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Effect of transplant age on growth and yield of broccoli (*Brassica oleracea* var. *italica*)

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ABSTRACT

An experiment was conducted during 2003–04 to find out the effects of transplant age on growth, harvest time and yield of broccoli (*Brassica oleracea* L. var. *italica* Plenck). Broccoli cultivars 'Jade' F_1, 'Monopoly' F_1 and 'Monaco' F_1 were sown on 24 April 2003 and 25 April 2004 and transplanted at 10 days intervals, starting from 23 May 2003 to 24 May 2004, to obtain transplants at age of 30, 40 and 50 days. Transplant age affected growth, harvest time and yield of broccoli significantly. While the highest main head weight (385.1 g), diameter (9.3 cm), length (8.8 cm) and total yield (6054.0 g/lot); lateral shoots number (650.3), weight (39.6 g), diameter (6.4 cm) and length (5.7 cm) were obtained from 30 day-old transplants, the lowest values were obtained from 50 days old transplants in both the years. The effect of transplant age varied with cultivars. Results suggest that 30 days may be a reasonable target age for transplanting broccoli.

Key words: Broccoli, Growth, Harvest time, Transplant age, Yield

Broccoli production in all producer countries including Turkey has been expanding in recent years and the amount of broccoli production in Turkey was 19.890 tons (Tuik, 2008). Transplants are used extensively in Turkey to establish stands of a range of vegetable crops, including broccoli and other crucifer. Considerable research has been conducted on production, quality and establishment of vegetable transplants, particularly for certain solanaceous, crucifer and cucurbit crops (Damato and Trotta 2000, Babik 2001, Yarali *et al.* 2007). Most of the growers currently use transplants to establish broccoli in Turkey and other countries. Studies have been conducted about transplant age, it cannot be determined whether young or old transplant give more positive results or not. These studies sufficiently cloud the issue of transplant age in broccoli and it is recommended that more work must be conducted. Therefore, information on using transplants to produce broccoli is needed.

The issue of transplant age and its possible influence on crop performance is important and growers often contract to receive transplants at specific times and whether conditions may not be ideal for immediate planting in the field. There are concerns in these situations as to whether older or younger transplants will perform satisfactorily once conditions are favourable for planting. Therefore, the objective of this research was to examine the influence of transplant age on growth and yield of broccoli.

MATERIALS AND METHODS

This study was conducted out in field conditions at Atatürk University, College of Agriculture, Erzurum, Turkey in 2003 and 2004. In this study, three broccoli (*Brassica oleracea* L. var. *italica* Plenck) cultivars ('Monaco' F_1, 'Monopoly' F_1 and 'Jade' F_1) were used.

The soil of the experimental area was loamy texture with *p*H 6.5. It had 4.25–4.60% organic matter, 42.5–45.6 kg/ha P_2O_5 and 210–287 kg/ha K_2O in 2003 and 2004.

All plots received 200 kg N/ha and P_2O_5/ha (Elkner 2001) each of ammonium nitrate and triple super phosphate, respectively. Entire quantity of P_2O_5 and half of N fertilizer were applied uniformly prior to planting onto soil surface and incorporated. The remaining N was applied after transplanting when heading began (Decoteau 2000).

Seeds of all cultivars were sown in multiple trays filled with peat in an unheated glasshouse. Transplants were planted on plots of 6 m^2 in the field. Seeds were sown on 24 April in 2003 and 25 April in 2004. To obtain transplants in age 30, 40 and 50 days, seedlings were transplanted on inter-row spacing of 30 cm and intra-row spacing of 45 cm (Jett *et al.*

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1995) in 10 days intervals, starting from 23 May 2003 and 24 May 2004. The plants were irrigated with furrow irrigation. During the development phases, crop management was done on the plants in each plot.

In experiment, the main heads were harvested by hand while the clusters were still compact and before the individual flowers begin to mature (Decoteau 2000). After main heads harvest, lateral shoots (often emerge from the main stalk) were harvested. Main head weight, diameter and length; lateral shoots number, weight, diameter and length and total main head yield were recorded for marketable heads. Observations were recorded on 9 plants selected randomly from 15 plants in each plot.

The experimental design was a completely randomized block design with three replications. ANOVA was applied on the data obtained in this study and the differences between means were compared using Duncan's multiple range test. In addition critical difference (CD) is given in the Tables.

RESULTS AND DISCUSSION

The effects of transplant ages on main head growth of broccoli cultivars are shown in Table 1. The effect of transplant age on weight, diameter and length of head were significant. While the highest main head weight, diameter and length were obtained from 30 day old seedling, the lowest values were recorded on 50 day-old seedlings in 2003 and 2004. In spite of the fact that increasing transplant age from 30 to 50 days, head weight of 'Monaco' $F_1$was lower than 'Jade' F_1 and 'Monopoly' F_1 in 2004, increasing plant age beyond 30 days decreased head diameter on 'Jade' F_1 more than other cultivars. Furthermore, head length of Jade F_1 was longer than 'Monaco' and 'Monopoly' F_1 in both experiment years. It is clearly said that the effect of transplant age varied in cultivars. Field experiments of transplant age indicated that weight, diameter and length of main head decreased due to delayed transplant age from 30 to 50 days in both the years (Table 1).

That total yield and main head yield were affected by transplant age and the lowest yield and main head weight were obtained with 50 days old transplants. Babik (2001) Wlazlo and Kunicki (2003) and Yarali *et al.* (2007) suggested that using young transplants resulted in higher yield and quality. In this study, it is suggested that 30 days is a reasonable target age for transplanting broccoli to have better yield and results of this work confirm Yarali *et al.* (2007), Wlazlo and Kunicki's (2003) and Babik's (2001).

There were significant differences among cultivars for total yield in both years (Table 2). The highest total yield was obtained from 30 day-old transplant ages, while the lowest total yield was observed for the oldest transplants (40 and 50 days). The results indicated that total yield of cultivars, especially 'Monaco' F_1, decreased due to delayed transplant age from 30 to 50 days in 2003 and 2004. 'Jade' F_1 compared to other cultivars ('Monopoly' F_1 and 'Monaco' F_1) showed a better performance in terms of total yield, which ranged from 5 898 to 6 054 g/plot in both experiments.

Yarali *et al.* (2007) and Babik (2001) observed that the oldest transplants reduced yield of broccoli. Wlazlo and Kunicki (2003) suggested that use of young transplants resulted in higher yield and better quality. Results of this

Table 1 Effects of transplant ages on main head growth of broccoli cultivars

Transplant age (days)	Cultivars			Mean
	'Jade' F_1	'Monopoly' F_1	'Monaco' F_1	
	Head weight (g)			
	Experiment I (2003)			
30	367.6^{a}	375.0^{a}	370.4^{a}	371.0^{A}
40	317.1^{a}	305.9^{b}	300.0^{a}	307.7^{B}
50	191.9^{b}	205.1^{c}	215.3^{b}	204.1^{C}
Mean	292.2^{NS}	295.3	295.3	
CD (P = 0.01)	65.31	36.51	73.01	46.86
	Experiment II (2004)			
30	385.1^{a}	373.3^{a}	338.3^{a}	365.6^{A}
40	314.2^{b}	243.3^{b}	231.1^{b}	262.9^{B}
50	199.0^{c}	201.2^{c}	144.9^{c}	181.7^{C}
Mean	299.5^{A}	272.6^{B}	238.1^{C}	
CD (P = 0.01)	45.38	17.05	56.58	33.40
	Head diameter (cm)			
	Experiment I (2003)			
30	8.5^{a}	8.6^{a}	8.6^{a}	8.6^{A}
40	7.2^{b}	7.6^{b}	7.5^{b}	7.5^{B}
50	5.9^{c}	6.1^{c}	6.3^{c}	6.1^{C}
Mean	7.2^{NS}	7.4	7.5	
CD (P = 0.01)	0.90	0.75	0.95	0.68
	Experiment II (2004)			
30	8.6^{a}	9.3^{a}	8.8^{a}	8.9^{A}
40	7.5^{b}	7.8^{b}	7.7^{b}	7.7^{B}
50	6.3^{c}	6.2^{c}	6.5^{c}	6.3^{C}
Mean	7.5^{B}	7.8^{A}	7.7^{AB}	
CD (P = 0.01)	0.81	0.42	0.67	0.51
	Head length (cm)			
	Experiment I (2003)			
30	8.7^{a}	7.2^{a}	7.5^{a}	7.8^{A}
40	7.5^{b}	6.6^{b}	6.5^{b}	6.9^{B}
50	6.8^{b}	6.4^{b}	6.4^{b}	6.5^{C}
Mean	7.7^{A}	6.8^{B}	6.7^{B}	
CD (P = 0.01)	0.90	0.49*	0.78	0.63
	Experiment II (2004)			
30	8.8^{a}	8.1^{a}	7.6^{a}	8.2^{A}
40	7.4^{b}	6.7^{b}	6.5^{b}	6.9^{B}
50	6.9^{b}	6.4^{b}	6.3^{b}	6.6^{B}
Mean	7.7^{A}	7.1^{B}	6.8^{B}	
CD (P = 0.01)	0.64	0.57	0.84	0.54

*P = 0.05; NS, Non-significant. Means with different letters are significantly different at P = 0.01

Table 2 Effects of transplant ages on total yield of broccoli cultivars

Transplant age (days)	Cultivars			Mean
	'Jade' F_1	'Monopoly' F_1	'Monaco' F_1	
	Yield (g/lot)			
	Experiment I (2003)			
30	5898.0^{a}	3498.0^{a}	3495.7^{a}	4297.2^{A}
40	3343.0^{b}	2801.3^{b}	2767.0^{b}	2970.4^{B}
50	2073.3^{c}	1870.0^{c}	1957.0^{c}	1966.8^{C}
Mean	3771.4^{A}	2723.1^{B}	2739.9^{B}	
CD (P = 0.01)	622.34	335.41	657.05	432.62
	Experiment II (2004)			
30	6054.0^{a}	3635.7^{a}	3201.0^{a}	4296.9^{A}
40	3318.7^{b}	2223.0^{b}	2112.7^{b}	2551.5^{B}
50	2199.7^{c}	1824.0^{c}	1325.0^{c}	1782.9^{C}
Mean	3857.5^{A}	2560.9^{B}	2212.9^{C}	
CD (P = 0.01)	544.59	98.11	510.98	337.61

Means with different letters are significantly different at P = 0.01

work were similar and confirmative of recent studies by Yarali *et al.* (2007), Wlazlo and Kunicki (2003) and Babik (2001).

The harvest time of cultivars was affected by transplant age; increasing seedling age delayed harvest time across cultivars (Table 3). Thirty days old transplants of 'Jade' F_1 were harvested earlier than the other transplant ages in both years. Although, the earliest harvest time of 'Monaco' and 'Monopoly' F_1 were observed in 40 days old transplants in 2003. There were no statistical differences between 30 and 40 days old transplants in 2004. In addition, the latest harvest dates were determined in 50 days old transplants of all cultivars in both experiment years. Jade F_1 was the earliest and 'Monaco' and 'Monopoly' F_1 were the latest cultivars;

Table 3 Effects of transplant ages on harvest time of broccoli cultivars

Transplant age (days)	Cultivars			Mean
	'Jade' F_1	'Monopoly' F_1	'Monaco' F_1	
	Experiment I (2003); Harvest time (day)			
30	61.0^{c}	82.0^{b}	82.0^{b}	75.0^{B}
40	71.0^{b}	70.0^{c}	67.0^{c}	69.3^{C}
50	82.0^{a}	106.0^{a}	108.0^{a}	98.7^{A}
Mean	71.3^{B}	86.0^{A}	85.7^{A}	
CD (P = 0.01)	4.28	5.24	6.05	4.07
	Experiment II (2004)			
30	65.0^{c}	87.0^{b}	87.0^{b}	79.7^{C}
40	87.0^{a}	90.0^{b}	90.0^{b}	89.0^{B}
50	78.0^{b}	107.7^{a}	107.0^{a}	97.6^{A}
Mean	76.7^{B}	94.9^{A}	94.7^{A}	
CD (P = 0.01)	6.05	7.28	6.05	5.04

Means with different letters are significantly different at P = 0.01

Table 4 Effects of transplant ages of lateral shoot growth of broccoli cultivars

Transplant age (days)	Cultivars			Mean
	'Jade' F_1	'Monopoly' F_1	'Monaco' F_1	
	Experiment I (2003); Shoot number			
30	526.3^{a}	5.3^{a}	6.0^{a}	179.2^{A}
40	154.0^{b}	3.3^{b}	4.6^{ab}	54.0^{B}
50	118.0^{b}	1.6^{b}	2.0^{b}	40.5^{B}
Mean	266.1^{A}	3.4^{B}	4.2^{B}	
CD (P = 0.01)	69.02	1.75	2.67	30.97
	Experiment II (2004)			
30	650.3^{a}	7.0^{a}	5.0^{a}	220.8^{A}
40	140.6^{b}	3.3^{b}	2.6^{b}	48.9^{B}
50	126.0^{b}	1.7^{b}	2.0^{b}	43.2^{B}
Mean	305.6^{A}	4.0^{B}	3.2^{B}	
CD (P = 0.01)	130.04	2.26	1.76*	58.31
	Experiment I (2003); Shoot weight (g/plant)			
30	4.9^{a}	23.1^{a}	27.2^{a}	18.4^{A}
40	3.2^{b}	14.5^{b}	14.2^{b}	10.6^{B}
50	2.9^{b}	14.3^{b}	9.1^{b}	8.8^{B}
Mean	3.6^{B}	17.3^{A}	16.8^{A}	
CD (P = 0.01)	0.42	4.55	8.29	4.24
	Experiment II (2004)			
30	4.0^{a}	39.6^{a}	31.5^{a}	25.0^{A}
40	3.5^{ab}	9.7^{b}	11.7^{b}	8.3^{B}
50	3.2^{b}	7.7^{b}	10.2^{b}	7.0^{B}
Mean	3.6^{B}	19.0^{A}	17.8^{A}	
CD (P = 0.01)	0.68*	16.02	6.06	7.69
	Experiment I (2003); Shoot diameter (cm)			
30	3.4^{a}	4.3^{a}	3.7^{a}	3.8^{A}
40	3.1^{ab}	2.9^{b}	2.5^{b}	2.8^{B}
50	2.9^{b}	2.9^{b}	2.6^{b}	2.8^{B}
Mean	3.1^{B}	3.4^{A}	2.9^{C}	
CD (P = 0.01)	0.36	0.30	0.23	0.23
	Experiment II (2004)			
30	2.9^{a}	6.4^{a}	2.6^{a}	3.9^{A}
40	2.7^{a}	2.9^{b}	2.5^{ab}	2.7^{B}
50	2.4^{b}	2.1^{b}	2.0^{b}	2.2^{C}
Mean	2.7^{B}	3.8^{A}	2.4^{B}	
CD (P = 0.01)	0.32	0.95	0.48*	0.56
	Experiment I (2003); Shoot length (cm)			
30	5.5^{a}	4.7^{a}	4.0^{a}	4.7^{A}
40	3.5^{b}	3.4^{b}	3.5^{b}	3.5^{B}
50	3.7^{b}	3.5^{b}	3.5^{b}	3.6^{B}
Mean	4.2^{A}	3.9^{B}	3.7^{B}	
CD (P = 0.01)	0.90	0.6^{4}	0.25	0.50
	Experiment II (2004)			
30	5.7^{a}	5.7^{a}	4.1^{a}	5.2^{A}
40	3.6^{b}	3.3^{b}	3.5^{ab}	3.5^{B}
50	3.2^{b}	3.1^{b}	2.8^{b}	3.0^{C}
Mean	4.2^{A}	4.0^{A}	3.5^{B}	
CD (P = 0.01)	0.63	0.37	0.98	0.74

* P = 0.05; Means with different letters are significantly different at P = 0.01

the earliest and the highest yield were determined from the youngest transplants of Jade F_1.

In general, 30 and 40 days old transplants harvested earlier. The trend was toward a reduced harvest time from younger transplants of all cultivars. Damato and Trotta (2000) found differences between cultivars and reported that 'Gran Vert' and 'ML 423' were the earliest and latest cultivars, respectively. These results are in conformity with the findings of Damato and Trotta (2000).

Lateral shoot development was statistically effected by transplant age. Increasing transplant age decreased lateral shoot values across cultivars. In this study, it is clearly observed that increasing transplant age decreased lateral shoot number, weight, diameter and length (Table 4).

As the transplant age influences growth and yield of broccoli cultivars, therefore, growers must consider the transplant age. The trend was towards an increased yield from younger transplants of all cultivars. Experimental results suggest that 30 days may be a reasonable target age for transplanting broccoli and could be used in broccoli growing to have better yield.

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