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Effects of Pre-Sprouting and Planting Time on Quality Characteristics of Tuber Potatoes (*Solanum tuberosum* L.)

Ön Sürgünlendirme ve Dikim Zamanlarının Patatesin (*Solanum tuberosum* L.) Bazı Kalite Özelliklerine Etkileri

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ABSTRACT

This study was carried out in Erzurum in 2015 and 2016 to determine the effects of pre-shooting and planting times on some quality characteristics of potatoes. In the experiment, there were four different pre-sprouting (23 March, 3 April, 23 April, and Control), three planting times (5, 15, and 25 May), and two varieties (Binella and Slaney). The experimental design was the "Randomized Complete Blocks Design" in "Split Split Parcel" arranged as three planting times (5th, 15th, and 25th days of May), two varieties (Binella and Slaney), and four pre-shooting times (March 23, April 3, April 13, and Control) with four replications. According to the average of the trial factors, there was a statistical difference between the years in terms of tuber specific weight, dry matter, starch, protein ratios, and chips yield, but there was no difference in terms of chips' oil absorption rate. According to the pre-shooting times, the highest dry matter, protein, chip ratio, and oil absorption rates of the chips were determined in the application on March 23, while the specific gravity and starch ratio were determined from the application on April 3. According to the planting times, the maximum specific gravity was determined in the 5th and 15th May plantings, the oil absorption rate of the dry matter and chips was determined on the 3rd of April, and the protein ratio was determined in the 25th of May plantings. The specific gravity, dry matter, starch, and oil absorption ratio of chips were higher in Slaney variety, and protein ratio was lower than Binella variety. As a result, although there is no difference between pre-sprouting and planting times, there were differences between cultivars in terms of pre-sprouting time and planting time for high chips productivity and chips efficiency and low oil absorption rate of chips, and accordingly, among the examined cultivars, Slaney cultivar took longer time than the other cultivars. İt has been suggested that a period of pre-sprouting should be required and a later planting should be done.

Keywords: Planting time, potato, pre-sprouting, quality

ÖZ

Bu çalışma, patatesin bazı kalite özellikleri üzerine ön sürgünlendirme ve dikim zamanlarının etkilerini belirlemek amacıyla 2015 ve 2016 yıllarında Erzurum'da yapılmıştır. Denemede dört farklı önsürgünlendirme (23 Mart, 3 Nisan, 23 Nisan ve Kontrol) üç dikim zamanı (5, 15 ve 25 Mayıs) ve iki çeşit (Binella ve Slaney) bulunmaktadır. Deneme "Şansa Bağlı Tam Bloklar" Deneme Deseninde "Bölünen Bölünmüş Parseller" düzenlemesine göre 4 tekrarlamalı olarak kurulmuştur. Deneme faktörlerinin ortalamasına göre, yıllar arasında yumru özgül ağırlığı, kuru madde, nişasta, protein oranları ve cips verimliği yönünden istattistiki olarak farklılık olup, cipsin yağ çekme oranı yönünden farklılık olmamıştır. Ön sürgünlendirme zamanlarına göre, en fazla kuru madde, protein, cips oranı ve chipsin yağ çekme oranları 23 Mart uygulamasında, özgül ağırlık ve nişasta oranı ise 3 Nisan'daki uygulamadan tespit edilmiştir. Dikim zamanlarına göre en fazla özgül ağırlık 5 ve 15 Mayıs dikimlerinde, kuru madde ve chipsin yağ çekme oranı 3 Nisan, protein oranı ise 25 Mayıs dikimlerinde belirlenmiştir. Slaney çeşiinin özgül ağırlık, kuru madde, nişasta ve cipsin yağ çekme oranı Binella çeşidine göre yüksek, protein oranı ise düşük bulunmuştur. Sonuç olarak, ön sürgünlendirme ve dikim zamanları arasında farklılık olmamasına rağmen, yüksek cips verimliliği ve cipsin düşük yağ çekme oranı için ön sürgünlendirme süresi ve dikim zamanları bakımından çeşitler

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arasında farklılık olduğunu, buna göre incelenen çeşitlerden slaney çeşidinde diğer çeşitlere göre daha uzun süre ön sürgünlendirme ve daha geç dikim yapılmalıdır

Anahtar Kelimeler: Dikim zamanı, patates, ön sürgünlendirme, kalite

Introduction

Potato is an important food for human nutrition. Especially water, dry matter, starch, protein, minerals, and vitamins make potato an important nutrient (Esendal, 1980). It has important place in agricultural enterprises, and its production requires more labor force, for example, it needs hoeing during the growing period, compared to other field products so it enables employment in agricultural enterprises.

In order to obtain high yield per unit from potato, one of the most important factors is to use high-quality seed tubers in addition to applying practices such as irrigation, fertilization, pre-sprouting, haulm killing, and planting time. These cultural practices have important effects on the quality of potatoes.

Studies on the subject, the negative effect of late planting on some quality parameters of tuber potatoes such as dry matter and starch content, and cooking quality can be eliminated with pre-sprouting (Lunden, 1944). Pre-sprouting treatment can give the producers at least a 2-week or more advantage of growing potatoes; especially in short-season climate, it may provide a significant benefit for early planting and the longer growing season because the seed tuber potatoes are ready for planting.

A lot of research has been carried out that states that there are positive and negative aspects of early planting and pre-sprouting on quality characteristics of potatoes. According to Emilson (1950), the content of starch increases more than dry matter due to pre-sprouting. Kara and Unal (1991) stated that pre-sprouting date has no effect on tuber specific gravity, dry matter, and protein, it has effect on starch content and chip yield. As the date of pre-sprouting delays, the rate of starch decreased and the chips productivity of sprouted was less than that of non-sprouted.

Kara et al. (2005) practiced pre-sprouting on seed tubers on different dates (15 March, March 30, April 14, and Control) in Erzurum. They stated that pre-sprouting has effect on protein content, it has no effect on dry matter and starch content, and it is suitable that seed tubers can be pre-sprouted under Erzurum conditions in 14 April.

Taşkıran (1988) stated that planting date has no effect on dry matter rate of tuber, and Kara et al. (2002) detected that planting date has no effect on tuber dry matter, protein, chips yield, and oil absorption ratio of chips.

Akeley et al. (1955) stated that an early planting date increases the dry matter content of tubers and high-quality chips are obtained. Koch et al. (1969) detected that late planting decreases tuber dry matter and quality. Also, Günel (1976) detected that the late planting date delays the dry matter rate and chip yield decreased gradually, and it has no effect on the starch, protein, and oil absorption ratio of chips.

This study was carried out to determine the effects of pre-sprouting date and planting date on potato quality characteristics of potato cultivars.

Methods

Experimental Site and Materials

This study was carried out at Atatürk University, Faculty of Agriculture Experimental field in years 2015 and 2016. In the studies, cultivars of Binella and Slaney were used for their high adaptation and high yield, resistance to disease, technological characteristics. For fertilization, 24 kg nitrogen, 6 kg phosphorus, and 5 kg potassium were applied as pure substance per decare (Ilisulu, 1986; Oztürk, 2001).

Climate Properties

Between May and September, which is the vegetation period of potato in Erzurum, total rainfall was 285.1 mm in 2015, 303.7 mm in 2016, and 195.5 mm in long-term average. Average temperature was 14.8 ˚C in 2015, 14.8 ˚C in 2016, 14.5 ˚C in the long-term average; relative humidity was 60.4% in 2015, 53.3% in 2016, and 57.0% in the long-term average (Anonymous, 2017).

Soil Characteristics

The soil of the study field was clay and loamy, pH values varied between 7.20 and 7.73, poor in the sense of organic matter (1.04% and 2.28%), available phosphorus amount was changed between 8.7 and 11.9 kg da^{-1} and rich in potassium was136.0–154.8 kg da^{-1}

Experimental Treatments

The experimental design was the Split-Split Plot with three planting dates (May 5, May 15, and May 25) as main plots, four pre-sprouting treatments (no pre-sprouting, starting of pre-sprouting on March 23, April 3, April 13) as subplots, and two cultivars (Binella and Slaney) as sub-sub plots with four replications. In the plantings, hills were designed with 70-cm interrow spacing and 35-cm intrarow spacing (Şenol, 1973). Each plot was composed of 4 lines, and there were 10 hills on each line. There were 96 plots and the size of each plots was 9.8 m^2 (2.8 m × 3.5 m), the total experimental area was 2507.76 m^2.

Results

Variance analysis results of tuber specific gravity, dry matter content, starch content, protein content, oil absorption rate, and chips yield determined according to experiment factors were given in Table 1, and the averages were given in Table 2.

Specific Gravity of Tuber

The statistical difference in specific gravity of tubers between experiment years was significant ($p < .05$). The specific gravity of tubers was 1.077 in the first year of the experiment and 1.067 in the second year (Tables 1 and 2). This may result from the fact that the growth period in the first year of the experiment was long and the temperature was high, thereby dry matter content was high.

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Table 1.
Variance Analysis Results of Specific Gravity, Dry Matter, Starch, Protein Content, Chips Yield, and Oil Absorption Rate of Potatoes, Which Were Pre-sprouted and Planted at Different Dates

Variation Source	*df*	Specific Gravity	Dry Matter Content	Starch Ratio	Protein Ratio	Chip Efficiency	Oil Absorption of Chips
Year (A)	1	51.8*	137.1**	160.1**	0.67 30.7*	57.9**	0.1
$Error_1$	3	–	–	–	–	–	–
Planting time (B)	2	2.0	0.5	0.6	1.9	0.3	1.1
(A) × (B)	2	0.4	0.2	0.1	1.6	1.9	0.4
$Error_2$	12	-	-	-	-	-	-
Pre-sprouting date (C)	3	1.6	0.9	1.7	0.7	0.9	1.9
(A) × (C)	3	0.7	1.6	0.6	0.1	1.7	0.1
(B) × (C)	6	0.7	2.2	1.5	1.8	1.2	0.9
(A) × (B) × (C)	6	2.1	3.8*	2.1	1.8	0.7	0.1
Error	54	-	-	-	-	-	-
PVariety (D)	1	8.9*	2.7	0.6	8.8**	0.7	4.5*
(A) × (D)	1	0.3	0.3	0.1	0.7	2.8	0.6
(B × D)	2	1.4	0.2	0.95	0.99	0.3	1.7
(C) × (D)	3	0.8	2.2	1.3	2.0	0.3	0.2
(A) x (B) x (D)	2	0.6	0.9	2.1	3.7*	0.1	0.3
(A) x (C) x (D)	3	0.3	1.6	1.03	0.8	1.2	2.7*
(B) x (C) x (D)	6	0.5	0.5	1.03	2.3*	2.7*	0.5
(A) x (B) x (C) x (D)	6	1.1	0.9	0.7	0.7	0.97	0.7
$Error_4$	72	–	–	–	–	–	–

**Marked *F* values are 1%, *Marked *F* values are significant at a 5% level.

Table 2.
Average Values of Tuber Specific Gravity, Dry Matter, Starch, Protein, Chips Yield, and Oil Absorption Rates of Chips at Different Pre-shooting and Planting Times

Treatments		Specific Gravity	Dry Matter Content	Starch Ratio	Protein Ratio	Chip Efficiency	Oil Absorption of Chips
Year	2015 2016	1.075 ± 0.001[a]	21.6 ± 0.233[A]	16.3 ± 0.168[A]	12.8 ± 0.167[a]	34.6 ± 0.240[A]	31.7 ± 0.305
		1.067 ± 0.001[b]	18.9 ± 0.233[B]	11.4 ± 0.168[B]	10.9 ± 0.167[b]	32.0 ± 0.240[B]	32.0 ± 0.305
Mean		**1.071**	**20.3**	**13.9**	**11.9**	**33.3**	**31.9**
Pre-sprouting date	23 March 13 April 3 April Control	1.072 ± 0.001	20.6 ± 0.330	13.9 ± 0.238	12.1 ± 0.236	33.7 ± 0.339	32.3 ± 0.431
		1.074 ± 0.001	20.3 ± 0.330	14.2 ± 0.238	11.7 ± 0.236	33.2 ± 0.339	31.1 ± 0.431
		1.070 ± 0.001	20.2 ± 0.330	13.4 ± 0.238	12.0 ± 0.236	32.9 ± 0.339	32.3 ± 0.431
		1.073 ± 0.001	20.0 ± 0.330	14.1 ± 0.238	11.6 ± 0.236	33.4 ± 0.339	31.7 ± 0.431
Mean		**1.072**	**20.3**	**13.9**	**11.9**	**33.3**	**31.9**
Planting time	5 May 15 May 25 May	1.073 ± 0.001	20.3 ± 0.286	14.0 ± 0.206	11.6 ± 0.204	33.5 ± 0.294	32.1 ± 0.373
		1.070 ± 0.001	20.5 ± 0.286	13.9 ± 0.206	11.8 ± 0.204	33.2 ± 0.294	32.2 ± 0.373
		1.072 ± 0.001	20.0 ± 0.286	13.7 ± 0.206	12.2 ± 0.204	33.2 ± 0.294	31.3 ± 0.373
Mean		**1.073**	**20.3**	**13.9**	**11.9**	**33.3**	**31.9**
Varieties	Binella Slaney	1.071 ± 0.001	20.0 ± 0.233	13.8 ± 0.168	12.2 ± 0.167	33.7 ± 0.240	31.1 ± 0.305
		1.074 ± 0.001	20.5 ± 0.233	14.0 ± 0.168	11.5 ± 0.167	33.2 ± 0.240	31.7 ± 0.305
Mean		**1.073**	**20.3**	**13.9**	**11.9**	**33.5**	**31.4**
5 May x 23 March		1.075	20.6	14.2	11.8	33.4	32.3
5 May x 3 April		1.071	21.2	14.8	11.0	34.5	32.2
5 May x 13 April		1.067	19.9	13.9	12.0	32.3	32.0
5 May x Control		1.067	19.4	13.3	11.7	34.4	31.9
15 May x 23 Mart		1.066	20.7	10.9	12.1	33.6	33.9
15 May x 3 April		1.067	20.0	10.6	12.4	33.1	32.4
15 May x 13 April		1.068	20.1	9.9	11.2	32.6	31.6
15 May x Control		1.068	21.2	10.9	11.5	31.1	30.9
25 May x 23 March		1.068	20.4	13.8	12.7	32.6	31.0
25 May x 3 April		1.064	19.9	13.6	12.4	34.4	31.6
25 May x 13 April		1.064	19.8	13.6	13.1	32.6	31.8
25 May x Control		1.070	20.5	13.9	10.9	33.2	30.9
5 May x 23 March x Binella		1.072	20.1	13.7	13.0	34.2	32.3
5 May x 23 March x Slaney		1.077	21.1	14.7	10.6	32.6	32.3
5 May x 3 April x Binella		1.077	22.0	15.6	11.3	34.9	30.9
5 May x 3 April x Slaney		1.073	20.3	14.0	10.7	34.0	33.4
5 May x 13 April x Binella		1.072	20.5	13.4	12.9	32.3	33.3
5 May x 13 April x Slaney		1.075	19.3	14.4	11.1	32.2	30.6
5 May x Control x Binella		1.068	19.0	12.6	12.1	33.4	31.9
5 May x Control x Slaney		1.072	19.8	14.0	11.3	34.4	31.9

15 May x 23 March x Binella	1.069	19.5	10.8	12.1	34.5		34.6
15 May x 23 March x Slaney	1.073	21.8	10.9	12.1	32.7		33.1
15 May x 3 April x Binella	1.071	20.3	11.1	12.7	32.6		32.6
15 May x 3 April x Slaney	1.074	19.7	10.0	12.0	33.6		32.2
15 May x 13 April x Binella	1.073	20.7	9.9	11.5	32.1		31.8
15 May x 13 April x Slaney	1.074	19.5	9.9	10.8	33.0		31.3
15 May x Control x Binella	1.075	22.1	11.5	11.5	32.1		31.1
15 May x Control x Slaney	1.072	20.2	10.3	11.4	30.0		30.6
25 May x 23 March x Binella	1.071	20.8	13.3	12.6	33.0		32.0
25 May x 23 March x Slaney	1.074	20.0	14.2	12.7	32.1		30.0
25 May x 3 April x Binella	1.069	19.9	14.0	12.2	35.1		32.7
25 May x 3 April x Slaney	1.068	19.1	13.1	12.5	33.7		30.4
25 May x 13 April x Binella	1.070	19.5	13.8	13.6	34.0		32.0
25 May x 13 April x Slaney	1.066	20.0	13.4	12.5	31.1		31.6
25 May x Control x Binella	1.074	21.2	14.1	10.8	33.0		30.5
25 May x Control x Slaney	1.073	19.7	13.6	11.0	33.4		31.2

Capital letters are significant at 1%, small letters are significant at 5% level.

Although there was a numerical difference, planting date and pre-sprouting time had no significant effect on the specific gravity of tubers (Table 1). The highest specific gravity of tubers was determined for tubers planted on April 3 (1.074), followed by control (1.073), March 23 (1.072), April 13 (1.070) pre-sprouting treatments (Table 2). In previous study carried out by Kara and Unal (1991), and Kara and Kavurmacı (2003), it was stated that pre-sprouting dates have no effect on the specific gravity of tuber, and therefore, it is compatible with the experiment results.

According to the planting times, the highest starch was in the May 5 and 15 plantings (1.073), followed by the May 25 (1.072) planting time. While the results obtained from the experiment were similar to the results of Günel (1976), they are unsimilar to the results of Kara et al. (2002), Taşkıran (1988), and Yıldırım et al. (2005).

There were statistically significant ($p < .05$) differences between tuber specific gravity of cultivars (Table 1). Tuber specific gravity of the Slaney cultivar was 1.074, and it was detected as 1.071 for the Binella cultivar (Table 2). Differences between cultivars may probably result from the genetic structure.

Dry Matter Content (%)

In terms of dry matter content, statistical significance ($p < .01$) was found between the study years (Table 1). Dry matter content was 21.6% in the first experiment year and 18.9% in the second year (Table 2). This may have resulted from the fact that the growth period was longer and the temperature was higher in the first study year.

In terms of planting time, the highest dry matter content of potato tubers was on May 15 plantings (20.5%), followed by May 5 and 25 plantings (Table 2). In the previous studies of Günel (1976), Kara et al. (2002), and Taşkıran (1988), it was detected that planting date had no effects on dry matter content. The average dry matter content of the Binella cultivar was 20.0%, and it was 20.5% for the Slaney cultivar (Table 2).

Due to the fact that the dry matter ratio did not show stability according to the pre-sprouting dates and planting times in the study years caused the interaction of year × pre-sprouting date × planting time to be statistically significant ($p < .05$) (Table 1, Figure 1).

Starch Content (%)

There was a statistically significant difference between experiment years in the sense of starch content of tubers ($p < .01$) (Table 1). Starch content of tubers was 16.3% in the first year of the experiment and 11.4% in the second year. This may result from dry matter content in the first study year (Table 2). Although the starch ratios of the tubers were numerically different between the pre-sprouting, planting times, and the varieties, there was no statistical difference (Tables 1 and 2).

The highest starch content of tubers was obtained from April 3 pre-sprouting treatment (14.2%) followed by the control treatment (14.1%), March 23 (13.9%), and April 13 treatments (Table 2). Results of the experiment are compatible with the results of Kara et al. (2002), incompatible with the results of Prosba-Bialoczyk (1989), and reported that pre-sprouting increased the rate of starch.

The highest starch rate determined in tubers according to planting times was obtained on May 5 (14.0%), followed by 15 (13.9%) and

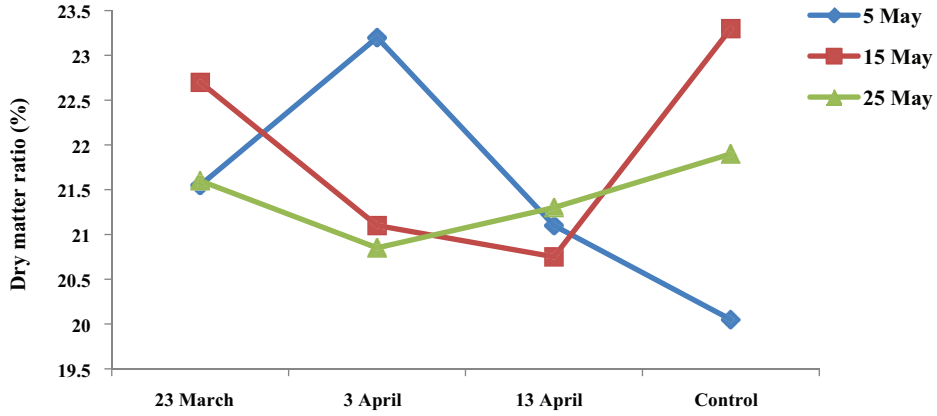

Figure 1.
Pre-sprouting Date × Planting Time Interactions in Terms of Dry Matter Rate in Average of Study Years.

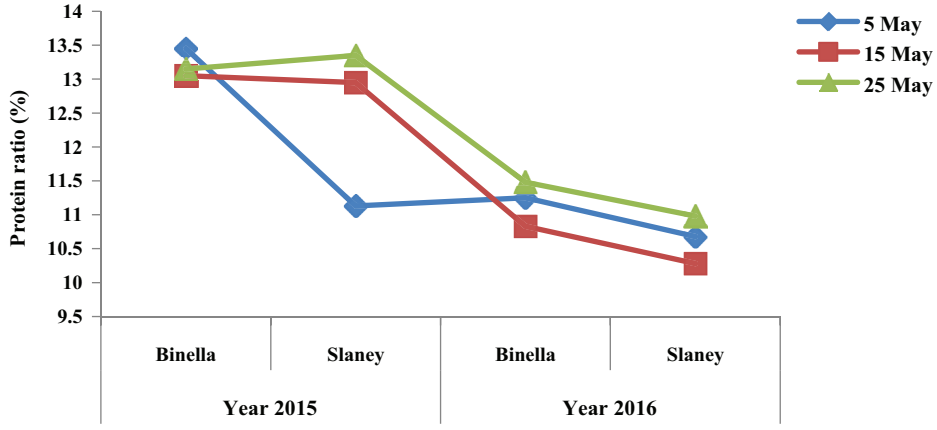

Figure 2.
Year × Planting Time × Variety Interaction in Terms of Protein Ratios in Average of Study Years.

May 25 (13.7%). The results were similar to the results of Taşkıran (1988), and it was determined that the starch ratio decreased as the planting time was delayed. The average starch ratio was 13.8% in the Binella cultivar and 14.8% in the Slaney cultivar.

Protein Content (%)

There was a statistically significant difference between experiment years in the sense of protein content of tubers ($p < .05$) (Table 1). The protein content of tubers was 12.8% in the first year of the experiment and 10.9% in the second year (Table 2).

Although there is a numerical difference between the protein content of potato tubers according to pre-sprouting date and planting time, there was no statistical difference (Tables 1 and 2).

According to the pre-sprouting times, the highest protein content was determined in March 23 treatment (12.1%), followed

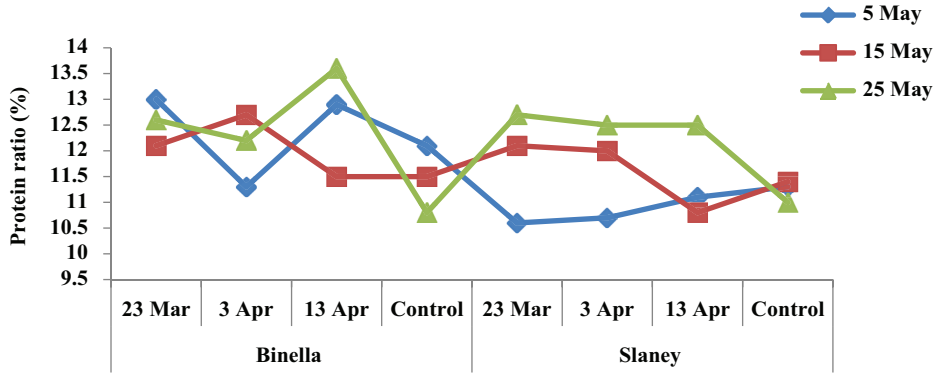

Figure 3.
Pre-sprouting Date × Planting Time × Variety of Interactions in Terms of Protein Ratios in the Average of Study Years.

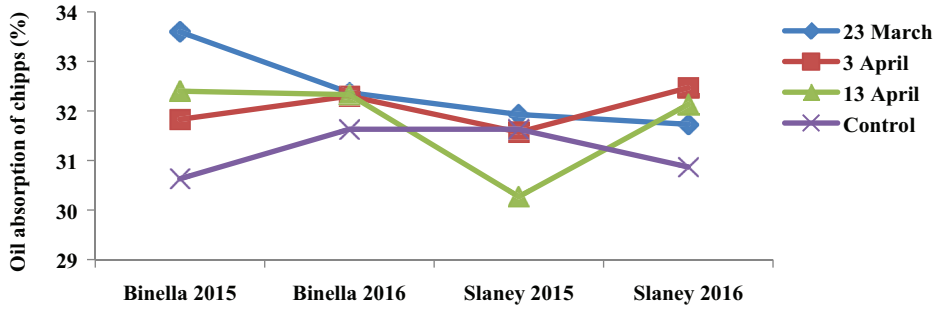

Figure 5.
Years × Pre-sprouting Time × Variety in Terms of Chips Oil Absorption Rates in Study Years.

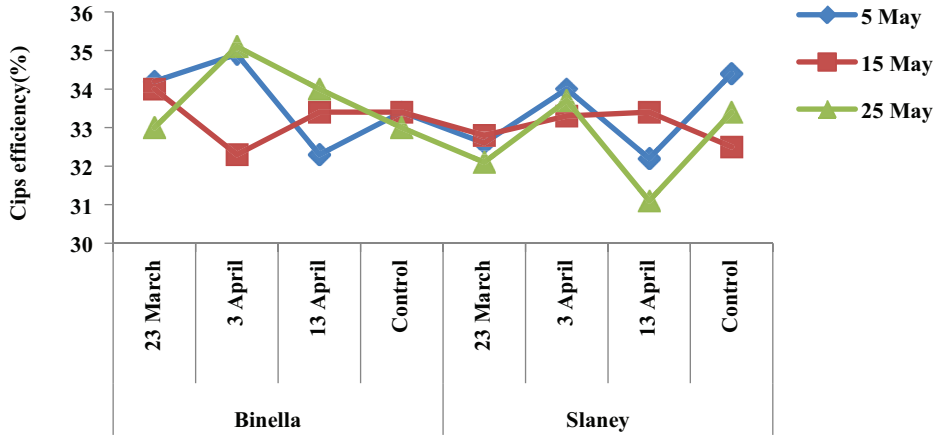

Figure 4.
Pre-sprouting Date × Planting Time × Variety in Terms of Chips Productivity in the Average of Study Years.

by April 13 (12.0%), April 3 (11.7%), and control (11.6%) treatments (Table 2).

According to planting times, the highest protein content was detected in May 25 (12.2%) plantings, followed by May 15 (11.8%) and 5 (11.6) plantings (Table 2). The results obtained from the experiment were not similar to the results of Prosba-Bialoczyk (1989).

There was a significant difference ($p < .01$) in terms of protein content between cultivars. Protein content was determined as 12.2% in Binella variety and 11.5% in Slaney variety (Tables 1 and 2).

Due to the fact that the protein contents of the cultivars were not stable according to the planting times in the average of years caused the year × planting time × variety interaction to be statistically significant ($p < .05$) (Table 1, Figure 2). Also, the protein content of the varieties did not show stability according to the pre-sprouting dates and planting times caused the pre-sprouting date × planting time × variety interaction to be statistically significant ($p < .05$) (Table 1, Figure 3).

Chips Yield

There was a statistically significant difference ($p < .01$) between experiment years in the sense of chips yield (Table 1). Chips yield was 34.6% in the first study year and 32.0% in the second year (Table 2).

In terms of chip yield, there was no significant difference between pre-sprouting and planting times and cultivars (Table 1).

According to the pre-sprouting times, the highest chip yield was determined in March 23 (33.7%), followed by control (33.4%), April 3 (33.2%), and April 13 (32.9%) pre-sprouting treatments (Table 2). The results obtained from the experiment were similar to the results reported by Kara et al. (2002).

According to the planting times, the highest chip yield was determined in the May 5 (33.5%) planting, followed by the May 15 and 25 (33.2%) plantings (Table 2). The results obtained from the experiment did not show similarity with the results reported by Günel (1976).

Chip yield was determined as 33.5% in the Binella variety and 33.2% in the Slaney variety.

Due to the fact that the chips yield of the cultivars did not show stability according to the pre-sprouting dates and planting times caused the pre-sprouting date × planting time × variety interaction to be statistically significant ($p < .05$) (Table 1, Figure 4).

Oil Absorption Ratio of Chips (%)

There was no statistically significant difference between the years, pre-sprouting, and planting times in terms of the oil absorption ratio of the chips, while it was statistically significant ($p < .05$) between varieties (Table 1).

As the average experiment factors, the oil absorption ratio of chips was 31.7% in 2015 and 32.0% in 2016, the difference between years was not found statistically significant (Tables 1 and 2).

According to the pre-sprouting dates, the highest oil absorption rate was determined in the March 23 and April 13 (32.3%),

followed by control (31.7%) and April 13 (31.1%) treatments (Table 2). The results from the experiment were not similar to the results reported by Kara et al. (2002) and Kara and Unal (1991).

In terms of the oil absorption rate of chips, according to planting times, the highest oil absorption rate was determined in May 15, followed by May 5 (32.1%) and 25 (31.3%) plantings. In similar studies (Günel, 1976), it was reported that planting time had no effect on the oil absorption rate of the chips.

Oil absorption rates of chips were determined as 31.1% in the Binella variety and 31.7% in the Slaney variety (Table 2).

Due to the fact that the oil absorption ratio of the chips did not show stability according to the pre-sprouting dates on the average of the years caused the year × pre-sprouting date × variety interaction to be statistically significant ($p < .05$) (Table 1, Figure 5).

Conclusion

As a result, although there is no difference between pre-sprouting and planting times, there were differences between cultivars in terms of pre-sprouting time and planting time for high chips productivity and chips efficiency and low oil absorption rate of chips, and accordingly, among the examined cultivars, Slaney cultivar took longer time than the other cultivars. İt has been suggested that a period of pre-sprouting should be required and a later planting should be done.

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