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Full Length Research Paper

Effects of harvesting time on some yield and quality traits of different maturing potato cultivars

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The effect of harvesting time was investigated on yield and quality traits for spring season production in different maturing potato (*Solanum tuberosum* L.) cultivars under agro-climatic conditions of southern of Turkey in 2006 and 2007. The experimental layout was a randomized split plot with three replications, including six potato cultivars as main plots and four harvesting times as subplots. The cultivars tested were adora (early), carrera (early), felsina (mid-early), marfona (mid-early), mondial (mid-late) and vangogh (mid-late). Samples of tubers were harvested at 75, 90, 105 and 120 days after planting (DAP) in spring crop. Early cultivars carrera and felsina gave more than 2 t ha^{-1} tuber yield at 120 DAP. However, vangogh and mondial (mid-late cultivars) proved to be superior cultivars in relation to dry matter, specific gravity or starch content at 105 DAP.

Key words: Potato, harvesting time, cultivar, yield, quality.

INTRODUCTION

Abiotic factors, such as drought and high temperature are the major constrains for potato production limiting tuber yield and affecting tuber quality in southern of Turkey. In several countries of Mediterranean Basin, such as north African countries, Cyprus, Turkey and in southern Italy, potatoes are not grown in the usual cycle (spring-summer) due to high temperatures and considerable demand for water, but are mainly grown in off season cycles (mainly winter-spring and summer-autumn) for early potato production (Ierna, 2009). However, the main growing areas are those of the Central Anatolia of Turkey, where it is usual that most potatoes are lifted in September or October. There is still an increasing demand for early tubers, harvested at different stages of their maturity and consumed as cooked potatoes. Thus, potatoes in Mediterranean region of Turkey are harvested before reaching maturity, extends from the mid-May to the end of June, particularly, when prices are high. The growing period for early potatoes are extremely short; only 50 to 80 days from planting to harvest. As tuber yield and quality during a short growing season are affected mainly by intercepted radiation, methods to increase tuber yield should focus on reducing the time to emergence, improving haulm growth after emergence and increasing the harvest index (Mustonen, 2004). Furthermore, tuber's yield and quality of potato crop depend mainly on a genotype and weather conditions, as well as cultivation technology. The purpose of this study is to define the influence of harvesting time and different maturing potato varieties on yield and quality of early potatoes.

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MATERIALS AND METHODS

Field trials were carried out in Diyarbakir, Turkey during 2006 and 2007 spring growing season to compare for tuber yield, mean tuber fresh mass, tuber number per plant, tuber dry matter, specific gravity and starch content of different maturing potato cultivar (early: adora and carrera; mid-early: felsina and marfona; mid-late: mondial and vangogh) harvested at different date (15 days interval from 15th May to 30th June).

Diyarbakir province is located in south east Anatolian region of Turkey. Soils are classified as clay. The region has a warm climate in summer and the mean annual rainfall is around 450 mm, most of which fall in a major cropping season which extends from November to June. Thus, the region is a typical area for off-season (winter-spring) potato cultivation. Monthly rainfall, mean air temperature and humidity for 2006 and 2007 are presented in Table 1. As seen in Table 1, throughout the winter-spring crop, the mean monthly temperatures gradually increased from 20.4°C to 31.5°C in

Table 1. Monthly temperature (°C), rainfall (mm) and humidity (%) in Diyarbakir, Turkey in the years 2006 and 2007.

Months	Mean temperature (°C)		Rainfall (mm)		Humidity (%)	
	2006	2007	2006	2007	2006	2007
March	20.4	18.0	5.4	97.5	45.0	54.0
April	26.4	26.4	26.9	16.0	24.5	23.3
May	31.5	31.1	0.0	0.0	14.0	11.9
June	31.5	30.0	0.3	0.0	14.6	14.1

Source: Diyarbakir Meteorology Bulletin.

Table 2. Analysis of variance for marketable tuber yield, mean tuber fresh mass, tuber number per plant, tuber dry matter, specific gravity and starch content of potato cultivars harvested at different times, 2006 and 2007.

Source of variation	DF	Marketable tuber yield (t ha^{-1})	Mean tuber fresh mass (g)	Tuber number per plant	Tuber dry matter (%)	Specific gravity	Starch content (%)
Year (Y)	1	*	ns	ns	ns	ns	ns
Harvesting time (HT)	3	**	**	**	**	**	**
Y x HT	3	ns	*	ns	ns	ns	ns
Cultivar(C)	5	**	**	**	**	**	**
Y x C	5	ns	**	ns	ns	ns	ns
HT x C	15	**	**	**	**	**	**
Y x HT x C	15	ns	**	ns	ns	ns	ns
CV%		15.5	13.9	14.6	13.2	0.6	10.4

DF: Degrees of freedom; CV: coefficient variation. **, *significant at $P \leq 0.01$ and 0.05, respectively; ns, non significant.

2006, from 18.0 to 30.0°C in 2007. Climatic data were taken from weather station in Diyarbakir.

The experiment was undertaken in a randomized split-plot design with three replications, including six cultivars as main plots and four harvesting time as subplots. The four tuber harvests in both years were realized at 75, 90, 105 and 120 days after planting (DAP) in winter-spring crop. The size of each plot in six rows was 4.2 x 6.0 m. Row spacing was 0.7 m and the distance between plants in the row was 0.3 m, providing a sowing density of 4.7 plants m^2. Sowing was carried out on March 1 in both years. The crop was fertilized with 100 kg N and 100 kg P_2O_5 ha^{-1} applied as basal dose in the form of 20-20-0 fertilizer prior to sowing. In addition, top dressing nitrogen was provided at the time of emergence at the rate of 100 kg ha^{-1} as ammonium nitrate (33% N) for all plots. Tubers were harvested at bi-weekly intervals from mid-May to late-June. For each harvesting time, the harvest area consisted of 20 plants from the centre plot. Tubers were selected by diameter class as marketable tuber (35 <mm), counted and weighed to determine tuber yield, tuber fresh mass and tuber number per plant. Selected tubers were washed to remove any soil, blotted dry and sliced into strips 10 mm wide but with differing lengths. The dry matter of fresh potato tubers was determined after being dried at 65°C and until constant weight was achieved (AOAC, 2005). Specific gravity was determined using a standard Zeal potato hydrometer requiring a 3.63 kg subsample (Draper et al., 1979). The percentage of starch was calculated from specific gravity measurements using the regression equations of C. Von Scheele (Murphy and Michael 1959). All values are mean of observations in three independent samples.

Data were subjected to analyses of variance (ANOVA) using the general linear model (GLM) of the Statistical Package for the Social Sciences (SPSS) 12.0 version for years, cultivar and harvest time. When the F test was significant ($P > 0.05$) the Tukey's test for paired comparisons was used to compare means.

RESULTS AND DISCUSSION

Analysis of variance

The combined analyses of variance for tuber yield, mean tuber fresh mass, tuber number per plant, tuber dry matter, specific gravity and starch content are shown in Table 2. Year main effects influenced only tuber yield. The main effects of harvesting time were significant for all characters examined. Similarly, all characters examined varied among the genotypes. In general, all interactions were not significant for most of the tested characters except for mean tuber fresh mass. However, cultivars differed in their response to harvesting time as indicated between harvesting time and cultivar treatments for all characters examined.

Effects of years

Year main effects influenced only tuber yield (Table 2). On average of harvesting time and cultivar, tuber yields were 13.0 and 13.8 t ha^{-1} in 2006 and 2007, respectively.

Tuber yield was higher in 2007, averaging 0.8 t ha^{-1}

Table 3. Marketable tuber yield (t ha^{-1}) of potato as affected by harvesting time and cultivar interaction, 2006 to 2007 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)									
	2006					2007				
	75	90	105	120	Mean	75	90	105	120	Mean
Adora	6.7 ± 0.3	11.6 ± 1.8	13.0 ± 1.3	14.9 ± 2.2	11.5 ± 1.1	7.1 ± 0.2	11.6 ± 0.8	13.6 ± 1.1	16.3 ± 1.0	12.1 ± 1.1
Carrera	9.1 ± 0.2	16.6 ± 1.5	18.2 ± 3.1	21.4 ± 0.9	16.3 ± 1.6	10.3 ± 0.6	18.5 ± 1.0	18.8 ± 1.0	21.4 ± 1.2	17.3 ± 1.3
Felsina	9.7 ± 0.3	10.9 ± 0.7	11.6 ± 0.7	24.6 ± 1.9	14.2 ± 1.9	9.3 ± 1.2	10.3 ± 0.5	10.9 ± 0.5	27.8 ± 1.6	14.6 ± 2.3
Marfona	10.1 ± 0.2	11.0 ± 1.1	14.4 ± 3.1	14.7 ± 2.5	12.5 ± 1.1	11.4 ± 0.2	11.8 ± 0.6	16.7 ± 0.7	17.5 ± 0.5	14.3 ± 0.9
Mondial	8.5 ± 1.1	9.3 ± 0.4	12.4 ± 0.6	14.6 ± 2.0	11.2 ± 0.9	7.1 ± 0.9	9.6 ± 0.6	11.5 ± 0.5	14.7 ± 0.6	10.7 ± 0.9
Van Gogh	9.4 ± 0.9	12.5 ± 1.5	13.4 ± 0.8	13.4 ± 1.5	12.2 ± 0.7	10.3 ± 0.5	14.0 ± 1.2	14.9 ± 1.3	15.2 ± 1.3	13.6 ± 0.8
Mean	8.9 ± 0.5	12.0 ± 0.9	13.8 ± 0.7	17.2 ± 1.2	13.0 ± 0.5	9.2 ± 0.5	12.6 ± 0.8	14.4 ± 0.9	18.8 ± 1.2	13.8 ± 0.6

LSD (0.05) 4.7**.

Table 4. Mean tuber fresh mass (g) of potato as affected by harvesting time and cultivar interaction, 2006-2007 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)									
	2006					2007				
	75	90	105	120	Mean	75	90	105	120	Mean
Adora	29.0 ± 3.7	43.1 ± 2.4	58.5 ± 2.5	78.2 ± 0.5	52.2 ± 5.6	28.0 ± 1.3	49.6 ± 2.8	57.5 ± 2.2	79.3 ± 1.2	53.6 ± 5.6
Carrera	41.4 ± 4.0	54.6 ± 0.4	66.9 ± 5.3	79.6 ± 1.4	60.7 ± 4.5	43.9 ± 2.8	58.3 ± 1.7	69.7 ± 1.7	96.6 ± 1.9	67.1 ± 5.9
Felsina	37.7 ± 2.1	41.6 ± 3.9	63.1 ± 2.7	86.6 ± 1.9	57.2 ± 6.0	30.7 ± 2.3	44.0 ± 3.0	53.0 ± 2.2	92.2 ± 2.4	55.0 ± 6.9
Marfona	41.6 ± 2.9	44.2 ± 4.9	46.0 ± 2.7	76.5 ± 2.4	52.1 ± 4.5	45.7 ± 0.6	46.7 ± 2.1	49.0 ± 5.3	85.2 ± 4.2	56.2 ± 5.2
Mondial	37.7 ± 2.6	37.4 ± 1.3	53.9 ± 3.1	76.8 ± 0.3	51.5 ± 4.9	27.7 ± 1.7	34.7 ± 1.5	46.7 ± 1.2	71.6 ± 3.7	45.2 ± 5.1
Van Gogh	37.6 ± 5.6	56.1 ± 3.4	65.0 ± 2.2	84.2 ± 4.0	60.7 ± 5.3	38.1 ± 1.1	67.8 ± 2.3	68.1 ± 3.9	87.2 ± 3.2	65.3 ± 5.4
Mean	37.5 ± 1.6	46.2 ± 2.4	58.9 ± 2.5	80.3 ± 1.2	55.7 ± 2.1	35.7 ± 2.2	50.2 ± 2.6	57.3 ± 2.6	85.3 ± 2.2	57.1 ± 2.4

LSD (0.05) 6.8**

more tuber yield than in 2006. The differences between years for tuber yield may be due to yearly environmental variation, especially in initial growth period in March. In this respect, the considerable difference in temperature as well as rainfall between the years is noteworthy (Table 1). The rest of the evaluated parameters were not significantly different between the two years.

Effects of harvesting time

Time of harvesting had significant effects on tuber yield, mean tuber fresh mass, tuber number, tuber dry matter, specific gravity and starch content ($P < 0.01$). Tuber yield increased from 8.9 to 17.2 t ha^{-1} and from 9.2 to 18.8 t ha^{-1} in 2006 and 2007, respectively, when harvesting was delayed from 75 to 120 days from planting. At the first harvest, (75 DAP) tuber yield was lower than 105 and 120 DAP (Table 3).

Tuber yield increased with the progress of growth and maturing of the tuber. This may be explained with a progressive increase of day- length and sunlight intensity during the crop cycle (Ierna, 2009). Similarly, mean tuber fresh mass increased from 37.5 to 80.3 g in 2006, from 35.7 to 85.3 g in 2007 as harvesting was delayed (Table 4). The results indicate that the tuber fresh mass increased significantly with incremental increase in harvesting time. At the earliest harvest, (75 DAP) the average tuber fresh mass was 37.5 and 35.7 g in 2006 and 2007, respectively. The tuber fresh mass increase during the last 15 days (105 to 120 DAP) was 21.4 and 28 g in 2006 and 2007, respectively, resulting in average tuber fresh mass of 80.3 and 85.3 g in 2006 and 2007, respectively. These results are in agreement with finding of Ierna (2009) and Ozkaynak et al. (2005).

Tuber number per plant also changed significantly with time of harvest, their highest tuber number was attained when plants were harvested after 120 days of planting (Table 5). Tuber number per plant data reveals significant increase with extension in harvest time. The lowest tuber number of 3.8 $plant^{-1}$ (in 2006) and 4.2 $plant^{-1}$ (in 2007) in this experiment was recorded at 75 DAP. There was an incremental increase in tuber number when crop was allowed in the field for longer growth period. Results showed that, tuber number at 120 DAP was significantly more than the tuber number obtained in 75 DAP.

Table 5. Tuber number per plant of potato as affected by harvesting time and cultivar interaction, 2006-2007 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)									
	2006					2007				
	75	90	105	120	Mean	75	90	105	120	Mean
Adora	3.7 ± 0.4	4.3 ± 0.2	4.8 ± 0.6	5.7 ± 0.9	4.6 ± 0.3	4.2 ± 0.4	4.8 ± 0.6	5.0 ± 0.6	5.3 ± 0.3	4.8 ± 0.2
Carrera	4.7 ± 0.3	5.0 ± 0.7	5.6 ± 0.5	7.0 ± 1.1	5.6 ± 0.4	4.5 ± 0.3	5.0 ± 0.6	5.7 ± 0.3	6.7 ± 0.3	5.5 ± 0.3
Felsina	3.7 ± 0.3	4.8 ± 0.4	5.8 ± 0.4	6.0 ± 0.6	5.1 ± 0.3	4.3 ± 0.3	4.8 ± 0.4	6.3 ± 0.3	6.3 ± 0.3	5.5 ± 0.3
Marfona	3.7 ± 0.5	4.7 ± 0.3	5.5 ± 0.8	6.7 ± 0.9	5.1 ± 0.4	4.1 ± 0.3	5.0 ± 0.6	5.3 ± 0.3	7.7 ± 0.3	5.5 ± 0.4
Mondial	3.5 ± 0.3	3.9 ± 0.5	4.5 ± 0.3	7.0 ± 0.6	4.7 ± 0.4	4.3 ± 0.3	4.2 ± 0.4	5.3 ± 0.3	7.0 ± 0.6	5.2 ± 0.4
Van Gogh	3.5 ± 0.4	4.2 ± 0.2	4.7 ± 0.3	5.2 ± 0.2	4.4 ± 0.2	3.8 ± 0.4	4.3 ± 0.3	4.7 ± 0.7	5.5 ± 0.3	4.6 ± 0.5
Mean	3.8 ± 0.2	4.5 ± 0.4	5.4 ± 0.2	6.3 ± 0.3	4.9 ± 0.2	4.2 ± 0.2	4.7 ± 0.4	5.4 ± 0.2	6.4 ± 0.2	5.2 ± 0.1

LSD (0.05) 1.9**

However, tuber number at 75, 90 and 105 DAP was non-significantly different.

The specific gravity, starch content and dry matter of the potato were determined at each harvest stage. When averaged over cultivar, harvesting time differ significantly in tuber dry matter percentage. Differences in dry matter concentration among harvesting time were minor between 90 and 120 DAP, but highest dry matter percentage were observed at 105 DAP with 23.5% and 23.4 in 2006 and 2007, respectively (Table 6).

As seen in Table 7, delaying harvest until 105 DAP resulted in greater specific gravity. However, the results indicate that tuber specific gravity decreased in late harvesting time (120 DAP), which were harvested at warmer part of the season, showing that cooler temperatures during harvesting time is more crucial to the tuber specific gravity under warmer condition. The results showed that, like other parameters, starch content also varied significantly with harvesting time. It was higher when the crop harvests delayed to 105 DAP. The highest starch content was recorded at 105 DAP in both years (14%). When the crop is harvested at 75 DAP, the starch content decreased significantly with incremental decrease in harvest time so that at 75 DAP, it decreased to 13.2 and 13.1% in 2006 and 2007, respectively.

Since potato tubers are storage organs, the results indicated a reasonable trend of starch accumulation as harvesting is delayed from 75 to 105 DAP (Ali et al., 2003). The starch content of 13.2% (in 2006) and 13.1% (in 2007) at 75 DAP, gradually increased to 13.6 and 14.0% at 90 and 105 DAP. However, the difference in starch content between 90 and 105 DAP was non-significant. Starch content decreased after 105 DAP. Thus, harvesting on mid-June (105 DAP) resulted in higher specific gravity and starch content over crop harvest on late-June (120 DAP). This data suggest that, tuber dry matter accumulation was affected by late harvesting time which led to reduction in dry matter accumulation as a result of slow growth at high temperatures. The optimal range for tuber growth is 15 to 20°C and as temperatures rise to 27°C, tuber dry matter percentage decrease (Yamaguchi et al., 1964).

Effect of cultivar and interactions

Marketable tuber yield for cultivars are presented in Table 3. Significant differences were observed among cultivars for tuber yield. It appeared that carrera produced the maximum tuber yield (16.3 and 17.3 t ha^{-1}, in 2006 and 2007, respectively), which was significantly different from adora and mondial. The interaction effects of harvesting time and cultivar in respect of tuber yield ranged from 6.7 to 7.1 t ha^{-1} (in 2006 and 2007, respectively) and 24.6 to 27.8 t ha^{-1} (in 2006 and 2007, respectively). Thus, maximum tuber yield was recorded at late harvesting time (120 DAP) in association with carrera, while the minimum tuber yield was found in adora when harvested early (75 DAP) in each years.

Analysis of variance showed that the cultivar had significant influence on the tuber fresh mass (Table 2). The maximum weight of tuber was noted in carrera and vangogh (60.7 g in 2006 and 67.1 to 65.3 g in 2007), while it was minimum in mondial (51.5 and 45.2 g, in 2006 and 2007, respectively). Carrera (early cultivar) showed the highest tuber fresh mass. This was expected because carrera is a fast bulking cultivar which produces large tubers and high yield. Although, vangogh is mid-late cultivar, it had also the highest tuber fresh mass as aresult of the lowest tuber number per plant. The interaction between harvesting time and cultivar were found to be significant (Table 2). The highest tuber fresh mass were obtained with the interaction of late harvesting time and felsina in 2006 (86.6 g) and late harvesting time and carrera, in 2007 (96.6 g) (Table 4). Murti et al. (1979) showed that under warmer conditions tuber initiation is influenced greatly by night temperatures. In Diyarbakir, low night temperatures during growing period caused an increase of tuber initiation and accumulation until 120 DAP.

Table 6. Tuber dry matter (%) of potato as affected by harvesting time and cultivar interaction, 2006-2007 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)									
	2006					2007				
	75	90	105	120	Mean	75	90	105	120	Mean
Adora	18.6 ± 0.7	20.8 ± 1.1	21.3 ± 1.2	20.1 ± 1.4	20.2 ± 0.6	17.9 ± 0.1	19.6 ± 0.4	21.5 ±0 .3	20.4 ± 0.7	19.8 ± 0.4
Carrera	19.9 ± 0.8	20.8 ± 1.4	23.4 ± 1.0	19.9 ± 0.5	21.0 ± 0.6	19.6 ± 0.8	20.4 ± 0.4	24.4 ± 0.7	19.5 ± 0.5	21.0 ± 0.6
Felsina	18.9 ± 0.4	18.7 ± 1.7	19.8 ± 0.5	21.7 ± 0.5	19.7 ± 0.5	18.9 ± 0.2	18.7 ± 0.7	20.0 ± 0.5	21.4 ± 0.3	19.7 ± 0.4
Marfona	21.1 ± 0.4	23.1 ± 0.7	22.8 ± 1.0	22.9 ± 0.3	22.5 ± 0.4	20.4 ± 0.6	21.8 ± 0.5	22.7 ± 0.5	22.4 ± 0.8	21.8 ± 0.4
Mondial	20.7 ± 0.5	22.9 ± 1.6	24.6 ± 1.2	24.7 ± 0.6	23.2 ± 0.7	20.7 ± 0.3	25.2 ± 0.6	24.4 ± 0.7	24.2 ± 0.5	23.6 ± 0.6
Van Gogh	24.2 ± 0.8	27.1 ± 1.0	29.2 ± 1.4	26.2 ± 1.3	26.7 ± 0.7	24.0 ± 0.1	26.6 ± 0.5	27.4 ± 0.6	26.0 ± 0.9	26.0 ± 0.5
Mean	20.6 ± 0.5	22.2 ± 0.8	23.5 ± 0.8	22.6 ± 0.6	22.2 ± 0.4	20.2 ± 0.5	22.0 ± 0.7	23.4 ± 0.6	22.3 ± 0.6	22.0 ± 0.3

LSD (0.05) 0.9**

Table 7. Specific gravity of potato tubers as affected by harvesting time and cultivar interaction, 2006 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)				
	75	90	105	120	Mean
Adora	1.0673 ± 0.0003	1.0730 ± 0.0001	1.0713 ± 0.0006	1.0700 ± 0.0011	1.0697 ± 0.0007
Carrera	1.0687 ± 0.0006	1.0747 ± 0.0003	1.0720 ± 0.0001	1.0700 ± 0.0001	1.0713 ± 0.0006
Felsina	1.0727 ± 0.0006	1.0740 ± 0.0001	1.0770 ± 0.0010	1.0750 ± 0.0005	1.0747 ± 0.0005
Marfona	1.0750 ± 0.0010	1.0797 ± 0.0003	1.0826 ± 0.0014	1.0817 ± 0.0003	1.0797 ± 0.0009
Mondial	1.0837 ± 0.0006	1.0800 ± 0.0001	1.0813 ± 0.0009	1.0800 ± 0.0005	1.0812 ± 0.0005
Van Gogh	1.0853 ± 0.0003	1.0860 ± 0.0017	1.0960 ± 0.0006	1.0890 ± 0.0005	1.0891 ± 0.0013
Mean	1.0754 ± 0.0017	1.0779 ± 0.0011	1.0800 ± 0.0022	1.0776 ± 0.0016	1.0776 ± 0.0008

LSD (0.05) 0.0026**

When averaged over harvesting time, potato cultivars differed significantly in tuber number per plant ($P < 0.01$). Differences in tuber number among cultivars were minor with carrera having the highest value (5.6 and 5.5 plant^{-1} in 2006 and 2007, respectively) and vangogh being the lowest in tuber number (4.4 and 4.6 plant^{-1} in 2006 and 2007, respectively). Statistically significant interaction occurred between the effects of harvesting time and cultivars on tuber number per plant ($P > 0.01$). Although, carrera and mondial had relatively higher tuber number when harvested 120 DAP in 2006 (7.0 no. plant^{-1}), marfona yielded the higher tuber number when harvested 120 DAP in 2007 (7.7 no. plant^{-1}). Similar results were reported by Ozkaynak et al. (2005) and Caliskan et al., (1999).

The average dry matter content of tubers among the cultivars varied from 19.7 to 26.7% in 2006, from 19.7 to 26.0%, in 2007. The maximum dry matter content of tubers was recorded in vangogh in each year. The lowest dry matter content was recorded in felsina, adora and carrera (Table 6). Analysis of variance of the data revealed a significant effect of harvesting time x cultivar interaction (Table 2).

Tuber dry matter was the highest at 105 DAP for vangogh variety (29.2 and 27.4%, in 2006 and 2007, respectively). The lowest dry matter of tubers was recorded for adora, felsina and carrera (early and mid-early cultivars) when harvested at 75 DAP. This may be explained with an early maturity. In off-season potato production, when tubers are harvested very early, low dry matter content creates a soggy texture and decreases potato quality (Mustonen, 2004). Tuber dry matter increased for all cultivars until 105 DAP, but decreased at 120 DAP. Felsina showed a different behavior; dry matter was highest at 105 DAP, but increased considerable thereafter; the increase in dry matter was about 1.9 and 1.4%, in 2006 and 2007, respectively. Dry matter content of potato tubers has been known to vary between varieties for some considerable time and the fact that a proportion of this variation is heritable is also recognized (Akeley et al., 1955).

Starch is the major component of the dry matter content of potato tubers, accounting for approximately 70% of the total solids (Bradshaw and Mackay, 1994). Tuber specific gravity is also directly related to the dry matter content. Cultivars reacted differently ($P > 0.01$) for specific gravity and starch content. The highest specific gravity and starch content were found in the mid-late cultivars mondial and vangogh, while the early cultivars gave the lowest specific gravity and starch content as

Table 8. Specific gravity of potato tubers as affected by harvesting time and cultivar interaction, 2007 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)				
	75	90	105	120	Mean
Adora	1.0676 ± 0.0003	1.0730 ± 0.0001	1.0713 ± 0.0006	1.0713 ± 0.0006	1.0708 ± 0.0006
Carrera	1.0693 ± 0.0006	1.0747 ± 0.0003	1.0720 ± 0.0001	1.0707 ± 0.0006	1.0716 ± 0.0006
Felsina	1.0713 ± 0.0006	1.0740 ± 0.0001	1.0777 ± 0.0007	1.0733 ± 0.0003	1.0741 ± 0.0007
Marfona	1.0733 ± 0.0006	1.0797 ± 0.0003	1.0830 ± 0.0001	1.0820 ± 0.0010	1.0795 ± 0.0011
Mondial	1.0820 ± 0.0010	1.0800 ± 0.0001	1.0817 ± 0.0009	1.0813 ± 0.0003	1.0817 ± 0.0004
Van Gogh	1.0857 ± 0.0003	1.0880 ± 0.0010	1.0953 ± 0.0003	1.0850 ± 0.0010	1.0885 ± 0.0013
Mean	1.0749 ± 0.0016	1.0782 ± 0.0012	1.0801 ± 0.0020	1.0772 ± 0.0013	1.0776 ± 0.0008

LSD (0.05) 0.0026**

Table 9. Starch content (%) of potato tubers as affected by harvesting time and cultivar interaction, 2006-2007 (Values are mean ± standard error of mean).

Cultivar	Harvesting time (DAP)									Mean
	2006					2007				
	75	90	105	120	Mean	75	90	105	120	
Adora	11.8 ± 0.1	12.8 ± 0.1	12.1 ± 0.1	11.8 ± 0.3	12.1 ± 0.1	11.8 ± 0.1	12.8 ± 0.1	12.5 ± 0.3	12.5 ± 0.3	12.4 ± 0.1
Carrera	11.8 ± 0.1	12.8 ± 0.1	12.8 ± 0.1	11.8 ± 0.1	12.3 ± 0.1	11.8 ± 0.1	12.8 ± 0.1	12.8 ± 0.1	12.1 ± 0.3	12.4 ± 0.1
Felsina	12.8 ± 0.3	12.8 ± 0.1	13.8 ± 0.3	13.1 ± 0.1	13.1 ± 0.1	12.5 ± 0.3	12.8 ± 0.1	13.8 ± 0.1	12.8 ± 0.1	13.0 ± 0.1
Marfona	13.1 ± 0.3	13.8 ± 0.1	14.8 ± 0.3	14.4 ± 0.1	14.0 ± 0.2	12.8 ± 0.1	13.8 ± 0.1	14.8 ± 0.3	14.5 ± 0.1	14.0 ± 0.2
Mondial	14.8 ± 0.1	13.8 ± 0.1	14.5 ± 0.3	14.1 ± 0.3	14.3 ± 0.1	14.5 ± 0.3	13.8 ± 0.1	14.8 ± 0.3	14.5 ± 0.1	14.4 ± 0.1
Van Gogh	15.1 ± 0.3	15.4 ± 0.3	17.4 ± 0.3	15.8 ± 0.1	15.9 ± 0.3	15.4 ± 0.3	15.8 ± 0.1	17.1 ± 0.3	15.4 ± 0.3	15.9 ± 0.2
Mean	13.2 ± 0.3	13.6 ± 0.2	14.2 ± 0.4	13.5 ± 0.3	13.6 ± 0.2	13.1 ± 0.3	13.6 ± 0.2	14.3 ± 0.4	13.6 ± 0.3	13.7 ± 0.1

LSD (0.05) 0.7**

seen in Tables 8 and 9. Cultivars differed in their response to harvesting time as indicated by the significant interaction between harvesting time and cultivar treatments. Delaying harvest until 105 DAP resulted in greater specific gravity and starch content for mid-late maturing cultivars (mondial and vangogh), while, at the final harvesting time caused a small decrease in specific gravity and starch content for the other cultivars tested. These results are in accordance with the results obtained by Yilmaz and Tugay (1999).

Conclusions

As a result, when harvest was delayed until 120 DAP, tuber fresh mass, tuber number per plant and marketable tuber yield showed an important increase in winter-spring growing season. Because tuber yield in a short growing season is affected mainly by the intercepted radiation, methods to increase tuber yield need to be expanded the harvesting time until 120 DAP. Early cultivars carrera and felsina gave more than 2 t ha^{-1} tuber yield at 120 DAP. However, vangogh and mondial (mid-late cultivars) proved to be superior cultivars in relation to dry matter, specific gravity or starch content at 105 DAP. The different trend of dry matter, specific gravity and starch content of tubers during harvests is attributable to the different climatic conditions, mainly light and temperature. The results indicated that, early potatoes can be successfully grown during winter-spring season in southern Turkey.

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