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STINGING NETTLE CULTIVATION IN FLOATING HYDROPON*

SANJA RADMAN, SANJA FABEK, IVANKA ŽUTIĆ, BOŽIDAR BENKO, NINA TOTH[1]

SUMMARY: Stinging nettle (Urtica dioica L.) is a perennial plant which has been widely used in medicine, food, textile and cosmetic industries as well as in organic production. Whereas it is quality control of wild plant material difficult and expensive there is a need to introduce nettle in to agricultural production. Application of modern cultivation technology (floating hydropon) can eliminate mentioned problems. Higher yield and increased number of harvests in the period when the nettle is already dormant in the open field can be achieved. The experiment was laid out according to the randomized complete block scheme with three replications in unheated greenhouse. The effect of three sowing densities (0.2, 0.5 and 0.9 g m^{-2}) and two substrates (perlite, vermiculite) on the stinging nettle yield and number of harvest were tested. Sowing was conducted in the first decade of September in 2012. During the nettle cultivation five harvests were realized: two in autumn (October 23, November 29) and three in spring period (March 15, April 16 and May 6). In autumn season plants grown in perlite had significantly more leaves and the nodes compared to those grown on vermiculite. Higher sowing density resulted in higher yield in autumn growing period (0.57 kg m^{-2}) while in the spring higher yield was recorded in the lowest sowing density (1.01 kg m^{-2}). Regardless sowing density an equal yield of stinging nettle was achieved in vermiculite (0.93 kg m^{-2}) during autumn and in perlite (1.08 kg m^{-2}) during spring period. All tested parameters were significantly affected by sowing density×substrate interaction during the nettle cultivation. In autumn period the combination of vermiculite×0.5 g m^{-2} resulted with significantly highest yield (0.96 kg m^{-2}) while in spring the highest yield (1.41 kg m^{-2}) was achieved by combination of perlite×0.2 g m^{-2}.

Key words: *Urtica dioica L., floating hydropon, multyharvest, sowing density, yield*

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[1]Sanja Radman M.Sc., young reasearcher, Sanja Fabek PhD, assistant researcher, Ivanka Žutić PhD, assistant professor, Božidar Benko PhD, assistant professor, Nina Toth PhD, associate professor, Faculty of Agriculture, Zagreb, Croatia.
Corresponding author: Sanja Radman, e-mail: sradman@agr.hr, tel.: +385 1 239-3710.

INTRODUCTION

Stinging nettle (*Urtica dioica* L.) is a perennial herb widely distributed throughout the temperate regions of the world (Bacci et al., 2009). This valuable medicinal plant is perhaps best known as an abundant and perennial weed (Weiβ, 1993; Harwood and Edom, 2012). Nettle has a long history of usage in alternative medicine as an herbal remedy (Bisht et al., 2012) for the treatment of many diseases (Grevsen et al., 2008) and is currently receiving attention as a source of fiber (Harwood and Edom, 2012; Rutto et al., 2013). Despite great medicinal values stinging nettle is undervalued by almost all of us (Bisht et al., 2012). Fresh nettle leaves are rich in chlorophyll, vitamin C, vitamin K, panthotene acid, carotenoids, B group vitamins (B1 and B2), tannins, essential oil, proteins and minerals such as iron, copper, manganese, nickel (Kukrić et al., 2012) and calcium. Processed nettle can supply 90 – 100 % of vitamin A (including vitamin A as β-carotene) and is good source of protein (Rutto et al., 2013). According to Guil-Guerrero et al. (2003) stinging nettle could be used by humans as healthy food because of essential fatty acids and carotenoids which contain in high amounts. Because of great nutritional values the young leaves are the most appropriate for human consumption (Guil-Guerrero et al., 2003). In recent years the scientific studies are increased due to the positive impact of nettle on coronary heart disease, high blood pressure, diabetes, cancer, inflammative, viral and parasitic disease, psychotic disorders (Otles and Yalcin, 2012) and expressed antioxidant and antimicrobial activities (Kukrić et al., 2012; Gülçin et al., 2004).

The largest percentage of *Urtica dioca* L is wild-harvested (Upton, 2013), grown in rich soils in forest clearings, old fields and wasted places (Bisht et al., 2012). Nettle prefers to grow in soil that is nitrogen rich in areas high in inorganic nitrates in heavy metals. Collection should be done in selected areas, avoiding locations where agribusiness and industrial runoffs occur (Upton, 2013). When nettles are gathered from natural habitat the control of quality standards is rather difficult and cost extensive (Weiβ, 1993). Considering that in the last few years the quality standards for medicinal plants have been tightened (Weiβ, 1993) it is necessary to introduce nettle in to agricultural production. Cultivation enables to control some environmental factors and so enhance the quality of the product. According to Weiβ (1993) main quality factors are high leaf yield of herbaceous medicinal plants, homogeneity of plant material, a low nitrate content and low contaminations such as residues of pesticides or heavy metals. Stinging nettle as nitrophilous plant should be fertilized at the beginning of cultivation with 150 kg N ha^{-1} and with 30 – 40 kg N ha^{-1} after each harvest (Stepanović et al., 2009). According to Biesiada et al. (2009) the highest yield of raw material was provided by nitrogen fertilization in the dose of 150 kg N ha^{-1}. However, in order to achieve higher yield producers often apply to large amounts of nitrogen fertilizer which can result in accumulation of nitrate, reducing the quality of plant material (Fabek et al., 2012). Application of appropriate modern cultivation technology can eliminate problems of growing nettle in the open field, i.e. higher yield and increased number of harvest in the period when the nettle is already dormant. Higher yield in hydropon is based on the efficient use of nutrients and water, resulting in rapid growth, an early harvest, a larger number of production cycles and biomass production per unit time and area (Osvald and Kogoj-Osvald, 2005; Toth et al., 2008; Toth et al., 2012). Soilless systems, and especially hydroponics (water culture), allow a direct control of plant nutrient supply (Gonnella et al., 2004).

Hydroponic production of medicinal crops in controlled environments provides opportunities for improving quality, purity, consistency, bioactivity, and biomass production on a commercial scale (Hayden, 2006). The floating system is rather new, inexpensive and easy hydroponic technique. It can be used to produce ready-to-use vegetables (D'Anna et el., 2003). In this production system trays continuously float on a water bed or nutrient solution (Pimpini and Enzo, 1997; Nicola et al., 2007). According to Nicola et al. (2007) floating system is suitable to produce vegetables both with short cultural cycle and with high plant density.

Because of the capability of the apical plant parts regeneration it is possible to achieve several harvests at intervals what depends on the purpose and the period of cultivation. During the first harvest the plants should be cut 0.5 cm above cotyledons to avoid damage to plant growing point and ensure rapid and abundant regeneration (Toth et al., 2012).

Since stinging nettle is usually collected from natural habitats very little information about its cultivation has been published. There are no results about the stinging nettle cultivation in floating hydropon. Therefore, the aim of research was to examine the possibility of growing nettle in floating hydropon and to determinate the effect of sowing densities and different substrates on morphological characteristics and nettle yield.

MATERIAL AND METHODS

The two factorial trials were conducted according to the randomized complete block scheme with three replications in unheated greenhouses. The effect of three sowing densities (0.2, 0.5 and 0.9 g m^{-2}) and two substrates (perlite, vermiculite) on the stinging nettle yield and number of harvest were tested. Sowing was made manually in polystyrene boards in the first decade of September in 2012. Nutrient solution adjusted for leafy vegetables was prepared according to Tesi (2002). Nettle cultivation in floating hydropon is shown in Picture 1.

Picture 1. Cultivation of stinging nettle in floating hydropon

During the nettle cultivation five harvests were realized: two in autumn (October 23, November 29) and three in spring period (March 15, April 16 and May 6). In autumn growing period the production cycle from sowing to the first harvest lasted 47 days, and the second harvest was conducted after 38 days. After winter dormancy which lasted 106 days, in spring growing period the production cycle were shorter and lasted 32 and 20 days, respectively. The cutting was at the height approximately 5 centimeters and the plants were weighted just after cutting.

The abiotic parameters of nutrient solution (temperature, pH- and the EC-values) and air (relative humidity, minimum, maximum and mean temperature) were measured daily.

The effects of sowing density and substrate were determined using analysis of variance (ANOVA) and average values were tested by the least significant difference (LSD) test at the significance level $p \leq 0.05$ and $P \leq 0.01$.

RESULTS AND DISCUSSION

If nettles is grown as a leafy vegetable, harvest should be done just before flowering (Upton, 2013) which occurs in summer months when the temperatures increase. According to Stubljar et al. (2013) in the first year of stinging nettle cultivation plant growth is slow due to the undeveloped rhizomes so a significant contribution to the green herb cannot be expected. However, cultivation in unheated greenhouses can result with an earlier harvest and higher yields even in the first year of cultivation.

Optimal temperatures for nettle growth are between 15 and 25 °C while at temperatures higher than 30 °C may appear early flowering causing lower yield (personal experience). In unheated greenhouses optimal temperatures for nettle growth can be achieved much earlier than in the open field which is the reason an earlier beginning of harvest. Abiotic parameters of air (minimum, maximum and mean temperature, relative humidity) and nutrient solution (pH- and EC-values) during the nettle cultivation in floating system are shown in Fig. 1. In autumn growing period pH of nutrient solution was in range from 6.38 to 7.02, 6.76 in average. Average pH value in spring season was slightly higher (6.82), however smaller variations between the decades were recorded (from 6.66 to 6.96). Similar to the pH value average value of nutrient solution EC was higher (2.38 dS/m) in spring compare to autumn growing period (2.34 dS/m). D´Anna et al. (2003) had proven in their research that different EC levels have not affected the plant height and slightly influenced the yield of rocket.

The first harvest was in autumn and it was realized 47 days after sowing (October 23) while second harvest was after 38 days (November 29). After winter dormancy beginning of nettle harvest was on March 15 which is almost three months earlier comparing to first harvest achieved by Grevsen et al. (2008) in the open field. Second harvest was after 32 days (April 16) and third after 20 days (May 6). Higher temperatures in spring growing season resulted in shorter production cycles. Although the average mean temperatures were similar in both growing period (16.79 in autumn and 16.31 °C in spring) in spring season have been recorded more days with maximum temperatures above 25 °C resulting shorter period between harvests. Weiß (1993) claims that in spring and mainly in early summer due to photoperiodic reaction plant senescence is accelerated. Relative humidity in growing period was between 54 and 81 % which is within the recommended values for leafy vegetables.

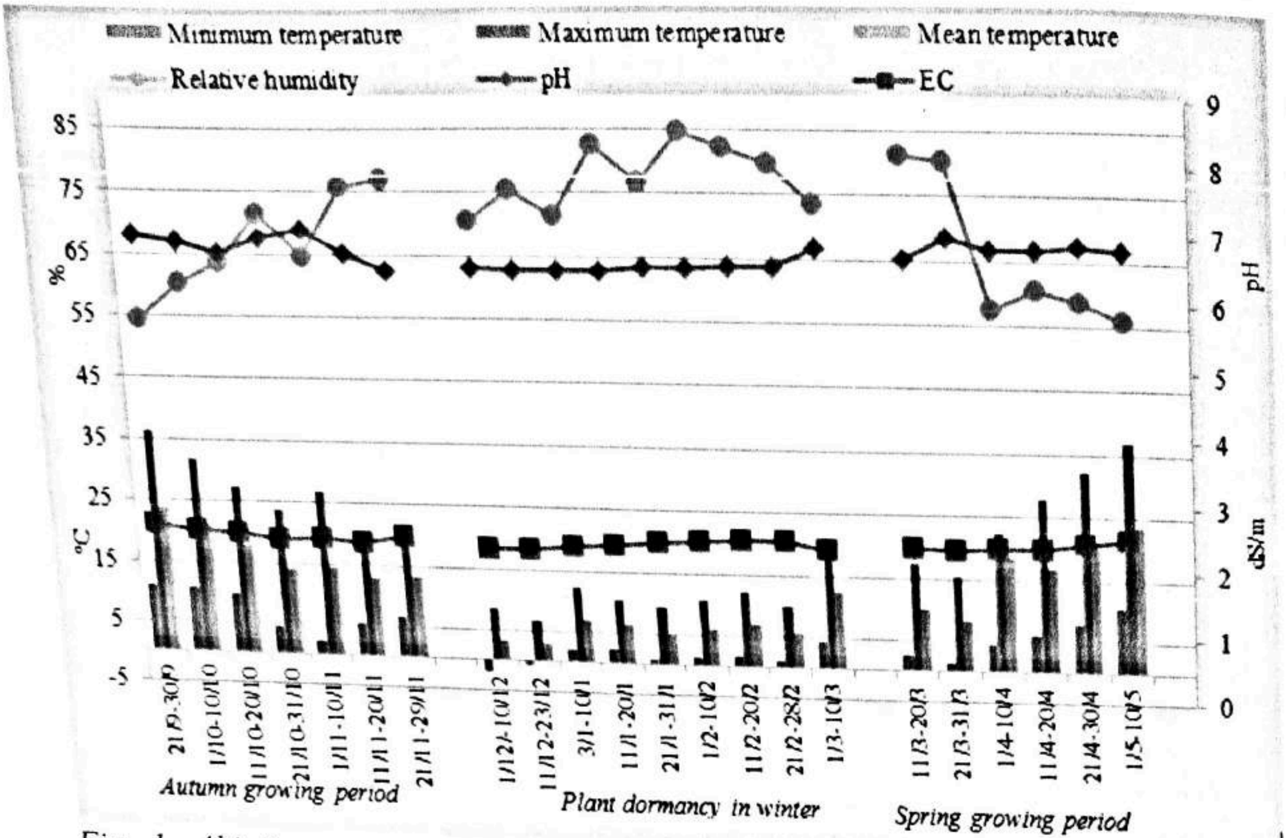

Fig. 1. Abiotic parameters of air (minimum, maximum and mean temperature, relative humidity) and pH- and EC-values of nutrient solution

In the autumn growing period all measured morphometric parameters (number of leaves, length and width of leaves, number of nodes, plant height and plant mass) were significantly affected by substrate×sowing density interaction (Table 1 and 2). Regardless sowing density, plants grown in perlite had significantly more leaves and the nodes compared to those grown on vermiculite. Lower sowing density in perlite in first and in vermiculite in second harvest resulted with more leaves (9.0 and 13.5) comparing to higher sowing density. According to Žnidarčić and Kacjan-Maršić (2008) in higher sowing density plants produce less leaves due to increased competition. The highest leaf length was measured in combination vermiculite×0.2 g m^{-2} (42.75 mm) which is contrary to the literature. According to Zanin et al. (2009) leaf length increased along with plant densities. In the same combination of substrate and sowing density, significantly higher plants (190.00 mm) with greater mass (1.02 g) were recorded. In the second harvest this was achieved with combination perlite×0.2 g m^{-2} (121.26 mm; 3.29 g).

Table 1. Analysis of variance for morphometric parameters of stinging nettle in autumn growing period

Source of variance	Plant mass, g	Number of leaves	Length of leaves, mm	Width of leaves, mm	Number of nodes	Plant height, mm
			First harvest			
Substrate (S)	*	*	*	**	*	**
Sowing density (D)	**	*	n.s.	**	*	**
S×D	*	*	**	**	**	**
			Second harvest			
Substrate (S)	*	*	*	**	**	*

Sowing density (D)	**	**	**	**	**	**
S×D	*	**	**	**	*	**

*significant at p≤0.05, **P≤0.01, n.s.=not significant

In the spring growing period significantly influence substrate×sowing density interaction was recorded. Plants grown in perlite were higher and had more leaves which were shorter compared to vermiculite. The highest values all measured morphometric parameters (except leaf length) were recorded at the lowest sowing density (data not shown).

Table 2. Effect of substrate×sowing density on stinging nettle morphometric parameters in autumn growing period

Substrate	Sowing density / g m^{-2}	Plant mass / g	Number of leaves	Lenght of leaves / mm	Width of leaves / mm	Number of nodes	Plant height / mm
			First harvest				
Perlite	0.2	0.85 bc	**9.00 a**	30.25 C	**52.50 A**	**4.75 A**	48.00 E
	0.5	0.55 d	8.00 b	35.00 B	39.50 B	4.00 B	124.50 C
	0.9	0.72 c	8.33 b	32.25 BC	41.75 B	4.25 B	77.50 D
Vermiculite	0.2	1.02 a	8.00 b	**42.75 A**	34.75 C	4.00 B	**190.00 A**
	0.5	0.84 bc	8.00 b	35.50 B	27.50 D	4.25 B	**183.25 A**
	0.9	0.94 ab	8.00 b	**41.25 A**	30.50 D	4.00 B	163.00 B
			Second harvest				
Perlite	0.2	3.29 a	11.00 B	32.50 C	**46.26 A**	**5.50 a**	**121.26 A**
	0.5	1.91 bc	**13.50 A**	29.26 D	36.00 B	4.50 b	68.75 D
	0.9	1.55 cd	**13.33 A**	34.50 B	37.00 B	3.50 c	72.50 D
Vermiculite	0.2	2.18 b	**13.50 A**	**35.00 AB**	34.00 C	4.76 b	80.00 C
	0.5	1.08 d	10.00 C	28.26 D	26.26 E	2.76 d	90.00 B
	0.9	1.72 bc	12.00 B	**36.76 A**	30.50 D	2.50 d	80.00 C

*Mean values followed by the same letter within each column do not differ significantly at p≤0.05 and P≤0.01 according to the LSD test

Significant influence of substrate, sowing density and substrate×sowing density interaction in the autumn and spring growing period on stinging nettle yield was recorded (Table 3). Greater sowing density in autumn growing season resulted in higher yield (0.74 and 0.70 kg m^{-2} at 0.5 and 0.9 g m^{-2}) while in spring higher yield was recorded in the lowest sowing density (1.31 kg m^{-2} at 0.2 g m^{-2}). This indicates that in spring growing period greater sowing density had negative impact on yield, contrary to the plants grown in autumn. Similar results have been achieved with cultivation nettle in controlled environment agriculture aeroponic and soil-less medium system (Pagliarulo et al., 2004). It is contrary to Toth et al. (2012) which have achieved an equal average total yield in lowest and in greater sowing density in spring growing period. Regardless the sowing density an equal yield of stinging nettle was achieved in vermiculite (0.93 kg m^{-2}) during autumn and in perlite (1.09 kg m^{-2}) during spring period.

The highest yield was achieved by combination perlite×0.2 g m^{-2} (1.41 kg m^{-2}) and vermiculite×0.2 g m^{-2} (1.22 kg m^{-2}) what was reached in the last harvest in spring growing period. This is contrary to Grevsen et al. (2008) which claim that first harvest and second re-harvest (cut) gave the highest yield whereas the third re-harvest is not profitable. These results confirm that the floating system gave a continuous water flow and supply from the roots to the shoots, which was an advantage for leaf mass production (Nicola et al., 2007).

Table 3. Effect of substrate and sowing density on stinging nettle yield

Treatment	Yield (kg m^{-2})				
	Autumn period		Spring period		
	First harvest	Second harvest	First harvest	Second harvest	Third harvest
Substrate					
Perlite (P)	0.36 B	0.37	0.71 b	0.68	**1.09 a**
Vermiculite (V)	**0.93 A**	0.43	**0.83 a**	0.60	0.97 b
Sowing density					
0.2 g m^{-2}	0.50 b	0.42	**0.91 A**	**0.80 A**	**1.31 A**
0.5 g m^{-2}	**0.74 a**	0.39	0.65 B	0.56 B	0.90 B
0.9 g m^{-2}	**0.70 a**	0.39	**0.74 AB**	0.56 B	0.87 B
Substrate × Sowing density					
P × 0.2 g m^{-2}	0.09 c	**0.38 ab**	**0.86 ab**	**0.92 a**	**1.41 a**
P × 0.5 g m^{-2}	0.52 b	0.35 b	0.64 c	0.62 b	0.93 b
P × 0.9 g m^{-2}	0.47 b	**0.38 ab**	0.62 c	0.49 b	0.93 b
V × 0.2 g m^{-2}	**0.90 a**	**0.45 a**	**0.96 a**	0.69 b	**1.22 a**
V × 0.5 g m^{-2}	**0.96 a**	**0.43 ab**	0.67 bc	0.49 b	0.87 b
V × 0.9 g m^{-2}	**0.94 a**	**0.41 ab**	**0.86 ab**	0.62 b	0.82 b

*Mean values followed by the same letter within each column do not differ significantly at $p \leq 0.05$ and $P \leq 0.01$ according to the LSD test

The cumulative yield of two growing periods (autumn and spring) is shown in Fig 2. The highest accumulated yield after five harvest (two in autumn and three in spring) was recorded in combination vermiculite×0.2 g m^{-2} (4.22 kg m^{-2}). The lowest accumulated yield (2.89 kg m^{-2}) was achieved by sowing in perlite in the greatest sowing density.

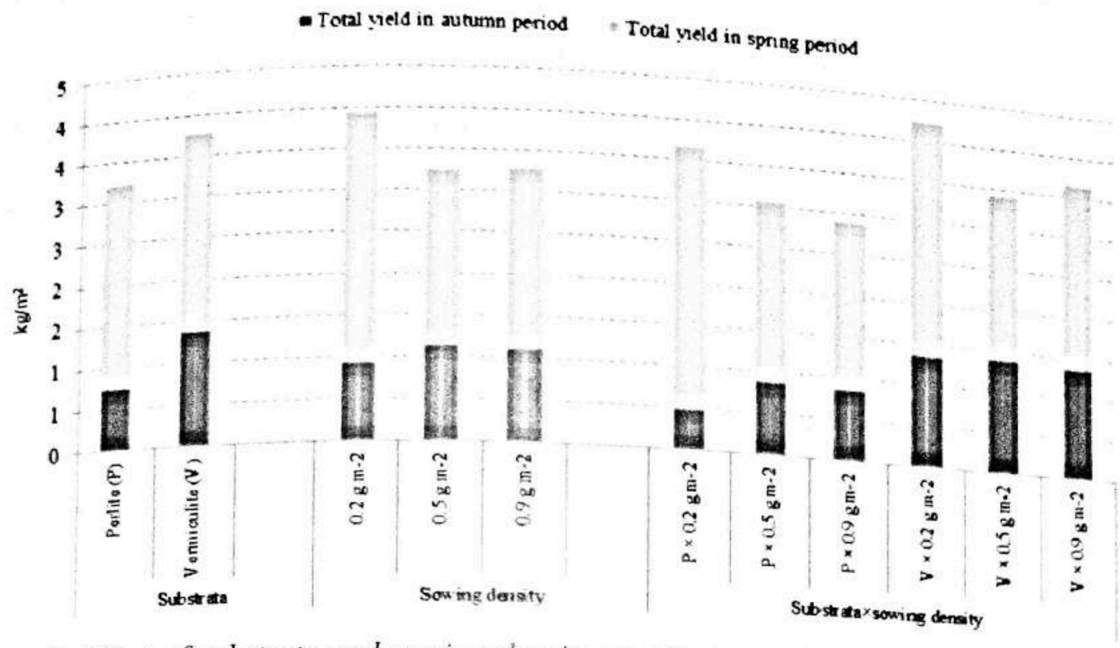

Fig 2. Effect of substrate and sowing density on stinging nettle total (after autumn and after spring harvests) and cumulative (autumn+spring harvests) yield during nettle cultivation

CONCLUSION

Stinging nettle showed good suitability to soilless cultivation by floating system achieving satisfactory yield per harvest already in the first year of cultivation. High yield and increased number of harvests have been achieved in the months when the nettle is dormant in the open field. The highest yield were recorded in spring growing period in combination perlite×0.2 g m^{-2} (1.41 kg m^{-2}) and vermiculite×0.2 g m^{-2} (1.22 kg m^{-2}).

Lower plant density has to be preferred because it gives higher yield and it allows reducing the leaf length enhancing quality especially in spring growing period. Due to economic cost effectiveness combination of perlite×0.2 g m^{-2} can be recommended for nettle cultivation in floating hydropon.

Further investigations are required to research nutritional and chemical values of stinging nettle grown in floating system at different nutrient solutions in order to produce high quality of plant material for nutritional and medicinal purpose.

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