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REACTION OF A FEW POTATO CULTIVARS GROWN UNDER ORGANIC SYSTEM TO IRRIGATION

Summary

In the years 2014-2015 at the Institute of Plant Breeding and Acclimatization, Branch Jadwisin the investigation concerned the influence of irrigation of organic potato plantation on tuber yield and tuber size distribution was carried out. Eight potato cultivars of different maturity class were assessed. It was stated that irrigation significantly influenced both the total tuber yield and the share of different-size tubers (excluding medium size). Under irrigation the increase in total yield was observed but it was not equal for all cultivars. The increase for cultivar Cyprian was 3 times bigger than for cultivar Ignacy. The highest changes due to irrigation concerned the share of big tubers (>60 mm). Seven among all cultivars reacted by a very high increase in this size tubers (to 80%), but one of them reacted by decrease in this tuber fraction.
***Key words**: potato, organic system, irrigation, cultivar, yield*

REAKCJA KILKU ODMIAN ZIEMNIAKA UPRAWIANYCH W SYSTEMIE EKOLOGICZNYM NA NAWADNIANIE

Streszczenie

W latach 2014-2015 przeprowadzono w Instytucie Hodowli i Aklimatyzacji Roślin - PIB, Oddział w Jadwisinie badania dotyczące wpływu nawadniania plantacji ekologicznej na wielkość plonu bulw i jego strukturę. Badano 8 odmian ziemniaka o różnej wczesności. Stwierdzono, że nawadnianie wpłynęło w sposób istotny zarówno na wielkość plonu ogólnego, jak i udział w nim poszczególnych frakcji (oprócz udziału bulw średnich). Pod wpływem nawadniania nastąpił wzrost plonu ogólnego ale nie był on jednakowy u wszystkich odmian. Przyrost plonu u odmiany Cyprian był ponad dwukrotnie większy niż u odmiany Jurata. Duże zmiany pod wpływem nawadniania dotyczyły udziału bulw dużych. Siedem spośród badanych odmian zareagowało wzrostem udziału tej frakcji (do20 %), u jednej zaś odnotowano spadek udziału bulw dużych pod wpływem nawadniania.
***Słowa kluczowe**: ziemniak, system ekologiczny, nawadnianie, odmiana, plon*

1. Introduction

More and more frequent rainfall shortages in our country mean that both the total yield and participation in the marketable fraction are unsatisfactory. This applies in most organic farming. The potato is a plant with relatively high water and fertilizer demands [1, 3, 4, 11, 12]. Water scarcity or uneven delivery inhibits the growth of plants, which directly affects tuber yield and size distribution. Potato water requirements vary throughout the growing season. The greatest demand for water is observed during the period from the start of tuberization through tuber bulking. According to the growth profile for early varieties this period lasts from June through early July in Poland, and for later varieties starts in the second half of June and lasts until the end of August [2, 7, 8]. The shortage of rainfall can be solved by irrigation. Irrigation is allowed and recommended for organic production. But in small farms, where potato is mostly grown in organic production systems, irrigation is rarely available [13]. If restricted nutrient availability is combined with water shortages (which often happens in organic production), the decrease of the crop can even be even greater.

The aim of the study was to assess the influence of irrigation on total tuber yield and tuber size distribution of potatoes grown under organic system.

2. Materials and Methods

Material for the study comes from field experiments conducted in the years 2014-2015 at the Institute of Plant Breeding and Acclimatization - Jadwisin (central Poland) on light: pseudopodsolic formed from light loamy sands soil. Potatoes were grown under organic system. The crop rotation was following:
potatoes→ field peas → oat → rye with under sown serradella→ phacelia + white mustard as catch crops.

In both years the drip irrigation was used.

In 2014 the shortage of rainfall occurred in July, so the plantation was irrigated twice:
18. 07-19,8 mm and 29 07- 17,8 mm.

In 2015 the shortage of rainfall started in June, so during all vegetation period the plantation was irrigated 4 times: 18.06-15,1mm, 23 06 -18,5 mm , 1 07- 20,0 mm, 7 07 – 16,3 mm.

The total rate of irrigation in 2014 was 37,6 mm, in 2015 – 69,9 mm.

The dose of irrigation was adjusted to water requirements of potato.

The experiment was carried out in two replications.

Eight potato table cultivars were chosen for this study based on maturity class and resistance to late blight.

After harvest the total yield and tubers' size distribution were assessed.

Results were analyzed using the ANOVA program, with means separated by Student's t-test.

To test the difference between the average values at a significance level $\alpha < 0.05$ Tukey test was used.

Agronomic input is given in table 1.

Table.1. Agronomic inputs in organic system

Crop production practice	
Fertilization	Manure – 28 t.ha^{-1} + mustard as a catch crop
Weed control	Only mechanical tillage
Colorado potato beetle control	Biological insecticide (*Bacillus thuringensis*) 2014, 2015: twice per season-4l/ha
Late blight control	Copper fungicides 2014: Cuprate 50-2 times season-3 l/ha 2015: Cuprate 50-3 l/ha

Table. 2. Characteristics of tested cultivars

Cultivar	Maturity	Resistance to *Phytophthora infestans**
Lord	very early	3
Cyprian	early	5
Ignacy	early	3
Michalina	early	3
Bogatka	mid early	3,5
Jurata	mid early	4
Malaga	mid early	3
Oberon	mid early	3,5

**1- no resistance, 9- full resistance* *Source*: Own study

3. Results

3.1. Statistical analysis

Among the tested factors the biggest influence on tuber yield and tuber size distribution had a cultivar. It effected all parameters. Irrigation effected most of parameters excluding the share of medium tuber. The year of investigation has effected neither tuber yield or tuber size distribution (tab. 4).

There were a significant interaction between cultivars and irrigation concerning share of big tubers.

3.2. Influence of irrigation on tuber yield and tuber size distribution

Irrigation increased the total tuber yield by 34,3%, share of big tubers by 8,0 % and mass of 1 tuber by 20,3% (tab. 5). Under irrigation the share of small tuber was by 1,7% smaller. The share of medium tubers was by 5,4% smaller but the difference was not significant (tab. 5).

3.3. Influence of cultivar on tuber yield and tuber size distribution

Cultivars differed in all yield parameters. The highest total yield was noticed for cultivars Jurata and Michalina, the lowest for mid early cultivar- Bogatka. Bogatka cultivar had also the largest share of small tubers (<35 mm). The smallest share of small tubers was observed for cultivar Michalina. The scope of participation of medium-sized tubers ranged from 64, 9 for cultivar Cypraian to 91,4 for cultivar Lord.

Table. 3. Total monthly rainfall (R) and mean monthly temperatures (T) during the vegetation period in the years 2012-2013 for Jadwisin

Year	May		June		July		August		September	
	R (mm)	T (^{0}C)	R (mm)	T (^{0}C)	R (mm)	T (^{0}C)	R (mm)	T (^{0}C)	R (mm)	T (^{0}C)
2014	41,3	14,1	69,8	15,8	23,5	21,5	79,2	18,2	11,9	14,8
2015	39,5	12,9	15,4	17,8	62,6	19,6	8,6	22,5	36,6	15,1

Source: Own study

Table. 4**.** Significance of differences in parameter means

Tested factor	Irrigation	Cultivar	Year
Total yield	++	+	-
Share of small tubers (< 35 mm)	++	++	-
Share of medium tubers (35-60 mm)	-	++	-
Share of big tubers (> 60 mm)	++	++	-
Mass of 1 tuber	++	++	-

++ = significant at α ≤0.05 *Source*: Own study
+ = significant at α ≤0.01
- = non significant
Significant interaction
Share of big tubers : cultivar x irrigation

Table. 5. Influence of irrigation on tuber yield and tuber size distribution

Combination	Total yield (dt·ha^{-1})	Share of small tubers (%)	Share of medium tubers (%)	Share of big tubers (%)	Mass of 1 tuber (g)
Irrigated	333a	3,8b	82,0a	14,1a	88,9a
Non irrigated	248b	5,5a	87,4a	6,1b	73,9b
Difference in relation to non irrigated combination (%)	34,3	- 1,7	- 5,4	8,0	20,3

Source: Own study

Table. 6. Influence of cultivars on tuber yield and tuber size distribution

Cultivar	Total yield(dt·ha^{-1})	Share of small tuber (%)	Share of medium tu bers (%)	Share of big tubers (%)	Mass of 1 tuber (g)
Lord	302b	4,1	91,4b	4,5b	75,1a
Cyprian	246ab	6,9b	64,9a	28,2c	93,2b
Ignacy	328b	4,5ab	91,0b	4,5b	74,6a
Michalina	338b	2,4a	74,2ab	23,4c	93,3b
Bogatka	190a	7,8b	88,5b	3,7a	75,5a
Jurata	346b	4,1ab	90,6b	5,3b	90,4b
Malaga	304b	7,1b	89,7b	3,2a	71,3a
Oberon	269ab	4,2ab	87,3b	7,9b	78,3a

a, b-statistically different groups *Source*: Own study

Table. 7. Increase in total tuber yield (dt·ha^{-1}) under irrigation

Cultivar	Non irrigated	Irrigated	Increase (%)
Lord	257	347	35,0
Cyprian	198	295	48,9
Ignacy	271	386	42,4
Michalina	288	389	35,0
Bogatka	161	218	35,4
Jurata	315	378	20,0
Malaga	270	337	24,8
Oberon	224	314	40,1

Source: Own study

Large differences concerned also the share of big tubers. Cultivars Cyprian and Michalina were characterized by much higher share of this size tubers as compared to the rest. These cultivars had also the biggest mass of 1 tuber. The smallest mass of 1 tuber was noticed for cultivar Malaga (tab. 6.).

The reaction of cultivars to irrigation was different. All cultivars responded by yield increase but amount of this increase was different. The strongest reaction to irrigation revealed cultivar Cyprian (48,9%), the weakest cultivar Jurata- only 20,0% (tab. 7).

Big differences in reaction of cultivars to irrigation concerned the participation of large tubers.

Seven of the tested cultivars reacted by an increase in the share of this fraction tubers, while in one variety it was found a decrease in the share of large tubers due to irrigation. The increase of big tuber share under irrigation amounted from 3 % for cultivar Ignacy to 20 % for cultivar Cyprin (tab. 8).

Table. 8. Increase or decrease of big tubers share under irrigation (%)

Cultivar	Non irrigated	Irrigated	Increase or decrease
Lord	2,3	6,8	4,5
Cyprian	18,0	38,4	20,4
Ignacy	3,0	6,0	3,0
Michalina	15,0	31,8	16,8
Bogatka	1,1	6,2	5,1
Jurata	6,3	4,3	-2,0
Malaga	1,0	5,5	4,4
Oberon	2,3	13,5	11,2

Source: Own study

4. Discussion

Factors that to the greatest extent in limiting the yield of various agricultural crops in the organic system are large restrictions on the use of pesticides, and the deficit of nutrients caused by lack of use of mineral fertilizers. It is therefore necessary to seek solutions that can help to increase crop yields. Treatment, which largely can overcome these restrictions is irrigation the plantation.

This treatment results in an increase in both the total yield and marketable-size tubers . Such effect of irrigation is widely known in practice and confirmed by many authors [5, 6, 11, 17]. This is confirmed by the current study.

The use of irrigation in organic potato production can, however, lead to negative consequences. Irrigation of plantation increases the threat of late blight and could cause the leaching of nutrients from the rhizosphere to the deeper layers of the soil. Used in our research drip irrigation seems to be the ideal solution [10, 13]. In previous studies, the authors confirmed the positive impact of this type of irrigation on both plant growth and increase in tuber yield [17-20].

It has been found, although slightly larger late blight infection than on the combination without irrigation, but in both cases the disease infection was low (own observations).

The reaction of different cultivars to irrigation treatment is interesting. Although all cultivars responded rise in the yield, the amount of the increase, was very different. Even more interesting situation occurred in the case of participation of large tubers. The majority of cultivars responded increase in the share of this fraction of tubers under irrigation with the exception of one cultivar in which there was an inexplicable decrease in the share of this fraction.

In the majority of works devoted to the organic potato production one underlines just big diminutive tuber crops in this system [9, 14, 15, 16, 19], and therefore, all the treatments that are allowed in organic production and that contribute to the increase in yield and improve its structure should be more widely used.

When analyzing the response of cultivars to irrigation, we can get information about the suitability of these cultivars for organic production. The lower response to this treatment means lower water requirements and such cultivars should be recommended to farms which do not have an irrigation system. On the farms using irrigation more efficient would be cultivars giving a higher yield increase.

5. Conclusions

The irrigation significantly influenced tuber yield and tuber size distribution.

All cultivars reacted by increase in total yield due to irrigation. This increase was different and ranged from 20,0 to 48,9% depending on cultivar.

The influence of irrigation concerned also the share of big tubers (> 60 mm). The increase in this fraction under irrigation amounted up to 20,4%. One cultivar reacted by decrease in big tubers share due to the irrigation.

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