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EFFECT OF DRIP IRRIGATION AND COMPLEMENTARY NUTRITION WITH NITROGEN ON POTATO QUALITY AND YIELD

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Abstract

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A small-plot field experiment started in 2016 studied effect of drip irrigation on potato tuber yield and starch levels in the tubers. Two potato varieties with different vegetation periods (Monika, Jolana) were exposed to four drip irrigation intensity levels. They were non-irrigated controls and irrigated tubers with 60%, 65% and 70% usable soil water capacity levels. The other studied parameter was represented by the effect of nitrogen fertilisation with the nitrogen nutrient added to the irrigation water (fertigation) in the course of the vegetation period in contrast to one-off application of the whole nitrogen dose before the potato planting. All irrigated variants in comparison to the non-irrigated controls showed 30–60% yield increase. The effect of fertigation on yields was statistically insignificant. Starch levels in the tubers were mostly affected by the variety. The irrigated variants in comparison to the non-irrigated controls showed higher starch levels in the harvested tubers but the differences were statistically insignificant.

Keywords: Potatoes, drip irrigation, fertigation, yield, starch level

INTRODUCTION

Drought is becoming a very important phenomenon in our region, as it has been more and more frequent in recent years (drought occurred in the Czech Republic in 2012, 2013, 2014 and 2015). The reason for the droughts in the Czech Republic is below normal amounts of precipitation and/or very high temperatures (Štěpánek *et al.*, 2016). Drought is a problem not only in our country but also across the whole Central European region. Trnka *et al.,* (2016) says that up to 45% of the evaluated stations became significantly drier during the 1961–2014 period except for areas in the west and north of the region.

According to the prediction models for the South Moravia Region one may expect that the future period of 2021–2050 will be warmer by an average of 1.5 °C and the period of 2071–2100 will be even warmer by 3.4 °C than 1961–1990. Also, the average monthly temperature will rise. The increasing trend was also observed in the number and duration of heat waves. In the future, there will be an increased incidence of precipitationless periods which will also be longer. (Fukalová, 2014).

Drought in the course of the vegetation period negatively affects potato yields. Irrigation is one of the options for prevention of the negative effect of drought on potato yield. Application of drip irrigation may lead to up to 70% higher profitability of potato production in comparison to seepage irrigation (Matovic *et al.*, 2016). Reyes-Cabrera *et al.* (2016) says that drip irrigation uses 48% to 88% less

water compared to seepage irrigation, with the same yield levels of most potato varieties. Some varieties, however, show yield drops after drip irrigation application in comparison to seepage.

Most authors say that application of drip irrigation increases tuber yield which increases with increasing quantity of irrigation water. The yield increase depends on agroclimatic conditions and range from a couple of percent to several multiples in comparison to non-irrigated controls (Ayas, 2013; Badr *et al.*, 2010; Ondera *et al.*, 2005). Advantages of drip irrigation in comparison to traditional seepage also include limited nutrient wash off from the soil (Shock *et al.*, 2007).

The purpose of our experiment was to find out the optimum limit soil humidity for drip irrigation of potatoes resulting in sufficient increase of potato yield and effective use of irrigation water at the same time. Together with this we tried to compare the effect of nitrogen fertilisation before planting and in the course of the vegetation period by the fertiliser dissolved in the irrigation water where there was an assumption of lower nitrogen loss and its better utilisation by the potato plant.

MATERIAL AND METHODS

The small-plot trials were performed at the Žabčice Field Test Station of the Mendel University in Brno. According to its agroclimatic parameters the station is situated in the warmest and driest region of the Czech Republic. According to the Lang rain factor the Žabčice locality is very dry (Brotan *et al.*, 2013)

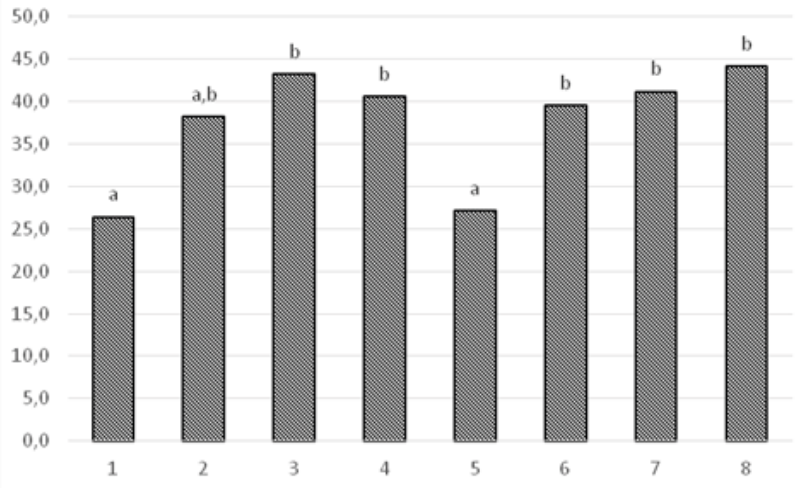
The planting was performed across a unified span of 750 × 250 mm on 21st April 2016. Two different varieties with different vegetation period lengths were planted – the early-ripening variety called Monika and the semi-early variety called Jolana. Together up to 8 experimental variants with different combinations with nitrogen fertilisation were performed in four repetitions (Tab. I)

Soil humidity was measured separately for each irrigation variant by a VIRRIB sensor. The particular humidity causing automatic start of irrigation was calculated from the UWC values and the fading point on the basis of soil hydro limit specification for the locality. Each irrigation dose was the same, equal to 10 mm precipitation. Nitrogen fertilisation through the irrigation in the course of the vegetation period was performed with YaraLiva Calcinit fertiliser applied with the irrigation water in four doses.

I: *Experimental variants*

Variant no	Irrigation at soil humidity	Nitrogen fertilisation before planting	Nitrogen fertilisation during vegetation
1	No irrigation	120 Kg.ha^{-1}	-
2	60% UWC	120 Kg.ha^{-1}	-
3	65% UWC	120 Kg.ha^{-1}	-
4	70% UWC	120 Kg.ha^{-1}	
5	No irrigation	60 Kg.ha^{-1}	60 Kg.ha^{-1}
6	60% UWC	60 Kg.ha^{-1}	60 Kg.ha^{-1}
7	65% UWC	60 Kg.ha^{-1}	60 Kg.ha^{-1}
8	70% UWC	60 Kg.ha^{-1}	60 Kg.ha^{-1}

UWC =usable water capacity



1: *Tuber yield (t.ha^{-1})–comparison of variants*

Irrigation-mediated fertilisation was performed in the period of extension growth of the plants. The fertiliser was applied via Dosatron D3, a mixer feeding the fertiliser solution into the irrigation water on the basis of the preset concentration. In the case of the non-irrigated variant no. 5, with fertilisation in the course of the vegetation period the nitrogen dose was applied in the same fertiliser in a one-off dose spread across the soil surface.

The specimen for yield and quality analyses were taken on 20 July 2016 (Monika variety) and 27 July 2016 (Jolana variety). Ten plants were manually dug out of each plot for on-the-spot analysis of yield-generating indicators. The sampled tubers were analysed for starch levels by Ewers method and starch yield per hectare was calculated. The obtained data were afterwards subjected to statistical analysis by the dispersion method using STATISTICA software version 12.0.

RESULTS AND DISCUSSION

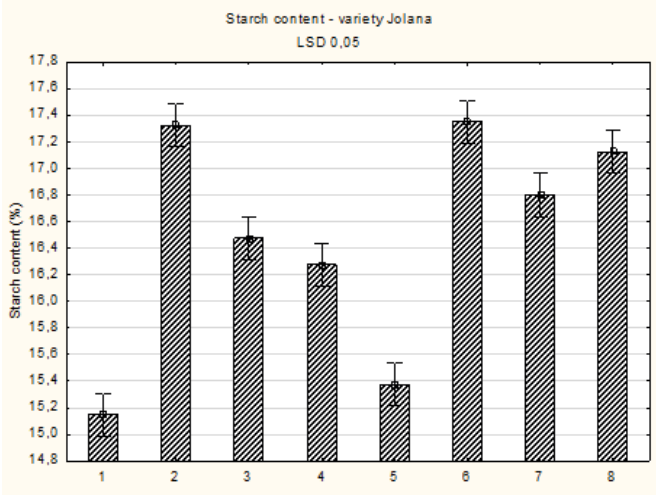
Tuber yield was statistically highly significantly affected by both the variety and the irrigation variant (Fig. 1). Significant influence was above all found in the quantity of the applied irrigation water, with the lowest yields achieved by the two non-irrigated variants. All irrigated variants achieved similar yield results. No statistically significant differences were found between the individual intensities of the applied irrigation. The observed outcomes allow for the conclusion that increasing quantity of irrigation water was accompanied by yield increase. Similar results were also observed by Onder *et al.* (2005) or Matovic *et al.,* (2016). According to Fabeiro *et al.* (2001) medium irrigation doses are optimal. Higher quantities of the applied irrigation water do not result in corresponding yield increase anymore and therefore increased irrigation intensity no longer pays back.

The small differences between the irrigated variants in our experiment can probably be explained by the relatively small differences between the individual quantities of the applied irrigation water, caused by increased precipitation means in the vegetation period of the experimental year 2016.

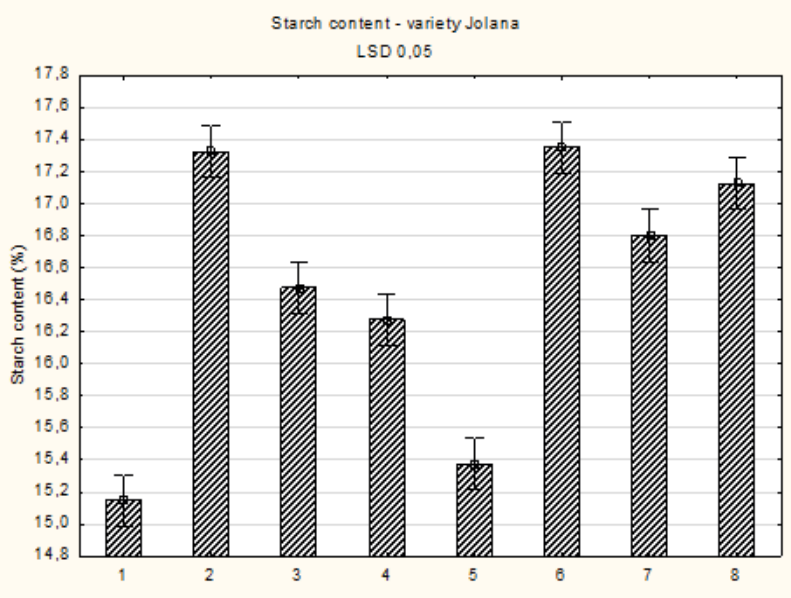
Identically no statistically significant influence of the fertilisation time was observed. From the yield point of view it was therefore insignificantwhethe the whole nitrogen dose was applied before planting or whether half of the dose was applied by fertigation, i.e. with the applied irrigation water in the course of the vegetation period. Both fertilisation variants increased the yield of the irrigated variants by 40–60% in comparison to the non-irrigated controls (Tab. II). Rolbiecki *et al.* (2015) say that fertigation with nitrogen in the course of vegetation may increase potato yield by up to 25%. This difference may be explained by different soil conditions. Our experiment was performed in heavy soil where no significant nitrogen loss occurs

II: *Yield increase–fertilisation variants*

No fertigation with irrigation			With fertigation via irrigation		
Variant	Yield (t.ha^{-1})	Increase (%)	Variant	Yield (t.ha^{-1})	Increase (%)
1	26.4	--	5	27.1	--
2	38.2	44.5	6	39.6	45.8
3	43.2	53.8	7	41.2	51.8
4	40.6	63.7	8	44.2	62.8



2: *Starch levels (%)– Jolana variety*



3: *Starch levels (%)–Monika variety*

while the above quoted authors performed their experiment in very light soils where nitrogen loss may be much higher.

Statistically highly significant difference was found between the yields of the individual varieties in our experiment. The early-ripening Monika variety achieved by nearly 7 t.ha^{-1} higher yield on average in comparison to the semi-early Jolana variety. The effect of the variety on humidity conditions, or drought tolerance, is further confirmed by Deblonde and Ledent (2001), who say that in the case of water shortage most potato varieties reduce stem length, which reduces the size of the photosynthetic apparatus of the plant.

The effect of drip irrigation on starch levels in the tubers was statistically insignificant. The lowest starch levels were found in the two non-irrigated variants (Figs. 2–3). The difference in comparison to the irrigated variants was very small, though. According to Pszcólkowski *et al.* (2016) irrigation may affect starch levels but only subject to locality and soil conditions. Increasing quantity of irrigation water usually reduces starch levels in tubers but the total starch yield per hectare grows. The time of nitrogen fertilisation did not affect starch yield at all. Significant differences were thus only found between the two varieties with the mean starch level in the case of the Jolana variety was 16.5% versus 13.5% in the case of the Monika variety.

CONCLUSION

On the basis of the above mentioned results the following conclusion may be drawn: drip irrigation is an effective method of potato quality and yield increase. Significant yield increase in comparison to the non-irrigated variant was achieved even by the variants with the lowest irrigation intensity. However, medium soil humidity appears most practical in the case of drip irrigation use, i.e. between 60–65% of UWC. Higher irrigation intensity no longer results in significant yield increase sufficiently compensating the increased consumption of irrigation water. As the experiment only covered on-year period and the results were partly affected by the weather in the experimental year further verification across more experimental years is needed. On the basis of the results achieved so far drip irrigation may be recommended as a very effective way of elimination of the risk of water shortage in potato fields, especially in drier regions where short-term droughts and extreme weather fluctuations are more common, negatively affecting yield and quality of the harvested potato tubers.

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