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Effect of plant density on growth, development and quality of ribwort plantain (*Plantago lanceolata* L.)

INTRODUCTION

High popularity of herbal medicine and the growing demand for herbal medicinal products called the attention of phytopharmaceutical industry to the plant raw materials. High interest in medicinal usage of plantains *(Plantago* spp.) has recently been observed, which results from the promising results of phytochemical and ethnopharmacological studies confirming anti-inflammatory, spasmolytic, and protective effects of the raw materials obtained from these plants.

The studies carried out on the species of Plantago genus indicate high intraspecific variability. It seems that in order to obtain the raw materials of high and uniform quality, easy for standardisation, it is necessary to introduce the selected populations into cultivation. Ribwort plantain (*Plantago lanceolata* L.) is a plant of Euro-Asiatic origin, well known and commonly occurring in Poland. The content of biologically active compounds in the raw material and thus its pharmacological activity is affected by numerous endo- and exogenic factors, including genetic and ontogenetic variation, climatic and soil conditions and agrotechnical treatments. The aim of this study was to determine the effect of plant density (sowing rate) and stage of plant development on morphological traits of plants representing three populations of ribwort plantain and on the quality of raw material obtained thereof.

MATERIALS AND METHODS

For establishing the experiment the seeds obtained from 3 populations of ribwort plantain from natural sites in Poland were used

Seeds were sown in the third decade of April, at the rate of 3 kg/ha and 6 kg/ha. The experiment was established in the randomised block design with 4 replications. The single plot area was 10 m^2.

Plants were harvested at 3 stages of development: I – vegetative growth, II – blooming, and III – seed maturity. Each time plants were cut from 1 m^2 of each plot. The leaves were dried in a drying chamber at 30-35 ^{0}C. The yield of air-dry leaves was determined. Moreover, at each of the 3 developmental stages, 5 randomly selected plants from each combination were evaluated in respect of biometrical traits (plant weight, root length, leaf length and width, number and length of seed stalks).

In the air-dry leaves the contents of iridoid glycosides, tannins, flavonoids, and phenolic acids were determined, according to the methods described in the Polish Pharmacopoeia (Farmakopea Polska VIII 2008).

RESULTS

Table 1. Yield of air-dry leaves (kg/m^2)

Stage of plant development	Population	Sowing rate (kg/ha)		Mean
		3	6	
Vegetative growth	P1	0.09	0.06	0.08
	P2	0.07	0.06	0.07
	P3	0.05	0.04	0.05
	Mean	0.07	0.05	0.06
Blooming	P1	0.31	0.27	0.29
	P2	0.30	0.28	0.29
	P3	0.20	0.35	0.28
	Mean	0,27	0.30	0.29
Seed maturity	P1	1.46	1.55	1.51
	P2	1.13	1.44	1.29
	P3	1.18	1.32	1.25
	Mean	1.26	1.44	1.35
Mean	P1	0.62	0.63	0.63
	P2	0.50	0.59	0.55
	P3	0.48	0.57	0.53
Mean		0.53	0.60	

A – sowing rate, B – stage of plant development, C – population

Table 2. Content of iridoid glycosides in the leaves (g/100g)

Stage of plant development	Population	Sowing rate (kg/ha)		Mean
		3	6	
Vegetative growth	P1	2.88	0.81	1.85
	P2	1.22	1.14	1.18
	P3	1.06	0.79	0.93
	Mean	1.72	0.91	1.32
Blooming	P1	1.50	1.44	1.47
	P2	2.10	1.22	1.66
	P3	2.18	2.18	2.18
	Mean	1.93	1.61	1.77
Seed maturity	P1	2.79	2.54	2.67
	P2	2.80	2.50	2.65
	P3	2.22	2.70	2.46
	Mean	2.60	2.58	2.59
Mean	P1	2.38	1.59	1.99
	P2	2.03	1.62	1.83
	P3	1.82	1.89	1.86
Mean		2.08	1.70	

A – sowing rate, B – stage of plant development, C – population

$LSD_{0.05}$ A=0.08 $LSD_{0.05}$ B=0.14 $LSD_{0.05}$ A/B=0.05 $LSD_{0.05}$ A/C=0.06
$LSD_{0.05}$ B/A=0.08 $LSD_{0.05}$ B/C=0.29 $LSD_{0.05}$ A/BC=0.11 $LSD_{0.05}$ B/AC=0.05
$LSD_{0.05}$ ABC=0.04 $LSD_{0.05}$ C/B=0.03 $LSD_{0.05}$ C/A=0.05 $LSD_{0.05}$ C/AB=0.05

Table 3. Content of polyphenolic acids in the leaves (g/100g)

Stage of plant development	Population	Sowing rate (kg/ha)		Mean
		3	6	
Vegetative growth	P1	0.48	0.39	0.44
	P2	0.51	0.42	0.47
	P3	0.36	0.55	0.46
	Mean	0.45	0.45	0.45
Blooming	P1	0.47	0.39	0.43
	P2	0.70	0.37	0.54
	P3	0.31	0.29	0.30
	Mean	0.49	0.35	0.42
Seed maturity	P1	0.19	0.20	0.20
	P2	0.24	0.22	0.23
	P3	0.33	0.29	0.31
	Mean	0.25	0.24	0.25
Mean	P1	0.40	0.33	0.37
	P2	0.48	0.34	0.41
	P3	0.33	0.38	0.36
Mean		0.40	0.35	

A – sowing rate, B – stage of plant development, C – population

$LSD_{0.05}$ A=0.02 $LSD_{0.05}$ B=0.03 $LSD_{0.05}$ C=0.03 $LSD_{0.05}$ A/B=0.03
$LSD_{0.05}$ B/A=0.02 $LSD_{0.05}$ B/C=0.03 $LSD_{0.05}$ A/BC=0.04 $LSD_{0.05}$ B/AC=0.02
$LSD_{0.05}$ ABC=0.02 $LSD_{0.05}$ C/B=0.03 $LSD_{0.05}$ C/A=0.02 $LSD_{0.05}$ C/AB=0.03
$LSD_{0.05}$ A/C=0.02

CONCLUSION

1. Sowing rate does not significantly affect the yield of ribwort plantain leaves but it affects the content of biologically active compounds in the leaves.
2. Lower sowing rate (3 kg/ha), resulting in lower plant density, is favourable for the accumulation of iridoid glycosides, tannins, flavonoids, and polyphenolic acids in the leaves.
3. The highest yield of leaves characterised by the highest content of iridoid glycosides can be obtained at the stage of seed maturity.
4. Taking into consideration the yield of herb and the content of biologically active compounds, especially iridoid glycosides and tannins, population P1 from Lubelskie region seems to be a good source of the raw material.

The participation in the Conference is financed from EU "FP7 - Capacities" REGPOT project 2011-1-286093-WULS Plant Health