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Research Article

Dependence of Pepper and Tomato Seeds Germination on Fruit Ripening

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Abstract: The seeds germination of six pepper and tomato varieties were evaluated during the years of 2012 and 2013 in three stages of ripening, in four intervals after harvest. When watching the seeds germination of tomatoes and peppers in green maturity, it was found zero germination in all varieties. In case when pepper fruits were in transition maturity, the average germination of varieties was 38% in one month after harvesting. The highest average germination (68%) was determined after nine months of harvest. The highest pepper seeds average germination (89%) was reached after nine months of harvest in botanical ripeness. The highest final germination was found in the botanical maturity of variety *Barkol* (97%) and lowest in varieties *Amy* (82%) and *Alma* (84%). Providing tomato seeds collected in the transitional maturity, the highest germination was in one month after harvest (89%) in a variety *Darinka* and lowest germination was found in the variety *Šejk* (71%). In a variant of seeds collected in the botanical maturity the highest germination was in a variety *Darinka* and *Denár* (100%) and lowest in variety *Kecskeméti* (82%).

Keywords: pepper, tomato, seed, germination, fruit ripening

INTRODUCTION

Pepper (*Capsicum annum* L.) and tomato (*Lycopersicon esculentum* Mill.) belong to the most widely grown vegetables ¹. They are necessary as a component of the human diet and an important raw material in the canning and processing industry. They have excellent taste and nutritional properties. The fruits of the pepper and tomato accumulate a significant amount of β -carotene (pro-vitamin A), vitamin C and lycopene which are beneficial to human health ^{2, 3}. One of the fundamental factors for successful cultivation of plants is the use of valuable seeds. Breeding and seed production aims to improving of agricultural crops and seeds properties. Getting high quality of fruiting vegetable seeds depends on agro-technical conditions of production, pollination, fertilization, also the time of collection and the degree of ripeness of the fruit ⁴.

MATERIALS AND METHODS

The aim of this work was to investigate the fruit ripening influence on seeds germination. For experimental purposes, there were selected six varieties of peppers and six varieties of tomatoes **Table 1**. Varieties were grown in 2012 and 2013 in Botanical Garden land of Slovak Agricultural University in Nitra. The soil is heavy black soil, formed on alluvial silt. Most clay particles are below the topsoil at a depth of 0.30 m - 0.60 m. The soil has medium humus content in the range of 2.2 to 2.8%. It has a high strength to binding the water and nutrients. For the experimental area it is characteristic a high groundwater level. The previous crop of experiment area was carrots in both evaluated years. Data of the monthly average air temperatures and monthly rainfall totals were measured at the meteorological station in Nitra.

Table 1 : Name and origin of peppers and tomatoes varieties.

Name of pepper varieties	Origin	Name of tomato varieties	Origin
<i>Alma</i>	Hungary	<i>Darinka</i>	Czech
<i>Amy</i>	Czech	<i>Denár</i>	Czech
<i>Barkol</i>	Slovak	<i>Kecskeméti</i>	Hungary
<i>Katrena</i>	Slovak	<i>Orange</i>	Czech
<i>PCR</i>	Slovak	<i>Pavčina</i>	Czech
<i>Slovakia</i>	Slovak	<i>Šejk</i>	Czech

The information was provided by the Slovak Meteorological Institute in Bratislava **Table 2**. Field experiments with six variety peppers and tomatoes varieties were established in 3 replications with 10 plants per row and 30 plants per variant. Spacing of pepper cultivation was 0.40 x 0.50 m and of tomatoes 0.50 x 0.60 m. Sowing of tomatoes and peppers was conducted in the greenhouse in 27th of March 2012 and 04th of May 2013. After creating two true leaves, the plants were transplanted into the mini cultivation trays. Planting in field conditions was carried out in the period in 20th of May 2012 and in the following year 24th of May 2013. During the vegetation plants were commonly nursed, watered and fertilized with calcium nitrate.

Table-2: Monthly average air temperatures and rainfall totals for the Nitra locality in 2012 and 2013

Month	Average temperatures in °C		Total rainfall in mm	
	2012	2013	2012	2013
May	17	16	20	101
June	21	19	70	76
July	23	22	61	10
August	21	22	7	78
September	17	15	33	74

The collection was carried out in three stages of maturity, namely:

(A) Green maturity (B) Transient maturity - half red and (C) Botanical maturity – red.

Pepper seeds were collected from the fruit by hand. Tomato juice was pushed with seeds in a container and allowed to ferment for 3 days at 25 ° C to remove slime. Subsequently, the seeds were rinsed with water and dried. The germination tests of peppers and tomatoes seeds were done at the Department of Vegetable Production in the laboratory in 2012 and 2013 in three variants of maturity, four intervals after harvest and three replicates. There were used 100 seeds of each variety, each variant, and repetition interval. Germination was evaluated in Petri dishes with filter paper and the lid. For watering there was used distilled water. Texts and the results were processed by Microsoft Word and Microsoft Excel 2003. Tables and graphs are presented average values of the two years and three repetitions.

STATISTICAL ANALYSIS

The analysis of variance (ANOVA), the multifactor analysis of variance (MANOVA) and the multiple Range test were done using the Statgraphic Centurion XV (Stat Point Inc. USA).

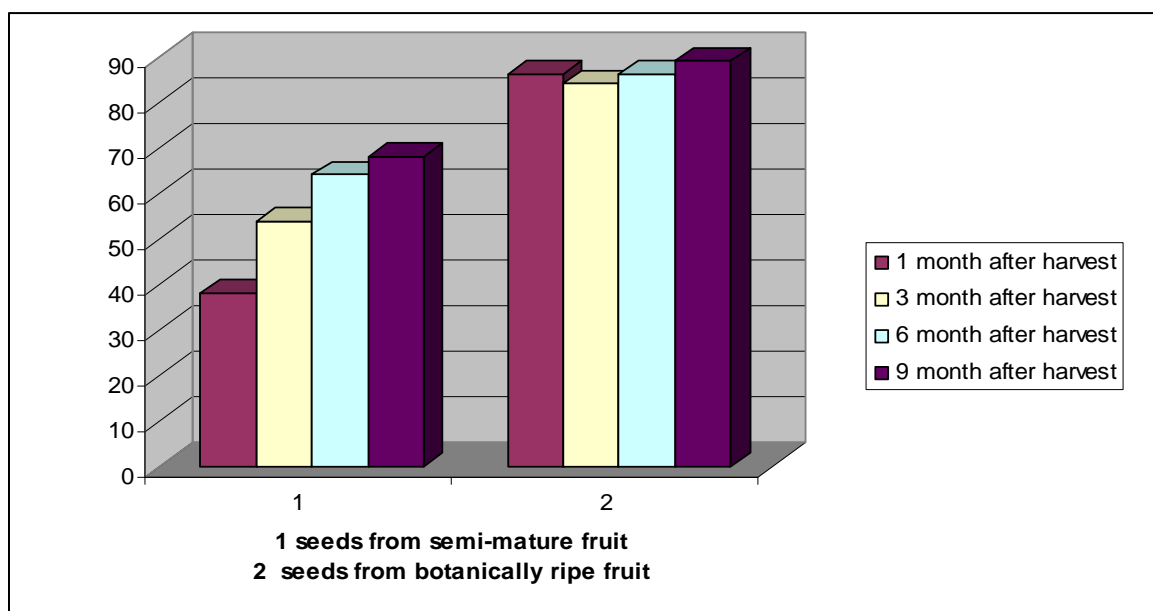
RESULTS

Evaluation of pepper seeds germination: In assessing the germination test of pepper seeds it can be said that the first variant of the green maturity had zero germination in case of all varieties. Second variant (transient – half red maturity stage) and one month after harvest there was achieved an average germination of varieties for 38 %. This transient maturation increased germination by increasing time after harvest. The highest average germination after nine months of harvest was 68 %. Ripening of fruits caused constant increasing of the germination. In the botanical ripeness seeds had the highest average germination (89%) after nine months after seeds harvest.

The highest final germination was found in the botanical maturity of varieties *Barkol* (97%) and *PCR* (95%), lowest in varieties *Amy* (82%) and *Alma* (84%). By the Collection of Laws no. 58/2007, page 455, annex. 2 for pepper seeds there are required a minimum germination ⁵ of 65%. The named value of germination achieved all varieties harvested in botanical ripeness and some varieties harvested in the transitional maturity after six to nine months of storage. The results can also be seen in **Table 3** and in **Figure 1**.

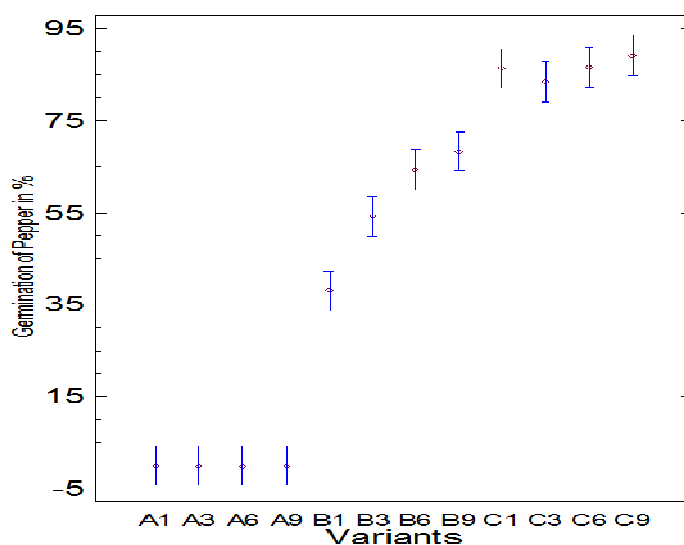
Table 3: Average germination of pepper seeds (%).

Varieties	Germination monitored 1, 3, 6, 9 months after harvest of seeds								
	Seeds harvested in green maturity (A)	Seeds harvested in half red maturity (B)				Seeds harvested in red maturity (C)			
		1	3	6	9	1	3	6	9
<i>Alma</i>	0	37	66	68	71	80	78	84	84
<i>Amy</i>	0	50	62	69	73	78	79	80	82
<i>Barkol</i>	0	11	31	52	58	91	92	96	97
<i>Katrena</i>	0	40	49	71	76	97	84	82	88
<i>PCR</i>	0	40	42	49	64	87	92	95	95
<i>Slovakia</i>	0	50	76	76	68	85	76	79	89
Average	0	38	54	64	68	86	84	86	89

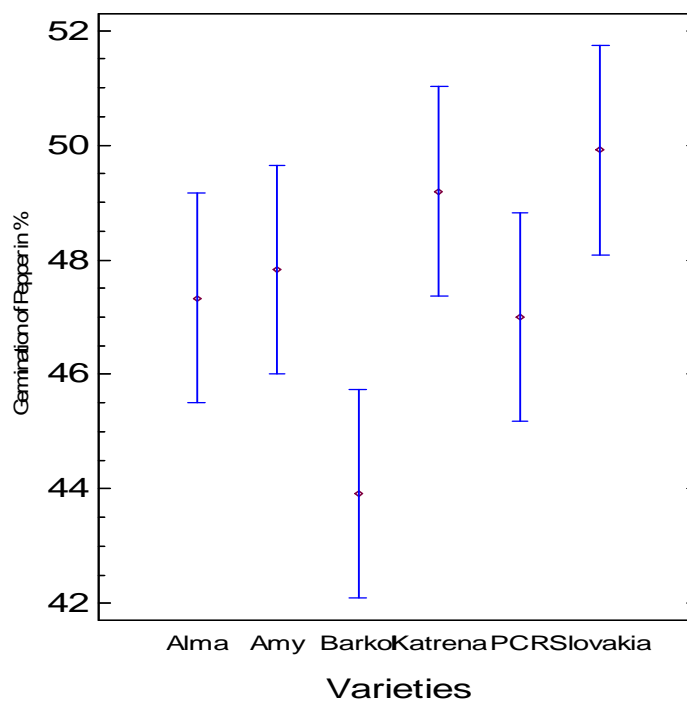
**Figure 1:** Average germination of pepper seeds monitored from 1 to 9 months after harvest of seeds.

On the basis of statistical evaluation by the analysis of variance (ANOVA) method there was found very high statistically significant influence of variants on pepper seeds germination. According to **Figure 2**, significant differences were determined between all variants except of couples A1 – A3, A1 – A6, A1 – A9, A3 – A6, A3 – A9, A6 – A9 (in case of seeds in green maturity), B6 – B9 (in case of seeds in transient maturity - half red), C1 – C3, C1 – C6, C1 – C9, C3 – C6, C6 – C9 (in case of seeds in botanical maturity – red). The influence of variety on seeds germination was also statistically significant according to used statistical analyses. Following the **Figure 3**, statistically significant difference in germination was denoted in case of varieties *Amy* - *Barkol*, *Barkol* - *Katrena* and *Barkol* - *Slovakia*.

Means and 95,0 Percent Tukey HSD Intervals

**Figure 2:** Dependency of pepper seeds germination on observed variants.

Means and 95,0 Percent LSD Intervals

**Figure 3:** Dependency of pepper seeds germination on observed varieties.

EVALUATION OF TOMATO SEEDS GERMINATION

When evaluating the germination of tomato seeds varieties which were harvested in the green maturity, it was found zero germination. Seeds collected in the transitional maturity had the highest germination in the variant monitored one month after harvest (89%) in variety *Darinka* and 84% in *Orange* variety. Lowest germination was determined in case of *Šejk* variety (71%). In the third variant of seeds collected in the botanical maturity was the highest germination in a variety *Darinka* and *Denár* (100%) and lowest in variety *Kecskeméti* (82%). No significant differences between tomato seeds germination after one to nine months of seeds harvest is showed in **Table 4** and **Figure 4**. Month after harvest the tomatoes seeds has satisfies performance requirements of tomato seed, according to Law Code No.58/2007, which calls for minimum 75 % of germination.

Table 4: Average germination of tomato seeds (%).

Varieties	Germination monitored 1, 3, 6, 9 months after harvest of seeds								
	Seeds harvested in green maturity (A)	Seeds harvested in half red maturity (B)				Seeds harvested in red maturity (C)			
		1	3	6	9	1	3	6	9
<i>Darinka</i>	0	89	76	81	84	100	96	92	94
<i>Pavčina</i>	0	73	76	79	81	87	98	94	90
<i>Kecskeméti</i>	0	75	74	81	78	86	82	89	92
<i>Šejk</i>	0	71	74	76	79	94	88	98	94
<i>Denár</i>	0	81	78	74	71	87	100	95	94
<i>Orange</i>	0	84	80	79	75	98	86	93	97
Average	0	79	76	78	78	92	92	94	94

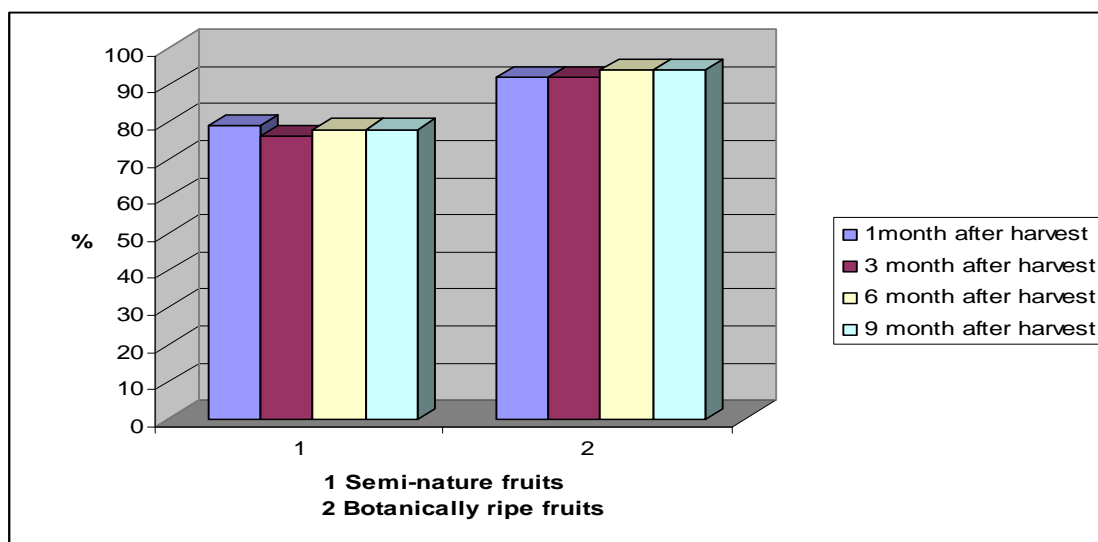


Figure 4: Average germination of tomato seeds monitored from 1 to 9 months after harvest of seeds.

Providing tomatoes it was found very high statistically significant effect in case of both observed factors – variety and variants.

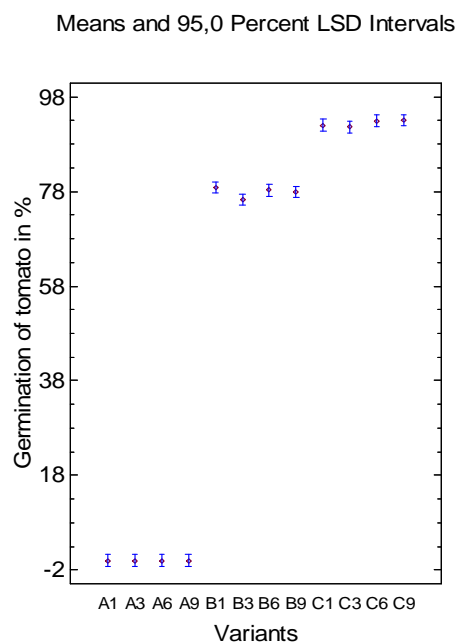


Figure 5: Dependency of tomato seeds germination on observed variants.

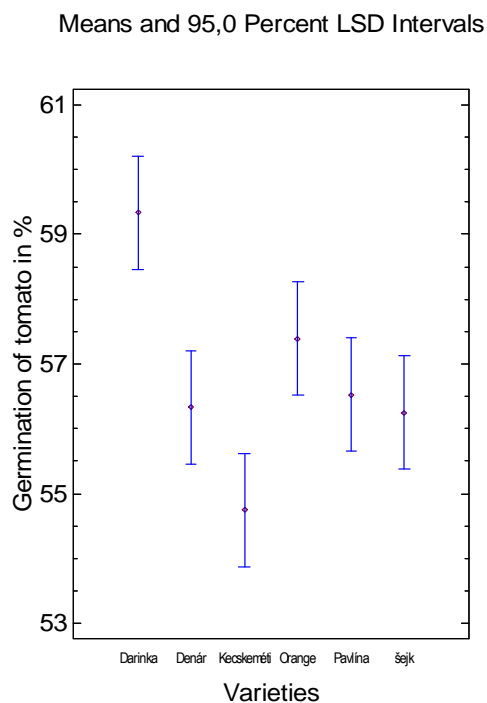


Figure 6: Dependency of tomato seeds germination on observed varieties.

Following the **Figure 5**, significant differences are figured between most of observed variants except of couples A1 – A3, A1 – A6, A1 – A9, A3 – A6, A3 – A9, A6 – A9 (in case of seeds in green maturity), B1 – B6, B1 – B9, B3 – B6, B3 – B9, B6 – B9 (in case of seeds in transient maturity - half red), C1 – C3, C1 – C6, C1 – C9, C3 – C6, C3 – C9, C6 – C9 (in case of seeds in botanical maturity – red), within which there are no statistically significant differences. The influence of tomato varieties on seeds germination was very high statistically significant at the 95 % confidence level. As it is obvious in **Figure 6**, there was noticed statistically significant difference between varieties *Darinka – Denár*, *Darinka – Kecskeméti*, *Darinka – Orange*, *Darinka – Pavlína*, *Darinka – Šejk*, *Kecskeméti – Orange*, *Kecskeméti – Pavlína*.

DISCUSSION

The results in **Table 3** indicate the seeds germination of different pepper varieties. The highest germination was achieved by varieties in the third variant in botanical ripeness. Seeds germination of all pepper varieties in the botanical maturity was on average 87%. One month after harvest in botanical maturity the seeds had 86 % germination, after three months 84 %, after six months 86 % and after nine months 89 %. It can be said that the values were lower than the data reported by Kóňa, Jakábová, Marek ⁶ with an average germination of 90%. Our results show that the quality of the seeds should be obtained from botanically ripe fruits. The similar results achieved Raymond ⁷ and Viddgal *et al* ⁸. In cases of emergency, seeds may be obtained from the fruits that begin to pass into botanical maturity ⁹. Older standards required for first class quality of pepper seeds germination of 80%, in second class 70% and in the third class 60% of germination ¹⁰. Today's standards require a minimum germination of pepper seeds for 65% ¹¹.

The presented results show in **Table 4** the germination of tomato varieties seeds, where the highest germination was reached in the third variation of the varieties in botanical maturity. Seed germination of different varieties in the botanical maturity ranged on average around 93 %. In the germination test one month after the harvest and three months after collection, there was found the same germination capacity of 92%. Six and nine months after the harvest, the average germination was 94%. Uher, Kóňa, Valšíková, Andrejiová ⁴ indicate germination for tomato seeds from 75 to 80%.

Actual Laws Collection No.58/2007 indicates 75% minimum germination of tomato seeds. The results we have obtained can be affected by agro-technical factors during cultivation such as date of sowing, fertilizing influence, pollinating by insects and etc. Demir and Ellis ¹², Demir and Samit ¹³, Dias *et al* ¹⁴ studied similar changes in seed quality during seed development of tomato. Vidigal *et al* ¹⁵ have dealt with the relationship between the quality of tomato seeds and storage after harvest. They received similar results as ours.

CONCLUSION

Results were obtained by monitoring of pepper and tomato seeds germination. In the first variant, the pepper and tomatoes seeds harvested in green maturity reached zero germination and in case of all varieties because of undeveloped seeds. In the second variant, pepper varieties were in transition maturity. Satisfactory average germination (68%) was reached 9 months after harvest. During ripening of tomatoes all the dates of germination tests after harvest have good results. The

average germination ranged between the values 76 to 78%, which exceeds the minimum requirement of 75%. The highest seed germination reached peppers and tomatoes in a third variant of the botanical ripeness in all varieties. One month after the harvest the germination of pepper seeds was 86%, three months after harvest 84%, six months after harvest 86% and nine months after harvest 89%. In doing so, the required minimum germination represents only 65% germination. During testing of tomato seeds germination, the term of testing after harvest had no significant impact on the results of germination. One to three months after harvest varieties showed average germination 92 % and after six and nine weeks after collection the germination was 94 %. Effect of varietal characteristics to germination capacity was not conclusive.

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