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EFFECT OF A NITROGEN FERTILIZATION RATE ON THE YIELD AND YIELD STRUCTURE OF MILK THISTLE (*Silybum marianum* (L.) Gaertn.)

WPŁYW POZIOMU NAWOŻENIA AZOTEM NA PLONOWANIE I STRUKTURĘ PLONU OSTROPESTU PLAMISTEGO (*Silybum marianum* (L.) Gaertn.)

Abstract: In the following experiment, the effect of nitrogen fertilization on the yield and biomass structure of two forms of milk thistle has been examined. A higher yield of achenes and biomass produced by milk thistle was obtained by growing a Polish population variety than the cultivar Silma. The yield of achenes rose proportionally to the increasing rates of nitrogen. The population variety responded better than cv. Silma to the increased nitrogen fertilization rates. The highest percentage of achenes in the total biomass structure was achieved when applying 2 g N per pot.

Keywords: milk thistle, yields, nitrogen

Introduction

Milk thistle (*Silybum marianum* (L.) Gaertn.) is one of the major medicinal plant species. Milk thistle extracts, which contain silymarin, are used in treatment of hepatic disorders. Silymarin protects liver cells from damaging agents and stimulates recovery processes [1, 2]. Moreover, milk thistle fruit (achenes) contain about 25 % of oil (including 63 % of linoleic acid and *ca* 20 % of oleic acid), 25–30 % of proteins, sterols (0.63 %) with tocopherol (0.038 %) and *ca* 2 % of flavonoids [3].

Owing to its relatively high content of proteins and oil containing the fatty acids beneficial to human health, milk thistle has drawn attention of animal feed and animal nutrition experts [4, 5], functional food producers and cosmetics manufacturers [6–8].

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With its abundant biomass production and low agronomic costs of cultivation, the plant can also serve as an energy crop.

The purpose of this study has been to evaluate the effect of a level of nitrogen fertilization on the yield and biomass production of two forms of the milk thistle.

Methods

The foregoing objective has been achieved in a two-factorial pot trial set up in a completely random design with four replications. The pots were filled with 10 kg of light soil each. The average content of available elements in the soil was as follows: 58 mg P $\cdot$ kg^{-1}, 97 mg K $\cdot$ kg^{-1} and 32 mg Mg $\cdot$ kg^{-1}. The soil reaction was slightly acid (pH_{KCl} = 5.8). A uniform PKMg fertilization regime (0.4 g P as $Ca(H_2PO_4)_2$; 1.5 g K as KCl and 0.3 g Mg as $MgSO_4 \cdot 7H_2O$ per pot) was combined with the following doses of nitrogen in the form of urea: N_0 – 0.0 g N; N_1 – 1.0 g N; N_2 – 2.0 g N; N_3 – 3.0 g N per pot. The PKMg fertilizers and 1 g of nitrogen (treatments N1, N2 and N3) were introduced to soil before sowing whereas the remaining doses of nitrogen (treatments N2, N3) were applied as a top-dressing treatment during the leaf rosette stage.

Two forms of the milk thistle were grown: cultivar Silma and a Polish population variety. Five plants were grown in each pot. The plants were harvested during the technological maturity phase, dissected into parts, dried and subjected to the following determinations: the weight of achenes, flower heads, stems and leaves per pot. In addition, a 1000 achenes weight as well as the number of achenes per plant and the harvest index were determined.

The results underwent analysis of variance and the significance of differences at α = 0.01 was verified by Tukey's test.

Results and discussion

The two forms of milk thistle differed significantly in the weight of achenes, flower heads and stems (Table 1). The population line produced a 41 % higher yield of achenes and a 14 % higher yield of green parts than cv. Silma. The yield of the population plants was superior owing to the higher number of achenes (27 % more than the cultivar), which were also filled in better (a 9 % higher 1000 achenes weight). No such dependence was observed for the weight of leaves (Table 2). The population line produced the highest weight of leaves under the effect of 1 g N and the cultivar Silma achieved the highest leaf weight when fertilized with 3 g of nitrogen per pot. The fertilization treatment consisting of 3 g N per pot resulted in an over two-fold and three-fold increase in the yield of achenes produced by cv. Silma and the population variety, respectively, compared with the pots which had not received nitrogen fertilization. The most wholesome achenes from both forms of milk thistle were obtained when the plants had been fertilized with the highest nitrogen dose. Compared with the nitrogen unfertilized treatments, an increment in the weight of 1000 achenes from the plants receiving the highest nitrogen rate was about 11 % for cv. Silma and over 22 % for the population variety. These plants also formed twice as many achenes

Table 1

Mass of milk thistle organs (g per pot)

Variety	N0	N1	N2	N3	Mean	$LSD_{0.01}$
Mass of achenes						
Silma	11.57	15.02	24.69	26.05	19.33	A = 2.525;
Population	11.47	30.96	32.89	34.03	27.34	B = 3.570;
Mean	11.52	22.99	28.79	30.04	—	C = 5.049
Mass of flower heads						
Silma	11.14	12.82	24.52	27.16	18.91	A = 1.965;
Population	10.38	28.32	28.51	32.16	24.84	B = 2.779;
Mean	10.76	20.57	26.52	29.66	—	C = 3.930
Mass of stalks						
Silma	10.47	14.03	23.08	24.04	17.91	A = 2.283;
Population	13.26	26.44	25.67	29.05	23.61	B = 3.229;
Mean	11.87	20.24	24.38	26.55	—	C = 4.567
Mass of leaves						
Silma	31.84	44.66	53.93	59.22	47.41	A = n.s.
Population	29.72	53.19	48.88	29.05	47.70	B = 6.973;
Mean	30.78	48.93	51.41	59.11	—	C = 9.861
Vegetative mass						
Silma	53.45	71.51	101.54	110.42	84.23	A = 8.161;
Population	53.36	107.96	102.86	120.20	96.10	B = 11.547;
Mean	53.41	89.74	102.20	115.31	—	C = 16.330

A – $LSD_{0.01}$ variety; B – $LSD_{0.01}$ doses of nitrogen; C – $LSD_{0.01}$ interaction.

Table 2

Selected elements of milk thistle yield structure

Variety	N0	N1	N2	N3	Mean	$LSD_{0.01}$
1000 achenes weight [g]						
Silma	23.05	21.82	25.37	25.66	23.98	A = 1.356;
Population	22.87	26.12	27.81	28.05	26.21	B = 1.918;
Mean	22.96	23.97	26.59	26.86	—	C = 2.713
Number of achenes per plant						
Silma	100.39	135.90	194.62	203.06	158.49	A = 22.67;
Population	100.26	226.65	236.45	244.55	201.98	B = 32.06;
Mean	100.32	181.28	215.54	223.81	—	C = 45.34

A – $LSD_{0.01}$ variety; B – $LSD_{0.01}$ doses of nitrogen; C – $LSD_{0.01}$ interaction.

as the ones grown without nitrogen fertilization. In a study conducted by Andrzejewska and Sadowska [10], the yield of milk thistle fruit was significantly correlated with the plants' height before harvest, number of fruits in an inflorescence on the main stem and on branch stems, weight of 1000 achenes, number of all flower heads on a plant and number of flower heads with pappus.

Kozera and Nowak [11] observed a positive response of milk thistle to an increasing mineral fertilization rate. The highest yield of achenes was reported by these authors when 261 kg NPK ha^{-1} had been applied as fertilizer. In addition, the yield was found out to have increased significantly after micronutrients had been applied in a top-dressing treatment. Other authors as well indicate that the yield of achenes produced by milk thistle plants rose proportionally to the increased rates of nitrogen [12]. In turn, Geneva et al [13], who tested top-dressing application of NPK and micronutrients, achieved an over 70 % increase in the yield of milk thistle compared with the control, unfertilized treatment.

Some researchers suggest that achene yields produced by milk thistle are considerably affected by the weather conditions, the date when forecrops are sown and the way the soil is tilled [10, 14–16]. It has been demonstrated that milk thistle grown in a short-term monoculture yielded 40 % lower than in a crop rotation [17]. Some authors claim that the weight of 1000 achenes is related to the colour of achenes. Higher weight is attained by dark brown seeds [18].

The harvest index, *ie* the percentage of achenes in the biomass yield, depends on the nitrogen fertilization rate, which has been confirmed by high determination coefficients (Fig. 1). The percentage of achenes in the biomass yield of plants grown without nitrogen fertilization was similar for both forms of milk thistle, and reached *ca* 16.5 %. The highest value of this parameter (over 24 %) was obtained for the population plants fertilized with 2 g N per pot. The average value of the harvest index for each of the tested varieties was higher for the population line (over 21 %) than for cv. Silma.

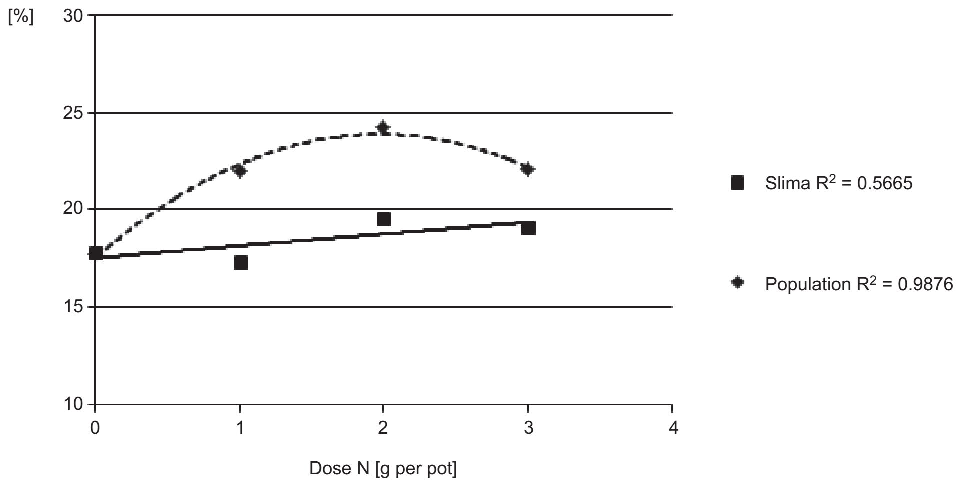

Fig. 1. Harvest index of milk thistle depending on the level of nitrogen fertilization

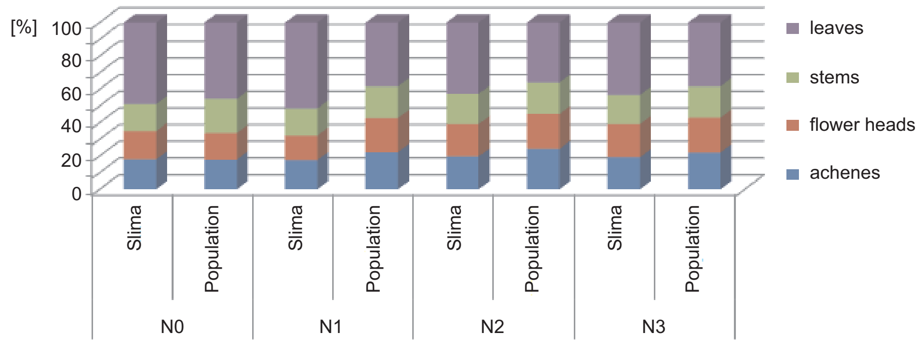

Fig. 2. Structure of biomass

The two forms of milk thistle were only slightly different in the structure of biomass (Fig. 2). In cv. Silma, depending on the fertilization rate, 43 to 52 % of the dry mass was accumulated in leaves and 16–18 % was in stems. With respect to the population line, leaves accumulated from 36 to 46 % of dry mass while stems contained 19–20 % of dry mass. In both forms, the highest share of achenes, and the lowest one of leaves, in the total dry mass accumulation were found after the application of 2 g N per pot.

Conclusions

1. Higher yields of achenes and green parts of milk thistle were obtained when growing the population line (on average 27.3 g) than cv. Silma (on average 19.3 g).
2. The yield of milk thistle achenes increased proportionally to the rates of nitrogen, and population plants responded more strongly to the increased nitrogen fertilization than the cultivar Silma.
3. The population line produced more achenes than cv. Silma. The average number of achenes on the population plant was 202 versus just 158 on a single plant of the cultivar Silma. Achenes produced by the population plants were also larger.
4. The highest share of achenes in the total biomass structure was obtained when the rate of nitrogen fertilization was 2 g per pot.

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WPŁYW POZIOMU NAWOŻENIA AZOTEM NA PLONOWANIE I STRUKTURĘ PLONU OSTROPESTU PLAMISTEGO (*Silybum marianum* (L.) Gaertn.)

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Abstrakt: W pracy badano wpływ poziomu nawożenia azotem na plonowanie i strukturę biomasy dwóch form ostropestu plamistego. Większy plon niełupek i masy wegetatywnej ostropestu plamistego uzyskano, uprawiając wyselekcjonowaną populację krajową niż odmianę Silma. Plon niełupek wzrastał proporcjonalnie do dawek azotu. Rośliny krajowej populacji silniej reagowały na wzrost poziomu nawożenia azotem niż odmiana Silma, ponadto rośliny krajowej populacji wytwarzały więcej i bardziej dorodnych owoców niż odmiana Silma. Największy udział niełupek w strukturze biomasy uzyskano, stosując nawożenie w dawce 2 g N na wazon.

Słowa kluczowe: ostropest plamisty, plonowanie, azot