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THE INFLUENCE OF DIFFERENT TEMPERATURES AND EXPOSITION TIME ON POTATO TUBER SPROUTING

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Research on the influence of different temperatures and exposition time on potato tuber sprouting was carried out at the Laboratory of Food Raw Materials, Agronomic and Zootechnical Research, Faculty of Agronomy, Lithuanian University of Agriculture, in the year 2009.

Chemical analyses of potato tubers were carried out at the Laboratory of Chemical Research, Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry.

Different temperatures -10°C - +50°C influenced the tubers sprouting. The highest number of sprouts, compared to the primary number of eyes, was established in the tubers of potato cv. 'Goda' exposed to -10°C for 60 min. (192.6%) and to +50°C for 90 min. (194.7%); and in the tubers of potato cv. 'Solara' exposed to -10°C for 60 min (126.1%) and to +30°C for 60 min (167.8%).

Key words: tubers, thermal influence, exposition time, sprouting.

INTRODUCTION

Potato tuber sprouting has been known for a long time. Sprouted potatoes develop more rapidly, produce higher and earlier yield. A few sprouting methods are available; however, inhibition of apical domination of potato tubers in order to stimulate a greater number of stems and leaves per plant has not been investigated. The objective of the present study is to induce stress to tubers, which will result in more active sprouting process as well and to assess its influence on further development of plants.

Potato (*Solanum tuberosum* L.) plants ehibit a unique growth pattern. They may be propagated by tubers, parts, shoots, draws and seeds. Potatoes are commonly propagated by tubers. A potato tuber is a modified stem exhibiting the same structure as an over-ground stem. Eyes are arranged around the tuber in a spiral shape, whereas the greatest number is concentrated in the upper part of a tuber [25]. Naturally, each eye contains some three shoots, and germination of the most developed one occurs first of all.

Sprouting of shoots from tuber eyes starts at the end of the dormancy period. First of all, an eye of the upper part sprouts. Sprouting of other shoots contained in a tuber eye is blocked. This is called the apical domination effect. If tubers are planted within the apical domination period, the potato plant will probably grow just one stem overall resulting in low yield [22, 10].

To produce mature potato yield as early as possible, different tuber sprouting methods are applied including the method of temperature influence [3]. This method stimulates enzymic activity in a tuber, encourages more rapid germination of eyes, shortens the sprouting period and accelerates development of a plant. With increasing temperature, however, respiration intensity grows, therefore, energy resources of a plant are lost [15, 12].

Other authors [25] maintain that removal of a dominating shoot (e.g. shoot breaking-off) leads to more active sprouting of other shoots contained in an eye, however, such stimulation of tuber sprouting has a negative influence on the tuber as the latter loses energy, moisture and withers. Quantitative phenological observations of over-ground and underground plant parts considering environment factors [19] and distinguishing features of cultivars constitute a very important step in order to achieve comprehensive understanding of potato germination and development [9].

Low or high temperatures cause abiotic stress. Depending on the intensity and duration of stress, effects on plants may be twofold: positive – elimination of apical dominance and promotion of sprouting, and negative – lesions on plants or even death [2].

In Lithuania, is recommended to begin sprouting of seed potato tubers in March already under conditions of natural light, 35-45 days prior to planting, maintaining constant temperature (+12-+15^{o}C), but not higher than +17^{o}C [16].

The aim of the present research is to determine the influence of temperatures (down to -10^{o}C) and temperatures (up to +50^{o}C) and of different exposition time on apical dominance elimination, sprouting and development.

MATERIAL AND METHODS

Laboratory studies were carried out at the Laboratory of Food Raw Materials, Agronomic and Zootechnical Research, Faculty of Agronomy, Lithuanian University of Agriculture, in the year 2009. Research object – potato (*Solanum tuberosum* L.) cultivar ‘Goda’ and ‘Solara’. The test containing 16 treatments was carried out in three replications according to the following scheme:

Treatment	Temperature	Exposure time
1. Control	+18^{o}C	24 h
2.	-10^{o}C	30 min.
3.	-10^{o}C	60 min.
4.	-10^{o}C	90 min.
5.	+5^{o}C	30 min.
6.	+5^{o}C	60 min.
7.	+5^{o}C	90 min.
8.	+30^{o}C	30 min.
9.	+30^{o}C	60 min.

10.	+30°C	90 min.
11.	+40°C	30 min.
12.	+40°C	60 min.
13.	+40°C	90 min.
14.	+50°C	30 min.
15.	+50°C	60 min.
16.	+50°C	90 min.

Sprouting of potato tubers was assessed visually 21 days after exposure. The following was established: number of shoots in the upper, middle and bottom parts of a tuber (number and %); mass, by the weight method (in grams and %).

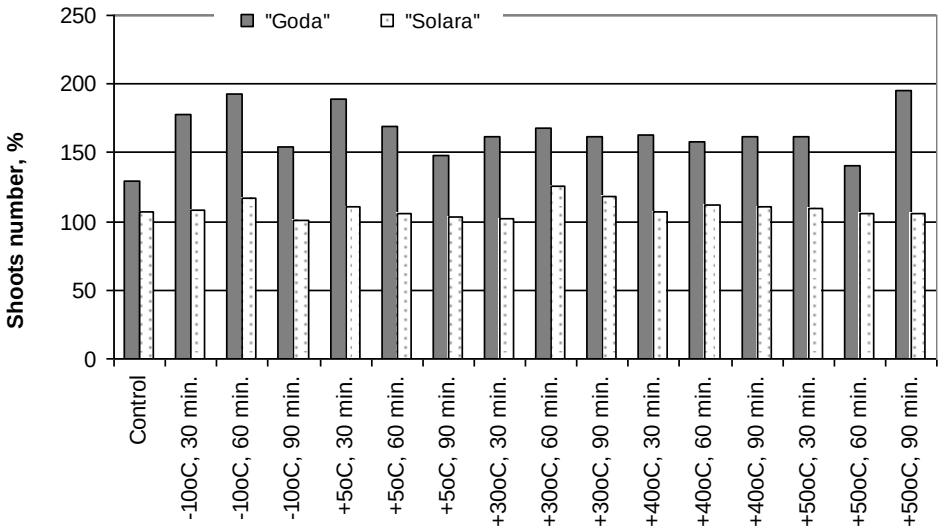
Shortly after exposure, chemical analyses of potato tubers were carried out at the Laboratory of Chemical Research, Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry. The following was established: protein content by Kjeldahl method; dry matter content by the weight method.

Statistical data processing. A standard deviation for research data average was computed by "MS Excel" software. Research data were processed by *Anova* [20].The following symbols were applied in the paper: R_{05} – the least significant difference at the probability level of 95%. $S_{\bar{x}}$ – standard error of the mean. Sprouting was computed from the initial number of eyes and expressed in percent.

RESULTS

Studies on the influence of different temperatures and exposition time on potato tubers suggested that combinations with the different impact make influence on sprouting of potato tubers. The significant effects of the combinations were established.

The greatest positive result of the thermal treatment influence on tuber sprouting was demonstrated by tubers of cultivar 'Goda' cooled to -10°C for 60 min (192.6%) and heated in a thermostat at +50°C for 90 min (number of the shoots sprouted to 194.7% of the number of the eyes contained in a tuber). For medium-early potato cv. 'Solara', the greatest percentage of sprouting, i.e. 126.1%, was shown by the tubers cooled to -10°C for 60 min and heated at + 30°C for 60 min (167.8%) (Figure 1).



LSD_{05} Goda – 15,14; Solara – 9,00.

Figure 1 – The effect of different temperatures and exposition time on tuber sprouting of ‘Goda’ and ‘Solara’, 2009

During research, the number of eyes germinated in different parts of tubers was assessed. The obtained results demonstrated that the influence of different temperatures and exposition time decreased apical domination of potato tubers and stimulated sprouting of the shoots developed from side eyes [13].

The lowest number of the shoots sprouted in the upper part of tubers was observed for the treatments (2, 5, 8, 11 and 14) where the influence of temperature lasted for 30 minutes (‘Goda’). The distribution of eyes sprouted in the upper, middle and bottom parts of tubers was as follows: some 30-35%, 30-55%, from 20 to 45% of the total eyes of the tuber respectively. At exposition time of 90 min at +30, +50°C, the number of the sprouted eyes demonstrated by the upper and middle parts of a tuber was 52-58% and 48-42% respectively. The bottom part of a tuber showed no sprouting of eyes as apical domination was displayed by tubers.

Distribution of the shoots sprouted in the upper, middle and bottom parts of of ‘Solara’ tubers was as follows: 42%, 25%, 30% (treatment 2) of the total eyes of the tuber respectively; Tubers stored at +30°C for 90 min demonstrated the following: some 40%, 30%, 30% of the total eyes in the upper, middle and bottom parts of tubers respectively [13].

Temperature that is close to unfavourable one activates inner plant response and this may increase plant resistance and stimulate acclimatisation. Plant response to temperature changes (frost or heat shock) is the result of gene expression [21]. Frost activates genes and increases frost resistance; synthesis of more proteins dehydrin replacing membrane conductivity is observed [5, 4]. Usually, plant injuries caused by low positive temperature manifest themselves in temporary metabolism disorders, whereas negative temperatures may even

lead to irreversible changes. Influence of negative temperatures -10°C exposition time 60 and 90 min of 'Goda'; and exposition time 30, 60, 90 min of 'Solara' violated the cell structure of tubers. 21 days after the influence of different temperature and exposition time, injuries in potato tubers were displayed.

Potato tubers of individual cultivars differ in chemical composition, physical properties [7] and response to low storage temperature Changes in chemical composition of potatoes established during research are related to the influence of storage temperature [14], effect of fertilisation and storage conditions [17], and impact of potato treatment with germination inhibitors [23]. Different temperature and exposition time made an influence to changes in the content of proteins and dry matter of potato tubers.

Table 1 – The effect of different temperatures and exposition time on the chemical composition of 'Goda' and 'Solara' tubers, 2009

No.	Effects of combination	Characteristics, % natural materials			
		Proteins		Dry matter	
		Goda	Solara	Goda	Solara
1.	+18°C	1.94	2.19	23.3	20.3
2.	-10°C, 30 min.	1.72	2.63	24.3	19.9
3.	-10°C, 60 min.	1.67	2.19	24.3	19.6
4.	-10°C, 90 min.	1.66	2.30	22.0	21.1
5.	+5°C, 30 min.	1.81	2.47	23.8	20.7
6.	+5°C, 60 min.	1.75	2.38	23.2	20.4
7.	+5°C, 90 min.	2.00	2.13	23.8	20.0
8.	+30°C, 30min.	2.19	2.14	25.3	20.0
9.	+30°C, 60min.	2.18	2.48	27.0	19.7
10.	+30°C, 90min.	1.75	2.33	23.7	21.5
11.	+40°C, 30min.	1.94	2.70	24.0	19.1
12.	+40°C, 60min.	1.91	2.44	20.0	20.4
13.	+40°C, 90min.	2.06	2.34	23.4	18.2
14.	+50°C, 30min.	1.99	2.50	24.1	18.9
15.	+50°C, 60min.	2.20	2.48	22.0	21.2
16.	+50°C, 90min.	1.94	2.69	23.6	20.5
R_{05}		0.10	0.10	0.09	0.90
$S_{\bar{x}}$		0.04	0.04	0.03	0.31

During investigation, we determined the content of proteins and dry matter in different cultivars. Table 1 illustrates the changes in protein and dry matter content as influenced by different temperatures and exposition time. Significant effects of the treatments were established. The total content of proteins in the tubers of cv. 'Goda' significantly increased (13%) after exposure

to +50°C for 60 min. and to +30°C for 30 and 60 min. The proteins content in the tubers of cv. 'Solara' was established to be the highest after exposure to -10°C for 30 min. – 20% and after exposure to +40°C for 30 min. – 23% temperatures influence.

Under the influence of temperatures (-10°C), the greater content of dry matter was observed in tubers of cv. 'Goda' compared to the control treatment, however, the longer influence at -10°C decreased the dry matter content. In other treatments, higher dry matter content was observed compared to the control treatment. Under the influence of different temperatures, slightly lower dry matter content in potato tubers of cv. 'Solara' was observed. The highest dry matter content, i.e. 21.1% and 21.5%, was exhibited by the tubers exposed to -10^{o}C for 90 min and to +30^{o}C for 90 min respectively. Increase in the dry matter content is maintained to demonstrate the sprouting start of tubers [17]. The tubers stored at higher temperature consume nutrients more actively and show earlier sprouting compared to those stored at lower temperature.

According to literature [16], the best conditions for potato sprouting are at the temperature not higher than +17^{o}C, under light, as shoots in this situation are short and strong; when temperature increases up to +25^{o}C, shoots start lignifying, the tops blacken and sprouting becomes loss making as tubers wither and stop sprouting. Potato tubers are heat sensitive. Sprouting is one of the major factors determining the number of stems that are considered the yield limiting element.

The effects caused by stress factors are determined by treatment intensity and duration [2]. Plant response to temperature changes depends on a cultivar, physiologic age and development level [11, 1]. The potato tubers stored at higher temperature get old physiologically, however, the tubers stored at low temperatures both get old and experience a stress. A few potato cultivars featuring greater resistance to low temperatures are also available. Low temperatures retard the natural ageing processes; however, the injuries caused by a stress to less resistant potato cultivars accelerate the ageing processes [18]. The results obtained by us have also illustrated that the response of the potatoes under investigation to the stress caused by temperatures depended partially on a cultivar.

According to literature, the best way to overcome apical domination and to stimulate sprouting of side eyes is to extend storage duration of tubers as long as the apical domination period expires. Potato tubers shall be stored at (+4^{o}C) temperature as long at the apical domination period expires; then temperature shall be increased up to (+15^{o}C) that should stimulate germination of side eyes. For physiologically old potato tubers, however, such a sprouting method may be harmful as this way tubers may dehydrate and stop sprouting [6]. Eremeev et al. (2003) maintain that the longer is the storage period of seed tubers at high temperature the older physiologically they become.

CONCLUSIONS

1. Different temperatures –10°C – +50°C influenced the tubers sprouting. The highest number of sprouts, in comparison to the primary number of eyes, was established in the tubers of potato cv. 'Goda' exposed to –10°C for 60 min. (192.6%) and to +50°C for 90 min. (194.7%); and in the tubers of potato cv. 'Solara' – correspondingly exposed to –10°C for 60 min. (126.1%) and to +30°C for 60 min. (167.8%).

2. Analysis of the influence of different temperatures and exposition time showed that the percentage of proteins in tubers of cv. 'Goda' significantly increased ~ 13%, having treated them with +30°C for 30 and 60 min., and with +50°C for 60 min. The tubers of cv. 'Solara' treated with -10°C for 30 min. up to 20% and with +40°C for 30 min. up to 23%, in comparison to the control plants.

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