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INFLUENCE OF MULCHING AND NITROGEN NUTRITIONON BEAR GARLIC (*Allium ursinum* L.) GROWTH

Tadeusz Kęsik, Marzena Błażewicz-Woźniak, Anna Ewa Michowska

University of Life Sciences in Lublin

Abstract. Bear garlic (*Allium ursinum* L.) has antiseptic, bacteriostatic, and anti-parasitic properties. Besides medicinal features, it is characterized by excellent taste quality. It can be used as a spice and component of numerous dishes. Due to an increase of needs for that material in cuisine, it is necessary to work out nutritional requirements of the species. Therefore, the aim of present study was to evaluate the influence of mulching using pine bark and various nitrogen nutrition rates (0; 75, and 150 kg $N \cdot ha^{-1}$) on bear garlic growth in the field cultivation. Mulching the soil with a bark had positive effects on bear garlic growth, which was expressed as the length and width of leaf blades, length of petioles, as well as weight of leaves and bulbs. The bear garlic leaves were of 263.1 mm length and 58.6 mm width in bark-mulched objects at the harvest time. The weight of foliage from a single plant ranged from 5.64 to 7.10 g, which was almost twice as high as in non-mulched cultivation. Nitrogen nutrition had no univocal influence on morphological traits of bear garlic, while some positive effects of that factor on weight and yield of leaves was recorded. The highest-weight bulbs were achieved in objects that were mulched with pine bark and fertilized with 75 kg $N \cdot ha^{-1}$. It was found that optimum growth and yielding conditions for bear garlic were created by field cultivation using pine bark as a mulching and moderate nitrogen nutrition.

Key words: *Allium ursinum,* cultivation*,* pine bark, nitrogen, growth, yield, leaves, bulbs

INTRODUCTION

Bear garlic (*Allium ursinum* L.) is not a pharmacopoeia plant species, although its pro-health features were known by the ancients. The bear garlic herb *HerbaAlliursini* along with its bulbs *BulbusAlliursini* are materials used in popular medicine even at present. The species has antiseptic, bacteriostatic, and anti-parasitic properties. It can be

Corresponding author – Adres do korespondencji: Marzena Błażewicz-Woźniak, Department of Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, Leszczyńskiego 58, 20-068 Lublin, Poland, e-mail: marzena.wozniak@up.lublin.pl

used during hypertension, hyperlypemia, and hypercholesterolemia treatment. Bear garlic also shows a protective action at arrhythmia during ischaemic heart disease and reperfusion [Rietz et al. 1993, Carotenuto et al. 1996,Chybowski 1997]. Besides medicinal features, it is characterized by excellent taste.

Bear garlic can be used as a spice and a component of numerous dishes [Boss-Teichmann 2009]. There are more and more products containing bear garlic on market. Mainly sensitive and fragile leaves, that should be harvested at the beginning of flowering, are the usable parts of the plant. Their bulbs can be also consumed. Bear garlic is a common vegetable in Ukraine, Russia, and Caucasus. It is sold as raw, pickled, or salted. Bear garlic gets its wider and wider popularity also in Czech Republic and Germany [Łuczaj 2004].

Because bear garlic has been under partial species protection in Poland since 2004 (Dz. U. from 2004, No 168, pos. 1764), it is impossible to achieve that plant from its natural habitat. Thus, due to the increase of demands for material for consumers, there is a need to work out the nutritional requirements of the species, and therefore, the present study aimed at evaluating the influence of mulching with pine bark and varied nitrogen nutrition rates on bear garlic growth.

MATERIALS AND METHODS

The field experiment as bi-factorial, taking into account mulching and varied nitrogen nutrition in *Allium ursinum* L. cultivation, was set in The Experimental Farm Felin in Lublin (Poland, 51°23'N, 22°56'E), by means of randomized blocks in 4 replicates. The replicate consisted of 2.94 m^2plot, where 36 bear garlic bulbs were planted in 2006 at 20 × 30 cm spacing. Bulbs of 3.1 to 4.4 g weight each were set up to 10 cm depth. Before planting, the plot was tilled using rototiller. The experiment was carried out on an open area, which was previously a wasteland. In order to provide plants with conditions close to the natural habitat, a protective screen (80% shading) was spanned on a special frame.

Pine bark was applied as a mulch; it was put around on randomly chosen plots in autumn, after bear garlic bulbs setting and systematically completed to maintain the insulation layer of about 5 cm thickness. Two rates of nitrogen nutrition were applied (75 and 150 kg $N \cdot ha^{-1}$) in a form of ammonium nitrate (34% N) and also control object (with no nitrogen nutrition) was taken into account. The nutrition was used before plant vegetation (the end of February or beginning of March). Weeds were mechanically controlled during the vegetation period.

The Experimental Farm Felin is covered by lessive soils developed from loess formations over the chalky marls. Considering the granulometric composition, the soils are moderate dusty loams. The 0–20 cm soil layer contained following average concentrations of nutrients during bear garlic cultivation: 23.2 mg P, 9.4 mg K, and 8.9 mg $Mg \cdot 100\ g^{-1}$ at acidity within the range from pH 5.8 to pH 6.2.

Biometric measurements of plants were made in subsequent years. Length and width of leaves as well as length of petioles were measured every year at two dates: in April and May (i.e. month after emergence and at the beginning of flowering). The weight of

leaves was also determined at the beginning of flowering (because they become fibrous), while bulb weight after three years of vegetation.

Achieved results were statistically processed applying variance analysis and the difference significance was determined using Tukey test at significance level of p = 0.05.

RESULTS

In April, length of bear garlic leaves, depending on cultivation combination and study year, ranged from 93.5 up to 221.8 mm (tab. 1).

Table 1. Length of bear garlic leaves, depending on bark mulching and nitrogen fertilization in years 2007–2009

Tabela 1. Długość liści czosnku niedźwiedziego w zależności od ściółkowania korą i nawożenia azotowego w latach 2007–2009

	Nitrogen nutrition Nawożenie azotowe	2007		2008		2009		Mean – Średnia		
		*IV	V	IV	V	IV	V	IV	V	mean średnia
Without mulch Bez ściółki	N_0	93.5	173.9	182.3	240.5	201.8	258.3	159.2	224.2	191.7
	N_1	105.5	187.7	139.3	255.0	207.5	236.8	150.8	226.5	188.6
	N_2	110.0	165.2	154.8	263.8	205.0	282.3	156.6	237.1	196.8
	mean – średnia	103.0	175.6	158.8	253.1	204.8	259.1	155.5	229.3	192.4
Bark mulch Ściółka z kory	N_0	111.4	168.9	163.0	275.5	221.8	345.5	165.4	263.3	214.3
	N_1	111.3	167.8	163.3	273.5	211.3	339.8	161.9	260.3	211.1
	N_2	112.1	166.8	147.5	275.8	212.8	354.8	157.4	265.8	211.6
	mean – średnia	111.6	167.8	157.9	274.9	215.3	346.7	161.6	263.1	212.4
Mean Średnia	N_0	102.4	171.4	172.6	258.0	211.8	301.9	162.3	243.7	203.0
	N_1	108.4	177.7	151.3	264.3	209.4	288.3	156.3	243.4	199.9
	N_2	111.0	166.0	151.1	269.8	208.9	318.5	157.0	251.4	204.2
	mean – średnia	107.3	171.7	158.3	264.0	210.0	302.9	158.5	246.2	202.4
$LSD_{0.05}$ for: NIR dla:										
Mulch – ściółki		n.s.	n.s.	n.s.	n.s.	n.s.	25.1	n.s.	9.8	7.0
Nutrition – nawożenia		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Month – miesiąca		-	17.9	-	17.9	-	17.9	-	-	7.0
Year – roku badań		-	-	-	-	-	-	15.1	14.5	10.3

N_0 – Control withoutnutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogennutritionrates – dawka nawożenia azotowego 75 kg N·ha^{-1},
N_2 – 150 kg N·ha^{-1};
*IV, V – month of measurement – miesiąc pomiaru;
n.s. – no significantdifferences – różnice nieistotne statystycznie

No significant influence of bark mulching or nitrogen nutrition on leaf length measured that time, was observed. The longest leaves were recorded in the third year of ex-

periment in bark-mulched object, though with no nitrogen fertilization, while the shortest in 2007 in object where no mulching and no nitrogen were applied. Leaves got longer in subsequent years. They were the shortest in April 2007 (107.3 mm), whereas the longest in 2009 (210.0 mm, on average).

Table 2. Width of bear garlic leaves, depending on bark mulching and nitrogen fertilization in years 2007–2009

Tabela 2. Szerokość liści czosnku niedźwiedziego w zależności od ściółkowania korą i nawożenia azotowego w latach 2007–2009

	Nitrogen nutrition Nawożenie azotowe	2007		2008		2009		Mean – Średnia		
		*IV	V	IV	V	IV	V	IV	V	mean średnia
Without mulch Bez ściółki	N_0	42.5	52.4	43.5	54.3	39.3	40.0	41.7	48.9	45.3
	N_1	44.0	54.1	38.5	57.8	39.5	39.8	40.7	50.5	45.6
	N_2	35.0	45.1	40.0	61.0	41.7	36.5	38.9	47.5	43.2
	mean – średnia	40.5	50.5	40.7	57.7	40.2	38.8	40.4	49.0	44.7
Bark mulch Ściółka z kory	N_0	36.4	46.3	65.8	61.3	49.3	63.5	50.5	57.0	53.7
	N_1	37.4	47.5	75.5	62.0	49.8	66.5	54.2	58.7	56.4
	N_2	39.8	49.8	69.0	68.0	48.8	63.0	52.5	60.3	56.4
	mean – średnia	37.8	47.8	70.1	63.8	49.3	64.3	52.4	58.6	55.5
Mean Średnia	N_0	39.4	49.3	54.6	57.8	44.3	51.8	46.1	52.9	49.5
	N_1	40.7	50.8	57.0	59.9	44.6	53.1	47.4	54.6	51.0
	N_2	37.4	47.4	54.5	64.5	45.2	49.8	45.7	53.9	49.8
	mean – średnia	39.2	49.2	55.4	60.7	44.7	51.5	46.4	53.8	50.1
$LSD_{0,05}$ for: NIR dla:										
Mulch – ściółki		n.s.	n.s.	6.6	n.s	6.6	7.9	2.6	3.1	2.0
Nutrition – nawożenia		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Month – miesiąca		-	5.1	-	5.1	-	5.1	-	-	2.0
Year – roku badań		-	-	-	-	-	-	3.8	4.6	2.9

N_0 – Control withoutnutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogennutritionrates – dawka nawożenia azotowego 75 kg $N \cdot ha^{-1}$,
N_2 – 150 kg $N \cdot ha^{-1}$;
*IV, V – month of measurement – miesiąc pomiaru;
n.s. – no significantdifferences – różnice nieistotne statystycznie

The leaves have become significantly longer since April till May, regardless of the experimental year (by 87.7 mm, on average). In May, the bear garlic leaf length ranged from 165.2 to 354.8 mm. Pine bark mulching exerted positive effects on leaf growth, because they were considerably longer in mulched rather than non-mulched objects. The beneficial influence of mulching was manifested namely in the third year of study. Bear garlic leaves from mulched plots were by 87.6 mm than those from plants cultivated with no mulching that year. No significant dependencies between leaf lengths in May

vs. nitrogen nutrition level were recorded. The longest leaves were produced by bear garlic in the third year, where the highest nitrogen rate was applied (354.8 mm, on average). Length of bear garlic leaves varied in subsequent years of cultivation. The longest leaves were formed in the third year (302.9 mm), while the shortest in the first year of experiment (171.7 mm). Leaves were longer by 76.4% in 2009 as compared to those in 2007.

Width of bear garlic leaves depended on mulching, measurement date, and year of study (tab. 2). In April, leaf blade width ranged from 35.0 to 75.5 mm, meanwhile in 2007, experimental factors seemed to have no influence on that trait. In subsequent years of study, a positive effect of pine bark mulching on leaf width measured in April, was observed. Regardless of the year, leaf blade width of bear garlic grown in mulched objects was by 12.0 mm higher than those with no mulching. Varied nitrogen nutrition did not affect the leaf width that measurement date.

Table 3. The length of petioles of bear garlic leaves, depending on bark mulching and nitrogen fertilization in years 2007–2009

Tabela 3. Długość ogonka liściowego czosnku niedźwiedziego w zależności od ściółkowania korą i nawożenia azotowego w latach 2007–2009

	Nitrogen nutrition Nawożenie azotowe	2007		2008		2009		Mean – Średnia		
		*IV	V	IV	V	IV	V	IV	V	mean średnia
Without mulch Bez ściółki	N_0	48.1	73.9	43.3	64.5	55.0	85.3	48.8	74.5	61.7
	N_1	45.8	72.0	38.5	79.0	55.0	67.0	46.4	72.7	59.5
	N_2	45.5	84.0	40.0	82.3	53.0	87.8	46.2	84.7	65.4
	mean – średnia	46.5	76.6	40.6	75.3	54.3	80.0	47.1	77.3	62.2
Bark mulch Ściółka z kory	N_0	57.5	94.1	65.8	79.6	51.3	110.5	58.2	94.7	76.4
	N_1	59.0	107.4	75.5	91.5	44.5	125.3	59.7	108.0	83.9
	N_2	58.0	104.5	69.0	86.3	49.0	124.8	58.7	105.2	81.9
	mean – średnia	58.2	102.0	70.1	85.8	48.3	120.2	58.8	102.6	80.7
Mean Średnia	N_0	52.8	84.0	54.5	72.1	53.1	97.9	53.5	84.6	69.1
	N_1	52.4	89.7	57.0	85.3	49.8	96.1	53.0	90.4	71.7
	N_2	51.8	94.3	54.5	84.3	51.0	106.3	52.4	94.9	73.7
	mean – średnia	52.3	89.3	55.3	80.5	51.3	100.1	53.0	90.0	71.5
$LSD_{0,05}$ for: NIR dla:										
Mulch – ściółki		10.8	15.0	10.8	n.s.	n.s.	15.0	4.2	5.9	3.6
Nutrition – nawożenia		n.s.	n.s.	n.s.	n.s.	n.s.	22.9	n.s.	8.7	n.s.
Month – miesiąca		-	9.1	-	9.1	-	9.1	-	-	3.6
Year – roku badań		-	-	-	-	-	-	n.s.	8.7	5.2

N_0 – Control withoutnutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogennutritionrates – dawka nawożenia azotowego 75 kg N·ha^{-1},
N_2 – 150 kg N·ha^{-1};
*IV, V – month of measurement – miesiąc pomiaru;
n.s. – no significantdifferences – różnice nieistotne statystycznie

Leaves considerably increased their width during month between subsequent measurements in all years of experiment. The mean increment was 7.4 mm, which was the highest in 2007 (10.0 mm). Bear garlic leaf width in May amounted from 36.5 to 68.0 mm. Positive influence of mulching on bear garlic leaf width was manifested namely in the third study year, when they were by 25.5 mm wider in objects with mulching as opposite to those growing with no pine bark mulching. No significant dependence between nitrogen fertilization and leaf blade width was observed. At both dates of measurement, bear garlic produced the widest leaves in 2008, while the narrowest in 2007.

Table 4. Influence of bark mulching and nitrate nutrition on fresh matter of bear garlic leaves in years 2007–2009 and on increase bulb weight after 3 years

Tabela 4. Wpływ ściółkowania korą i nawożenia azotowego na świeżą masę liści czosnku niedźwiedziego w latach 2007–2009 oraz na przyrost masy cebulek po 3 latach uprawy

	Nitrogen nutrition Nawożenie azotowe	Weight of 1 leaf in g Masa 1 liścia w g				Weight of leaves per 1 plant Masaliści w g·roślina^{-1}				Weight of 1 bulb in g Masa 1 cebulki w g	Increase bulb weight Przyrost-masy cebulki %
		2007	2008	2009	mean średnia	2007	2008	2009	mean-średnia		
Without mulch Bez ściółki	N_0	1.67	2.09	1.96	1.91	3.19	4.01	3.74	3.65	5.9	78.6
	N_1	1.82	2.58	1.84	2.08	3.21	4.54	3.24	3.66	6.5	83.2
	N_2	2.17	3.07	2.19	2.48	3.55	5.04	3.59	4.06	8.6	131.4
	mean średnia	1.89	2.58	2.00	2.15	3.32	4.53	3.53	3.79	7.0	97.8
Bark mulch Ściółka z kory	N_0	2.34	3.27	2.40	2.67	5.64	7.89	5.80	6.44	8.3	87.1
	N_1	2.79	4.22	2.56	3.19	6.31	9.54	5.78	7.21	9.8	162.1
	N_2	3.01	4.00	3.32	3.44	6.45	8.57	7.10	7.37	9.5	161.3
	mean średnia	2.71	3.83	2.76	3.10	6.13	8.67	6.23	7.01	9.2	136.9
Mean Średnia	N_0	2.00	2.68	2.18	2.29	4.42	5.95	4.77	5.05	7.1	82.9
	N_1	2.31	3.40	2.20	2.64	4.76	7.04	4.51	5.44	8.1	122.7
	N_2	2.59	3.54	2.75	2.96	5.00	6.80	5.34	5.72	9.0	146.4
	mean średnia	2.30	3.21	2.38	2.63	4.73	6.60	4.88	5.40	8.1	117.3
$LSD_{0,05}$ for:											
Mulch – ściółki					0.27				0.48	1.9	n.s.
Nutrition– nawożenia					0.43				0.82	n.s.	n.s.
Year – roku badań					0.43				0.82	-	-

N_0 – Control withoutnutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogennutritionrates – dawka nawożenia azotowego 75 kg N·ha^{-1},
N_2 – 150 kg N·ha^{-1};
n.s. – no significantdifferences – różnice nieistotne statystycznie

The length of petioles at bear garlic during the three experimental years was significantly affected by the following items: pine bark mulching, measurement date, and cultivation year (tab. 3). Influence of nitrogen nutrition was prominent in the second date (May) of measurements.

In April, mean length of petioles was 53 mm and no dependence of that trait vs. nitrogen fertilization was recorded. Instead, mulching exerted some positive influence. Bear garlic grown on plots mulched using pine bark produced leaves with longer petioles. It was particularly visible during the first two years of experiment. In a month, i.e. since April till May, length of petioles increased twice (by 37.0 mm, on average). Positive impact of mulching on that feature was also manifested in May. Petioles were by 25.3 mm longer on mulched plots than on non-mulched ones. A significant dependence between nitrogen nutrition and petiole length was moreover recorded that date. The longest petioles (94.9 mm) were produced by bear garlic that was fertilized using the highest nitrogen rate (150 kg $N \cdot ha^{-1}$), while the shortest (84.6 mm), when no nitrogen fertilization was applied. Bear garlic petiole length in April did not vary among subsequent years of study, meanwhile remarkable differences arose in May. The longest petioles that date were measured in the third experimental year (2009), while the shortest in 2008.

Fresh matter of a single bear garlic leaf, depending on experimental factor, ranged from 1.67 to 4.22 g (tab. 4). Mulching had positive effects on that trait. Leaves from mulched objects had significantly larger weight than those from plots without mulching. Influence of nitrogen fertilization was also beneficial. Along with increasing nitrogen rate, leaf weight increased considerably as well. Leaves with the highest weight were produced by bear garlic in 2008.

Influence of experimental factors on leaf yield per a single plant was similar as for a single leaf weight (tab. 4). By 3.22 g more fresh leaf matter was achieved from plants grown on pine bark mulched objects than from those cultivated with no mulching. Increasing nitrogen nutrition rates also increased the leaf yield from 5.05 $g \cdot plant^{-1}$ (without nutrition) to 5.72 g, when the highest nitrogen rate was applied (150 kg $N \cdot ha^{-1}$). Bear garlic produced the highest leaf matter in the second (6.60 $g \cdot plant^{-1}$), while the lowest in the first cultivation year (4.73 g).

Mean weight of bear garlic bulbs after 3 years of experiment amounted from 5.9 to 9.8 g (tab. 4). That period of time, weight of bulbs increased by 117.3%, on average. Pine bark mulching had positive effects on bear garlic bulb growth. In mulched objects, the unit weight of bulbs was by 2.2 g higher than in objects with no mulching. Moreover, a tendency to increase bulb weight due to higher nitrogen nutrition rates, was prominent. Bulbs with the highest weight were produced in objects with pine bark mulching and where nitrogen was applied at 75 kg $N \cdot ha^{-1}$ rate.

DISCUSSION

Morphological traits of bear garlic grown in the field depended on agricultural technology applied: both pine bark mulching and nitrogen nutrition. Leaves of the species at the full development phase, i.e. in May, reached average length of 246.2 mm (oscillat-

ing from 165.2 to 354.8 mm). Eggert [1992] found that leaf blade of *Allium ursinum* ranged from 293 to 326 mm, while Kuklováand Kukla [2006] reported mean length of bear garlic leaves as 449 mm. These values are similar to results achieved in here analyzed experiment, which confirms the fact that conditions should be possibly as similar during the cultivation as those in natural habitat of *Allium ursinum*. It can be supposed that long leaf blades in studies made by Kuklováand Kukla [2006] resulted also from the plant's age. In here presented experiment, bear garlic formed the longest leaves in the third year. *Allium sativum*plants grown from larger diameter bulbs were characterized by more intensive growth and more numerous leaves [Dyduch and Najda 2003]. Significant differences in length of garlic leaves between measurement dates were probably associated with plant's vegetative development; the gain amounted to 87.7 mm, on average.

The study revealed a positive influence of pine bark mulching on bear garlic leaf length. Corrêa et al. [2003] recorded better growth of *Allium sativum*, which was expressed as shoot length and head diameter on mulching objects. Increased garlic plant height by 9.45 cm as compared to plants cultivated with no mulching was observed by Bhuiya et al. [2003]. In similar experiment, Islam et al. [2007a] achieved *Allium sativum* plants by 7.61 cm higher from straw-mulched objects than from the control. Common garlic was also characterized by better growth (by 6 to 13 cm, on average) on soil that was mulched using straw and sawdust [Jamil et al. 2005].

Forest, where soils are covered with natural litter, is a natural habitat for *Allium ursinum* [Popiołek et al. 1994]. Litter made of pine bark applied in the field cultivation provided plants with better growth conditions resulting from prevention against water loss and injuries due to a frost. Covering the soil with an organic litter assures better water retention, improves its aggregation, and protects from sudden temperature changes [Zaongo et al. 1997, Kęsik et al. 2006 a, b, Błażewicz-Woźniak and Kęsik 2010].

Fully shaped bear garlic leaves were characterized by width from 35.0 to 75.5 mm (at mean value of 53.8 mm). Literature data on the width of *Allium ursinum* leaves quote it for 20 to 50 mm [Szafer et al. 1986]. However, bear garlic formed slightly wider leaves in present experiment. Like for leaf length, the influence of pine bark mulching appeared to have positive effects also for leaf blade width in the field cultivation. Leaf blades of bear garlic grown in mulched objects were by 12 mm wider than those cultivated without any mulching. Positive impact of mulching manifested namely in the third year of experiment. Covering the soil with pine bark provided plants with better moisture conditions than cultivation with no mulching. Increase of the soil humidity by 4.1% within 20 cm layer under a black foil as compared to uncovered soil was found by Aulakh and Sur [1999]. Applying a mulching is particularly beneficial at the lack of irrigation and during low rainfall amounts [Pliszka et al. 1997]. Due to evaporation process, narrower and more elongated leaves were produced by plants grown without mulching, whereas leaves had larger surface area when those formed by*Allium ursinum* plants cultivated in objects covered with pine bark.Bear garlic produced leaves wider by 25.5 mm in mulched objects in 2009 than in non-mulched ones. Nitrogen nutrition did not significantly affect the length and width of bear garlic leaves,

which can be accounted for by poor nutritional requirements of the species, the natural habitat of which are forest communities.

Leaves of bear garlic formed petioles of 72.7 to 108.0 mm length (90 mm, on average). These values are much higher than those cited in literature references. According to Szafer et al. [1986], the length of *Allium ursinum* petioles ranged from 5 to 20 mm. It is difficult to explain such difference. Perhaps, short petioles of bear garlic described by Szafer et al. [1986] resulted from the traits of particular genotype. Like in the case of leaf width and length, a positive influence of pine bark mulching on petiole length at *Allium ursinum*was recorded. Najda and Dyduch [2005] as well as Siwek and Libik [2005] confirmed analogous effect of mulching on morphological traits expressed as petiole length at celery, and similarly asBłażewicz-Woźniak [2009] in fennel cultivation after covering with black PP fiber and PE foil. Influence of nitrogen nutrition on bear garlic petiole length differed depending on the measurement date. In April, no dependence between nutrition and petiole growth was observed; however, in May, the length of petioles was positively correlated with nitrogen rate giving the longest petioles by bear garlic fertilized with 150 kg $N \cdot ha^{-1}$. It was also confirmed by literature data [Błażewicz--Woźniak 2006].

Mainly leaves, then bulbs (due to a difficulty of their achieving) are herbal and consumable products of *Allium ursinum*, therefore their weight and yields are important parameters [Łuczaj 2004, Fijałkowski and Chojnacka-Fijałkowska 2009]. The influence of agricultural factors manifested namely in reference to bear garlic leaf weight in analyzed experiment. It significantly depended on nitrogen nutrition and mulching. Mean leaf weight per a single plant grown in control objects (without nitrogen nutrition) amounted to 5.05 g. Much lower weight characterized *Allium ursinum* plants in studies carried out by Kuklova and Kukla [2006], who reported that above ground shoots of bear garlic from natural habitat weighed from 0.213 g to 0.607 g, while weight of a single plant amounted to 1.468 g, on average. During the field experiments, bulbs increased their weight after three years by 117.3%, which was within the range from 5.9 to 9.8 g.

Weight of bear garlic leaves increased along with the increase of nitrogen nutrition rate – and that dependence is justified, because of yield-forming function of nitrogen [Mairapetyanet al. 1999, Markiewicz et al. 2002, Dzida and Pitura 2008]. The highest leaf yield (5.72 $g \cdot plant^{-1}$) was harvested after nitrogen nutrition at 150 kg $N \cdot ha^{-1}$ dose. There were no agrotechnical studies upon *Allium ursinum*yet, hence there is no information on the reaction of the species towards nutrition in literature references; only comparison of achieved results for bear garlic with other *Allium* species is possible. When studying the effect of nitrogen and sulfur nutrition on *Allium sativum*yields, considerable increase of bear garlic bulb weight was recorded after application of the highest nitrogen rate (200 kg $N \cdot ha^{-1}$) as compared to objects fertilized using its lower doses [Farooqui et al. 2009]. Lošák et al. [2010] reported the increase of bulb yield when nitrogen was applied at 0.9 g $N \cdot dm^{-3}$ rate as compared to null nitrogen dose, but the authors did not find any differences in yields between rates 0.9 and 1.2 g $N \cdot dm^{-3}$. In experiments performed by Islam et al. [2007b], the highest yield of bulbs was achieved at moderate nitrogen nutrition rate (120 kg $N \cdot ha^{-1}$), while at 240 kg $N \cdot ha^{-1}$ rate, the yields were lower. Gaviola and Lipiński [2008] reported similar results when achieved the largest yield of red *Allium sativum* ecotype heads from objects fertilized with

225 kg N·ha^{-1}, whereas the highest nitrogen rate (300 kg N·ha^{-1}) made the yields lower. According to Sady [2000], optimum nitrogen content in the soil under *Allium sativum* cultivation should be 80–100 mg N (NO_3+NH_4)·dm^{-3}. In here analyzed experiment, bulbs of the largest weight were produced by bear garlic in mulched objects and fertilized with 75 kg N·ha^{-1} rate.

Like for leaf growth, covering the soil with pine bark layer had positive effects on the leaf and bulb weights. *Allium ursinum* is very distinct from other garlic species in reference to its occurrence habitats, because it grows in wet deciduous forests [Łuczaj 2004]. The soil humidity in May in natural habitat of bear garlic amounted from 23.2 to 25.0% [Rychnovská and Bednáø 1998]. Appropriate subsoil moisture content is one of the habitat conditions that is preferred by *Allium ursinum* [Andersson 1993], and this can account for a positive influence of mulching on all growth and yielding traits of bear garlic. By 3.22 g more fresh leaf weight was achieved from plants grown on plots covered with pine bark than that without mulching. The unit leaf as well as bulb weight was also higher (by 2.2 g, on average). The bulb weight gain during the 3 years of cultivation in mulched objects was 136.9%, while with no mulching 97.8%. Rekowska [1998], when studying the influence of mulching made of black foil in *Allium sativum*-cultivation, reported significant increase of garlic commercial yield by 16.2% as compared to non-mulched system. Increase of common garlic head yield by 31–39% due to mulching was also confirmed by Islam et al. [2007a]. Mulching the garlic using straw exerted positive effects on fresh weight of leaves. That factor contributed to the increase of leaf weight by 1.99 g, which was almost 31% as compared to the control (with no mulching) [Bhuiya et al. 2003]. Islam et al. [2007a] reported the increase of *Allium sativum* leaf weight in straw-mulched objects for 0.66 g, on average, which confirmed here achieved results in experiments involving *Allium ursinum.*

CONCLUSIONS

1. Mulching the soil using pine bark had positive effects on bear garlic growth expressed as the length and width of leaf blade, petiole length, as well as weight of leaves and bulbs.

2. Nitrogen nutrition had no univocal influence of morphological traits of bear garlic; instead positive impact of that factor on the weight and yield of leaves was recorded.

3. In the field cultivation, bear garlic formed leaves of 165.2 up to 354.8 mm length and from 36.5 to 68.0 mm width. Weight of leaves per a single plant amounted from 3.19 to 9.54 g.

4. Bulbs with the highest weight were produced in objects with pine bark mulching and fertilized with 75 kg N·ha^{-1} rate.

5. It was found that optimum conditions for bear garlic growing and yielding were assured by pine bark mulching and moderate nitrogen nutrition.

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WPŁYW ŚCIÓŁKOWANIA I NAWOŻENIA AZOTOWEGO NA WZROST CZOSNKU NIEDŹWIEDZIEGO (*Allium ursinum* L.)

Streszczenie. Czosnek niedźwiedzi (*Alliumursinum* L.) ma działanie bakteriobójcze, bakteriostatyczne i przeciwrobacze. Oprócz właściwości leczniczych charakteryzuje się doskonałymi walorami smakowymi. Może być stosowany jako przyprawa oraz jako składnik wielu potraw. W związku ze wzrostem zapotrzebowania na surowiec dla celów spożywczych, zachodzi pilna potrzeba opracowania wymagań pokarmowych tego gatunku.

Celem przeprowadzonych badań była ocena wpływu ściółkowania gleby korą sosnową oraz zróżnicowanych dawek nawożenia azotowego (w dawkach: 0; 75 i 150 kg $N \cdot ha^{-1}$)na wzrost czosnku niedźwiedziego w uprawie polowej. Ściółkowanie gleby korą wpłynęło korzystnie na wzrost czosnku niedźwiedziego wyrażony przez długość i szerokość blaszki liściowej, długość ogonka liściowego oraz masę liści i cebulek. W obiektach ściółkowanych korą liście czosnku w chwili zbioru miały średnio 263,1 mm długości i 58,6 mm szerokości. Masa liści z 1 rośliny mieściła się w zakresie od 5,64 do 7,10 g i była prawie dwukrotnie większa niż w uprawie bez ściółki. Nawożenie azotowe nie oddziaływało jednoznacznie na cechy morfologiczne czosnku niedźwiedziego, natomiast stwierdzono dodatni wpływ tego czynnika na masę i plon liści uprawianych roślin. Cebulki o największej masie uzyskano w obiektach ściółkowanych korą i nawożonych dawką 75 kg $N \cdot ha^{-1}$. Wykazano, że optymalne warunki dla wzrostu i plonowania czosnku niedźwiedziego stworzyła uprawa w gruncie przy zastosowaniu ściółkowania z kory sosnowej i umiarkowanego nawożenia azotowego.

Słowa kluczowe: *Alliumursinum,* uprawa*,* kora sosnowa, azot, wzrost, plon, liście, cebulki

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