ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 10(3) 2011, 133-144*

FLOWERING OF BEAR GARLIC (*Allium ursinum* L.) CULTIVATED IN THE FIELD AT VARIED NITROGEN NUTRITION AND MULCHING

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Abstract. Bear garlic (*Allium ursinum* L.) has been well-known to popular medicine for ages and its pharmacological action is similar to that of common garlic. It is a typical geophyte; occupies wet habitats in ravines and near springs, mainly among beeches and riparian forests. Generative reproduction is the main way for population spreading. The present study aimed at evaluating the influence of mulching using pine bark and varied nitrogen nutrition rates (0; 75 and 150 kg $N \cdot ha^{-1}$) on flowering traits of bear garlic under conditions of the field cultivation. Mulching using pine bark had positive effects on the length of inflorescence shoot, peduncle, inflorescence diameter, as well as number of flowers in the inflorescence and the plant. During a month, i.e. since April till May, significant increase of inflorescence shoot length at bear garlic has been recorded. In April, they length ranged from 9.0 up to 59.8 mm, while in May from 190.5 to 320.8 mm. Bear garlic inflorescences consisted of 13.4 to 24.0 flowers, with their diameters reaching 19.0 to 53.8 mm. The longest inflorescence shoots and inflorescences with the largest diameter and flower number were produced by bear garlic in the third year of vegetation. No remarkable influence of nitrogen nutrition on inflorescence shoot length and number of flowers per in an inflorescence was recorded.

Key words: *Allium ursinum*, inflorescences, pine bark, fertilization

INTRODUCTION

Bear garlic (*Allium ursinum* L.) has been well-known to popular medicine for ages and its pharmacological action is similar to that of common garlic [Sendl et al. 1992]. First notes on that species, along with botanical description, can be found in the herbarium by Hieronymus Bock from 1539 [Clarke 2001]. Natural habitats of *Allium ursinum* L. in Poland are met on lowlands and mountains up to the deciduous forest level. The

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species prefers shadow and occupies wet stands in ravines and near springs, mainly among beeches – *Fagion* associations communities of *Querco-Fagetea* class, in ash-alder forest at the mountains bottom – *Carici Remotae-Fraxinetum,* and among hill-slope harnbeam-oak trees – *Acer platanoides-Tilia cordata* community [Janeczko and Sobolewska 1995, Fijałkowski and Chojnacka-Fijałkowska 2009, Załuski et al. 2009].

Allium ursinum is an autotrophy and typical spring geophyte [Raunkiær 1934, Hérault and Honnay 2005]. Bulbs of about 2 to 6 cm are the underground wintering organ of bear garlic. Bulbs can be reproduced due to forming side-bulbs [Szafer et al. 1986, Andersson 1993]. Generative reproduction is the main way for population spreading, although survivability of seedlings since their emergence till the fourth year of life never exceeds 10%. The plant reaches reproduction maturity at 4-5th year of vegetation [Tutint 1957, Bierzychudek 1982, Eggert 1992]. Loose apparent umbels consisting of highly self-pollinating flowers, that can be also pollinated by flies and bumble-bees, is an inflorescence [Szafer et al. 1986, Traczyk 1989, Fijałkowski 1994, Żuraw 2005a, b, 2007].

Mainly delicate and fragile leaves that should be harvested at the beginning of flowering phase, are bear garlic usable parts. Bear garlic has been under partial legal protection since 2004 in Poland (Dz. U. 2004, No 168, pos. 1764) and mentioned in "The Red Book of Polish Plants and Mushrooms" [Mirek et al. 2006], which makes impossible to achieve the plants from their natural habitats. Nevertheless, increasing needs for the material makes that it is necessary to work out the cultivation technology for bear garlic. Present study aimed at evaluating the influence of pine bark mulching and varied nitrogen nutrition rates on flowering traits of bear garlic cultivated in the field.

MATERIALS AND METODS

The field experiment upon *Allium ursinum* L. cultivation has been set in The Experimental Farm Felin in Lublin (51^{o}14' N and 22^{o}32' E) by means of randomized blocks in 4 replicates. Each replicate consisted of 2.94 m^2 plot where 36 bear garlic bulbs were planted in 20 × 30 cm spacing in 2006. Bulbs of 3.1 to 4.4 g weight were planted at 10 cm depth. Prior to planting, the field was tilled using rototiller. The experiment was carried out on an open area that was previously a wasteland. In order to provide plants with similar conditions as their natural habitat, a screen (80% shading) was spread on a frame. The Experimental Farm Felin is covered with lessive soils developed from loess formations on chalky marls. Considering granulometric composition, the soils are moderate dusty loams. During the bear garlic cultivation, mean contents of particular nutrients within 0–20 cm soil layer were following: 23.2 mg P, 9.4 mg K, and 8.9 mg Mg·100 g^{-1} at acidity from pH 5.8 to pH 6.2. Weather course during the experiment is presented in table 1.

Mulching was composed of pine bark that was spread over random plots in autumn after bear garlic bulbs setting and it was systematically completes in order to maintain an insulation layer of 5 cm thickness. Two nitrogen nutrition rates were applied (75 and 150 kg N·ha^{-1}) in a form of ammonium nitrate (34% N) as well as control was also included (without nitrogen nutrition). The fertilization was made before plant's vegetation

beginning (end of February or beginning of March). During the vegetation period, weeds were mechanically controlled. The course of phonological phases for bear garlic by recording the dates of emergence, a single leaf phase, flowering beginning, and seed formation, was observed. Biometric measurements of plants were performed in subsequent years of experiment. Length of inflorescence shoot was measured annually at two dates: in April and in May (i.e. a month after emergence and at the beginning of flowering). Length of peduncle and inflorescence diameter, as well as number of flowers in an inflorescence were determined as well.

Table 1. Mean monthly air temperatures and amount of precipitation at ES Felin in the years 2007–2009*

Tabela 1. Średnie miesięczne temperatury powietrza i sumy opadów w GD Felin w latach 2007–2009

Month Miesiąc	Temperature – Temperatura (°C)				Amount of precipitation – Suma opadów (mm)			
	2007	2008	2009	mean for years średnia z lat 1951–2000	2007	2008	2009	mean for years średnia z lat 1951–2000
I	2.6	0.4	-2.7	-3.6	51.5	36.2	20.2	21.7
II	-1.6	2.2	-1.2	-2.8	22.3	17.8	36.9	24.8
III	6.2	3.4	1.4	1.0	30.2	64.8	69.6	25.8
IV	8.7	9.3	11.4	7.5	17.4	55.8	2.9	40.6
V	15.0	12.8	13.6	13.0	81.5	101.6	71.1	58.3
VI	18.1	17.7	16.4	16.5	87.8	25.9	125.5	65.8
VII	19.2	18.3	19.9	17.9	87.0	77.1	57.1	78.0
VIII	18.4	19.3	19.0	17.3	37.6	55.0	54.7	69.7
IX	13.0	12.6	15.3	12.9	129.8	102.2	21.0	52.1
X	7.6	10.1	6.9	7.9	17.7	55.5	103.6	40.3
XI	1.0	4.8	5.5	2.5	31.1	31.1	43.1	39.1
XII	-1.2	0.9	-1.7	-1.4	14.9	43.8	37.7	31.5

*according to Agro-meteorological Laboratory at University of Life Sciences in Lublin
*według Stacji Agrometeorologii UP w Lublinie

Achieved results were statistically processed by means of variance analysis and determining the difference significance with a help of Tukey test at significance level of $p = 0.05$.

RESULTS

Course of phonological phases. The course of phonological phases of bear garlic varied depending on experimental year (tab. 2).

Plants began their vegetation the soonest in 2007 and the emergence was recorded on 27 February. The latest emergence of bear garlic occurred on 17 March in 2009. The single formed leaf phase appeared the earliest in 2008, then two days later in 2007, and a week later (on 27 March) in 2009. Plants formed their first leaf the soonest in 2009 – 10 days after the emergence, while in 2007 – after 21 days. Flowering phase of bear

Table 2. Observations over phonological phases of bear garlic in 2007–2009
Tabela 2. Obserwacje faz fenologicznych czosnku niedźwiedziego w latach 2007–2009

Phase – Faza	2007		2008		2009	
	date data	*A	date data	*A	date data	*A
Emergence – Wschody	27.02.		5.03.		17.03.	
A single leaf – Faza 1 liścia	20.03.	21	18.03.	13	27.03.	10
Beginning of flowering – Początek kwitnienia	17.04.	48	28.04.	54	5.05.	49
Full flowering – Pełnia kwitnienia	23.04.	54	3.05.	59	12.05.	56
Seed formation – Formowanie nasion	15.05.	76	28.05.	84	1.06.	76

*A – number of days after emergence – Liczba dni od wschodów

Table 3. Length of inflorescence shoot (in mm) of bear garlic, depending on bark mulching and nitrogen fertilization in years 2007–2009
Tabela 3. Długość pędu kwiatostanowego czosnku niedźwiedziego (w mm) w zależności od ściółkowania korą i nawożenia azotowego w latach 2007–2009

	Nitrogen nutrition Nawożenie azotowe	2007		2008		2009		Średnia		
		*IV	V	IV	V	IV	V	IV	V	mean średnia
Without mulch Bez ściółki	N_0	36.8	215.0	59.8	211.0	15.8	221.0	37.4	215.7	126.5
	N_1	28.6	210.0	44.3	231.5	15.0	190.5	29.3	210.7	120.0
	N_2	31.0	211.1	40.3	205.0	23.8	219.3	31.7	211.8	121.7
	mean – średnia	32.1	212.0	48.1	215.8	18.2	210.3	32.8	212.7	122.7
Bark mulch Ściółka z kory	N_0	35.5	274.3	50.3	240.5	22.8	310.0	36.2	274.9	155.5
	N_1	27.0	274.0	47.0	244.0	9.0	306.0	27.7	274.7	151.2
	N_2	30.5	272.0	45.8	225.3	17.2	320.8	31.2	272.7	151.9
	mean – średnia	31.0	273.4	47.7	236.6	16.3	312.3	31.7	274.1	152.9
Mean Średnia	N_0	36.1	244.6	55.0	225.8	19.3	265.5	36.8	245.3	141.0
	N_1	27.8	242.0	45.6	237.8	12.0	248.3	28.5	242.7	135.6
	N_2	30.8	241.6	43.0	215.1	20.5	270.0	31.4	242.2	136.8
	mean średnia	31.6	242.7	47.9	226.2	17.2	261.3	32.2	243.4	137.8
$LSD_{0,05}$ for: NIR dla:										
mulch – ściółki		n.s.	25.09	n.s.	n.s.	n.s.	25.09	n.s.	9.85	5.72
nutrition – nawożenia		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
month – miesiąca		-	14.52	-	14.52	-	14.52	-	-	5.72
year – roku badań								8.94	14.50	n.s.

N_0 – Control without nutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogen nutrition rates – dawka nawożenia azotowego 75 kg $N \cdot ha^{-1}$, N_2 – i 150 kg $N \cdot ha^{-1}$,
*IV, V – month of measurement – miesiąc pomiaru;
n.s. – no significant differences – różnice nieistotne statystycznie

garlic began depending of the study year: 48 to 54 days after the emergence. That phase was earliest observed in 2007 (on 17 April), later in 2008 (on 28 April), and the latest (on 5 May) in 2009. The full flowering phase for bear garlic occurred in similar se-

quence, which depending on the year fell since 23 April till 12 May. Plants reached their full flowering phase the soonest (54 days after emergence) in 2007, the latest (59 days after emergence) in 2009. Seeds were formed the earliest in 2007 (on 15 May), while the latest (on 1 June) in 2009. Despite of differences in vegetation beginning date, 76 days after emergence passed both in 2007 and in 2009, whereas by 8 days more in 2008.

Length of inflorescence shoot. In April, mean length of bear garlic inflorescence shoot ranged from 9.0 up to 59.8 mm, while in May from 190.5 to 320.8 mm (tab. 3). That value varied due to mulching and the measurement date.

However, significant influence of mulching manifested only during May measurements. No dependence between mulching vs. inflorescence length was recorded in April. Varied nitrogen nutrition did not affect the shoot growth at both measurement dates. For all study years. Shoots grew by about 200 mm between April and May (211.2 mm, on average). The longest inflorescences in May were produced by bear garlic in the third experimental year in mulched objects (mean 312.3 mm). During the April measurements, bear garlic produced the longest shoots in 2008, while the shortest in 2009. In May, the situation was inversed: plants formed the longest inflorescences in 2009, while the shortest in 2008.

Length of peduncle and inflorescence diameter. Average length of peduncle at bear garlic inflorescence ranged from 17.0 to 22.8 mm (tab. 4).

Table 4. Length of peduncle and inflorescence diameter of bear garlic, depending on bark mulching and nitrogen fertilization in years 2007–2009

Tabela 4. Długość szypułki kwiatowej i średnica kwiatostanu czosnku niedźwiedziego w zależności od ściółkowania korą i nawożenia azotowego w latach 2007–2009

	Nitrogen nutrition Nawożenie azotowe	Length of peduncle in mm Długość szypułki kwiatowej w mm				Diameter of inflorescence in mm Średnica kwiatostanu w mm			
		2007	2008	2009	mean średnia	2007	2008	2009	mean średnia
Without mulch Bez ściółki	N_0	17.4	19.0	17.8	18.0	28.4	19.0	39.8	29.0
	N_1	17.3	19.7	17.0	18.0	27.5	20.8	36.3	28.2
	N_2	17.8	19.3	18.3	18.4	28.2	20.3	38.0	28.8
	mean – średnia	17.5	19.3	17.7	18.2	28.0	20.0	38.0	28.7
Bark mulch Ściółka z kory	N_0	19.8	20.6	21.0	20.5	33.5	20.3	48.8	34.2
	N_1	19.4	19.8	21.0	20.1	35.2	20.8	51.5	35.8
	N_2	21.0	21.2	22.8	21.6	36.6	21.4	53.8	37.2
	mean – średnia	20.1	20.5	21.6	20.7	35.1	20.8	51.3	35.7
Mean Średnia	N_0	18.6	19.8	19.4	19.3	30.9	19.6	44.3	31.6
	N_1	18.4	19.7	19.0	19.0	31.3	20.8	43.9	32.0
	N_2	19.4	20.3	20.5	20.0	32.4	20.9	45.9	33.0
	mean – średnia	18.8	19.9	19.6	19.4	31.5	20.4	44.7	32.2
$LSD_{0,05}$ for: NIR dla:									
mulch – ściółki		1.66	n.s.	1.66	0.88	3.59	n.s.	3.59	1.41
nutrition – nawożenia		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
year – roku badań					n.s.				2.07

N_0 – Control without nutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogen nutrition rates – dawka nawożenia azotowego 75 kg N·ha^{-1}, N_2 – i 150 kg N·ha^{-1},
n.s. – no significant differences – różnice nieistotne statystycznie

Significantly longer peduncles (by 2.5 mm, on average) were recorded in objects where pine bark mulching was applied (20.7 mm) than no-mulched ones (18.2 mm). Nitrogen nutrition had no remarkable impact on that trait, although slightly longer peduncles were produced by bear garlic fertilized with the highest nitrogen rate (20.0 mm). No significant differences in peduncle length between experimental years were found either.

Table 5. Number of flowers in 1 inflorescence and on 1 plant of bear garlic, depending on bark mulching and nitrogen fertilization in years 2007–2009

Tabela 5. Liczba kwiatów w 1 kwiatostanie i na 1 roślinie czosnku niedźwiedziego w zależności od ściółkowania korą i nawożenia azotowego w latach 2007–2009

	Nitrogen nutrition Nawożenie azotowe	Number of flowers – Liczba kwiatów							
		in 1 inflorescence w 1 kwiatostanie				on 1 plant na 1 roślinie			
		2007	2008	2009	mean średnia	2007	2008	2009	mean średnia
Without mulch Bez ściółki	N_0	15.3	17.8	14.8	15.9	11.87	13.81	11.48	12.39
	N_1	13.4	15.0	13.8	14.0	9.27	10.38	9.55	9.73
	N_2	15.4	17.0	15.8	16.0	12.87	14.21	13.21	13.43
	mean – średnia	14.7	16.6	14.8	15.3	11.34	12.80	11.41	11.85
Bark mulch Ściółka z kory	N_0	16.8	14.0	21.5	17.4	18.08	15.06	23.13	18.76
	N_1	18.8	18.0	21.5	19.4	18.65	17.86	21.33	19.28
	N_2	20.4	18.8	24.0	21.0	23.17	21.36	27.26	23.93
	mean – średnia	18.6	16.9	22.3	19.3	19.97	18.09	23.91	20.66
Mean Średnia	N_0	16.0	15.9	18.1	16.7	14.97	14.44	17.31	15.57
	N_1	16.1	16.5	17.6	16.7	13.96	14.12	15.44	14.51
	N_2	17.9	17.9	19.9	18.5	18.02	17.78	20.24	18.68
	mean – średnia	16.6	16.8	18.5	17.3	15.65	15.45	17.66	16.25
$LSD_{0.05}$ for: NIR dla:									
mulch – ściółki		4.12	n.s.	4.12	1.62	4.18	4.18	4.18	1.41
nutrition – nawożenia		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	2.22
year – roku badań					n.s.				2.22

N_0 – Control without nutrition – kontrola bez nawożenia azotowego,
N_1 – nitrogen nutrition rates – dawka nawożenia azotowego 75 kg N·ha^{-1}, N_2 – i 150 kg N·ha^{-1},
n.s. – no significant differences – różnice nieistotne statystycznie

Diameter of bear garlic inflorescence varied depending on mulching and study year, which ranged from 19.0 to 53.8 mm (tab. 4). Pine bark mulching exerted positive effect on inflorescence diameter. In mulched objects, inflorescences were larger (35.7 mm) than in no-mulched ones (28.7 mm). Considerable influence of mulching on the inflorescence size was observed in the first and third years of study.

Nitrogen nutrition had no significant effect on inflorescence diameter; only a tendency to increase that value along with higher nitrogen rates could be noted. The largest inflorescences of 37.2 mm diameter were produced by bear garlic in pine bark mulched objects where the highest nitrogen nutrition rate was applied (150 kg N ha^{-1}). In the third year of cultivation, bear garlic inflorescences were the largest (44.7 mm), while in 2008 – the smallest (20.4 mm diameter).

Number of flowers. Inflorescences of bear garlic consisted of about 13.4 to 24.0 flowers, on average (table 5). Pine bark mulching had positive effect on the trait. In mulched objects, inflorescences contained 19.3 flowers, while those cultivated without mulching – only 15.3 flowers. The positive influence of mulching manifested significantly in 2007 and 2009. On the other hand, no considerable differences in number of flowers depending on nitrogen nutrition rates and year of study, was recorded. Only a tendency to increase that value along with increasing nitrogen rate, was observed.

Not all bear garlic plants formed inflorescences every year. Mean number of flowers recalculated onto a single plant reached values from 9.27 up to 27.26 flowers (table 5). Mulching with pine bark exerted positive effects on bear garlic flowering. Number of flowers on a single plant in mulched objects was by 8.81 higher than in no-mulched ones. Nitrogen nutrition also influenced the trait, although the impact was no so univocal. The largest number of flowers were recorded in objects fertilized with 150 kg $N \cdot ha^{-1}$ rate, while the lowest – at 75 kg $N \cdot ha^{-1}$ rate. Bear garlic flowered the most abundantly in the third cultivation year; the first and second years did not differ in this respect.

DISCUSSION

Plant's growth and development are highly determined by weather conditions [Żuraw 2005a, b, Gvozdanović-Varga and Vasić 2008]. Thermal and moisture influences play the major roles in shaping the weather. Bear garlic is a perennial, the wintering organ of which in a bulb, therefore it is reasonable to analyze the whole-year distribution of temperatures and rainfalls during studies upon habitat requirements of the species. The emergence and flowering dates of *Allium ursinum* were associated with the weather course in particular years of experiment. Relatively warm January 2007 at mean air temperature of 2.6°C contributed to early vegetation beginning; hence that year, bear garlic emergence occurred on 27 February. Bear garlic started its vegetation the latest in 2009. January 2009 was the most coldest of all three experimental years. Mean monthly air temperature amounted to only –2.7°C. Also March 2009 was cold. Mean decade temperatures oscillated around 0.23°C to 3.07°C. Probably, that is why plants began their emergence with 2-week delay as compared to previous years of study. At the end of April 2009, not a rainfall drop fell, and rainfall sum that month was 2.9 mm. As a consequence, all phonological phases for bear garlic in 2009 were delayed as compared to previous years. It indicates that the moment of vegetation beginning by *Allium ursinum* affected the course of subsequent stages and it is greatly associated with temperature distribution over a year. During studies upon *Allium ursinum* carried out near Vienna where average March air temperature that time was 6°C, plant's emergence began on 7 and 28 February depending of a year [Jandl et al. 1997]. McCrea [1924] reported the beginning of *Allium ursinum* flowering between 1 and 14 May, when mean temperatures before flowering – both in the first and second experimental years – amounted to 10.18°C. In here analyzed experiment, bear garlic flowering occurred the soonest in 2007 (on 17 April), while the latest - in 2009 (on 5 May). Average March air temperature in 2007 was 6.2°C, which was the highest for that month during the three years of study. March 2009 at mean temperature of 1.4°C did not favor bear garlic vege-

tation and warmer weather in April (up to 11.4°C) made plant's flowering. Studies made by Bartošová and Žalud [2008] revealed that over 46 years of observations (1961–2007), the beginning of bear garlic flowering occurred sooner by 9.6 days, on average, which can be attributed to so-called *"climate warming"*. A significant influence of changing weather conditions on the course of particular phonological phases was confirmed in experiments upon the fenology of 10 ornamental garlic cultivars [Płoszaj and Szymańska 2008]. Żuraw [2005a] reported similar dependence when observing the chives (*Allium schoenoprasum* L.) flowering. Significant influence of varied temperature distribution as well as rainfalls on yielding of common garlic was proved by Majkowska-Gadomska and Wierzbicka [2006]. The rainfall sum during critical period for the plant was crucial for shaping the garlic yields. Here analyzed data revealed that 76 days passed since emergence till seed production by *Allium ursinum* both in 2007 and 2009, despite of differences in vegetation beginning dates. Only in 2008, the period was longer by 8 days, which could be attributed to the fact that May 2008 was cooler than other years, which made the flowering and seed formation phases slightly delayed.

In analyzed experiment, not all bear garlic plants formed inflorescences every year. Kuklová and Kukla [2006] determined 92 *Allium ursinum* shoots of 44,9 ± 7.3 cm length on 1 m^2 of a forest area. Average length of inflorescence shoots of bear garlic at full development phase in the field cultivation oscillated from 210.7 to 274.9 mm. According to Traczyk [1989], length of bear garlic scape should be from 200 to 500 mm. *Allium ursinum* originating from natural stand in "Chynoriansky luh" reserve formed inflorescences of about 338 mm to 537 mm length [Kuklová and Kukla 2006]. Ernst [1979] reported that height of inflorescence shoots of *Allium ursinum* – depending on a stand – amounted from 186 to 270 mm.

Mulching with pine bark exerted positive impact on the inflorescence shoot length. Mean length of inflorescence shoot amounted to 61.4 mm due to mulching. Organic mulch had also positive effect on height and number of inflorescences at *Allium cepa* [Anisuzzaman et al. 2009]. Kocira and Laskowska [2006a] recorded longer inflorescence shoots of peacock flower (*Acidanthera bicolor* var. *murielae*) on plots mulched with a bark as compared to those without any mulching. Pine bark mulching also positively resulted in the length of scilla (*Scilla campanulata*) inflorescence shoots. Due to the bark mulching, scilla produced inflorescence shoots longer by 3.5 cm than plants cultivated with no mulching [Laskowska 1998]. In present experiment, the best growth of bear garlic inflorescence shoots was recorded in the third year of study (2009), a while scapes were the shortest in 2008. Probably abundant rainfalls in April 2008 exerted negative influence on inflorescence shoots formation and stimulated plant's vegetative growth, which could be confirmed by the largest leaf weight produced that year by *Allium ursinum*.

Length of peduncle at bear garlic amounted from 17.0 to 22.8 mm, which was modified by mulching. Longer peduncles in the inflorescence (by 2.5 mm, on average) were produced by plants grown in pine bark mulched objects. Such dependence can be explained by more beneficial conditions for growing plants cultivated on mulched soil. No influence of nitrogen nutrition nor year of experiment on that trait was observed. Dependence between inflorescence diameter vs. experimental factors was similar, because

both parameters are associated to each other. Laskowska [1998] reported positive effect bark mulching on the length of racemes of scilla (*Scilla campanulata*). Inflorescences of plants from mulched plots were longer by 2 mm than those grown on non-mulched soil. Flower diameter in the inflorescence of rose cv. 'Meidomonac' in mulched objects was significantly larger than that at rose flowers from no pine bark mulching stands [Korszun and Zalewska 2005].

Żuraw [2005b] reported that bear garlic inflorescence consists of 11.8 individual flowers. In the field cultivation, garlic inflorescences were composed of 17.3 flowers, while their number oscillated from 13.4 to 24.0. Pine bark mulching had positive influence on the number of flowers in bear garlic inflorescence as well as number of flowers recalculated onto 10 plants. By 4 more flowers were in bark-covered objects than on the soil without mulching; considering a single plant – the number increased by 8.81 flowers, on average, which is of a great importance for enhancing the reproduction efficiency of the species. Landshuter et al. [1994] reported that particular *Allium ursinum* plant produces about 20 seeds annually. Studies upon the effect of organic mulching on yield and quality of *Acidanthera bicolor* var. *murielae* flowers did not reveal any significant dependence between mulching application vs. number of formed flowers [Kocira and Laskowska 2006a, b]. Number of flowers at bear garlic inflorescence did not change due to nitrogen nutrition. It should be supposed that this is the trait more dependent on a genotype rather than fertilization. According to Rabinovitch and Currah [2002]. Number of flowers in *Allium* raceme depends on a species, age, and condition of plants. In analyzed experiment, slightly more flowers were counted at plants during the third year of cultivation. Jadczak [2005] reported increased number of inflorescence shoots in clusters during the second and third years of tree onion growing. Recalculating the results onto 10 plants also revealed that garlic fertilized with the highest nitrogen rate (150 kg $N \cdot ha^{-1}$) produced the largest number of flowers in the field cultivation, which resulted from the number of inflorescences formed. Also in reference to large-flower tickseed (*Coreopsis grandiflora*) and Siberian larkspur (*Delphinium grandiflora*), some positive influence of increasing nitrogen dose on the number of flowers at both species was found [Kozik and Szymankiewicz 2004].

CONCLUSIONS

1. Mulching using pine bark exerted beneficial results to the length of inflorescence shoot, peduncle, inflorescence diameter, as well as number of flowers in the inflorescence and on the plant.

2. Since April till May, significant increase of bear garlic inflorescence shoot growth was recorded. Their length in April ranged from 9.0 to 59.8 mm, while in May from 190.5 up to 320.8 mm.

3. Inflorescences of bear garlic consisted of 13.4 to 24.0 flowers, on average, and their diameter ranged from 19.0 to 53.8 mm. The longest inflorescence shoots and inflorescences with the largest diameter and number of flowers were produced by bear garlic in the third year of vegetation.

4. No significant influence of nitrogen nutrition on inflorescence shoot length, inflorescence diameter, nor number of flowers in particular inflorescences, was recorded.

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KWITNIENIE CZOSNKU NIEDŹWIEDZIEGO (*Allium ursinum* L.) W UPRAWIE POLOWEJ PRZY ZRÓŻNICOWANYM NAWOŻENIU AZOTOWYM I ŚCIÓŁKOWANIU GLEBY

Streszczenie. Czosnek niedźwiedzi (*Allium ursinum* L.) jest znany medycynie ludowej od wieków, a jego działanie farmakologiczne jest podobne do czosnku pospolitego. Jest typowym wiosennym geofitem. Zajmuje stanowiska wilgotne w wąwozach i przy źródłach, głównie w buczynach i łęgach. Głównym sposobem rozprzestrzeniania się populacji jest rozmnażanie generatywne. Celem przeprowadzonych badań było określenie wpływu

ściółkowania gleby korą sosnową oraz zróżnicowanych dawek nawożenia azotowego (0; 75 i 150 kg $N \cdot ha^{-1}$) na cechy kwitnienia czosnku niedźwiedziego w warunkach uprawy polowej. Ściółkowanie gleby korą wpłynęło korzystnie na długość pędu kwiatostanowego, szypułki kwiatowej i średnicę kwiatostanu oraz liczbę kwiatów w kwiatostanie i na roślinie. W ciągu miesiąca, tj. od kwietnia do maja, odnotowano istotny wzrost pędów kwiatostanowych czosnku niedźwiedziego. Ich długość w kwietniu mieściła się w przedziale od 9,0 do 59,8 mm, natomiast w maju od 190,5 do 320,8 mm. Kwiatostany czosnku niedźwiedziego składały się średnio z 13,4 do 24,0 kwiatów, a ich średnica mieściła się w przedziale od 19,0 do 53,8 mm. Najdłuższe pędy kwiatostanowe i kwiatostany o największej średnicy i liczbie kwiatów tworzył czosnek w trzecim roku wegetacji. Nie stwierdzono istotnego wpływu nawożenia azotowego na długość pędów kwiatostanowych, średnicę kwiatostanów i liczbę kwiatów w kwiatostanie.

Słowa kluczowe: *Allium ursinum*, kwiatostany, kora sosnowa, nawożenie

ACKNOWLEDGMENTS

The research financed from the budget funds for science in 2010-2011 as research project N N310 451038

Accepted for print – Zaakceptowano do druku: 1.06.2011