Effect of storage temperature during tuber pre-sprouting on sprout and yield development of organically grown potatoes

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Abstract

In the frame of the on-farm-research project 'Organic Pilot Farms in North Rhine-Westphalia' (Germany) the influence of different storage temperatures (8, 12, 16°C) during pre-sprouting under full light (> 200 lux) on tuber development was tested. Sprout length and yield development of cultivars 'Belana' and 'Nicola' as affected by the pre-sprouting regime were recorded in five field trials on two sites over three years. Increasing storage temperature during pre-sprouting resulted in significantly longer sprouts at planting. The higher risk of sprout breaking during mechanical planting of seed tubers with longer sprouts was overcompensated by faster crop development. As a function of higher temperatures during pre-sprouting all measured parameters showed consistently the same tendency of faster shoot growth and higher tuber yield. These results were significant only in 2012 when late blight infestation started extremely early in the season.

Introduction

Reducing copper application is a highly ranked objective in organic crop production. However, no applicable alternative to copper for controlling late blight (*Phytophtora infestans*) is currently available for organic potato growers. Seed tuber pre-sprouting is known to be one of the most efficient preventive methods to reduce yield losses by late blight in organically grown potatoes (Karalus & Rauber 1997, Paffrath 2007). For successful pre-sprouting light (Stumm & Köpke 2011) and storage temperature are the most relevant factors. Krug & Pätzold (1968) and Allen et al. (1978) showed a clear positive correlation between temperature and the elongation of sprouts even under conditions of high illumination that tends to reduce sprout growth. Longer sprouts are prone to breaking at planting and should therefore be avoided by lower storage temperatures during pre-sprouting (Haverkort et al. 1990). However, this approach may also reduce sprouting capacity, which is induced by higher temperatures during pre-sprouting (van Loon 1987). Due to the fact, that the influence of temperature during pre-sprouting on organic potato tuber yield is still unclear, field trials with two cultivars pre-sprouted under full light and different temperatures, were carried out on two sites and three growing seasons.

Material & methods

During 2010 and 2012 the cultivars *Belana* (slow germination) and *Nicola* (fast germination) were pre-sprouted in climatically controlled rooms at the research centre of the Chamber of Agriculture in Cologne-Auweiler. Pre-sprouted tubers were planted in a total of five field trials on the commercial organic farm 'Stautenhof' (ST) in the Lower Rhine region (N 51°16' E 06°28', 45 m above sea level, temperature 9.3 °C, precipitation 700 mm, sandy loam) and on the organic experimental farm of the University of Bonn 'Wiesengut' (WG) in Hennef/Sieg (N 50°48', E 7°17', 65 m above sea level, temperature 10.2 °C, precipitation 800 mm, silty loam, more details see: www.leitbetriebe.oekolandbau.nrw.de). Potato tubers were stored over a six weeks period under full light (> 200 Lux) and different temperatures (8, 12, 16°C). Prior to planting sprout length of all sprouts was recorded from ten tubers. The field experiments were carried out in a two factorial block design with the factors 'cultivar' and 'temperature' with four replications. The percentage of emerged shoots was counted in the whole plot area. Tuber yield was assessed at an early stage during blooming (1.5 m^2 $plot^{-1}$) and at tuber maturity (12 m^2 $plot^{-1}$). Data were evaluated by a two-factorial ANOVA followed by the Tukey-test. In cases of significant interactions between the factors, a one-factorial ANOVA was separately carried out for each cultivar. All statistical calculations were operated with SAS Version 9.3.

Results & discussion

Mean sprout length was significantly higher in tubers pre-sprouted at 12 and 16°C compared with storage at 8°C (Tab. 1). Differences in sprout length between 12 and 16°C were significant in 2010 only. Sprout length

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differentiation was higher for the faster sprouting cv. *Nicola*. Generally, average sprout length was relatively short (< 15 mm) in all treatments due to the high illumination with more than 200 lux. Our findings underline the clear correlation between storage temperature and sprout length (Krug & Pätzold 1968, Allen et al. 1978).

Tab. 1: Length of tuber sprouts (mm) at the time of planting as affected by cultivar and temperature during pre-sprouting. Different letters in one line within one cultivar indicate significant differences (Tukey-test, p < 0.05).

Cultivar	***Belana***						***Nicola***					
°C	**8**		**12**		**16**	***HSD***	**8**		**12**		**16**	***HSD***
2010	7.87	c	8.86	b	10.23	a	*0.82*	6.29	c	11.62	b	13.44	a	*1.44*
2011	5.15	b	7.56	a	7.97	a	*0.64*	4.84	b	10.85	a	10.82	a	*1.01*
2012	6.44	b	9.43	a	10.00	a	*0.98*	6.96	b	10.56	a	10.59	a	*1.13*

Dates of measurements: 19th April 2010; 26thApril 2011; 17th April, 2012; HSD = honestly significant difference

The rate of emergence tended to be higher with rising storage temperature (Tab. 2). *Nicola* showed a stronger reaction on higher pre-sprouting temperature than cv. *Belana*. Greatest and mostly significant differences in crop emergence were determined between 8 and 12°C for both cultivars while a further increase to 16°C was significant only in one case for cv. *Nicola*. These observations confirm the assumed impact of higher temperatures on sprouting capacity, a factor which may compensate higher sprout losses during planting (Haverkort et al. 1990).

In 2011, when late blight pressure was low, there was only a slight tendency to higher yields at early stage as a function of higher storage temperature in both trials (Tab. 3). Contrarily in 2012, when late blight infestation already occurred early in June, tuber yield at early stage was clearly lower than in the year before and the influence of temperature during pre-sprouting was mostly significant. In 2012 cv. *Belana*, pre-sprouted with 12 and 16°C gave tuber yields twice as much compared with pre-sprouting at 8°C.

Tab. 2: Rate of emergence (% of planted tubers) as affected by cultivar and temperature during pre-sprouting. Different letters in one line within one cultivar indicate significant differences (Tukey-test, p < 0.05).

Cultivar	***Belana***						***Nicola***					
°C	**8**		**12**		**16**	***HSD***	**8**		**12**		**16**	***HSD***
2010	54.2	b	80.8	b	85.0	a	*16.8*	50.8	b	85.8	a	90.8	a	*10.2*
2011	8.0		15.5		24.5		*n.s.*	23.0	b	32.0	b	55.5	a	*19.9*
2012	0.0		23.5		38.5		*n.s.*	23.5	b	82.5	a	89.5	a	*8.4*

Dates of measurements: 19th May 2010 ST; 20th May 2011 ST; 17th May 2012 WG; HSD = honestly significant difference

For *Nicola* a significant difference was measured in 2012 on one site (Wiesengut) only. Tuber yield of cv. *Belana* was higher at early stage than *Nicola* in nearly all trials, although shoot development of cv. *Nicola* was earlier and stronger (Tab. 2).

Tab. 3: Tuber yield at an early stage (t^{-1} ha) as affected by cultivar and temperature during pre-sprouting. Different letters in one line within one cultivar indicate significant differences (Tukey-test, $p < 0.05$).

Cultivar	***Belana***				***Nicola***			
°C	**8**	**12**	**16**	***HSD***	**8**	**12**	**16**	***HSD***
2011 ST	22.10	23.72	24.31	*n.s.*	18.59	20.93	21.44	*n.s.*
2011 WG	15.85	16.04	19.35	*n.s.*	10.50	12.21	13.86	*n.s.*
2012 ST	4.11 b	8.12 a	9.44 a	*2.20*	3.29	3.56	3.80	*n.s.*
2012 WG	3.11 b	8.60 a	10.72 a	*4.40*	3.97 b	6.94 a	6.75 a	*1.80*

Dates of measurements:, 12th July 2011 ST; 30th June 2011 WG; 21st June2012 ST; 19th June 2012 WG; HSD = honestly significant difference

In all trials tuber raw yield was higher when seed potatoes were pre-sprouted at higher temperatures (Tab. 4). Similar to the results of harvest at early stage (Tab. 3) in 2012 this impact was significant for *Belana* at both sides and for *Nicola* at the experimental farm Wiesengut only. In all other trials these findings were visible in trend. In 2012, when late blight infestation occurred extremely early especially at 'Stautenhof' nearly no further yield formation was recorded after early tuber lifting on 21st June.

Tab. 4: Raw tuber yield (t^{-1} ha) as affected by cultivar and temperature during pre-sprouting. Different letters in one line within one cultivar indicate significant differences (Tukey-test, $p < 0.05$).

Cultivar	***Belana***				***Nicola***			
°C	**8**	**12**	**16**	***HSD***	**8**	**12**	**16**	***HSD***
2010 ST	16.38	20.68	21.63	*n.s.*	24.74	24.93	28.00	*n.s.*
2011 ST	21.90	25.60	27.27	*n.s.*	28.40	29.09	31.87	*n.s.*
2011 WG	38.32	41.11	42.82	*n.s.*	38.55	41.87	39.83	*n.s.*
2012 ST	3.10 b	8.53 a	10.83 a	*4.06*	6.08	7.44	9.56	*n.s.*
2012 WG	12.89 b	22.95 a	23.82 a	*4.33*	20.75 b	23.56 ab	24.88 a	*3.13*

Dates of measurements: 22nd Sept. 2010 ST; 13th Sept. 2011 ST; 1st Sept. 2011 WG; 4th Sept 2012 ST; 29th Aug. 2012 WG; HSD = honestly significant difference

The observation that lower storage temperature during pre-sprouting phase leads to more sprouts, shoots and tubers (Allen et al. 1978, van Loon 1987) could not be confirmed in our study (data not shown). In some cases this effect could be observed in the comparison of the treatments 12 and 8°C whereas between 16 to 12°C the result was vice versa and in other cases no effect was visible.

Summary

Higher temperatures than 8°C during pre-sprouting increased sprout length significantly. In-between 12 and 16°C only small differences in sprout length were determined. The rate of emergence was significantly higher when seed tubers were pre-sprouted with 12 than with 8°C while continued increase to 16°C was

significant in one case only. Tuber yield was higher at early stage as well as at final harvest after pre-sprouting with 12 or 16°C compared with 8°C, and more pronounced in 2012, when late blight occurred very early.

Conclusions

The results suggest that the positive effect of higher temperatures on sprouting capacity is more important for yield formation than the assumed negative impact of higher losses of longer sprouts during planting. Optimisation of pre-sprouting conditions can be considered as an important measure to protect organically grown potatoes against yield losses in case of early infection with late blight (*Phytophtora infestans*).

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