

Full Length Research Paper

Adaptation of eight American blackberry (*Rubus fruticosus* L.) cultivars for Central Anatolia

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Blackberry is an important fruit plant cultivated for its delicious fruit throughout Europe and America. Although the fruit has wide acceptance in Turkey, it is not cultivated on large scale. The study aimed to evaluate the performance of Arapaho, Black Satin, Cherokee, Chester Thornless, Dirksen Thornless, Jumbo, Navaho and Loch Ness cultivars of American origin for adaptation under Central Anatolian conditions at Ankara during 2002 - 06. The results showed that changes in the environmental conditions affected yield, performance of number of canes, cane length, cane diameter, yield per plant, fruit weight and total acid content (g/l) significantly. Overall comparison of the results showed that cv. Chester Thornless is most suitable for the environmental conditions of Central Anatolia.

Key words: Blackberry, adaptation, Ankara condition, fruit, cane.

INTRODUCTION

The blackberry, belonging to genus *Rubus*, family Rosaceae, is a widespread perennial shrub. It grows in many parts of world including Europe and U.S and has gained considerable importance in Turkey during recent years. It grows to 3 m (10 ft) and produces soft-bodied berries, which are popularly used in the preparation of desserts, jams, seedless jellies and wine. It is known to contain naturally occurring polyphenol antioxidants that can regulate certain beneficial metabolic processes in mammals.

Blackberry is a fruit of mild climate and can easily adapt to different ecological conditions. The plant grows very fast in woods, scrub, hillsides, hedge rows and colonizes large areas in a relatively short time. They are more durable to drought and warm, than raspberries (Keipert 1972, Crocker et al., 1998). It flowers from May to August and ripe to produce purple, black and red colored blackberry fruits. They are categorized into two groups - primocane (vegetative cane) and florican (generative cane), in terms of brunch structure. The brunch that is formed during first year is vegetative in nature turns into

generative canes during second year. Blackberry fruits twice a year; both in autumn (primocane) and spring (floricane).

In addition to the Pacific Northwest of the USA, many blackberry cultivars have been successfully introduced into the United Kingdom, New Zealand, Chile, and the Mediterranean countries. Adaptation performance of blackberry cultivars imported from U.S has shown variable performance in 16 regions of Turkey for 9 years (Agaoglu, 2003). The study aimed to evaluate agronomic performance of eight blackberry cultivars of American origin under Central Anatolian conditions, Turkey for adaptation purpose.

MATERIAL AND METHODS

Field studies were conducted at the Ayas Applied Agricultural Research Farm of the Faculty of Agriculture, University of Ankara, Turkey during 2002 - 06, (32°52' North, 39°56' East). It has a continental climate with wide variations in temperature, both among seasons and different times of day. It has hot and dry summers and cold and wet winters. Monthly mean temperatures, relative humidity and total precipitation under Ankara ecological conditions during the experimental years (Table 1), showed that total precipitation during 2002, 2003, 2004, 2005 and 2006 was 429, 321.1, 321.9, 386.2, and 386.6 mm, respectively. Precipitation had range of 9.3 to 42.9 mm during 2002, 0 to 65 mm during 2003, 0 to 77.9 mm during

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Table 1. Mean monthly temperature and precipitation from 2002 - 2006 for Ankara.

Year		Month												Total
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
2002	Precip. (mm)	39.6	9.3	23.8	102.7	29.6	41.9	42.9	12.2	31.7	25	41.3	29	429
	Temp. (°C)	-3.3	4.9	9.4	11.6	17.7	22.1	25.8	23.5	19.6	14.2	7.8	-0.2	12.8
2003	Precip. (mm)	51.6	43.7	6.9	61.7	27.3	17.7	7	39.1	1.1	65	0	0	321.1
	Temp. (°C)	5.6	0.6	4.2	10.7	20.6	24.1	24.9	25.8	19.3	14.9	8.1	2.5	13.4
2004	Precip. (mm)	77.9	20.1	39.5	37.3	18.6	25.8	4	22.3	9.3	44.2	22.9	0	321.9
	Temp. (°C)	1.2	2.3	7.8	12.7	17.1	21.4	25.7	24	20.9	15.5	7.8	2.7	13.3
2005	Precip. (mm)	29.7	48.2	68.4	62.7	27.5	47.6	18.7	1.8	4.8	15.9	43.9	17	386.2
	Temp. (°C)	3.6	3	6.8	12.5	17.6	20.9	26.3	26.6	20.3	12.2	7.1	3.6	13.4
2006	Precip. (mm)	60.9	84.7	43	14.1	13.3	9.2	39.1	0.3	82.8	19.9	17.5	1.8	386.6
	Temp. (°C)	-0.8	-0.4	8.1	14.3	18.1	23.1	24.7	28.7	19.5	14.9	6.3	1.3	13.2

State Meteorology Institute, Ankara 2006.

2004, 1.8 to 62.7 mm during 2005 and 0.3 to 84.7 mm during 2006. Average monthly temperatures during 2002, 2003, 2004, 2005 and 2006 were 12.8, 13.4, 13.3, 13.4 and 13.3°C, respectively. Average monthly temperatures had range of -0.2 to 25.8°C during 2002, 0.6 to 25.8°C during 2003, 1.2 to 25.7°C during 2004, 3 to 26.6°C during 2005 and -0.8 to 28.7°C during 2006. The soil of experimental area is characterized by 1.4% total soil organic matter, 0.07% total salts, 56% soil saturation percentage, 7.5% lime (CaCO₃), 51.3 kg ha⁻¹ phosphorus (P₂O₅), 1409.8 kg ha⁻¹ potassium (K₂O) with soil pH of 7.2 in distilled water (1.5 v/v).

The adaptation studies were carried out on eight blackberry cultivars; Arapaho, Black Satin, Cherokee, Chester Thornless, Dirksen Thornless, Jumbo, Navaho and Loch Ness. Two rows of each shrub plants were set at 2 x 2 m spacing using Randomised complete design with three replications. Blackberry was harvested in August during each year. Blackberries were weighed as fresh fruit. Average fruit weights were calculated from 50-fruits sampled randomly from each of three plots of each cultivar. Total acid for berries was measured by titration. Number of canes, cane length, cane diameter, yield per plant, fruit weight and total acid content were also determined as described by Eyduran et al. (2007).

The data were analyzed using GLM (General Linear Model) of SAS program with Repeated Random Complete Design (8 cultivar x 5 year x 3 replications), which is analogous to factorial experiment design (SAS, 2006). When cultivar by year interaction effect was significant, the mean differences were evaluated using MSTATC program using Duncan's Multiple Range Test (MSU, 1986).

RESULTS AND DISCUSSION

Plant height of black berry is very important, because it affects blooming. Changes in precipitation and temperatures affected number of canes, cane length, cane diameter, yield per plant, fruit weight and total acid content, which are the important yield components that affected yield performance of number of canes, cane length, cane diameter, yield per plant, fruit weight and total acid content (g/l) significantly ($P < 0.01$) (Table 2). The results showed that number of canes per plant even within same cultivar, varied from year to year. Average number of canes per plant varied from 8.30 to 12.96 per plant during 2002 - 06 period with the highest mean

number of 12.84 canes per plant recorded on cv. Jumbo and minimum mean number of 8.30 canes on cv. Loch Ness (Table 2). This shows that the changes in this character are largely due to the effects of phenotype. Cv. Cherokee (266.82 cm), Chester Thornless (266.78 cm) and Arapaho (263.78 cm) showed longest canes (Table 2). Cv. Dirksen Thornless (189.44 cm) and Black Satin (180.82 cm) were the shortest. The maximum cane length (232.28 cm) was recorded during 2005, and the minimum cane length (220.74 cm) was recorded during 2002.

Plant stem diameter is important character for plants bearing wind and others unfavourable environmental conditions that affect yield ultimately. Cv. Chester Thornless (24.16 mm) had the maximum stem diameter and cv. Black Satin (15.64 mm), Cherokee (15.48 mm) and Dirksen Thornless (15.35 mm) had the minimum stem diameter among all cultivars (Table 2). Although the maximum stem diameter (19.78 mm) was recorded during 2005, the least stem (14.90 mm) was noted during 2002. However, the stem diameter of cv. Chester Thornless did not change significantly during each year, and had a range of 18.20 - 28.20 mm (Table 2).

It was determined that among blackberry cultivar cv. Chester Thornless had the maximum fruit yield from canes (206.60 g). The minimum fruit yield from canes was recorded on cv. Jumbo (56.88 g) (Table 2). Furthermore, a comparison of years showed the minimum and maximum fruit yield from canes during 2002 (93.96 g) and 2005 (113.25 g), respectively. Contrary to other cultivars, with variable performance Chester Thornless was highly stable and had the highest fruit yield from canes during each year. A comparison of blackberry cultivars, showed that cv. Chester Thornless (5.19 g) had the maximum and cv. Black Satin (2.01 g) had the minimum fruit weight (Table 2). Although cv. Chester Thornless and Dirksen Thornless were two with the highest fruit weight during 2002 and 2004; cv. Chester Thornless was found as the best cultivar in general terms

Table 2. Effects of changes in environmental conditions due to years (2002 - 06) on number of canes per plant, cane length, cane diameter, yield per plant, fruit weight and total acid of eight blackberry cultivars of American origin under Central Anatolian conditions.

Cultivars	Number of canes per plant					
	2002	2003	2004	2005	2006	Average
Arapaho	9.50±0.06a	10.50±0.12c	12.50±0.12b	12.20±0.12c	10.10±0.06de	10.96±0.32 D
Black Satin	8.00±0.58b	10.40±0.12c	12.60±0.06b	13.80±0.06b	12.70±0.12b	11.50±0.56 BC
Cherokee	9.70±0.06a	10.30±0.12c	13.30±0.12ab	14.30±0.12ab	11.20±0.12c	11.76±0.47 B
Chester Thornless	10.00±0.58a	10.80±0.06c	9.70±0.12d	10.00±0.58d	9.30±0.12ef	9.96 ±0.19 E
Dirksen Thornless	6.70±0.06c	8.70±0.06d	9.60±0.06d	9.90 ±0.06d	8.90±0.06f	8.76±0.30 F
Jumbo	8.00±0.58b	13.00±1.15a	14.20±0.12a	15.10±0.06a	13.90±0.06a	12.84 ±0.71 A
Navaho	10.00±0.58a	12.00±0.06b	11.00±0.58c	11.70±0.06c	11.00 ±0.58cd	11.14±0.25 CD
Loch Ness	7.00±0.06c	8.30±0.06d	8.00±0.58e	9.70±0.06d	8.50±0.12f	8.30±0.25 G
Average	8.61±0.29 D	10.50±0.33 C	11.36±0.43 B	12.09±0.42 A	10.70±0.37 C	10.65±0.19 F
Cane length (cm)						
Cultivars	2002	2003	2004	2005	2006	Average
Arapaho	268.60±0.12a	268.30±0.12a	258.70±0.12b	263.20±0.06b	260.10±0.06b	263.78±1.09A
Black Satin	170.60±0.12c	181.40±0.12c	171.60±0.12e	190.90±0.06d	189.60±0.12d	180.82±2.29D
Cherokee	265.60±0.06a	270.40±0.12a	260.40±0.12b	270.40±0.12ab	267.30±0.12b	266.82±0.99A
Chester Thornless	223.00±1.15b	225.40±0.06b	297.10±0.06a	295.30±0.12a	293.10±0.06a	266.78±9.30A
Dirksen Thornless	168.00±0.58c	173.00±0.58c	201.30±0.12d	203.50±0.06d	201.40±0.12cd	189.44±4.16D
Jumbo	220.50±0.06b	223.40±0.12b	200.30±0.12d	202.80±0.12d	200.00±0.12d	209.40±0.14C
Navaho	229.30±0.12b	232.70±0.06b	228.90±0.06c	230.50±0.06c	227.10±0.58c	229.80±0.46B
Loch Ness	220.30±0.12b	222.20±0.12b	200.60±0.12d	201.60±0.06d	198.50±0.12d	208.64±2.77C
Average	220.74±7.25 B	224.60±6.84 AB	227.36± 8.13 AB	232.28±7.64 A	229.70 ±9.69 AB	226.93±3.52
Canes diameter (mm)						
Cultivars	2002	2003	2004	2005	2006	Average
Arapaho	17.30±0.06b	20.30±0.06b	22.20±0.12b	23.30±0.06b	21.40±0.12b	20.90±0.55B
Black Satin	10.00±0.58g	13.30±0.12g	18.10±0.06d	19.30±0.12d	17.50±0.06d	15.64±0.93E
Cherokee	16.00±0.58cd	19.20±0.12c	15.40±0.12f	14.70±0.06g	12.10±0.06g	15.48±0.63 E
Chester Thornless	18.20±0.12a	21.20±0.12a	27.00±0.58a	28.20±0.12a	26.20±0.12a	24.16±1.03A
Dirksen Thornless	12.00±0.58f	14.60±0.06f	16.60±0.12e	17.90±0.06e	15.67±0.03e	15.35±0.54E
Jumbo	13.70±0.12e	15.60±0.12e	17.60±0.06d	17.10±0.06f	15.90±0.06e	15.98±0.36D
Navaho	16.40±0.06c	19.30±0.12c	19.10±0.06c	20.80±0.06c	18.80±0.12c	18.88±0.38C
Loch Ness	15.60±0.06d	16.70±0.12d	16.50±0.58e	16.90±0.06f	14.80±0.12f	16.10±0.23D
Average	14.90±0.55 E	17.53±0.56 D	19.06±0.75 B	19.78±0.84 A	17.80±0.85 C	17.82±0.35
Yield per plant (g)						
Cultivars	2002	2003	2004	2005	2006	Average
Arapaho	81.40±0.12d	87.60±0.12d	88.40±0.12e	94.10±0.06e	88.30±0.12f	87.96±1.08D
Black Satin	56.40±0.12g	62.60±0.12f	70.30±0.12g	95.20±0.06d	93.80±0.06d	75.66±4.28G
Cherokee	78.60±0.12e	85.40±0.12e	86.30±0.06f	90.90±0.06g	85.40±0.06g	85.32 ±1.05F
Chester Thornless	203.50±0.12a	210.20±0.12a	200.70±0.06a	210.50±0.12a	208.10±0.06a	206.60±1.03A
Dirksen Thornless	74.60±0.12f	85.60±0.06e	90.80±0.06c	93.20±0.06f	91.00±0.58e	87.04±1.79E
Jumbo	52.70±0.06h	58.90±0.06g	56.90±0.06h	60.70±0.12h	55.20±0.12h	56.88±0.75H
Navaho	120.80±0.12b	130.40±0.06b	140.20±0.12b	158.60±0.12b	153.70±0.12b	140.74±3.76B
Loch Ness	83.70±0.12c	88.50±0.12c	90.20±0.06d	102.80±0.06c	100.60±0.12c	93.16±1.96C
Average	93.96±9.53E	101.15±9.57D	102.98±9.01C	113.25±9.32A	109.51±9.42B	104.17±4.17
Fruit weight (g)						
Cultivars	2002	2003	2004	2005	2006	Average
Arapaho	3.18±0.01c	2.97±0.36cd	3.01±0.01c	3.25±0.01c	3.06±0.01c	3.09±0.07 D
Black Satin	1.56±0.01e	1.93±0.01e	2.06±0.01e	2.34±0.01de	2.15±0.01ef	2.01±0.07 G
Cherokee	2.00±0.58d	2.78±0.01d	2.60±0.06d	2.11±0.06e	2.02±0.01f	2.30±0.13 F
Chester Thornless	5.40±0.06a	5.48±0.01a	5.13±0.01a	5.08±0.01a	4.84±0.01a	5.19±0.06 A

Table 2. Contd.

Dirksen Thornless	5.34±0.01a	5.35±0.01a	4.88±0.01a	4.57±0.01b	4.36±0.01b	4.90±0.11 B
Jumbo	3.86±0.01b	4.24±0.01b	4.07±0.01b	4.36±0.01b	4.18±0.01b	4.14±0.05 C
Navaho	3.16±0.01c	3.25±0.01c	3.04±0.01c	2.97±0.01c	2.73±0.01d	3.03±0.05D
Loch Ness	3.14±0.01c	3.23±0.01c	2.76±0.01cd	2.53±0.01d	2.42±0.01e	2.82±0.09 E
Average	3.46±0.28 B	3.65±0.25 A	3.44±0.22 B	3.40±0.22 B	3.22±0.21 C	3.43±0.10
Total acid (g/l)						
Cultivars	2002	2003	2004	2005	2006	Average
Arapaho	24.50±0.06bc	26.40±0.12bc	29.40±0.12bc	27.40±0.06de	25.20±0.06e	26.58±0.46 D
Black Satin	22.70±0.06cd	27.10±0.06abc	29.70±0.06bc	29.80±0.06 cd	28.70±0.06cd	27.60±0.70 C
Cherokee	20.40±0.06d	29.70±0.12a	30.20±0.12bc	29.30±0.06d	27.10±0.06de	27.34±0.97 C
Chester Thornless	26.90±0.06ab	25.10±0.06c	27.80±0.12c	25.60±0.06e	22.40±0.06f	25.56±0.49 D
Dirksen Thornless	27.40±0.06a	29.40±0.12a	33.60±0.12a	35.10±0.06a	33.50±0.06a	31.80±0.78 A
Jumbo	21.60±0.12d	21.60±0.12d	30.20±0.12bc	32.10±0.06bc	30.00±5.77bc	27.10±1.56 C
Navaho	24.60±0.06abc	25.50±0.06bc	33.20±0.12a	33.90±0.06ab	31.80±0.06ab	29.80±0.57 B
Loch Ness	26.80±0.06ab	28.30±0.06ab	31.30±0.12ab	32.90±0.06ab	30.30±0.06bc	29.90±0.57 B
Average	24.36±0.51 D	26.64±0.52 C	30.68±0.38 A	30.75±0.64 A	28.63±0.93 B	28.21±0.35

Difference between two means in a column with different small letters is significantly different at 0.05 level using Duncan's test.

(Table 2). Fruit weight of cv. Arapaho (3.09 g) in this study was found less compared to those reported by Alleyne and Clark (1996) and Masabni and Wolfe (2002), who found average fruit weight of 3.22 and 3.50 g, respectively. Our finding on fruit weight of cv. Black Satin (2.01 g) was less compared to the fruit weight (3.46 g) of this cultivar reported by Wu and Gu (1995).

Cv. Dirksen Thornless (31.80 g/l) had the highest total acid and the cv. Arapaho (26.58 g/l), and Chester Thornless (25.56 g/l) had the least acidity (Table 2). The highest total acid values of 30.68 and 30.75 g/l were obtained during 2005. The means of the results showed reduced acidity during other years. Results of total acid contents showed great fluctuations from year to year.

Cangi and Islam (2003), reported cane length of 67.3 to 253.2 cm, cane diameter of 3.49 - 7.99 mm and fruit weight of 1.88 - 4.0 g among different cultivars of blackberry with the lowest performance of cv. Jumbo in terms of yield (44.00 g) per plant. In another study carried out at Samsun (Turkey) Black sea region of Turkey, the maximum fruit weight was recorded on the fruits of cv. Jumbo and the minimum fruit weight was recorded on cv. Navaho. Furthermore, the study also showed that cv. Dirksen Thornless, Navaho and Arapaho were among the least acidic cultivars. The results also revealed that cv. Ness and Chester have the best and cv. Cherokee and cv. Boysenberry had the least yield per plant (Akbulut et al., 2003).

Blackberry and raspberry could be harvested more than 3 times a year compared to other perennial plants that are harvested 2 to 3 times (Crandall, 1995). cv. Ness and cv. Jumbo had the least cane diameter. Cv. Jumbo had cumulative yield of 13439.00 g (Gerçekcioglu et al., 2003). It is well-known that ecology of an area affects performance of cultivars which equally holds for black-

berry (Facteau et al., 1986). It is assumed that differences among pomological traits are due to the effects of genotype and environmental variations (Eyduran et al., 2006). A comparison of this study with previous studies shows that ecological conditions seemed to have more effect on blackberry adaptation. Based on the results, it can be safely concluded that cv. Chester Thornless is the most appropriate blackberry cultivar for the ecological conditions of Central Anatolia.

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