ACTA AGROBOTANICA
Vol. 60 (2): 111–116
2007

THE INFLUENCE OF ORIGIN OF *HELICHRYSUM ARENARIUM* (L.) MOENCH INDIVIDUALS ON THEIR INFLORESCENCE YIELD AND GERMINATION ABILITY

Anna Katarzyna Sawilska

University of Technology and Life Sciences, Faculty of Agriculture, Department of Botany and Ecology
Prof. S. Kaliskiego 7, PL-85-789 Bydgoszcz, Poland; e-mail: sawilska@utp.edu.pl

Received: 18.09.2007

S u m m a r y

Helichrysum arenarium (L.) Moench is a perennial of the Asteraceae family. The species is partially protected in Poland. Its inflorescence is a source of valuable herbal material. The amount of fresh and dry mass of inflorescences collected from plants growing in natural stands and those obtained from experimental plantations was analyzed. The plants growing in the plantation were obtained from *in vitro* cultures. Germination ability of achenes was also tested. The number of flowering shoots per plant, the number of plants per area unit as well as the fresh and dry mass of inflorescences depended significantly on the soil conditions and precipitation. Cultivation of *H. arenarium* gives a significantly higher fresh and dry mass of inflorescences per plant and a higher yield per area unit. The yield of herbal material from a plantation can vastly exceed that from the natural stands. Stratification of achenes prior to their germination resulted in an increase in the number of seedlings by 9.6%. Germination ability markedly decreased with time. Therefore, it is likely that the achenes form a transient seed bank. Achenes from plants obtained by *in vitro* method exhibited the lowest germination ability, so they should not be used as seed material.

Key words: fresh and dry mass of inflorescences, germination ability, yield in natural stands and in a plantation

INTRODUCTION

Helichrysum arenarium (L.) Moench is a perennial of the Asteraceae family. The species is partially protected in Poland. Its inflorescence (*Inflorescentia Helichrysi* = *Flos Stoechados citrini*) collected at the beginning of the blooming season is a source of valuable herbal material (G a w r o n - G z e l l a et al. 2003; O ż a r o w s k i , 1983). *H. arenarium* grows in sunny places on sandy soils, in dry forests and thickets, along waysides and in abandoned fields (R u t k o w s k i , 1998).

Within the past few years, in many regions of Poland the cultivation of barren, sandy soils was stopped. As a result of vegetation succession, *H. arenarium* has started to grow in these areas. However, the advancing succession changes the floristic composition of these phytocoenoses and leads to retreat of the species (S a w i l s k a , 2006; 2007). In the years 1975-1977 P a c h o l a k and Z a ł ę c k i (1979) made an attempt at growing *H. arenarium* in plantations, but with no success, as many plants died in the second year of cultivation (B u c h w a l d , 1992). Therefore, a new project of growing *H. arenarium* was started to provide an effective method for establishing plantations. The *in vitro* procedures proved to be a successful technique for obtaining *H. arenarium* seedlings (S a w i l s k a and F i g a s , 2006; S a w i l s k a and J e n d r z e j c z a k , 2007).

The goal of this work was to determine the differences in inflorescence yield obtained form natural stands and plantations of the species. A detailed analysis of fresh and dry mass of inflorescences from natural sample plots and plantations of different age was performed. Germination ability of achenes of different age and origin was also examined.

MATERIALS AND METHODS

Inflorescences for the studies were collected in the years 2005 and 2006 from generative shoots of plants growing in natural stands and cultivated on experimental fields in University of Technology and Life Sciences Experimental Station in Mochełek. Natural phytocoenoses under study were located in the outskirts of Bydgoszcz (Fordon – population I) and in the Łosiny village within the Bory Tucholskie forest complex (population II). The phytocoenoses represented different stages of secondary succession (S a w i l s k a , 2006; 2007). Experimental plots with *H. arenarium* seedlings obtained by *in vitro* method were established in spring

2004. Micropropagules adapted to greenhouse conditions were planted in rows 40 cm apart with 15 or 30 cm between the seedlings.

The seed material used in this work was collected from plants of the two wild populations in the years 2003-2005 and from experimental fields in 2005. Achenes from Mochełek were collected from the following three groups of plants:
– specimens transferred in 2004 from natural stands,
– individuals obtained by *in vitro* method and planted in 2004,
– plants obtained from seeds collected in Bory Tucholskie sown in 2005.

The density of *H. arenarium* shoots was measured and samples of 30 individuals were collected in the blooming peak in July in the years 2005-2006. The number of flowering shoots per plant, the number of inflorescences per shoot and their fresh and dry mass were determined (F a l i ń s k a , 2002; S a w i l s k a , 2006; 2007). Inflorescence yield per 1 m^2 was estimated from the collected data for populations I and II. Plants from the experimental field in Mochełek were subject to thorough analysis: their flowering shoots were counted, the fresh and dry mass of inflorescences per individual as well as the inflorescence yield per 1 m^2 were measured.

The germination ability of achenes and the changes in the percentage of germinated seeds as a function of seed age and stratification were examined (E l l i s et al. 1985; F o r m a n o w i c z o w a et al. 1998). The following temperatures were applied for two weeks: 30ºC 8 h during day time and 20ºC 16 h during night time.

H. arenarium from both populations grew on natural soils classified as clayey sands, while in Mochełek it was grown on sandy clayey (see S a w i l s k a and J e n d r z e j c z a k , 2007 for detailed characteristics of the substrata). Because of different geographical locations, the plants from populations analyzed grew under various weather conditions. Mean month temperature was similar for both locations, but precipitation differed significantly (Tab. 1).

Statistical analysis was performed using EXCEL and STATISTICA PL software. Regression analysis was applied to determine the influence of habitat factors on the yield. Basic regression equations (Ł o m n i c k i , 1995) were computed to assess the associations between variables.

RESULTS

The number of flowering shoots, mass of the inflorescences per plant, the plant density and the yield varied with the geographical location and the origin of plants (natural stands or plantation); see Tab. 2. All features analyzed were highly correlated with weather conditions within the study period ($\pm 0.54 \leq r \leq \pm 0.93$).

Plants from natural stands produced less generative shoots compared to those grown in plantation. However, in the second year an increase in the number of generative shoots was reported for all four populations. The highest value of this feature was observed in 2006 for plants from the plantation in Mochełek. In turn, the highest plant density was observed in the natural stands (Tab. 2). The number of plants×m^{-2} increased in the sub-

Table 1
Air temperature and precipitation in the years 2005 and 2006 (data from Mochełek and Chojnice meteorological stations).

Month	Temperature [ºC]				Precipitation [mm]			
	2005		2006		2005		2006	
	Mochełek	Chojnice	Mochełek	Chojnice	Mochełek	Chojnice	Mochełek	Chojnice
I	0.4	0.8	-8.1	-7.0	38.1	57.4	2.8	5.6
II	-2.9	-2.6	-2.9	-2.3	28.7	30.0	19.1	20.4
III	-0.4	-0.1	-1.5	-1.2	22.5	34.5	27.4	21.3
IV	7.4	7.6	7.1	6.8	34.8	15.8	77.0	48.7
V	12.2	11.9	12.5	12.3	82.6	95.4	59.9	79.1
VI	14.9	14.5	16.8	16.6	30.5	40.0	21.8	24.8
VII	19.4	18.8	22.4	21.9	33.6	77.0	24.2	12.6
VIII	16.3	16.0	16.6	16.6	43.4	58.1	129.0	154.1
IX	14.8	15.1	15.2	16.0	17.8	29.7	40.6	42.1
X	8.7	9.1	9.6	10.4	15.1	33.7	12.1	28.5
XI	2.7	3.0	5.2	5.8	20.7	24.7	33.9	51.4
XII	-0.3	-0.4	3.7	4.2	71.5	98.1	31.4	38.0
x_{Mean}/Σ	7.8/-	7.8/-	8.1/-	8.4/-	-/439.3	-/594.4	-/479.2	-/526.6

sequent year. The highest plant density was observed for the population II: 25.0 plants×m^{-2} in 2005 and 30.1 plants×m^{-2} in 2006. In Mochełek, where the individuals were grown at 40×30 cm spacing, the plant density remained more or less constant (only 2 plants out of 90 died). However, in the years 2004-2006 on the field with 40×15 cm spacing almost one fourth of individuals withered.

In the natural stands, the highest fresh inflorescence mass was observed for the population I in 2006 (an increase by 78.6% compared to the previous year). Fresh inflorescence mass for the population II was similar in both study years. Dry inflorescence mass was higher in 2006 compared to the previous year by 81.8% for the population I and 25.0% for the population II (Tab. 2). Fresh inflorescence mass of the plants from Mochełek was lower in 2006 by 38.2% for individuals grown at spacing 40×30 cm and by 40.7% for individuals grown at spacing 40×15 cm, compared to the previous year. Dry inflorescence mass for spacing 40×30 was similar in both study years, while that for the spacing 40×15 increased by 18.7% in 2006 (Tab. 2).

Distinct differences between the natural populations and plants from Mochełek were recorded for fresh

Table 2
Features describing the field of *Helichrysum arenarium.*

The number of flowering shoots per specimen					
Year		2005		2006	
Natural stands	Population I	1.85		5.05	
	Population II	2.70		4.40	
Plantation in Mochełek	Spacing 40x30	105.12		118.36	
	Spacing 40x15	62.61		112.94	
The number of plants m^{-2}					
Year		2005		2006	
Natural stands	Population I	5.95		12.48	
	Population II	25.00		30.11	
Plantation in Mochełek	Spacing 40x30	8.16		7.99	
	Spacing 40x15	14.44		12.95	
Mean inflorescence mass per specimen [g]					
Year		2005		2006	
		Fresh mass	Dry mass	Fresh mass	Dry mass
Natural stands	Population I	0.25	0.12	1.17	0.66
	Population II	0.60	0.27	0.59	0.36
Plantation in Mochełek	Spacing 40x30	46.86	18.70	28.98	18.78
	Spacing 40x15	34.68	12.48	20.55	15.40
Inflorescence yield per 1 m^2 [g]					
Year		2005		2006	
		Fresh mass	Dry mass	Fresh mass	Dry mass
Natural stands	Population I	1.49	0.71	14.60	8.24
	Population II	15.00	6.75	17.76	10.84
Plantation in Mochełek	Spacing 40x30	382.37	152.59	231.55	150.05
	Spacing 40x15	500.78	180.21	266.12	199.43

and dry inflorescence mass (Tab. 2). Mean values of these features for the plants from Mochełek in 2005 resembled those for 2006 and were higher by 98.7% on average than the values determined for the natural populations.

The yield of fresh and dry inflorescence mass per 1 m^2 recorded for the natural populations changed over time. In 2006 the yield compared to that of the previous year increased in both populations. The increase was 89.8% of fresh mass and 91.4% of dry mass for the population I, and 15.5% and 37.7%, respectively, for the population II (Tab. 2). The differences (fresh vs. dry mass) recorded for the population from Mochełek in the years 2005-2006 were less distinct. In 2006 the fresh mass of inflorescences from plants grown at spacing 40x30 dropped by 39.4%, while the amount of dry mass remained relatively unchanged. For the 40×15-spacing, the fresh inflorescence mass dropped by 46.9%, and the dry mass increased by 10.7% in the second year.

The results of the experiment conducted in 2006 showed that stratification of achenes prior to their germination resulted in an increase in the number of seedlings by 9.6%. The highest germination ability was exhibited by the achenes of plants transferred from the natural stands to the plantation (Tab. 3). A high germination percentage was recorded also for achenes from the population I. However, germination ability markedly decreased with time.

Table 3
Germination ability of *Helichrysum arenarium* achenes (percentage of germinated seeds).

Harvest year	Natural stands		Plantation in Mochełek		
	Population I	Population II	Transferred	*In vitro*	From seeds
2003	37.67	19.00	–	–	–
2004	75.67	46.33	–	–	–
2005	97.67	72.00	99.33	62.67	64.00

DISCUSSION

Reproduction potential of a plant population depends on its age, the number of propagules produced, and longevity of individuals that build the population (Czarnecka, 2007). The number of inflorescences and the number of flowers per inflorescence is a function of a general habit of the plant (Czarnecka, 1995). The flowering pattern, in turn, is modified by small-scale habitat factors such as soil humidity and fertility, and light intensity (Czarnecka, 2006).

In the case of *Helichrysum arenarium*, the number and mass of inflorescences depend on the number of shoots per plant (Tab. 2). Growth and development of the individuals are also modified by habitat factors. The studies conducted show that the amount of precipitation significantly affects the number of shoots per plant and the plant population density (Sawilska, 2007). The density of the population II was much higher than that of the other population. This can be ascribed to the different age and phytosociological characteristics of the two *H. arenarium* communities (Sawilska, 2007). The differences in precipitation appear to be of some influence too (Tab. 1, 2).

The studies showed distinct differences in inflorescence mass between the natural populations and plants from the plantation (Tab. 2). Fresh and dry mass of inflorescences from plants grown in the plantation were on average higher as much as 98.7% than those for plants from natural stands. However, the inflorescence mass per plant was higher in 2006 for both populations, while in the plantation there was a drop in the mass by 39.2%. The fresh inflorescence yield was therefore reduced by 43.6%. This decrease could be caused by lower precipitation in May and June compared to that in the year 2005 and by plant aging (Tab. 1, 2). *H. arenarium* was grown under optimum conditions for its development, therefore the dry inflorescence yield was on average 25.7 fold higher than that obtained from natural stands.

40×15 spacing turned out to be better for growing *H. arenarium,* in spite of a higher mortality observed for that spacing (13.3% of the plants died by the first growing season, and 10.3% after the second year) and resulting weed emergence.

Germination experiments were carried out under optimal light, temperature and soil moisture conditions (Ellis et al. 1985). Yet there is another group of factors influencing seed germination, e.g. the number of diaspores per plant as well as their somatic and functional differentiation (Czarnecka, 1997). Almost all achenes collected from population I in 2005 and from plants transferred in 2004 from natural stands in Bory Tucholskie to Mochełek germinated (Tab. 3). Achenes from the plants obtained by *in vitro* method exhibited

the lowest germination ability, so they should not be used as seed material.

The studies on germination of achenes of *Calendula* and *Achillea* (Formanowiczowa et al. 1998) suggested that germination ability of *H. arenarium* achenes would also be retained for 2-3 years. It turned out, however, that the seeds were rapidly losing their viability (Tab. 3). Therefore, it is likely that the achenes form a transient seed bank. They are, however, easily dispersed by wind and capable of fast germination without dormancy that facilitates invasion of new areas (cf. Venable and Levin, 1983).

Summing up:

1. The number of flowering shoots per plant, the number of plants per area unit as well as the dry and fresh mass of inflorescences depended significantly on the soil conditions and precipitation. Spring showers boosted growth of *H. arenarium* and development of more and larger inflorescences.

2. Cultivation of *H. arenarium* on sandy soils can give a significantly higher (25.7-fold on average) dry mass of inflorescences (herbal material) than that from natural stands.

3. Stratification of achenes prior to their germination resulted in an increase in the number of seedlings. A considerable decrease in germination ability was observed with time course. Therefore, it is likely that the achenes form a transient seed bank. Achenes from the plants obtained by *in vitro* method exhibited the lowest germination ability, so they should not be used as seed material.

ACKNOWLEDGEMENTS: The author thanks Ms. Lucyna Nakiewicz, M. Sc., for excellent help in laboratory and field experiments.

This work was supported by grant from Ministry of Science and Higher Education No. 2P06R 073 30.

REFERENCES

Buchwald W., 1992. Sandy Everlasting as a vanishing species. Wiadomości Zielarskie, 34(5): 5-6 (in Polish).

Czarnecka B., 1995. Biology and ecology of isolated populations of *Senecio rivularis* (Waldst. et Kit.) DC. and *Senecio umbrosus* Waldst. et Kit. Rozpr. Wydziału Biologii i Nauk o Ziemi. Rozpr. habil. 48, Wyd. Univ. Mariae Curie-Skłodowska, Lublin, pp. 263 (in Polish with English summary).

Czarnecka B., 1997. Adaptation strategies of plants versus species composition of phytocoenoses. Wiad. Bot. 41(3/4): 33-42 (in Polish with English summary).

Czarnecka B., 2006. Large-scale vs. small-scale factors affecting flowering patterns in *Senecio macrophyllus* M.BIEB., a long-lived perennial. Acta Agrobot. 59(1): 233-239.

Czarnecka B., 2007. Reproductive potential versus generative reproduction effectiveness in a population of long-lived perennial adapted to stress. [In:] Botanika w Polsce: sukcesy, problemy perspektywy. E. Kępczyńska, J. Kępczyński (eds.). 54 Zjazd Polskiego Towarzystwa Botanicznego, Szczecin 3-8.09.2007, Streszczenia referatów i plakatów: 60 (in Polish).

Ellis R. H., Hong T. D., Roberts E. H., 1985. Handbooks of Seed Technology for Genebanks. Vol II. Compendium of Specific Germination Information and Test Recommendations, International Board for Plant Genetic Resources, Rome, pp. 667.

Falińska K., 2002. A guide to research in plant population biology. Vademecum Geobotanicum, Państwowe Wydawnictwo Naukowe, Warszawa, pp. 587 (in Polish).

Formanowiczowa H., Kozłowski J., Szczyglewska D., 1998. Germination ecology of medicinal plants Part XIX/a. Seed material of Asteraceae species. Herba Pol. 2: 95-102 (in Polish).

Gawron-Gzella A., Bylka W., Matławska I., 2003. Digestion improving herbal drugs. Herba Pol. 49(3/4): 350-351.

Łomnicki A., 1995. Introduction to statistics for naturalists. Państwowe Wydawnictwo Naukowe, Warszawa, pp. 245 (in Polish).

Ożarowski A., 1983. Medicinal plants in phytotherapy. [In:] Phytotherapy. A guide for physicians. A. Ożarowski (ed.). Państwowy Zakład Wydawnictw Lekarskich, Warszawa: 44-282 (in Polish).

Pacholak H., Załęcki R., 1979. Sandy Everlasting propagation methods. Wiadomości Zielarskie, 3: 10-11 (in Polish).

Rutkowski L., 1998. Klucz do oznaczania roślin naczyniowych Polski niżowej. PWN, Warszawa.

Sawilska A. K., 2006. The influence of habitat factors on flowering process of *Helichrysum arenarium* (L.) Moench. Acta Agrobot. 59(1): 241-249 (in Polish with English summary).

Sawilska A. K., 2007. Dynamics of *Helichrysum arenarium* (L.) Moench populations growing in fallow field on barren soil. Ecological Questions, X: xx-xx (in press).

Sawilska A. K., Figas A., 2006. Micropropagation of *Helichrysum arenarium* (L.) Moench. [In:] Biotechnology 2006. V. Řehout (ed.). University of South Bohemia, Faculty of Agriculture. Scientific Pedagogical Publishing, České Budějovice: 721-723.

Sawilska A. K., Jendrzejczak E., 2007. Adaptation of Sandy Everlasting [*Helichrysum arenarium* (L.) Moench] microseedlings to mineral and organic soils. Polish Botanical Studies, X: xx-xx (in press).

Venable D. L., Levin D. A., 1983. Morphological dispersal structures in relation to growth habitat in the Compositae. Plant. Syst. Evol. 143: 1-16.

Wpływ pochodzenia roślin *Helichrysum arenarium* (L.) Moench na plon kwiatostanów oraz zdolność kiełkowania niełupek

S t r e s z c z e n i e

Helichrysum arenarium (L.) Moench jest byliną z rodziny Asteraceae objętą w Polsce ochroną częściową. Jej kwiatostany są cennym surowcem zielarskim. W trakcie badań określono wielkości świeżej i suchej masy kwiatostanów otrzymanych z powierzchni obserwacyjnych na naturalnych stanowiskach oraz z poletek doświadczalnych, na których były sadzone kocanki otrzymane z kultur tkankowych. Sprawdzono także zdolność do kiełkowania niełupek opisywanego gatunku.

Stwierdzono, że liczba pędów kwiatostanowych na roślinie, roślin na jednostce powierzchni oraz świeża i sucha masa kwiatostanów są w istotny sposób uzależnione od warunków glebowych i opadów atmosferycznych. Okazało się, że uprawa kocanek piaskowych pozwala na osiąganie istotnie wyższych świeżych i suchych mas kwiatostanów z rośliny oraz ich plonów z jednostki powierzchni. Zbiór surowca zielarskiego z plantacji może wielokrotnie przewyższać liczbę kwiatostanów pozyskiwanych ze stanowisk naturalnych. Zaobserwowano również, że stratyfikacja niełupek przed kiełkowaniem powodowała wzrost liczby siewek o 9,6%. Niewskazane jest natomiast przechowywanie nasion kocanek piaskowych, ponieważ wraz z upływem czasu następował wyraźny spadek ich zdolności kiełkowania. Można więc przypuszczać, że tworzą one nietrwały bank nasion w glebie. Niełupki otrzymane z roślin pochodzących z kultur *in vitro* kiełkowały najsłabiej, dlatego nie stanowią dobrego materiału siewnego.