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Research Article

The Effect of Pre-Sprouting and Planting Time on Different Sized Potato Tuber Yields (*Solanum tuberosum* L.)

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Abstract: The purpose of this study was to see how pre-sprouting and planting dates affected potato tuber yields of varied sizes. The Split-split Plot was used as the experimental design, with four replications. The effect of years on medium, small, and discard tuber yields was significant, while the effect of planting times on total, big, small, and discard tuber yields per decare was not. The impact of pre-sprouting and planting timings on the traits studied were not statistically significant. There was no difference in total, medium, small, and discarded tuber yields per decare between the varieties; however, there was a difference in big tuber yield. According to the study's findings, the Binella variety should be pre-sprouted on March 23 (2 080.5 kg da^{-1}, 1169.3 kg da^{-1}) and the Slaney variety on April 13 (2 022.9 kg da^{-1}, 1207.5 kg da^{-1}), and both should be planted on May 15. The Binella variety should be pre-sprouted on April 13 (701.0 kg da^{-1}), and the Slaney variety on April 3 (892.4 kg da^{-1}) for medium tuber yield, and both should be planted on May 15. Plant the Binella variety without pre-sprouting (243.0 kg da^{-1}) and the Slaney variety with pre-sprouting on April 3 (223.8 kg da^{-1}) on May 5th for small tuber output. The Binella variety should be pre-planted on April 13th and planted on May 5th (123.4 kg da^{-1}) for the production of discarded tubers, but the Slaney variety should be planted on May 25th without pre-sprouting (113.8 kg da^{-1}).

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1. Introduction

Potatoes are an important food because of their high quantity of dry matter, carbohydrates, protein, minerals, and vitamins (Esendal, 1990). It has a significant role in agricultural enterprises, and its production necessitates more labor than other field goods, such as hilling and hoeing throughout the growing season, allowing employment in agricultural enterprises.

Almost half of the world's potato production is consumed fresh in various forms by humans (cooking in the oven, boiling, chips). The remaining portion is used to make processed foods (such as frozen chips), animal feed, industrial starch, and seed. The starch-rich shells of potatoes and other debris left behind after processing are liquefied and used to make ethanol.

Potatoes are grown in 79 percent of the world's countries. The global potato producing area is 19,3 million ha, with a total production of 388 million tons and a yield per decare of 2 042 kg. China

(26%) produces half of the world's output, followed by India (12%), Russia (8%), and Ukraine (2%). Turkey ranks 14th in world potato output with a share of 1.24 percent. In 2018, potatoes were grown on around 136 thousand hectares in 71 provinces, yielding 4.55 million tons. Potato intake per capita in our country is 50 kilograms per year (Anonymous, 2020).

Erzurum province is one of our country's major potato production centers with 3570.5 hectares of production area, 88.725 tons, and a yield per decare of 2485 kg (Anonymous, 2019). Due to the short and cool growing season in Erzurum, as well as the unavailability of various growth techniques, yield per unit area is low. In our region, the major cultivation techniques for increasing potato output per unit area are pre-sprouting and planting periods.

According to Davies and Allaby (1971), pre-sprouted plants may produce more marketable tubers than non-sprouted plantings.

Arslan and llisulu (1976) found that pre-sprouting treatments resulted in 14 days faster emergence than regular plantings, with a significant yield increase that varied by variety.

In a study conducted in Erzurum conditions by Günel (1982), it was discovered that the proportion of large tubers in planting on May 3 was 70% of total tubers, while this rate decreased by 53% in 17 June planting, the medium tuber ratio increased from 25% to 43%, and the small tuber ratio increased from 3% to 5%.

Pre-sprouting treatment in seed potato tubers, according to Günel (2002), enhances tuber production by promoting early emergence and robust plant development, in addition to using healthy seeds for high tuber yield.

In a study conducted by Kara and Sebahattin (1991), seed tubers with a diameter of 3.5-5.0 cm were pre-sprouted on March 20, April 4, and April 19 and planted on May 5 with the control. As a result of the research, they discovered that pre-sprouting dates had a substantial influence on medium tuber (3.5-5.0 cm) yield but not on tiny tuber (3.5 cm) or big tuber (> 5.0 cm) production.

Calışkan and Arıoğlu (1997) found that postponing the planting date enhanced tuber ratios and yields for small (10-30 mm), medium (30-50 mm), and big tuber (> 50 mm) tubers. During the 2004-2005 growing season, Khan et al. (2011) planted potatoes on four distinct dates (24 September, 1 January, 7 January, and 15 January) to identify the growing duration of the potato and the best planting dates. According to them, since the planting date was postponed, the number of stems in the plant rose. The percentage of large tubers (> 55 mm) was highest on September 24, the earliest planting date, while the percentage of tiny tubers (35 mm) rose when plantings were delayed. They discovered that the earliest planting (September 24) produced the maximum tuber production (15 t ha-1) and that the planting delay influenced dry matter buildup. The planting on January 15 yielded the greatest dry matter (18.31%).

In Erzurum, yield is low per unit area due to the short and cool growing season and also the lack of some cultivation techniques. Pre-sprouting and planting times are the main cultivation techniques to increase the yield of potatoes per unit area in our region.

Potatoes do not contain generative seeds and require a different technique to grow than other vegetables. One of these is pre-sprouting therapy, in which seed tuber potatoes are maintained in a warm environment with natural or artificial light before planting. This results in the production of short, robust, green sprouts and, as a result, quicker plant growth (Smith-Heavenrich, 2007). This treatment is critical for earlier plant emergence and production (Essah et al., 2004; Mikitzel and Wattie, 2000). Therefore, the purpose of this study was to look into the effects of pre-sprouting dates and planting timings on tuber yields of different sizes of potatoes.

2. Material and Methods

2.1. Material

This research was carried out at the experimental field of Atatürk University's Faculty of Agriculture in 2015 and 2016. Binella and Slaney cultivars were selected in the experiments due to their excellent adaptability and yield, disease resistance, and technical features. Binella is a cooking type, an early variety with a large yield, tuber shape oval, shell color yellow and smooth, interior color light yellow, and eye depth surface. Slaney cultivar is of the cooking type, plant height is long and very late, tuber form is short oval, tuber eye depth is surface, shell color is yellow, tuber inner color is cream, starch content is 11.9-14.8 percent, and dry matter content is 17.9-21 percent. For fertilization, 24 kg of nitrogen, 6 kg of phosphorus, and 5 kg of potassium were administered as pure substances per decares (Ilisulu, 1986; Ozturk, 2001).

2.1. Climate and Soil Characteristics of the Study Field

2.1.1. Climate Characteristics

Total rainfall in Erzurum between May and September, which is the potato vegetation period, was 285.1 mm in 2015, 303.7 mm in 2016, and 195.5 mm in the long term average. The average temperature in 2015 was 14.80 °C, 14.80 °C in 2016, and 14.5 0 °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).

2.1.2. Soil characteristics

The soil in the study field was clay and loamy, with pH values ranging from 7.20 to 7.73, low organic matter (1.04 to 2.28 percent), available phosphorus ranging from 8.70 to 11.93 kg da^{-1}, and potassium ranging from 136 to 154.8 kg da^{-1}.

2.2. Method

2.2.1. Study pattern

The Split-Split Plot was used as the experimental design, with three planting dates (May 5, May 15, and May 25) as main plots, four pre-sprouting treatments (no pre-sprouting, starting pre-sprouting on March 23, April 3, and April 13) as subplots, and two cultivars (Binella and Slaney) as sub-sub plots with four replications (Yıldız, 1994). Hills were planned with 70 cm inter-row spacing and 35 cm intrarow spacing in the plants (Şenol, 1976). Each plot consisted of four lines with ten hills on each line. There were 96 plots, each measuring 9.8 m^2 (2.8 m x 3.5 m), with a total experimental area of 2 507.76 m^2.

Seed tuber potatoes of egg size with three eyes were treated to pre-sprout after the dormancy period. The seed tuber potato should be kept at a warm, consistent temperature, such as room temperature until it sprouts strong green shoots. Seed tubers were hand-sewed at various times after this procedure. A few centimeters of soil were hilled up around the base of the stem after the potato plants produced stems to prevent developing tubers at shallow levels from being exposed to sunlight and to encourage the plant to continue generating tubers.

2.2.1. The investigation properties

2.2.1.1. Tuber yield (kg da^{-1})

Tubers were collected, weighted, and estimated tuber yield per decare in all plots.

2.2.1.2. Tuber yields with different sizes

Tubers were classified into four sizes (Günel, 1976). The harvested potato tubers from each plot were weighed after being passed through 5.0, 3.5, and 2.8 cm sieves, and the tubers in each tuber size class were weighed, and their yields per decare were determined.

2.2.2. Statistical Analysis

The Split-Split Plot was used as the experimental design, with three planting dates, four pre-sprouting treatments, two cultivars, and two years with four replications. 4 way ANOVA was used to analyze all parameters and interactions. Therefore Duncan multiple comparison test was used the compare the means.

3. Results and Discussion

Table 1 shows data from potato cultivars that were pre-sprouted and planted at various dates, and Table 2 shows the findings of associated variance analyses.

3.1. Total Tuber Yield (kg da^{-1})

In terms of total tuber yield per decare, although there was a numerical difference between trial years, pre-sprouting, and planting times, there was no statistical difference (Tables 1 and 2). The total tuber yield per decare was 1 552.6 kg in 2015 and 1 882.4 kg in 2016 (Table 2).

The maximum total tuber yield was determined on April 3 (1 861.1 kg da^{-1}), followed by 13 April yield (1 739.9 kg da^{-1}), Control (1 729.8 kg da^{-1}), and finally, March 23 (1 512.2 kg da^{-1}) according to the pre-sprouting timings (Table 2).

The maximum total tuber yield per decare (1 929.1 kg da^{-1}) was determined on May 15, followed by plantings on May 5 (1 727.1 kg da^{-1}) and May 25 (1727.1 kg da^{-1}) (1496.5 kg da^{-1}).

The total tuber production of the Binella variety was determined to be 1 645.9 kg, whereas the Slaney variety yielded 1 789.3 kg (Table 2).

Because total tuber yield did not exhibit consistency across years, pre-sprouting dates, and planting times, the interactions year x pre-sprouting date, pre-sprouting time x variety, planting time x pre-sprouting date, and variety were significant ($p<0.05$) (Table 1, Figer 1, 2, 3).

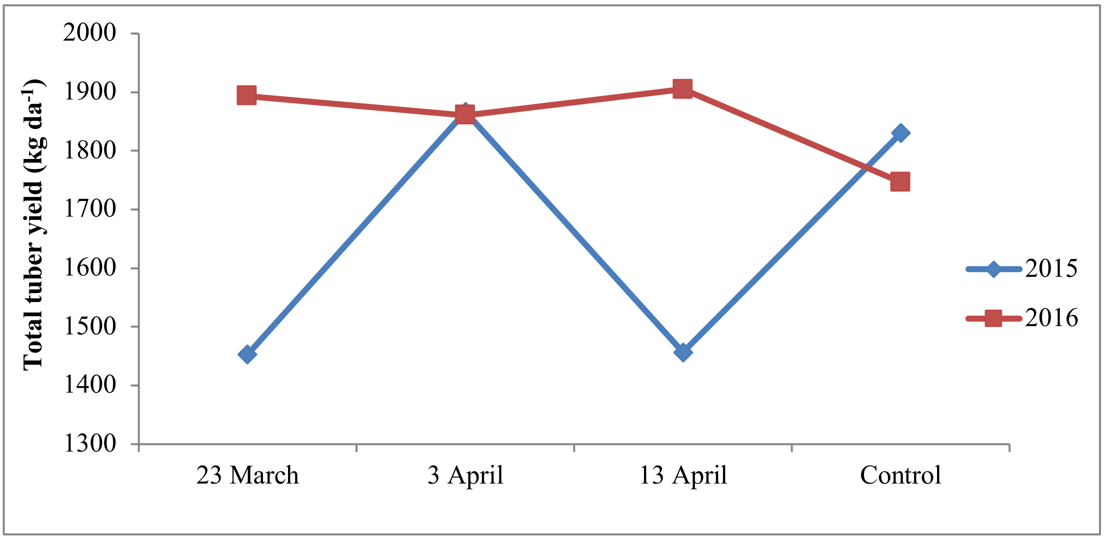

Figure 1. Year x pre-sprouting date interaction related to tuber yield per decare of years' average.

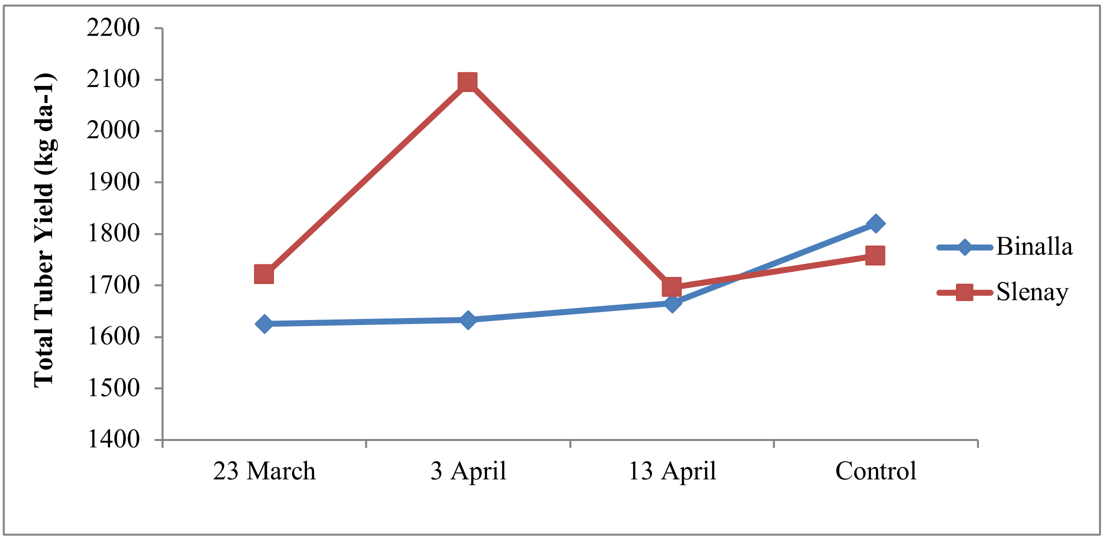

Figure 2. Pre-sprouting date x variety interaction regarding tuber yield per decare in years average.

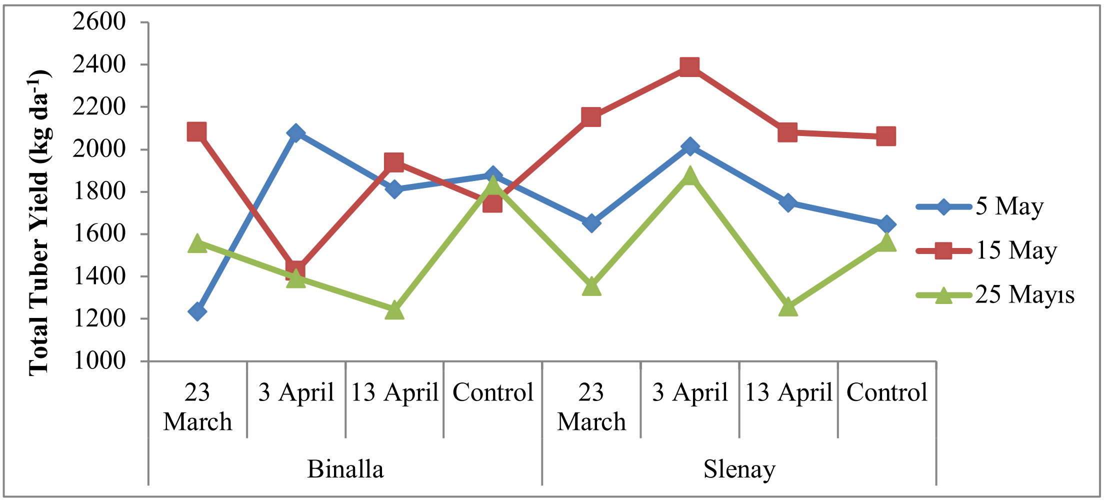

Figure 3. Planting time x pre-sprouting date x variety interaction in annual average of tuber yield per decare of cultivars.

3.2. Large tuber (>50 mm) yield per decare (kg da^{-1}) and its share in total tuber yield

Although there was a numerical difference in tuber yield per decare between the trial years, pre-sprouting, and planting dates, there was no statistical difference (Tables 1 and 2). Significant variations between the cultivars, on the other hand, were found at the p>0.05 level. The production of big tubers per decare was 995.4 kg (64.1%) in 2015 and 811.4 kg (43.1%) in 2016. (Table 1).

The maximum tuber yield per decare was calculated using data from the pre-sprouting application on April 3 (1011.0 kg da^{-1}, 54.3 percent), the application on April 13 (949.7 kg da^{-1}, 53.7 percent), the control (889.3 kg da^{-1}, 51.4 percent), and the application on March 23 (763, 7 kg da^{-1}, 50.5 percent). (Table 2).

According to the planting schedules, the 15 May planting produced the maximum tuber production per decare (1 051.0 kg da^{-1}, 54.5%), followed by the 5 May planting (898.8 kg da^{-1}, 51.5%) and the 25 May planting (769. kg da^{-1}, 51.4%). (Table 1).

The Binella variety yielded 842.0 kg of large tubers, whereas the Slaney cultivar yielded 964.8 kg. Because the cultivars' large tuber yield was not consistent from year to year, the pre-sprouting and planting times (year x pre-sprouting time, year x planting time x pre-sprouting time, planting time x pre-sprouting time, planting time x pre-sprouting time x variety, year x planting time x pre-sprouting time x variety) interaction was statistically significant (p<0.05) (Table 1, Figure 4, 5, 6 and 7).

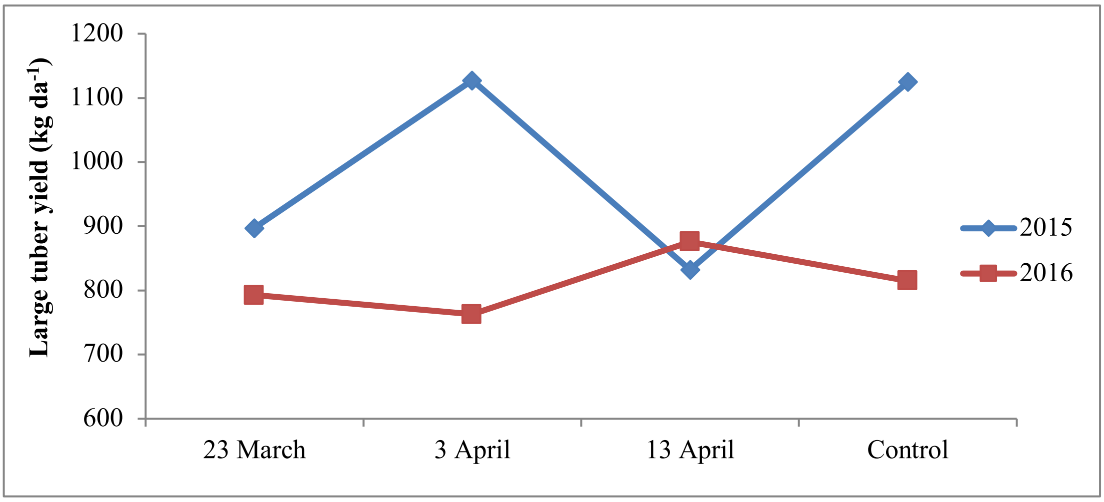

Figure 4. Interaction of year x pre-sprouting date related to the yield of big tuber per decare of years' average.

Table 1. Analysis of variance results of total, large, medium, small and discarded tuber yields per decare of pre-sprouted and planted potatoes at different times

Variation Source	df	Total tuber yields	Large tuber yield	Medium tuber yield	Small tuber yield	Discard tuber yield
Year (A)	1	4.8	3.2	35.9*	39.5*	279.1**
Error¹	3	-	-	-	-	-
Planting time (B)	2	1.2	1.0	2.4	2.6	0.5
(A) x (B)	2	1.7	1.4	4.2*	0.9	0.2
Error₂	12	-	-	-	-	-
Pre-Sprouting date (C)	3	2.1	2.8	0.9	1.0	0.5
(A) x (C)	3	2.8*	4.4*	1.5	1.4	0.3
(B) x (C).	6	0.7	0.6	1.2	0.7	2.8*
(A) x (B) x (C).	6	2.1	2.4*	0.8	0.7	2.5*
Error	54	-	-	-	-	-
Variety (D)	1	3.5	5.0*	0.2	0.01	0.4
(A)x (D)	1	0.1	0.02	0.4	0.7	0.02
(BxD)	2	2.3	0.9	3.1	1.1	0.3
(C)x(D)	3	2.8*	0.9	5.5	0.4	0.2
(A)x(B)x(D)	2	1.7	2.9	1.1	0.2	0.002
(A)x(C)x(D)	3	0.6	0.03	4.3*	0.3	0.4
(B)x(C)x(D)	6	2.4*	2.4*	1.2	2.9*	0.9
(A)x(B)x(C)x(D)	6	2.0	2.3*	0.8	1.5	1.3
Error₄	72	-	-	-	-	-

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

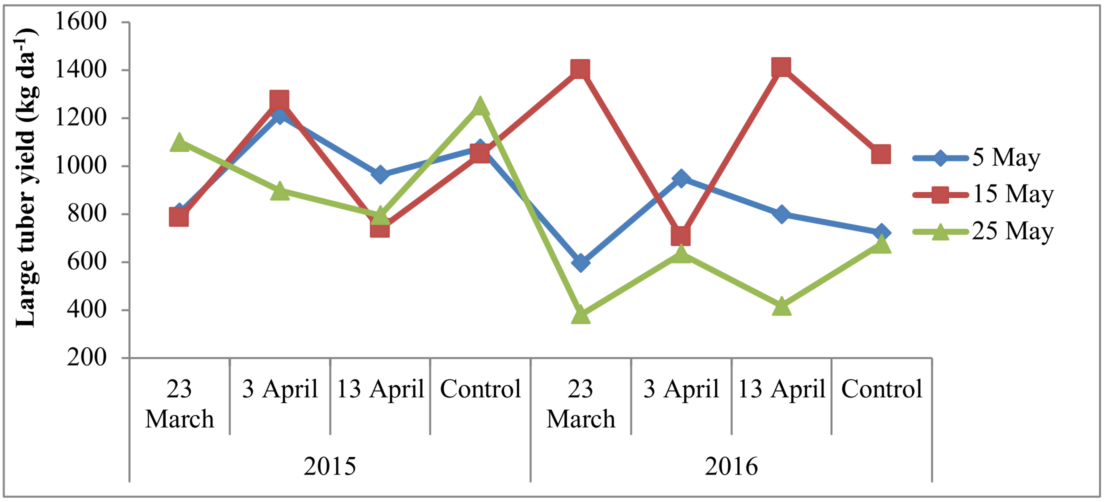

Figure 5. Interaction of year x planting time x pre-sprouting date related to large tuber yield per decare of years' average.

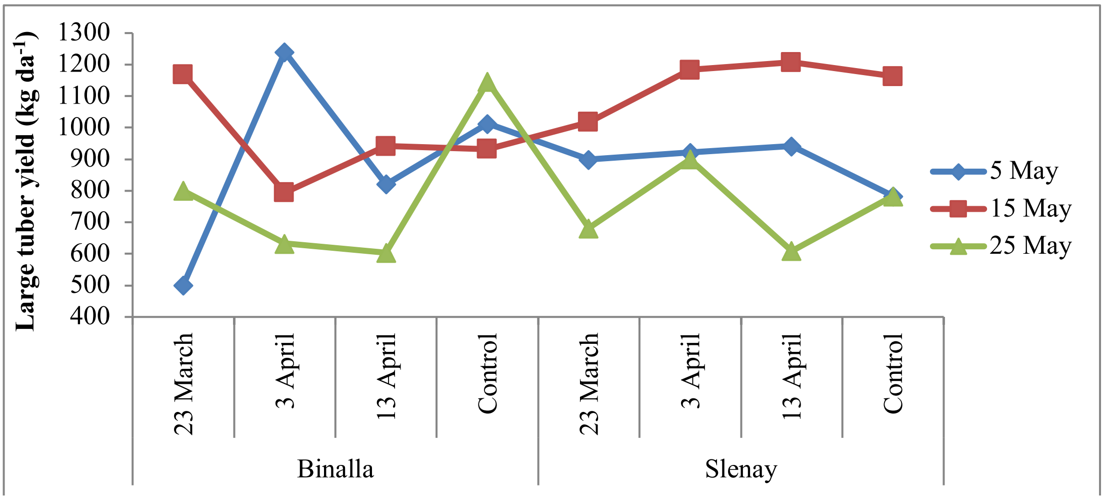

Figure 6. Planting time x pre-sprouting dates x variety interaction related to large tuber yield per decare of the year average of the cultivars.

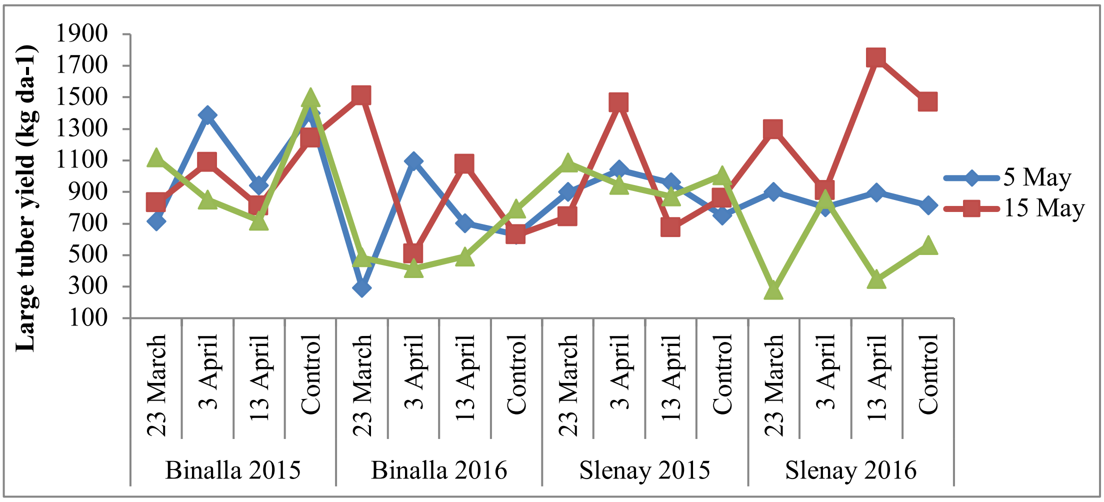

Figure 7. Year x planting time x pre-sprouting dates x variety interaction related to big tuber yield per decare the years average of cultivars.

3.3. Medium tuber (50 mm) yield per decare (kg da^{-1}) and its share in total tuber yield

The difference between the trial years in terms of mean tuber yield per decare was statistically significant ($p<0.05$), but no significance was found for pre-sprouting and planting dates or types (Tables 1 and 2). The medium tuber yield was 406.7 kg (26.2%) per decare in the first year of the experiment and 696.1 kg (37.0%) in the second year. This might be owing to the fact that the soils in the second trial year are nutrient-richer than those in the first (Table 2).

The maximum yield of medium tuber per decare was obtained on April 3 (601.7 kg da^{-1}, 32.3 percent), control (564.5 kg da^{-1}, 32.6 percent), April 13 (541.4 kg da^{-1}, 30.6 percent), and March 23 (498.0 kg da^{-1}, 32.9 percent) during the pre-sprouting period (Table 2).

The highest mean tuber yield per decare was found on May 15 (643.3 kg da^{-1}, 33.3 percent), followed by May 5 (552 kg da^{-1}, 32.0 percent) and May 25 (458.9 kg da^{-1}, 30.7 percent) according to planting timings (Table 2).

The experimental variety Binella yielded 543.9 kg per decare, whereas the Slaney variety yielded 558.9 kg per decare (Table 2).

Because the variety's medium tuber production per decare was not consistent across years, pre-sprouting, and planting periods, statistically significant ($p<0.05$) year x planting time, year x pre-sprouting time x planting time relationships emerged (Table 1, Figure 8, 9).

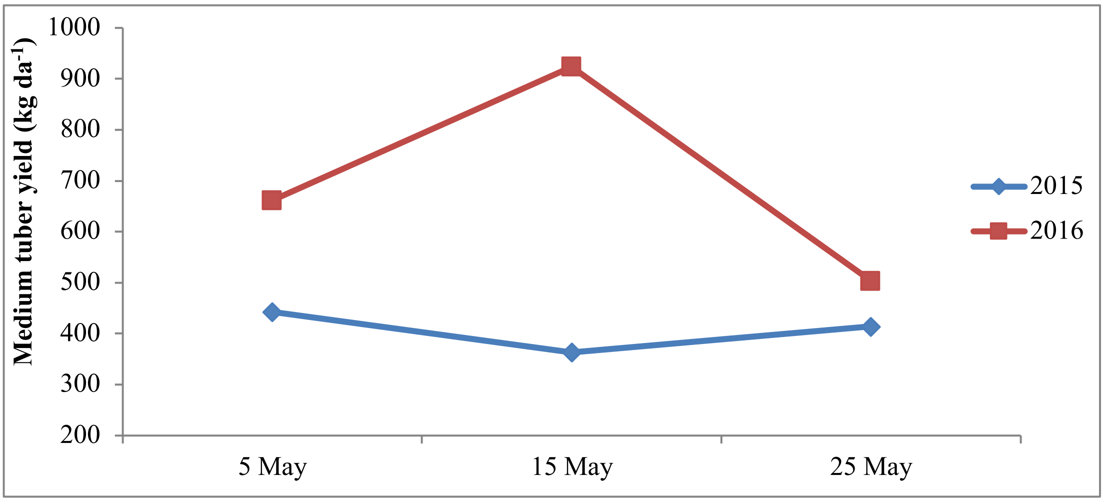

Figure 8. Interaction of year x planting time related to medium tuber yields per decare of years average.

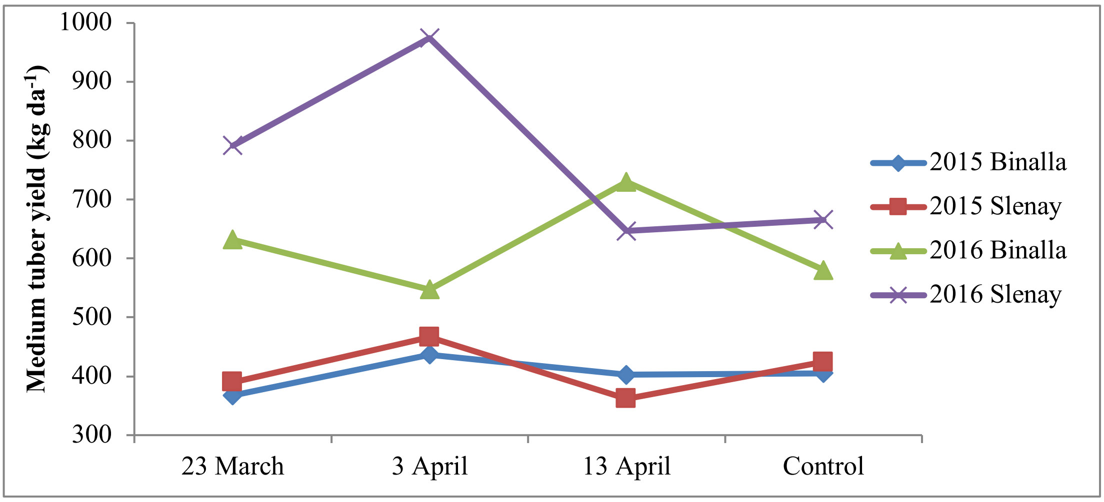

Figure 9. Year x pre-shooting date x variety interaction related to medium tuber yield per decare of years' average.

3.4. Small tuber (size 28-50 mm) yield per decare (kg da^{-1}) and its share in total tuber yield

The difference in small tuber yield per decare across trial years was statistically significant ($P<0.05$). In the case of decar tiny tuber yields, however, no correlation was found between pre-sprouting and planting periods and cultivars. Small tuber yield per decare was 116.2 kg in the first year of the experiment (7.5%) and 247.7 kg in the second year (13.2%). (Tables 1 and 2). This might be because the number of tubers per plant in the second trial year (8.5 counts) was greater than in the first year.

The interaction of variety x pre-sprouting time x planting time was significant ($p<0.05$) because the tuber yield per decare of the cultivars was not consistent according to pre-sprouting and planting periods. Tubers that were pre-sprouted on April 13 (192.3 kg da^{-1}, 10.9 percent) had the maximum small tuber yield, followed by control (189.5 kg da^{-1}, 11.0 percent), April 3 (173.7 kg da^{-1}, 9.3 percent), and pre-sprouted tubers (172.5 kg da^{-1}, 11.4 percent) on March 23 (Table 2).

In terms of planting dates, the May 5 planting had the largest tuber yield per decare (200.1 kg da^{-1}, 11.6 percent), followed by May 25 planting (184.4 kg da^{-1}, 12.3 percent) and May 15 planting (161.3 kg da^{-1}, 8.4 percent) (Table 2). The Binella variety yielded 181.5 kg per decare, whereas the Slaney variety yielded 182.4 kg (Table 2).

Table 2. The total and different size tuber yields in pre-sprouting and different planted time treatments

Treatments		Total Tuber Yield ($kg\ da^{-1}$)	Large Tuber Yield		Medium tuber yield		Small tuber yield		Discard tuber yield	
			($kg\ da^{-1}$)	%	($kg\ da^{-1}$)	%	($kg\ da^{-1}$)	%	($kg\ da^{-1}$)	%
Year	**2015**	1552.8	995.4	64.1	406.7 **b**	26.2	116.2 **b**	7.5	34.5 **B**	2.2
	2016	1882.4	811.4	43.1	696.1 **a**	37.0	247.7 **a**	13.2	127.2 **A**	6.8
Mean		**1717.7**	**903.4**	**52.6**	**551.4**	**32.1**	**182.0**	**10.6**	**80.9**	**4.7**
Pre-sprouting date	**23 March**	1512.2	763.7	50.5	498.0	32.9	172.5	11.4	78.0	5.2
	3 April	1861.6	1011.0	54.3	601.7	32.3	173.7	9.3	75.2	4.0
	13 April	1767.2	949.7	53.7	541.4	30.6	192.3	10.9	83.8	4.7
	Control	1729.8	889.3	51.4	564.5	32.6	189.5	11.0	86.5	5.0
Mean		**1717.7**	**903.4**	**52.6**	**551.4**	**32.1**	**182.0**	**10.6**	**80.9**	**4.7**
Planting time	**5 May**	1727.1	889.8	51.5	552.0	32.0	200.1	11.6	85.2	4.9
	15 May	1929.1	1051.0	54.5	643.3	33.3	161.3	8.4	73.5	3.8
	25 May	1496.5	769.4	51.4	458.9	30.7	184.4	12.3	83.8	5.6
Mean		**1717.7**	**903.4**	**52.6**	**551.4**	**32.1**	**182.0**	**10.6**	**80.9**	**4.7**
Varieties	**Binella**	1645.9	842.0 **b**	51.2	543.9	33.0	181.5	11.0	78.5	4.8
	Slaney	1789.3	964.8 **a**	53.9	558.9	31.2	182.4	10.2	83.2	4.6
Mean		**1717.7**	**903.4**	**52.6**	**551.4**	**32.1**	**182.0**	**10.6**	**80.9**	**4.7**
5 May x 23 March		1401.3	670.0	47.8	463.9	33.1	186.3	13.3	81.1	5.8
5 May x 3 April		1970.6	1080.8	54.8	615.1	31.2	204.0	10.4	70.7	3.6
5 May x 13 April		1810.9	880.9	48.6	608.0	33.6	212.5	11.7	109.5	6.0
5 May x Control		1696.3	897.8	52.9	521.1	30.7	197.7	11.7	79.7	4.7
15 May x 23 Mart		2098.2	1093.3	52.1	723.5	34.5	188.2	9.0	93.2	4.4
15 May x 3 April		1839.6	988.8	53.8	635.6	34.6	158.1	8.6	57.1	3.1
15 May x 13 April		1951.8	1074.5	55.1	646.0	33.1	159.1	8.2	72.2	3.7
15 May x Control		1827.3	1047.5	57.3	568.2	31.1	140.0	7.7	71.6	3.9
25 May x 23 March		1437.8	740.9	51.5	448.8	31.2	159.7	11.1	88.4	6.1
25 May x 3 April		1615.4	766.1	47.4	567.6	35.1	190.8	11.8	90.9	5.6
25 May x 13 April		1194.3	606.4	50.8	351.7	29.4	168.2	14.1	68.0	5.7
25 May x Control		1738.1	964.4	55.5	467.5	26.9	219.0	12.6	87.2	5.0
5 May x 23 March x Binella		1205.4	500.6	41.5	366.7	30.4	226.9	18.8	111.2	9.2
5 May x 23 March x Slaney		1657.1	899.3	54.3	561.1	33.9	145.7	8.8	51.0	3.1
5 May x 3 April x Binella		2079.2	1240.0	59.6	560.0	26.9	220.5	10.6	58.7	2.8
5 May x 3 April x Slaney		1861.9	921.6	49.5	670.2	36.0	187.4	10.1	82.7	4.4
5 May x 13 April x Binella		1777.8	820.5	46.2	632.7	35.6	201.2	11.3	123.4	6.9
5 May x 13 April x Slaney		1843.8	941.2	51.0	583.2	31.6	223.8	12.1	95.6	5.2
5 May x Control x Binella		1795.0	1012.4	56.4	452.2	25.2	243.0	13.5	87.4	4.9
5 May x Control x Slaney		1597.4	783.1	49.0	590.0	36.9	152.3	9.5	72.0	4.5
15 May x 23 March x Binella		2080.5	1169.3	56.2	634.0	30.5	183.4	8.8	93.8	4.5
15 May x 23 March x Slaney		2115.8	1017.3	48.1	813.0	38.4	192.9	9.1	92.6	4.4
15 May x 3 April x Binella		1344.3	794.2	59.1	378.8	28.2	126.0	9.4	45.3	3.4
15 May x 3 April x Slaney		2334.6	1183.3	50.7	892.4	38.2	190.1	8.1	68.8	2.9
15 May x 13 April x Binella		1880.5	941.4	50.1	701.0	37.3	154.9	8.2	83.2	4.4
15 May x 13 April x Slaney		2022.9	1207.5	59.7	591.0	29.2	163.2	8.1	61.2	3.0
15 May x Control x Binella		1690.1	932.4	55.2	536.5	31.7	160.9	9.5	60.3	3.6
15 May x Control x Slaney		1964.2	1162.5	59.2	599.8	30.5	119.0	6.1	82.9	4.2
25 May x 23 March x Binella		1542.7	800.8	51.9	498.5	32.3	160.1	10.4	83.3	5.4
25 May x 23 March x Slaney		1332.6	681.0	51.1	399.0	29.9	159.2	11.9	93.4	7.0
25 May x 3 April x Binella		1428.7	632.7	44.3	536.9	37.6	173.9	12.2	85.2	6.0
25 May x 3 April x Slaney		1801.9	899.4	49.9	598.3	33.2	207.6	11.5	96.6	5.4
25 May x 13 April x Binella		1250.3	603.7	48.3	364.7	29.2	198.3	15.9	83.6	6.7
25 May x 13 April x Slaney		884.6	609.0	68.8	83.3	9.4	138.0	15.6	54.3	6.1
25 May x Control x Binella		1532.8	1145.8	74.8	93.4	6.1	233.1	15.2	60.5	3.9
25 May x Control x Slaney		1187.0	783.0	66.0	85.2	7.2	205.0	17.3	113.8	9.6

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

The interaction of variety x pre-sprouting time x planting time was found to be significant ($p<0.05$) due to the inconsistency of tuber yield per decare of the cultivars when pre-sprouting and planting times were included (Table 1, Figure 10).

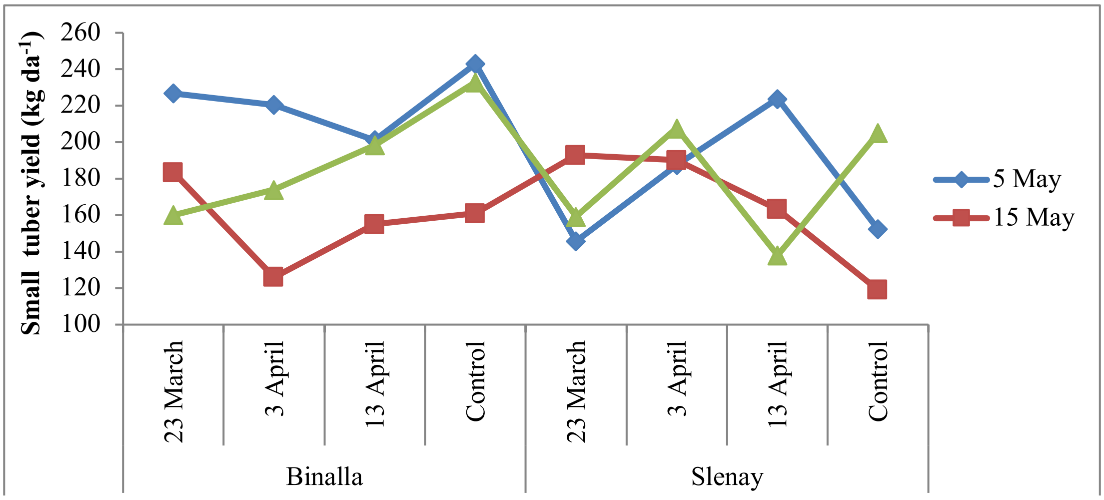

Figure 10. Pre-sprouting date x planting time x variety interaction related to small tuber yield per decare of cultivars over the years.

3.5. Discard tuber (< 28 mm) yield per decare (kg da^{-1}) and its share in total tuber yield

Between study years, there was a statistically significant ($p<0.01$) difference in discarded tuber yields (Table 1). The discarded tuber yield in the first research year was 34.5 kg da^{-1} (2.2%), while in the second year, it was 127.2 kg da^{-1} (6.8%) (Table 1). This might be due to greater tuber counts per plant in the second year compared to the first.

The control (86.5 kg da^{-1}, 5.0 percent) treatment had the greatest discarded tuber yield per decare among the pre-emergence dates, followed by the pre-emergence dates on April 13 (83.8 kg da^{-1}, 4.7 percent), March 23 (78.0 kg da^{-1}, 5.2 percent), and April 3 (75.2 kg da^{-1}, 4.0 percent) (Table 2).

The potatoes planted on May 5 had the highest output of discarded tuber per decare of all the planting periods (85.2 kg da^{-1}, 4.9 percent). Following this, planting on May 25 (83.8 kg da^{-1}, 5.6 percent) and May 15 (73.5 kg da^{-1}, 3.8 percent) took place (Table 2).

The discarded tuber yield of the Binella variety was found to be 78.5 kg per decare, whereas the Slaney variety yielded 83.2 kg (Table 2).

Because the discarded tuber yield per decare varied by year, pre-sprouting, and planting times, the interaction of pre-sprouting x planting time, year x pre-sprouting x planting time, and year x pre-sprouting x planting time was statistically significant ($p<0.05$) (Table 1). Pre-sprouting x planting time, year x pre-sprouting x planting time x interaction was statistically significant ($p<0.05$) because the yield of discarded tuber per decare was not constant across years, pre-sprouting, and planting periods (Table 1, Figure 11, 12).

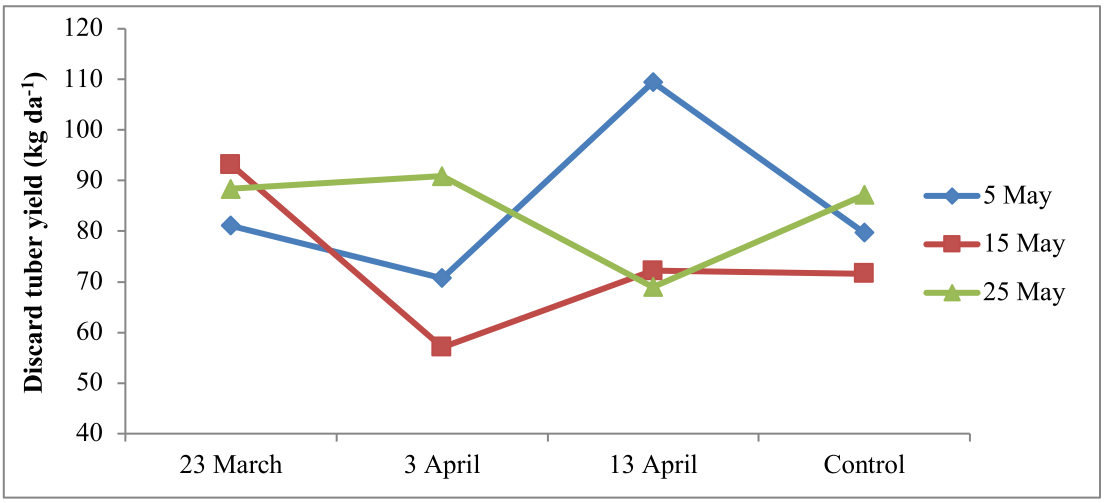

Figure 11. Pre-sprouting date x planting time interaction related to discarded tuber yield per decare on average of years.

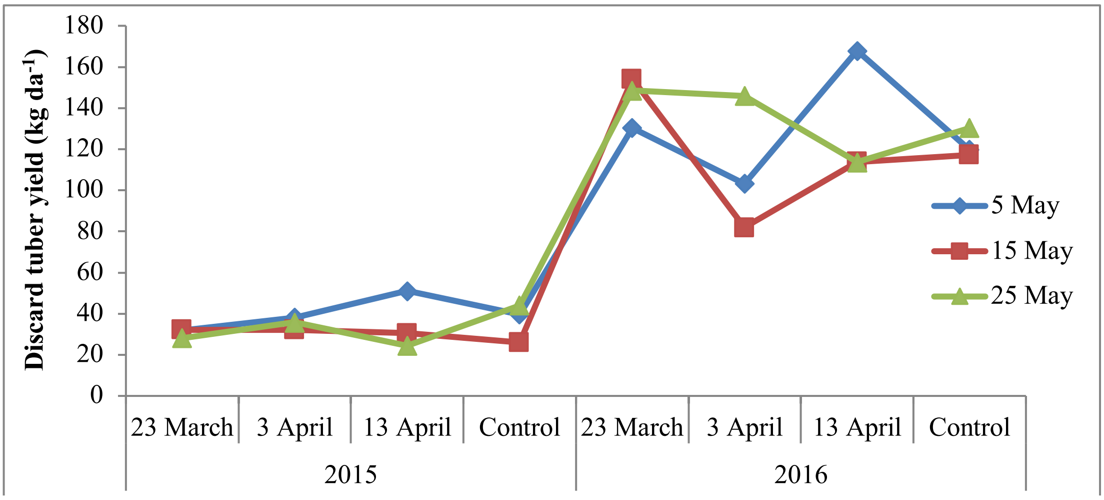

Figure 12. Year x pre-sprouting date x planting time interaction related to discarded tuber yield per hectare of years average.

Conclusions

As a consequence, the Binella variety should be pre-sprouted on March 23 (2 080.5 kg da^{-1}, 1 169.3 kg da^{-1}) and the Slaney variety should be pre-sprouted on April 13 (2 022.9 kg da^{-1}, 1 207.5 kg da^{-1}) for total and big tuber production, and both should be planted on May 15. The Binella variety (701.0 kg da^{-1}) and the Slaney variety (892.4 kg da^{-1}) should be pre-sprouted on April 13 and planted on May 15, respectively, for medium tuber output. The Binella variety should be pre-sprouted (243.0 kg da^{-1}) for small tuber production, whereas the Slaney variety should be pre-sprouted (223.8 kg da^{-1}) and planted on May 5 for small tuber output. The Binella variety should be pre-sprouted on April 13 and planted on May 5 (123.4 kg da^{-1}), but the Slaney variety should be planted on May 25th without pre-sprouting (113.8 kg da^{-1}) for discarded tuber production.

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