INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr III/2/2015, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 779–786
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2015.3.2.062

INFLUENCE OF DRIP IRRIGATION ON THE HEIGHT OF THE BIENNIAL CUP PLANT *(SILPHIUM PERFOLIATUM L.)* FROM THE MICROPROPAGATION SEEDLINGS

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Summary

A field experiment carried out in two vegetation seasons in the years 2010 and 2011 on a very light soil at Kruszyn Krajeński, in the vicinity of Bydgoszcz, Poland. Investigation of the influence of drip irrigation on some growth parameters of 2-year-old cup plant (*Silphium perfoliatum* L.) were done. The cup plants were cultivated from the micropropagation seedlings. The experiment was performed as one factorial in 4 replications. The main factor of the experiment was irrigation performed with following variants: O – without irrigation (control plots), D – with drip irrigation. Drip irrigation was scheduled according to tensiometers indications. Irrigation significantly increase the height of the plants, the length and number of internode, the thickness of the stalk,. Irrigation also increased the fresh weight of the shoots, and the number of the leaves.

Key words: drip irrigation, cup plant, in vitro seedlings, micropropagation, very light soil,

INTRODUCTION

As far as Polish climatic conditions are concerned, irrigation is one way to supplementing soil water shortage. Plants that have the highest needs of hydration, produce large overground parts. *Silphium perfoliatum* L. is tall, reaching up to 2.5 m, perennial plant that represents the *Asteraceae* family. The species

belongs to the C-4 plants and, thus, is characterized by a very efficient photosynthetic process, which is at least partly responsible for the large increase in biomass. In the first year of growth it produces only a rosette of leaves, the generative shoots grow in consecutive years. Cup plant is a perennial plant growing up to 2.5 meters in height. In the first year of growth, this plant forms a rosette, whereas generative shoots develop in the coming years. For the optimal growth and development it needs sunlight and temperature of approx. 20°C. When it comes to long lasting periods of drought, the reaction of the plant is dying of lower leaves and buds browning. In extreme cases, it ceases to grow and produces small flowers and a small amount of seeds (Stanford 1990, Kowalski and Wierciński 2004). The preliminary results of research on one year cup plants (Figas et al. 2011) indicate that they show a positive reaction to irrigation. Due to the dwindling water resources for irrigation dispositional, more and more attention is being paid to water-efficient systems, in other words micro irrigation systems, including drip irrigation (Rolbiecki 2013).

Silphium perfoliatum L. occurs in the natural environmental in the central and eastern part of the United States of America and in the southern part of Canada (Stanford 1990, Rutkowski 2011, Wróbel et al. 2013). The species may be used for reclamation of degraded areas, particularly for phytoremediation, for removal or detoxication of pollution from the environment (Klimont 2007, Majtkowski et al. 2010). It may be also treated as a potential species for cadmium phytostabilisation in soil (Zhang et al. 2010).

Due to high concentration of carbohydrates, minerals and crude protein, rich in exogenous amino acids it may be also useful for farm animal feeding (Piłat et al. 2007, Ţîţei et al. 2013]. On the other hand, inulin (polysaccharide) isolated from rhizomes and roots of *Silphium perfoliatum* L. functioning as prebiotic may be used in dietetics, veterinary medicine and cosmetics (Kowalski and Wierciński 2004). Medicinal properties of *Silphium perfoliatum* L. are determined by biologically active secondary metabolites. Therefore, extracts from this species tissues reveal pain-killing, anti-inflammatory, diaphoretic, restorative, antibacterial, antifungal and expectorant properties, as well as decrease cholesterol level. So far, the following compounds have been discovered in various organs of *Silphium perfoliatum* L.: terpens, essential oils, tripertenoid saponins (oleanosides), phenolic acids, tannin-tan compounds, carotenoids and flavonoids (Kowalski 2002, Kowalski and Wolski 2003, Kowalski and Kędzia 2007, Jemiołkowska and Kowalski 2012).

The aim of the present research was to investigate the effect of drip irrigation on selected parameters of growth 2-year-old cup plants (*Silphium perfoliatum* L.), derived from micropropagation grown on light soil.

MATERIALS AND METHODS

The trials with drip irrigation of the biennial cup plants were conducted in the years 2010 and 2011 at the experimenal field in Kruszyn Krajeński in the vicinity of Bydgoszcz (53°3´39″N, 17°52´52″E). The soil from the experimental plot represented Phaeozems produced from alluvial sand. The soil demonstrated a very low water retention capacity. The experiment was performed as a one-factorial in 4 replications. The factor of the experiment was irrigation with the following variants: O-without irrigation (control plots), D-with drip irrigation. Drip irrigation was scheduled according to tensiometers indications. The irrigation was started when the soil water pressure was up to – 0.04 MPa. The irrigation water rates were strictly connected with the rainfall distribution and amounted 119 and 162 mm for 2010 and 2011, respectively. Irrigation was done with the drip line 'T-Tape', with the efficiency of 5 l per one meter of line. The agrotechnical practises and fertilization adopted were the standard used across the country. The mineral fertilization was applied at the rates of 500 kg N:P:K · ha^{-1}. The nitrogen fertilization (ammonium nitrate) was supplied at three single rates. The first one in May and the next two in June and July, respectively. The single experimental plot was 11 m^2. The seedlings were planted in 1 x 0.7 m spacing.

Table 1. Weather conditions in the vegetation period of cup plant (*Silphium perfoliatum* L.)

Specification	Air temperature (°C)						
	Months						
	04	05	06	07	08	09	04-09
2010	7,8	11,5	16,7	21,7	18,4	12,2	14,7
2011	10,5	13,4	17,7	17,6	17,7	14,3	15,2
Mean for 2010-2011	9,15	12,45	17,2	19,65	18,05	13,23	14,95
Long period average 1981-2010	8,2	12,9	16,8	19,6	17,6	13,4	14,8
	Rainfall (mm)						
2010	33,8	92,6	18,1	107,4	150,7	74,7	477,3
2011	0,0	2,0	40,0	137,0	30,7	24,3	234,0
Mean for 2010-2011	16,9	47,3	29,05	122,2	90,7	49,5	355,65
Long period average 1987-2007	26,6	40,7	55,1	65,4	53,0	54,8	295,6

Figure 1. Biennial of cup plant (*Silphium perfoliatum* L.)

Field experiment was conducted while maintaining agronomic recommendations for field crops. Treatments were carried out mechanically appropriate depending on the needs. Measurements were made in the first decade of October, in each of the years of research. In the experiment rated the height of the plants (cm), the length (cm) and number of internode, the fresh weight of the shoots (kg plant $^{-1}$), the number of the leaves and the thickness of the stalk (mm).

The analysis of variance was performed using all the results applying FR-ANALWAR software based on *Microsoft Excel*. The significance of differences was evaluated by the Tukey test and LSDs were calculated at a significance level of α=0.05.

Table 2. Influence of drip irrigation on the height of cup plant (*Silphium perfoliatum* L.)

Parameter	Year				Mean in the years 2010-2011		Mean
	2010		2011				
	D	0	D	0	D	0	
Height of plants (cm)	134,00	86,00	137,75	94,75	135,88	90,38	113,13
	$LSD_{0.05}$ 24,62		$LSD_{0.05}$ 11,77		$LSD_{0.05}$ 9,65		
Lenght of internode (cm)	11,75	9,00	12,50	8,75	12,13	8,88	10,47
	$LSD_{0.05}$ ns		$LSD_{0.05}$ 2,72		$LSD_{0.05}$ 1,83		
Number of the leaves	18,75	14,00	17,25	15,50	18,0	14,75	16,38
	$LSD_{0.05}$ 3,53		$NLSD_{0.05}$ 0,80		$LSD_{0.05}$ 1,83		
Fresh matter (kg plant $^{-1}$)	2,83	1,08	3,32	1,04	3.08	1,06	2,07
	$LSD_{0.05}$ 0,71		$LSD_{0.05}$ 0,99		$LSD_{0.05}$ 0,48		
Number of internode	8,50	6,25	8,50	7,00	8,50	6,63	7,57
	$LSD_{0.05}$ 0,80		$LSD_{0.05}$ 0,92		$LSD_{0.05}$ 0,54		
Thickness of the stalk (mm)	18,75	9,25	17,50	8,70	18,13	8,98	13,55
	$LSD_{0.05}$ 4,01		$LSD_{0.05}$ 1,52		$LSD_{0.05}$ 1,51		

0 – control (without irrigation), D – drip irrigation, $LSD_{0.05}$ – the lowest significant difference (Tukey's confidence half-interval) for P=95% (α=0.05), ns – non-significant differences

RESULTS AND DISCUSSION

The mean height of cup plants on control plots (without irrigation) in the research period of 2010-2011 was 113.13 cm (Table 2). Drip irrigation had a significant effect on an increase in the mean plant height by 45.5cm (55.3%). The increase in the cup plant height was due to an increase in the length and number of internodes.

Their mean length and number was 10.47 cm and 7.57 cm both on the objects irrigated and non-irrigated, respectively. Drip irrigation increased the mean length of internodes by 36.6%. Wojtasik (2004) investigating the effect of irrigation on malting and fodder barley yielding recorded 24% higher barley plants on the plots irrigated as compared with the non-irrigated plants.

Drip irrigation significantly affected the fresh weight of shoots in 2-year-old cup plants (Table 2). The experimental factor applied resulted in, on average over the research years 2010-2011, its significant increase by 2.01 kg. The mean fresh weight was 2.07 kg plant^{-1}. The mean fresh weight of shoots from the plants collected from the objects irrigate was 3.08 kg plant^{-1}. Similar tendencies of the growth of fresh weight of leaves thanks to the application of drip irrigation was found in the case of one-year-old cup plants (Figas et al., 2011) and other plant species (Rolbiecki 2004).

The mean number of leaves per stem was 16.38 (Table 2). The number of leaves on control objects was 14.75, and on the objects treated with drip irrigation – 18.00. Stanford (1990) claims that the plant can have 8 to 14 pairs of stem leaves. The increase in the number of leaves as a result of the irrigation used was significant and it was 3.75. The regularity recorded coincides with earlier research results on the drip irrigation of the one-year-old cup plants (Figas et al. 2011) as well as other nursery plants (Klimek et al. 2009).

In this experiment, the average diameter of the cup plant stem was 13.55 mm. The plants on the irrigated plots had a 109.9% bigger stem diameter compared with the control. (Table 2) Koszański et al. (2008) While conducting research on irrigation of the northern highbush blueberries they found out that when the soil humidity was higher, the stem diameter increased significantly (by 8.8%), the growth of parenchyma building the core contributed to those changes. The authors also observed that the improvement in moisture conditions increased the thickness of the layers: the cuticle (29.5%), phloem (25.6%), wood (29.5%), as well as rind and cuticle (by 1.9%) of this species.

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Received: 12.02.2015
Accepted: 20.08.2015