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Potential reproduction and real seed productivity of *Vicia villosa* L.

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Seed number is one of the most important aspects of reproductive success in annual plants. Seeds play a vital role in agricultural development for both food and forage crops.

The aim of the present work was to investigate the potential reproduction and real seed productivity of *V. villosa*. The experimental object was wild *V. villosa* cenopopulations from different places of the country. The seeds were sown and investigated in the collection of the LUA Experimental Station (Central Lithuania, medium loam, pH 7) in 2000–2006. Phenological observations of vegetation stages were performed. The morphological plant assessment was based on measuring stem height, the number of inflorescences and flowers, the number of pods, seed number per pod and plant, the fresh weight of stems, leaves and flowers per plant. Diseases and pest activity were determined. Analysis of the material was done at the Laboratory of Crop Production Department of the LUA.

The experimental findings indicate that variable weather conditions affected the phenological, morphological and productivity parameters of *V. villosa* as well as the spread of fungal diseases and pests. The process and end of the growing season were greatly influenced by drought and diseases. Stresses at different times had different effects on leaf mass which is potentially able to photosynthesize and to provide energy for plant growth, flowering and fruiting. In *V. villosa*, water and temperature stress, leaf area loss due to fungal diseases and herbivory result in a reduced mass of a plant as well as a less number of flowers and pods produced per plant. A distinct linear correlation was determined between the mass of foliage and flower mass, as well as between flower mass and seed number per plant. *V. villosa* featured a great potential reproduction, but a low real productivity.

The most stable reproductive features were the number of seed per plant, pod formation frequency, matured seed ratio per plant.

Key words: reproduction, seed productivity, stress, fungal diseases, *Vicia villosa*

INTRODUCTION

Plastic responses to stress in reproductive components may have important effects on plant fitness and can vary both within and among species. Responses my also depend on the time a stress occurs [1]. In annual plants, there is only one opportunity to reproduce, and any stress can affect the year's reproduction in different ways [2]. In fact, seed number is one of the most important aspects of reproductive success in annual plants [3]. Seeds play a vital role in agricultural development for both food and forage crops [4].

Vicia villosa (winter vetch) is an archeophyte that arrived in Lithuania together with winter cereals [5]. *V. villosa* is grown for forage production. It is a valuable forage crop containing 23% protein from absolutely dry mass [6]. In many countries it is used for fodder as a productive, well-eaten annual plant [7]. *V. villosa* provides a good soil cover and is used as a weed control means in alternative cropping systems [8–12] and for soil amendment. It is among the best of the legumes in their ability to be productive in low fertility or acid soils [8, 9, 13]. Despite the undeniable practical interest in winter vetch, the usage of this plant is restricted by seed deficiency due to a low seed productivity [14].

In Lithuania, winter vetch like the wild one is a rather rare plant [15] and grows in phytocenoses as a weed [6]. Its breading was carried out from 1934 till 1952. Over 30 accessions of local winter vetch were accumulated, from which several winterhardly breeding numbers and the variety *Pūkiai* were released [16]. As was shown in 1964–1968, *V. villosa* tetraploids appeared to be more productive in terms of biomass accumulation, but lacked seed productivity in comparison to *V. villosa* diploids [7]. Within the "Genefund" program, *V. villosa* has been investigated at the Lithuanian University of Agriculture since 1998. A collection of 57 accessions of different cenopopulations has been accumulated. The Lithuanian population of winter vetch is polymorphic. Its high phenotypic plasticity determines the ability of cenopopulations to adapt to changing ecological conditions [17].

The aim of the current work was to investigate the potential reproduction and real seed productivity of *V. villosa*.

MATERIALS AND METHODS

The experimental object was wild *V. villosa* cenopopulations from different places of the country. The seeds were sown in the first half of September and investigated in the collection of LUA Experimental Station (Central Lithuania, medium loam, pH 7) in 2000–2006. Phenological observations of vegetation stages were performed. Morphological plant assessment was based on measuring stem height, the number of branches, the number of inflorescences and flowers, the number of pods, seed number per pod and plant, 1000 seed weight, fresh weight of stems, leaves and flowers per plant. The spread of diseases was evaluated visually [18], and pathogens were defined according to literature [19,20] by microscopy. Analysis of the material was done at the Laboratory of Crop Production Department of LUA. The collections were grown and field trials were conducted at the LUA Experimental Station. Some of the *V. villosa* cenopopulations sprouted in a successive spring season, and their flowering protracted until the first frosts, most likely due to unfavorable weather conditions, and delayed sowing in 2002, therefore, the data of the year 2003 were eliminated.

Quantitative features, including the number of inflorescences per plant, the number of seeds formed per pod and the total amount of seeds per plant, were used for evaluating of potential winter vetch reproduction. Real productivity was defined from pod formation frequency and the ratio of initiated and matured seeds per pod and per plant.

To estimate the weather data, the hydrothermal coefficient (HTC) was calculated [21] for three stages: late spring – early summer seasons (further HTCsp) (3rd decade of April – June), summer seasons (further HTCsm) (July–August) and autumn (further HTCo) (September–October).

Meteorological conditions. The meteorological conditions varied considerably during the *V. villosa* vegetative experiment, i. e. late spring – early summer seasons (3rd decade of April – June) in 2001, 2004 and 2006 were ordinarily wet, while wet in 2005 and dry in 2002 (Fig. 1).

Extremely hot and dry summer seasons (July–August) were observed in 2002 and 2006, but wet in 2000–2001 and 2003–2005. Meteorological conditions during autumn seasons (September–October), when winter vetch is sown and germinates, varied most – from dry in 2000 and 2005 to wet in 2001 and very wet in 2002.

RESULTS AND DISCUSSION

Differences in winter vetch morphometric and phenological features were determined most likely by meteorological conditions. The initial and mass flowering of *V. villosa* was influenced mainly by the weather in the late spring – early summer seasons (3rd decade of April – June). According to the rainfall and temperature ratio, the date of initial flowering differed up to 20 days and the date of total flowering up to 18 days (Table 1). A positive correlation between the hydrothermal coefficient of late spring – early summer seasons (HTCsp) and the date of initial flowering (r = 0.8428), and the HTCsp and the date of total flowering (r = 0.708) was estimated.

The date of termination of winter vetch vegetation cycle varied in the range of 29 days. The date of vegetation cycle termination was determined most likely by the hydrothermal co-

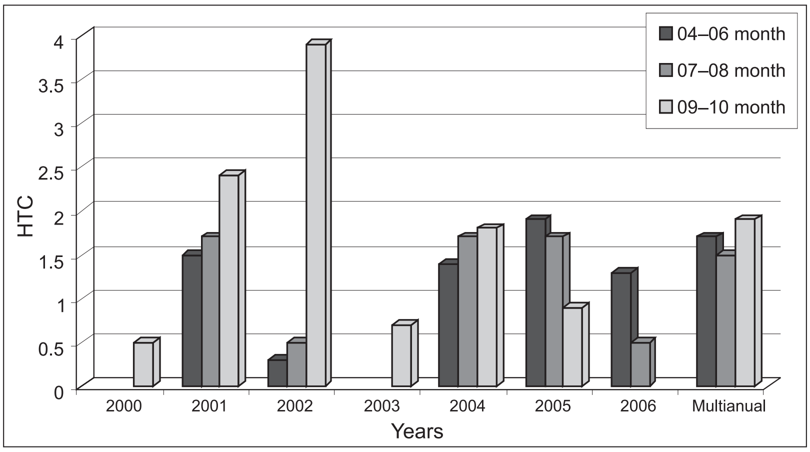

Fig. 1. Hydrothermal coefficient (HTC) of vegetation period 2000–2006

Table 1. ***V. villosa* phenological stages, disease and pests expression dates**
LUA Experimental Station, 2001–2006

Characters	Year of investigation				
	2001	2002	2003	2004	2005
Initial flowering	June 15	May 28	June 07	June 12	June 15
Mass flowering	June 25	June 10	June 25	June 20	June 27
Ascochyta (*Ascochyta* sp.)	July 10		July 07	June 21	July 03*
Powdery mildew (*Erysiphe communis* Grev. f. *vicea* Jacz.)	July 10	June 25*	July10*	July 08	July 03*
Aphids (*Aphis* sp.)	July 10*		July 07	June 30*	June 27
Bruchid seed beetle (*Bruchus atomarius* L.)	July 15*		July 10		
Vegetation cycle termination	July 25	July 07	August 06	August 01	July 17

efficient of summer seasons (HTCsm) because strong positive correlation (r = 0.8824) between HTCsm and the termination date was estimated. Plant diseases and pests affected the vegetation timescale as well. *Ascochyta* and *Erysiphe* fungi were identified as the main pathogens. Plants were damaged by powdery mildew caused by *Erysiphe communis* Grev. f. *vicea* Jacz. (Fig. 2 C, D), whenever the HTCsp reached 1.5 and more (in 2001 and 2005). Powdery mildew affected 5–9% of the study cenopopulations in which damage accounted from 1 to 25% (18% on average) of plant area. In general, the spread of powdery mildew was suppressed by heavy rainfalls. However, the greater amount of rainfall stimulated the spread of and damage caused by ascochyta (*Ascochyta* sp.) (Fig. 2 A, B). This disease was observed whenever the HTCsp reached 1.4 (in 2004) or more. During the wet seasons in 2001, 2004 and 2005, ascochyta caused damage in all the *V. villosa* cenopopulations studied. In 2004, such damage accounted from 25% to 100% (75% on average) and in 2001 and 2005 from 10% to 100% (45%) of plant area.

Humid weather induced the spread of aphids (*Aphis* sp.). This pest was detected throughout the experiment, but caused no considerable damage.

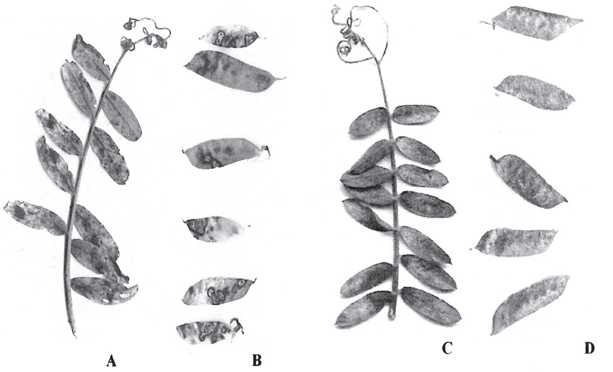

Fig. 2. Leaves and pods of *V. villosa* infected by ascochyta (*Ascochyta* sp.) (A, B) and by powdery mildew (*Erysiphe communis* Grev. f. *vicea* Jacz.) (C, D)

Increased activity of bruchid seed beetle (*Bruchus atomarius* L.) was determined in 2004 (Table 1) when it destroyed 15% to 60% (30% on average) of inflorescences and pods but caused a negligible damage to plant leaves.

Drought was the main reason for termination of winter vetch vegetation cycle in 2002 and 2006 as an early physiological desiccation of plant leaves occurred (Table 1). The end of winter vetch vegetation in various cenopopulations almost coincided, despite the forwardness of those processes.

A stable number of formed seed (ovules) per pod (5.0–5.6) were found throughout the experiment. The real pod productivity ratio accounted for 64.8% on average (Table 2). Very similar data on potential and real seed-per-pod productivity were presented by other authors [22]. The lowest real (matured) seed-per-pod productivity was observed in 2004, most likely due to the increased activity of bruchid seed beetle, and the highest productivity was determined in 2005 when especially favorable meteorological conditions for *V. villosa* growth and development occurred. The potential seed-per-plant productivity of *V. villosa* reached 209.5 on average (Table 2). However, this potential varied 5 times in separate years. The real seed-per-plant productivity (matured seeds per plant) accounted to 65.7% on average, which is very close to the values presented by other authors (55.7–82.8%) [22]. Year-by-year experimental observations revealed no significant variations of the real seed productivity, indicating the stability of this parameter. However, the activity of bruchid seed beetle still resulted in a decreased seeds-per-plant productivity in 2004 when inflorescences and pods were damaged.

The real pod productivity according to inflorescence number was low and accounted for only 19.8% on average (Table 2). The highest pod productivity was observed in 2002 and 2006 when the dry and sunny weather was favorable for activity of pollinating insects.

A total number of inflorescences per plant was the most unstable reproductive feature during the experiment. The experimental average of 459.52 inflorescences per plant was deter-

Table 2. **Means of *V.villosa* reproduction indices**
LUA Experimental Station, 2001–2006

Year	Number of cenopopulations	Plant height, cm	Total one plant weight, g	Part of inflorescences weight from total plant weight, %	Number of inflorescences per plant	Pod formation frequency, %	Number of formed seed pod	Matured seed ratio per pod, %	Total amount of seeds per plant	Matured seed ratio per plant, %
2001	31	133	19.2	16.2	257.6	10.7	5.2	66.2	133.5	68.4
2002	28	98.3*	7.8*	24	127.8*	12.1	5.0	63.5	77.5	69.8
2004	22	146	26.6	17*	542.3	6.3*	5.3	57.8	39.5*	51.7
2005	23	166*	42.1	17.7	1177.8*	9.7	5.6	70.7	641.3*	69.5
2006	25	129	10.7	27*	192.1	14.9	5.4	66	155.5	69.0
Mean of 2001–2006		134	21.28	19.78	459.52	10.74	5.3	64.84	209.5	65.7

mined. However, the annual average of inflorescences differed 9 times in certain years (Table 2). Leaf mass, while is potentially able to photosynthesize and provide energy for plant growth, determined the weight of inflorescences and other reproductive parameters. Positive correlations between the weight of leaves and inflorescences (r = 0.7654) and the weight of leaves and real seed productivity (r = 0.4592) was estimated. Plant height determined the reproductive parameters of *V. villosa* as well. A positive correlation between plant height and the number of inflorescences (r = 0.7065), plant height and the number of pods (r = 0.5922) and plant height and real seed productivity (r = 0.3853) was established. Humid weather stimulated *V. villosa* growth, the number of inflorescences formed, the total weight and the weight of leaves. A positive correlations was found also between plant height and the HTCsp (r = 0.6391), the number of inflorescences and HTCsp (r = 0.5922), and the weight of leaves and HTCsp (r = 0.4586). Wet and cool weather in summer favoured the spread of fungal diseases, which resulted in a reduced assimilative area of leaves and suppressed seed formation. The correlation between potential seed productivity and HTCsm (r = 0.4110) was negative.

The variation of morphometric parameters such as plant height, the number of inflorescences and plant weight under different weather conditions is indicative of a high winter vetch plasticity and adaptivity. The cenopopulations of *V. villosa* featured a high potential reproduction but a low real productivity. The most stabile genetically determined reproductive features of *V. villosa* were the number of seed per plant, pod formation frequency and matured seed ratio per plant. Drought stress, fungal diseases and pests, especially ascochyta and bruchid seed beetle were the main cause of the reduced real pod and seed productivity.

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REPRODUKCINIS POTENCIALAS IR REALUS *V. villosa* L. SĖKLŲ PRODUKTYVUMAS

Santrauka

Reprodukcinis potencialas ir realus laukinių *V. villosa* (ruginio vikio) sėklų produktyvumas buvo tiriamas LŽŪU bandymų stotyje 2000–2006 m. Meteorologinės tyrimo sąlygos turėjo įtakos vikių fenologiniams, morfologiniams ir produktyvumo parametrams, taip pat ligų ir kenkėjų paplitimui. *V. villosa* vegetacijos pabaiga labiau priklausė nuo sausros ir ligų. Įvairiuose fenologiniuose tarpsniuose aplinka paveikė augalo masę, žiedų ir sėklų kiekį. Nustatyta stipri tiesinė priklausomybė tarp augalo lapų ir žiedų masės, mažiau ryški – tarp žiedų ir sėklų masės. *V. villosa* pasižymėjo aukštu reprodukciniu potencialu ir palyginti mažu realiu produktyvumu. Stabiliausi rodikliai – užmegztų sėklų skaičius ankštyje, vieno augalo išaugintų ankščių ir žiedų skaičiaus santykis, subrandintų ir užmegztų sėklų santykis.