.*, 2006; Narendra Kumar *et al.*, 2007; Preeti signal *et al.*, 2009; Hanaa *et al.*, 2010 and Hanaa, 2011).

With respect to cultivars evaluation, many investigators studied some broccoli cultivars (Abou El-Magd *et al.*, 2006; Bianco *et al.*, 1996; Chung, 1985; Damato, 2000; Damato *et al.*, 1996; Diputado and Nichols, 1989; El-Hifny, *et al.*, 2002; Gajewshi *et al.*, 2008; Garcia *et al.*, 2006; Damato and Trotta, 2000; Hanaa *et al.*, 2010 and Hanaa, 2011).

The aim of this work was to study three planting dates and evaluate five broccoli cultivars under newly reclaimed soil conditions.

Materials and Methods

Two field experiments were conducted in the National Research center Agricultural station, Nubaria, Behera Governorate. Broccoli crop was subjected to fifteen treatments which were the combinations of three planting dates and five broccoli cultivars as follows:

A – Planting dates: Early (15th september), Medium (1stOctober) and late (15th October).

B- Broccoli cultivars: Centauro, Snowball, Heraklion H., Calabrese and Sakura.

Treatments of the experiment were arranged in a split-plot design in which planting dates treatments were arranged in the main plots and cultivars were assigned in the sub-plots.

Broccoli seeds were sown in foam trays filled with a mixture of peat moss and washed sand 1:1 in the nursery.

Normal growing system of cruciferous plants was followed in the nursery till transplanting times. After a period of 45 days trays of transplants were carried and transplants were planted in the field.

Every plot included four lines 75 cm. width and 4 m. length. Plot area was then 12 m². Drip irrigation was followed in which drippers were 50 cm. apart and lines 75 cm apart. One broccoli transplant was planted beside every dripper.

Broccoli plants were subjected to the normal agricultural program of growing cruciferous plants in which irrigation, fertilization as well as safe disease and pest control systems were followed.

Data recorded:

A- Vegetative growth: plant height, leaves number, fresh weight of leaves and apical heads as well as dry weight percentage of leaves and heads.

B- Total head yield: sum of the weights of three pickings of the apical heads.

C- Apical head quality: average head weight, diameter and height were recorded at harvest time.

Data were subjected to proper statistical analysis of variance according to **Snedecor and Cochran (1982)**.

Results and Discussion

A- Effect of planting dates:

1- Vegetative growth:

Data in Table (1) indicated that vegetative growth of broccoli plants was significantly affected by planting dates. Planting dates affected vegetative growth of broccoli plants expressed as plant height, leaves number and fresh weight. Medium planting date recorded the tallest plants, higher values of fresh weight of leaves and apical heads as well as their dry weight percentage compared with the early and late planting. The early planting date recorded lower values of vegetative growth parameters compared with the medium planting date. In comparison, the lowest values of vegetative growth parameters were recorded by the late planting date. On the other hand, leaves number of broccoli plant were denser in the early planting date.

These results were similar and true in both seasons of the experiment except head weight percentage which recorded insignificant differences in both seasons. These results were in agreement with those obtained by Metwally, (2006); El-Helaly, (2006); Narendra kumar *et al.*, (2007) and Preti singhal *et al.*, (2009). Hanaa *et al.*, (2010) and Hanaa, (2011) who found that late transplanting in mid oct. recorded the highest vegetative growth expressed as leaf numbers. Stem diameter and dry weight of leaves and stems.

The higher vegetative growth of the medium planting date plants might be due to the better meteorological conditions, i.e., temperature, sunshine and day length of the medium planting date compared with early and late planting dates. This superiority in vegetative growth might be also due to the narrow range of the difference between day and night temperature in the medium compared with early and late planting dates. These moderate conditions allows more photosynthesis and more metabolites reflecting better vegetative growth. In addition, suitable temperature for absorption and translocation of soil solution by the root system.

2- Total head yield:

Total head yield of broccoli crop was significantly affected by planting dates. Yield increase and percentage was also affected by planting dates. The highest values of head yield, head yield increases and yield increase percentage were recorded by the medium planting date. Lower values of total head yield, head yield increase and percentage were obtained by the early planting date. In addition, the lowest total head yield, head yield increase and percentage were recorded by the late planting date. These results were similar in both seasons of the experiment. Results of total head yield, head yield increase and percentage followed the same trend of vegetative growth. These results are in agreement with those obtained by Aboul-Nasr and Rgab, (2000); El-Hamd and Esmail, (2005); Emam, (2005); and El –Helaly, (2006). Hanaa *et al.*, (2010) and Hanaa (2011), who

indicated that primary and secondary head yield were the highest in the late transplanting date (mid Oct.) compared with 15 Sept. and 1st Oct. The highest total yield might be due to its vigor plants with denser leaves which intercept more sunlight, consequently more photosynthesis and compensate more photosynthesizes (carbohydrates, lipids and proteins), which in turn leads to better yield. Moderate temperature allows better photosynthesis and translocation of metabolites reflecting increases in vegetative growth and consequently total head yield.

3- Apical head quality:

Apical head quality expressed as head weight, diameter and height were statistically affected by planting dates. Higher head quality was recorded by the late planting date. Medium planting date recorded lower values of head quality, i.e. weight, height and diameter. The lowest values of apical head quality were obtained by the early planting date. These results were similar and true in both seasons of the experiment. The obtained results did not agree with those obtained by Bracy and Constantin (1991) who found that the greatest head weight was obtained by the early transplanting. They added that transplanting broccoli late produced unacceptable head weight. Aboul-Nasr and Ragab, 2000 reported that the average head weight and diameter was superior at the second planting date compared with the first. Meanwhile, Emam 2005, found that the late transplanting increased head weight and diameter compared with early plantation. In addition, Preeti Singh *et al.*, 2000 mentioned that stalk diameter was optimum when planting on 14 Nov. compared with 15 Oct. and 30 Oct. and the ascorbic acid content in the second year was greatest with late planting. Hanaa, *et al.*, 2010 and Hanaa, 2011 obtained the highest chemical and physical quality, i.e. N, P and K content as well as diameter, height and weight of main heads by late plantation in mid Oct. lower values were obtained by the medium and early plantations.

B. Evaluation of cultivars:

1- Vegetative growth:

Cultivars differed significantly in their vegetative growth expressed as plant height, leaves number as well as fresh weight of leaves and heads and their dry weight percentage. Heraklion hybrid plants were the vigor compared with the other cultivars. Plants of heraklion hybrid were the tallest with denser leaves and high values of fresh weight of leaves and heads and their dry weight percentage. The superiority of Heraklion plants vegetative growth might be owing to its potential heredity. Since it is hybrid cultivar, it allows higher potentiality for absorbing and translocation soil solution to the aerial parts. In addition, higher photosynthetic activity and Higher potentiality for condensation of metabolites which in turn reflects higher vegetative growth rate.

On the contrary, sakura plants recorded the lowest values of the vegetative growth parameters. Centauro, Snowball and calabrese cultivars ranged in their vegetative growth between heraklion hybrid and sakura. Values of their plant height, leaves number as well as fresh weight of leaves and heads and their dry weight percentage lies in between heraklion hybrid and sakura. These results were similar and significant in both seasons of the experiment. In Egypt, wide variations were recorded among vegetative growth of the different cultivars (Aboul – Nasr and Ragab 2000; Abou El-Magd, *et al.*, 2005 & 2006 and El-Helaly, 2006). Similar results were recorded in many foreign countries by Damto, (2000); Damato and Trotta,(2000); Sharma, (2003); Sterret *et al.*, (2004) and Siomos *et al.*, (2004).

2- Total head yield:

Cultivars differed significantly in their total head yield (Table 2). Heraklion hybrid recorded the highest values of total head yield compared with the other cultivars. On the contrary, the lowest head yield was recorded by calabrese cultivar. Centauro, sakura and snowball cvs. ranged in their head yield respectively between heraklion hybrid and calabrese. Higher head yield increases and increase percentage were recorded by heraklion hybrid cv. followed by centauro cv. Lower head yield increase and increase percentage were recorded by sakura and snowball cvs. respectively compared with calabrese. These results were similar and true in both seasons of the experiment. It was clear from these results that head yield results followed the same trend of the vegetative growth to more extent. Since heraklion is a hybrid cv., superior in its vegetative growth, leaf area and fresh weight which allows plants to receive more light energy and consequently more photosynthesis and photosynthetic metabolites which translocated and stored in the main yield. In the addition, potentiality of the hybrid cv., plants for absorbing and translation of soil nutrients might be also of the high yield components. Many investigators studied wide range of broccoli cultivars (Aboul- Nasr and Ragab 2000; Abou El- Magd *et al.*, 2005 & 2006; Hanaa *et al.*, 2010 and Hanaa, 2011)

3- Apical head quality:

Cultivars differed significantly in their head quality. Centauro apical heads were with higher quality compared with the other cvs. Higher head height and diameter were recorded by centauro followed by sakura cv. The lowest values of head height and diameter were recorded by heraklion apical heads. Calabrese and snowball cvs. ranged inbetween these cultivars in their quality of heads. Values of the head height and diameter lies between centauro and heraklion hybrid cvs. These results were similar and true in both seasons of the experiment. Abou El- Magd *et al.*, (2005) found differences in head diameter and number of flower stalks between cvs. Monotop and Atlantic hybrid. Meanwhile, Garcia *et al.*, (2006) evaluated 12 broccoli cultivars and found that the greatest average head weight was recorded by Merit, Monaco and Samson compared with other cultivars. Hanaa *et al.*, (2010) and Hanaa, (2011) found that Decathlon cv. was superior in head quality expressed as diameter, height, TSS and Vit. C. compared with premium crop and Green comet cvs.

C- Interaction of planting dates and cultivars:

1- Vegetative growth:

Vegetative growth of broccoli plants was statistically influenced by the combined effect of planting dates and cultivars. The highest values of vegetative growth were recorded by heraklion H. cv. in the late planting date. The highest values of plant height, leaves number, head fresh weight as well as head and leaf dry weight percentage were recorded by the combined effect of heraklion cv. and late planting date. These results were similar in most cases in the two seasons of the experiment. Higher values of leaves. heads fresh weight and their dry weight percentage were obtained by the combined effect of medium planting date and centauro cv. Hanaa, 2010 and Hanaa *et al.*, 2011 reported that the combined effect of decathlon in the late plantation (15th Oct.) produced higher leaf numbers and higher dry weight of leaves, stems and spears. Some investigators reported that the combined effect of planting date and cultivars affected broccoli growth (Diputado and Nichols, 1989; El-Hifny *et al.*, 2002 and Vagen *et al.*, 2004).

2- Total head yield:

Total head yield was significantly affected by interaction of planting dates and cultivars. The highest total head yield was obtained by the combined effect of the medium planting date and centauro. Planting centauro cv. in the medium planting date outyielded the other interaction treatments. These results indicates that medium planting date and centauro cv. affected total head complementary. These results indicates that medium planting date and centauro cv. dependently. Medium planting date and centauro cv. affected total head yield complementary. The lowest total yield was recorded by the interaction of late planting date and snowball cv. other interaction treatments ranged between these two interaction treatments. In addition, heraklion hybrid when planted in the late, medium or early date produced high considerable yield, respectively. These interaction treatments lies in the second order of interactions. These results were similar and true in both seasons of the experiment. Head yield increase and percentage followed the same trend of the total yield. The high values of yield increase and its percentage were obtained by the combined effect of medium planting date with centauro cv. followed by late planting date combined with heraklion H. Hanaa *et al.*, 2010 and Hanaa, 2011 reported that the combination of the late planting date (15th Oct.) with Decathlon cv. recorded the highest primary and secondary head yields of broccoli.

It seems also that Heraklion H. cv. and planting dates were with complementary effect. In general, it could be concluded from Table (3) that planting dates and cultivars affected broccoli total head yield complementary. Planting dates and cultivars act dependently.

3- Apical head quality:

Head quality expressed as head height and diameter were significantly affected by interaction of planting dates and cultivars. The highest values of head height and diameter were obtained by the combined effect of early plantation and centauro cv. In the second season, the highest head diameter was obtained by the combined effect of medium planting date and centauro cv. other interaction treatment ranged below these values. The lowest head height and diameter were recorded by heraklion and calabrese cvs. in all the planting dates. These results were similar and true in both seasons of the experiment. Hanaa *et al.*, 2010 and Hanaa, 2011 showed that physical and chemical quality of broccoli heads was widely affected by the combined effect of planting dates and cultivars. The highest values of head diameter, height and mean weight were recorded by the late planting date (15th Oct.) of Decathlon hybrid. In addition, the lowest values of head diameter, height and weight were obtained by Green Comet cultivar within the early planting date.

Table 1: Effect of planting dates on vegetative growth, head yield and quality of broccoli heads (2010/2011 and 2011/2012).

Planting dates	Plant height cm	Leaves number	Fresh weight		Dry weight %		Total yield ton /fed	Head height	Head diameter	Yield increase	
			Leaves	Head	Head	Leaf				Ton/fed	%
2011-2012											
Early	53.70	25.40	435.04	254.29	15.79	9.39	3.05	19.22	16.79	0.22	7.8
Medium	55.90	21.80	496.28	343.74	18.67	10.43	4.12	18.66	17.03	1.29	45.6
Late	51.30	19.50	377.46	235.63	14.42	8.36	2.83	21.71	18.79	--	--
LSD	0.49	0.70	26.73	34.23	NS	1.11	0.41	0.92	0.65	--	--
2012-2013											
Early	53.57	26.90	446.37	270.28	16.16	8.84	3.10	17.34	14.45	0.27	9.5
Medium	56.19	22.61	519.24	376.73	19.58	10.08	4.38	16.67	14.74	1.55	54.8
Late	50.72	19.88	377.84	248.07	14.53	7.62	2.83	20.30	16.83	--	--
LSD	1.14	2.15	39.52	18.40	NS	1.01	0.34	0.44	0.76	--	--

Table 2: Effect of varieties on vegetative growth, head yield and quality of broccoli heads (2010/2011 and 2011/2012).

Cultivars	Plant height cm	Leaves number	Fresh weight		Dry weight %		Total yield ton /fed	Head height	Head diameter	Yield increase	
			Leaves	Head	Head	Leaf				Ton/fed	%
2011-2012											
Centauro	52.83	15.00	385.12	320.97	17.05	9.12	3.85	22.45	20.93	1.87	94.4
Snow ball	52.50	23.67	518.55	206.74	15.59	8.23	2.48	18.46	17.87	0.5	25.3
Heraklion H.	56.83	25.83	502.08	482.98	23.12	12.73	5.80	16.13	15.39	3.82	192.9
Calabrese	56.00	27.17	408.57	164.67	10.19	8.63	1.98	20.23	15.92	--	--
Sakura	50.00	19.50	366.96	214.08	15.52	8.25	2.57	22.03	17.57	0.59	29.6
LSD	1.12	1.25	44.06	37.24	NS	1.14	0.44	1.36	0.92	--	--
2012-2013											
Centauro	52.54	14.52	386.97	349.62	17.66	8.52	4.05	21.18	19.37	2.23	122.5
Snow ball	52.15	24.83	545.74	213.69	15.92	7.47	2.42	16.44	15.74	0.60	33.0
Heraklion H.	57.30	27.41	526.15	542.42	24.88	12.82	6.37	13.67	12.79	4.55	250.0
Calabrese	56.31	29.00	414.87	163.62	9.49	7.94	1.82	18.54	13.41	--	--
Sakura	49.17	19.88	365.35	222.43	15.84	7.49	2.53	20.69	15.38	0.71	39.0
LSD	0.63	1.84	38.90	41.99	2.63	0.97	0.71	1.91	1.44	--	--

Table 3: Effect of interaction on vegetative growth, head yield and quality of broccoli heads (2010/2011 and 2011/2012).

Planting dates Cultivars	Plant height cm	Leaves number	Fresh weight		Dry weight %		Total yield ton /fed	Head height	Head diameter	Yield increase		
			Leaves	Head	Head	Leaf				Ton/fed	%	
2011-2012												
Early	Centauro	53.50	15.50	350.52	174.29	14.46	8.60	2.09	26.13	20.91	0.53	34.0
	Snow ball	53.00	27.00	458.55	216.20	18.39	9.80	2.59	16.76	16.49	1.03	66.0
	Heraklion	56.00	26.00	437.82	453.66	20.50	12.00	5.44	13.73	13.50	3.88	248.7
	Calabrese	51.50	33.50	386.46	161.52	10.52	8.25	1.94	19.19	15.26	0.38	24.4
	Sakura	54.50	25.00	541.85	265.79	15.10	8.30	3.19	20.30	17.78	1.63	104.4
Medium	Centauro	58.50	17.50	478.50	621.43	23.97	12.35	7.46	22.02	21.54	5.9	378.2
	Snow ball	53.50	24.00	709.93	273.97	16.93	8.70	3.29	19.88	17.55	1.73	110.9
	Heraklion	56.00	24.50	603.95	474.84	24.25	12.65	5.70	15.07	14.47	4.14	265.4
	Calabrese	65.50	26.00	426.09	165.61	10.52	8.35	1.99	18.50	16.16	0.43	27.6
	Sakura	46.00	17.00	262.92	182.87	17.66	10.10	2.19	17.81	15.44	0.63	40.4
Late	Centauro	46.50	12.00	326.35	167.19	12.72	6.40	2.01	19.19	20.33	0.45	28.8
	Snow ball	51.00	20.00	387.17	130.05	11.44	6.20	1.56	18.75	19.58	--	--
	Heraklion	58.50	27.00	464.49	520.46	24.61	13.55	6.25	19.60	18.21	4.69	300.6
	Calabrese	51.00	22.00	413.17	166.87	9.52	9.30	2.00	23.00	16.34	0.44	28.2
	Sakura	49.50	16.50	296.11	193.58	13.82	6.35	2.32	27.99	19.49	0.76	48.7
LSD	1.94	2.16	76.31	64.49	11.35	1.97	0.77	2.37	NS	--	--	
2012-2013												
Early	Centauro	53.34	15.12	345.79	175.08	14.57	7.90	1.96	25.56	19.35	0.63	47.4
	Snow ball	52.74	28.80	474.34	224.94	19.26	9.33	2.56	14.41	14.09	1.23	92.5
	Heraklion	56.31	27.61	449.68	507.52	21.76	11.95	5.95	10.81	10.54	4.62	347.4
	Calabrese	50.96	36.54	388.56	159.87	9.89	7.49	1.78	17.31	12.63	0.45	33.8
	Sakura	54.53	26.42	573.47	283.96	15.34	7.55	3.27	18.63	15.63	1.94	145.9
Medium	Centauro	59.29	17.50	498.09	707.17	25.90	12.37	8.34	20.67	20.10	7.01	527.1
	Snow ball	53.34	25.23	773.49	293.70	17.51	8.02	3.38	18.13	15.35	2.05	154.1
	Heraklion	56.31	25.83	647.36	532.73	26.22	12.72	6.25	12.40	11.69	4.92	370.0
	Calabrese	67.62	27.61	435.72	164.75	9.89	7.61	1.83	16.49	13.70	0.50	37.6
	Sakura	44.41	16.90	241.54	185.29	18.38	9.69	2.08	15.66	12.84	0.75	56.4
Late	Centauro	45.01	10.95	317.03	166.63	12.51	5.29	1.86	17.31	18.66	0.53	39.8
	Snow ball	50.36	20.47	389.40	122.43	10.98	5.05	1.33	16.78	17.77	--	--
	Heraklion	59.29	28.80	481.41	587.02	26.66	13.79	6.90	17.79	16.14	5.57	418.8
	Calabrese	50.36	22.85	420.34	166.25	8.69	8.74	1.85	21.84	13.91	0.52	39.1
	Sakura	48.58	16.31	281.03	198.03	13.81	5.23	2.23	27.78	17.66	0.92	67.7
LSD	6.02	2.76	59.48	44.41	6.88	1.01	0.39	2.71	3.53	--	--	

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