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Evaluation of Some Red Raspberry (*Rubus ideaus L.*) Cultivars in Central Anatolia, Turkey

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Abstract

We evaluated red raspberry cultivars for possible recommendation to growers in Central Anatolia. The experimental plots were planted with seven cultivars in 1998. Observations were made over 3 years, on the following traits: berry weight, berry shape, pH, total soluble solids, acidity, sensory analysis, shoot length and diameter and yield. The flowering period lasted 20-40 days and the harvest generally started in the second week of June. Mean berry weights ranged from 1.80 to 3.00 g. Mean yields ranged from 29261 kg.ha^{-1} (for 'Rubin') to 11093 kg.ha^{-1} (for 'Meeker')

Introduction

Although raspberries have been grown and consumed for years in the world, they are new to Turkey. Cultivars may be classified by fruit color and/or fruiting habit. Fruit color may be red, black, purple, or yellow. Red raspberries prefer cooler areas and black raspberries prefer moderate winters and may need to be protected in colder areas. Purple raspberries are hybrids of red and black raspberries and have a growth habit similar to black. Most yellow raspberries are similar to red raspberries in growth habit. Raspberries may also be classified as summer-bearing (floricane fruiting) or ever-bearing (primocane and floricane fruiting). Summer-bearing cultivars produce one crop in early summer (floricane), while ever-bearing cultivars can produce up to two crops a year, one crop being produced in the summer(floricane) and the second crop in the fall (primocane). Most everbearing raspberries are red or yellow (11, 15).

There are many studies (3, 4, 6, 9,10), that characterize fruit and plant of several raspberry cultivars, but none has been examined them for production in Turkey or Middle Eastern countries. In many regions such as Tokat/Turkey, most of growing areas are suitable for raspberry growing (13). The aim of this study was to compare different cultivars to recommend adapted cultivars to farmers of Tokat, Turkey.

Materials and Methods

Seven red raspberry cultivars used in the study were: 'Meeker', 'Tulameen', 'Cola II', 'Newburgh', 'Canby', 'Rubin', and 'Aksu Kırmızısı'. 'Aksu Kırmızısı' is a selection from the Marmara and Black Sea regions in Turkey.

The trial was established in 1998, in a randomized complete block design with three replicates, 30 fruits per replicate. Floricane fruiting cultivars were thinned to 16-20 canes/m^2 in the spring. Trickle irrigation was installed shortly after planting, and water was applied as needed. Fruiting of all cultivars started in 1999 with a small harvest; in this paper the results of 2000 to 2002 are presented. The ecological characteristics of the study area are given in Table 1. The fruits were harvested two or three times a week. Plant characteristics were examined during the dormant period. Yield data were obtained as kg.ha^{-1} (1, 16, 17). Only summer

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Table 1. Ecological characteristics for the experimental area at Tokat, Turkey*

Months	Max. temp.			Min. temp.			Mean temp.			Montly rainfall			Relative humidity		
	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002
Jan.	20.8	11.5	17.4	-9.1	-20.3	-7.3	2.6	-4.5	5.5	2.6	45.1	27.8	82.9	90.6	82.2
Feb.	17.4	18.2	15.0	-14.5	-7.9	-9.0	4.9	4.1	2.2	35.6	20.4	21.8	73.4	76.7	73.7
March	28.8	24.7	15.6	-4.4	-6.6	-9.8	11.3	9.3	3.0	19.3	29.2	16.4	64.4	63.8	75.0
April	29.6	24.0	27.2	1.2	-3.2	-3.8	13.5	11.1	11.0	39.6	68.4	75.6	68.0	76.6	70.2
May	30.0	33.3	33.5	2.7	0.0	-0.2	14.4	15.6	17.0	92.2	16.8	11.8	75.9	65.1	64.6
June	37.5	35.9	33.6	3.6	7.0	3.3	20.2	18.8	18.2	5.6	57.6	11.4	60.6	76.4	66.8
July	40.3	39.4	39.0	7.6	9.3	5.6	23.6	23.2	21.7	1.0	37.6	1.4	64.4	70.4	64.6
Aug.	37.3	37.4	35.9	8.2	7.9	7.4	23.3	21.4	21.2	1.2	11.2	0.2	65.5	72.1	66.5
Sept.	35.2	32.3	36.9	4.9	3.6	4.7	19.6	18.8	16.9	20.4	11.4	37.8	66.8	75.0	77.6
Oct.	29.6	29.4	34.1	-4.8	-4.4	-4.8	11.6	13.4	12.5	15.6	35.8	35.9	74.2	79.6	65.5
Nov.	22.4	23.6	28,0	-8.4	-3.2	-12.8	7.4	6.9	7.0	73.4	33.8	46.7	79.6	86.5	69.6
Dec.	17.3	18.6	25,0	-13.8	-28.0	-28.0	5.1	-2.0	3.2	50.5	25.0	45.9	77.2	86.1	71.4

*:The meteorological station of general directorate of rural services (the elevation is 585 m)

Table 2. Some cane characteristics of seven raspberry cultivars at Tokat, Turkey

Cultivars	1999			2000		
	Cane height(cm)	Cane diameter(mm)*		Cane height(cm)	Cane diameter(mm)*	
		at 5 cm	at 50cm		at 5 cm	at 50cm
Cola II	101	1.07	0.62	159	1.15	0.9
Tulameen	115	0.83	0.67	185	1.04	0.84
Canby	112	0.76	0.61	151	0.95	0.75
Aksu Kırmızısı	120	0.75	0.58	206	1.22	0.97
Meeker	142	0.74	0.56	248	0.88	0.69
Newburgh	112	0.88	0.59	159	0.88	0.69
Rubin	151	1.34	0.95	190	1.44	1.18

* : Cane diameter was measured over soil surface level

yields were considerated for everbearing cultivars. The cane diameter was measured 5 cm and 50 cm above soil level. Mean primocane length and diameter were measured, as recommended by Davidson(6).

Mean fruit weight (g) and fruit dimensions (length and width) of 90 berries were determined. Total soluble solids (TSS) were determined at 20 °C with a hand-held refractometer (Hand Sugar Refractometer, Model WYT-1). The pH was measured in the non-diluted juice, using a pH meter. Total acidity was expressed as percentage of citric acid; aliquots of 5-10 ml berry juice were diluted with 40-50 ml of water. Prepared juice was titrated with 0.1 N NaOH to pH 8.1. This potentiometer titration was performed with a pH combined electrode HI 2031 B / HI 2020 S (1).

A jury made the sensory analysis as recommended by Stevens & Albright (18). A 5–point hedonic scale was used: 1: dislike extremely; 3: either like or dislike and 5: like extremely. Each panelist was asked to note three main components of berry quality: color, firmness and flavor together with overall berry quality.

All the statistical analysis were conducted according to Gomez & Gomez (12). LSD procedure was used to test for significant differences among the raspberry cultivars.

Results and Discussion

Flowering started in all cultivars between March 25 and May 29, and bloom was between March 25 and July 2 (data not shown). Flowering periods were longer in 1999 and 2000 compared to other years.

Starting date of harvest and harvesting periods varied among years and the cultivars (data not shown). In general, harvest started on 29 May and lasted until 4 August (for 'Cola II' and 'Tulameen' in 2001). 'Aksu Kırmızısı' was harvested earlier than the others. Number of harvests was between 7 ('Meeker') and 14 ('Cola II'), and harvest periods varied from 14 days (for 'Meeker' in 2001) to 43 days (for 'Tulameen' in 2000). Phenological characteristics, including harvest periods, vary because of cultivars and ecological conditions (8,17). For example, in a study conducted at Cedar Springs Research Station (Ontario, Canada) between 1999 and 2001, 'Tulameen' was harvested between early and late July (20). The harvest period varied from year to year for this cultivar in Tokat. The earliest harvest was on June 15 (in 2001) and latest was on August 4 (in 2000). In another study carried out in British Columbia (Canada) with this cultivar, the harvest started at the end of June and lasted 6 weeks. Although the starting and finishing times of harvest in this study were

Table 3. Fruit weights (g) of seven raspberry cultivars at Tokat, Turkey

Cultivar	2000	2001	2002	Mean
Cola II	2.39	2.46	2.60	2.48 b
Tulameen	3.46	2.50	3.03	3.00 a
Canby	2.57	1.72	2.12	2.14 d
A.Kırmızısı	2.06	1.97	2.53	2.18 cd
Meeker	2.28	2.25	2.62	2.38 bc
Newburgh	1.69	1.70	2.01	1.80 e
Rubin	2.34	2.17	2.54	2.35 b
Mean	2.40 a	2.11 b	2.54 a	

LSD (Year) : 0.158 ** LSD (Cultivar) :0.241**

LSD (Year x Cultivar) :0.417**

* :Means with same letter are not different at the p=0.05(*) and p=0.01(**)

different from our results, the harvest duration was similar with our results in 2000.

Cane characteristics were observed only in 1999 and 2000 (Table 2). The largest diameter was in 'Rubin (*Bulgarska Rubin*)' in both years. Cane height ranged from 101 cm (for 'Cola II' in 1999) to 248 cm (for 'Meeker' in 2000).

Fruit mean weight ranged from 1.8 g to 3.0 g (Table 3). 'Tulameen' had the largest berry weight for all years followed by 'Cola II' and 'Rubin'. Our results were in agreement with the findings of Zandstra and Watt (21) in Ontario who reported 3.2 g for 'Tulameen'. Strik and Cahn (19) reported berry weights for 'Meeker' approximately 3.0 g in Oregon, higher than our findings.

The yield data of the cultivars used in this study are shown in Table 4. 'Rubin' had the highest average yield and 'Meeker' had the lowest. Yields for all cultivars were low in 2002 due to the dry summer following a harsh winter (16). The heavy fruit load due to everbearing fruiting cultivars as well as non-suitable ecological condition likely had a negative effect on new shoot formation in 2002 (Table 1). Mean yields of 'Meeker' were lower compared to these observations by Finn et al.(9); and mean yields of 'Tulameen' were higher than those found in studies of Finn et al. (9, 10). Zandstra and Watt(20, 21, and 22), and Bergefurd (2).

The highest TSS was in 'Meeker', 'Canby' and 'Tulameen' whereas 'Rubin' had lowest TSS (Table 5). For 'Meeker', cited TSS concentration were 12.07 % , and titratable acidity was 1.58 % (9)., These values are quite similar to our findings. Others reported TSS concentration and titratable acidity were 9.9% and 1.88 % respectively, for 'Tulameen' (3); TSS concentration and titratable acidity were 11.7% and 1.80 %, respectively, for 'Tulameen' (4). Mean TSS of 'Tulameen' in our study was higher than in studies of Daubeny and Anderson (3) and Daubeny and Kempler (4). However, mean acidity of 'Tulameen' in our study was similar to those found by others (Table 6). Mean pH ranged from 3.90 (for 'Tulameen') to 4.14 (for 'A. Kirmizisi'). Our values for pH were higher than values reported for 'Meeker' by Finn et al.(10).

The fruit shape index (length/width) of cultivars was circular and around 1.0 except of 'Tulameen' in which the fruit index was 1.14. Based on the texture and flavor, the cultivars 'Aksu Kırmızısı', 'Meeker' and 'Newburgh' can be categorized as the best, the

Table 4. Yield(kg.ha $^{-1}$) of seven raspberry cultivars at Tokat location, Turkey

Cultivar	2000	2001	2002	Mean
Cola II	16365	25918	7502	16595 b
Tulameen	25902	16201	5892	15998 bc
Canby	16931	13534	5615	12026 cd
Aksu Kırmızısı	17599	22591	11274	17155 b
Meeker	12942	10872	9463	11093 d
Newburgh	21934	18556	7747	16079 bc
Rubin	35233	32489	20062	29261 a
Mean	20987a	20223a	9651b	

LSD (Year) : 2892 ** LSD (Cultivar) : 4417** LSD (Year x Cultivar) :7650**

* :Means with same letter are not different at the p=0.05(*) and p=0.01(**)

Table 5. Total soluble solids of seven raspberry cultivars at Tokat, Turkey

Cultivar	2000	2001	2002	Mean
Cola II	10.17	12.19	11.50	11.29 b
Tulameen	12.22	12.69	12.25	12.39 a
Canby	11.67	13.25	11.80	12.24 a
A.Kırmızısı	10.89	11.97	10.27	11.04 b
Meeker	13.39	13.17	11.97	12.84 a
Newburgh	11.17	11.80	10.92	11.30 b
Rubin	9.89	11.13	9.20	10.07 c
Mean	11.34 b	12.32 a	11.13 b	

LSD (Year) : 0.500 ** LSD (Cultivar) :0.763** LSD (Year xCultivar) : 1.322 (ns)

ns: no significant

* :Means with same letter are not different at the p=0.05(*) and p=0.01(**)

Table 6. Total acidity(%) of seven raspberry cultivars at Tokat, Turkey

Cultivar	2000	2001	2002	Mean
Cola II	2.00	2.00	2.25	2.08 a
Tulameen	2.02	1.88	1.85	1.92 ab
Canby	1.79	1.84	2.03	1.89 b
A. Kırmızısı	1.44	1.58	1.67	1.56 c
Meeker	1.60	1.64	1.60	1.61 c
Newburgh	1.58	1.77	2.21	1.85 b
Rubin	1.68	2.18	2.06	1.97 ab
Mean	1.73 b	1.84 ab	1.95 a	

LSD (Year) : 0.116 ** LSD (Cultivar) :0.177**

LSD (YearxCultivar) :0.307*

* :Means with same letter are not different at the p=0.05(*) and p=0.01(**)

cultvars. 'Canby' and 'Rubin' can be categorized as good, and 'Cola II', and 'Tulameen' can be categorized as medium quality according to Stevens & Albright (18).

Conclusions

Among the tested cultivars, 'Rubin' seems to have better yield and fruit characteristics than the others. 'Cola II', 'Aksu Kırmızısı' and 'Tulameen' also had acceptable results and can be recommended to growers. In conclusion, floricane-fruiting red raspberry has good potential as a commercial crop in the Central Anatolia region of Turkey for fresh and processing markets.

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