Agronomy Research **7**(Special issue I), 233–238, 2009

Sensibility of two hairy vetch (*Vicia villosa* Roth.) genotypes to soil acidity

A. Dastikaitė[1], A. Sliesaravičius[1] and N. Maršalkienė[2]

[1]Department of Crop Science and Animal Husbandry
[2]Laboratory of Agrobiotechnology, Lithuanian University of Agriculture, Studentų 11, LT-4324, Akademija, Kaunas distr., Lithuania;e-mail: nijole.petraityte@delfi.lt

Abstract. Vetches are grown for pastures and mixtures with grain for forage. Hairy vetch is a legume primarily used for soil improvement and bank stabilization, is well adapted to organic cultivation and grows well on a wide range of soil types – on sandy, nitrogen depleted and lightly acidic soils. The analysis of hairy vetch sensibility to soil pH parameters was performed with phyto-cameras at the Lithuanian Institute of Horticulture in 2005–2006. The experiments were conducted with hairy vetch variety 'Pūkiai' and wild population sample No.34, and covered investigation of vetch sensibility to the substrates with pH from 6.5 down to 3.3. The greatest hairy vetch viability and productivity were observed in the substrates with pH 5.8–5.5, and were most inhibited in the substrates with pH 3.3–3.5. Vetch No.34 tolerated substrates with pH 5.8–5.2 better than vetch 'Pūkiai', whereas vetch 'Pūkiai' tolerated substrates with pH 6.5 and 3.3 relatively better than vetch No.34.

Key words: *Vicia villosa*, sensibility, pH, substrates, germination rate, toleration

INTRODUCTION

Most soils in Western, Eastern and South-East Lithuania originally are of acid reaction. According to the data of recent agro-chemical investigation, there are 618870 ha or 18.7% of acid soils and almost 1 million ha are likely to acidify. Most acid soils are located in Western (28.6%) and Eastern (26.6%) Lithuania (Mažvila, 1996; Mažvila et al., 2004). It is predicted that soils are to become even more acid in the future. Although they have formed in different areas, naturally acid and acidifying soils have tempos of acidification essentially depending on anthropogenic activity, farming systems being among them (Bernotas et al., 2005).

As studies of different crops show, up to 40% of yield might be lost due to more acid and low fertility soils. Multi-annual studies have proved that because of a genotype‘s inability to adjust to certain soil conditions, 20% of yield is lost every year (Udovenko, 1995). New varieties, created to be cultivated under conditions of copious fertilization, when chemical protection means are used in abundant amounts, have partly lost their abilities to adapt. Consequently, creating varieties that could be resistant to extreme impacts is a common task of breeders, physiologists and geneticists. To enhance creation of such varieties, it would be purposeful to select genotypes that have maintained agriculturally valuable characteristics of genome stability in the course of evolution.

Hairy vetch (V*icia villosa*) is a legume primarily used for forage, hay, silage and green manure (Duke, 1981; McLeod, 1982), and is often grown with wheat, oat, or rye, acting as a nurse crop (McLeod, 1982). Goar (1934) mentioned that hairy vetch is more drought resistant than other vetches, yielding well where other species fail. It can grow on acid soils that will not sustain clover and alfalfa, and it tolerates alkaline soils (McLeod, 1982). Duke (1981) stated that hairy vetch does best on sandy or sandy loam soil.

V. villosa provides a good soil cover and is used as a weed control means for alternative cropping systems (Fujii & Araki, 2000; Fujii, 2001; Hanono et al., 1998; Zhou & Everts, 2004; Sheaffer & Seguin, 2003) and as a soil amendment, it is among the best of the legumes in its ability to be productive in low fertility or acid soils (Hargrove, 1986; Mcleod, 1982; Sheaffer & Seguin, 2003).

In Lithuania winter vetch, like the wild variety, is a rather rare plant and grows in phytocenoses as a weed (Grigas, 1971; Sliesaravičius et al., 2004). Its breeding was carried out from 1934-1952. Over 30 accessions of local winter vetch were accumulated, from which several winter hardly breeding numbers and variety 'Pūkiai' were released (Lazauskas & Dapkus, 1992). In the "Genefund" program *V. villosa* has been investigated at the Lithuanian University of Agriculture since 1998. A collection of 57 accessions of different wild cenopopulations has been accumulated. The Lithuanian population of winter vetch is polymorphic: the high phenotypic plasticity stipulates the ability of cenopopulations to adapt in changing ecological conditions (Sliesaravičius et al., 2004).

The aim of this work was to study tolerance of two hairy vetch genotypes to soil acidity, assessing their viability and productivity.

MATERIALS AND METHODS

The study was carried out in 2008 with phyto-cameras at the Laboratory of Plant Physiology, at the Lithuanian Institute of Horticulture, with „Pūkiai" (released in 1952) variety and sample No.34, wild population of which was collected in Ilgininkai Varena region, South-East Lithuania, grown on sandy soil with pH – 5.3. Sensibility to substrates, with pH ranging from 6.5 (control) to 3.3 was studied.

Peat substrate was acidified by sulphuric acid on different concentrations that were poured on peat substrate before sowing. Every pot was filled with 3 liters of sulphuric acid solution. Plants were sown into 5-liter pots. To obtain substrates of different pH, the following concentrations of H_2SO_4 were used: 0.5 (pH 6.5); 1 (pH 6); 2 (pH 5.5); 3 (pH 5.0); 4 (pH 4.5); 5 (pH 3.5); 6 (pH 3.0) ml l^{-1}. Due to unequal acidity of peat used for substrate, the pH – 5.8; 5.2; 3.3 obtained was not exactly as planned.

Prior to sowing, seeds were scarified with emery-paper. The test was performed in three replications; in every pot – 50 seeds. The quantity of seeds for sowing in pots was set by the following formula:

$$Q = \frac{N \times 100}{G}$$

where Q is the necessary quantity of seeds;
N – number of seeds (in this case 50);
G – germination rate of scarified seeds, % (Pūkiai – 92%, No. 34 –88%).

The seedlings were watered with rain water. Plants were grown in phtyotrons for 45 days with a photoperiod of 16 hours, daytime temperature of 21°C and 15°C at night. Plants were irradiated with 'SON-T Agro' lamps (80-100W m^{-2}). Samples were taken when plants of hairy vetch arrived at the period of lateral shoots, stage 20-29 according to BBCH scale (Weber & Bleiholder, 2001). At the end of the experiment stem height, fresh and absolutely dry grass mass of the above-ground part of 30 control plants from every replication were assessed. Plant height was measured from the hypocotyl to the tip of the stem. Absolutely dry mass was estimated after 2 hours drying at the temperature 105°C in a desiccator.

Statistical indexes of research data were calculated by the method of analysis of variance. Statistical reliability of research data was assessed with the lowest significant difference (R_{05}). Data were processed with program *EXEL*. For statistical assessment of research data, one-factor statistical analysis of *SELEKCIJA* program was employed.

RESULTS AND DISCUSSION

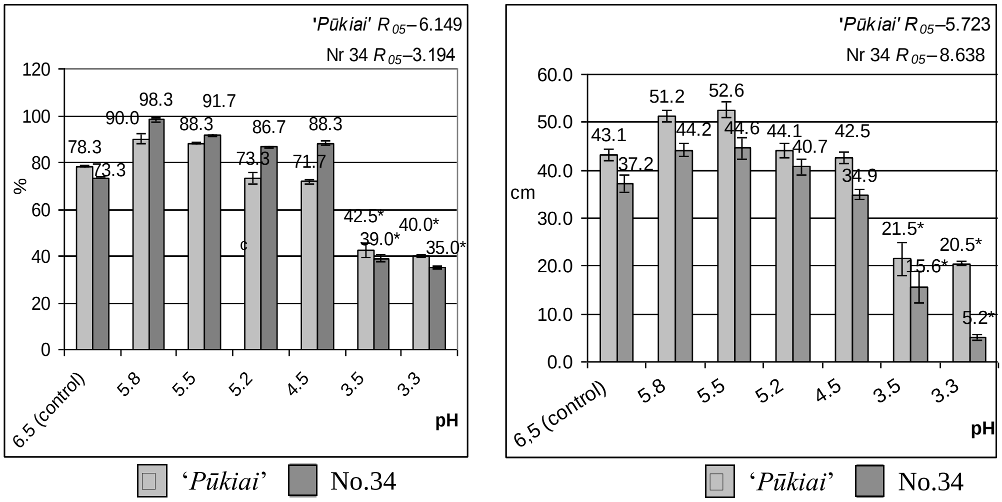
Having performed the analysis of research results, we found that seeds of 'Pūkiai' variety germinated in all substrates. However, the best germination from sown seeds was found in the substrate of pH 5.8 (Fig. 1, A). 'Pūkiai' also germinated well in the substrate of pH 5.5; but in pH 6.5, seeds germinated less well. The poorest germination from sown seeds of 'Pūkiai' variety was determined in the substrate with pH 3.3.

Seeds of studied hairy vetch No.34 also germinated in all substrates. Vetch No.34 germinated well in the substrate with pH 5.8 and 5.5 (Fig. 1, A), but less well in substrates with pH 3.5 and 3.3. Germination was comparatively good in substrates with pH 5.2 and 4.5.

It was observed that the seeds' germination rate often increased in field conditions, in comparison with the laboratorial rate (Galambosi & Peura, 1996). The seeds of 'Pūkiai' had a higher laboratorial germination rate than No.34 (see Materials and Methods), however seed germination of vetch No. 34 was clearly higher during the experimental season in the substrates pH 5.8–4.5 (Fig. 1, A).

Having measured the height of plants, the tallest stems of 'Pūkiai' were found in substrates with pH 5.5 and 5.8 (Fig. 1, B). Compared with control treatment, stems of 'Pūkiai' variety were 9.5 cm (18.0%) shorter than those in substrate pH 5.5 and 8.1 cm (15.8%) shorter than in substrate pH 5.8. The shortest stems of 'Pūkiai' vetch were found growing in substrate pH 3.3, compared to vetch grown in substrate pH 5.5. Their height was 32.1 cm (61.0%) less, compared to control treatment, stems of which showed stem inferiority of 22.6 cm (52.4%). The tallest stems of vetch sample No.34 were found in substrates 5.5 and 5.8 (Fig. 1, B). Compared to control treatment, they were respectively 7.4 cm (19.8%) and 7.0 cm (18.8%) taller. The shortest stems grew in the substrate with pH 3.3. They were 32.0 cm (86.0%) shorter than control.

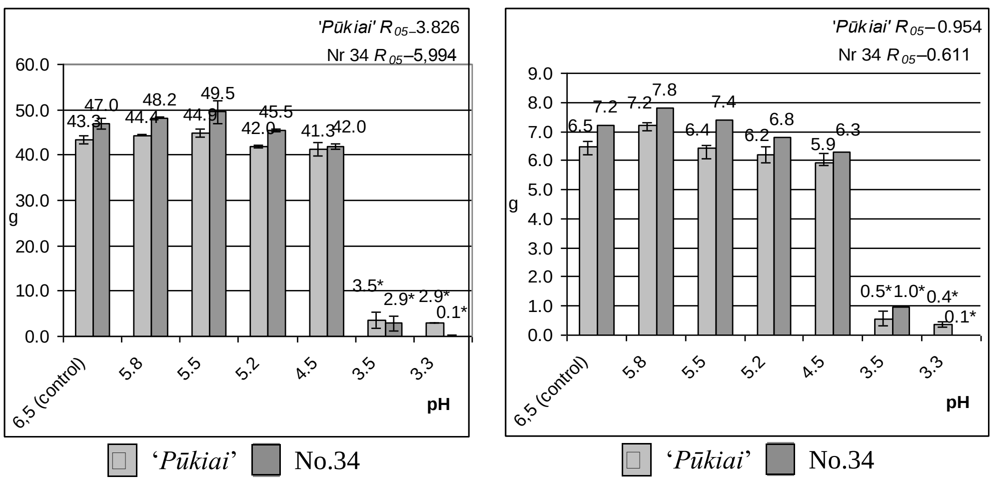
The greatest fresh mass of the above-ground part of 'Pūkiai' grew in substrates which had pH 5.8 and 5.5 (Fig. 2, A). Compared to control treatment, they were respectively 1.1 g (3.7%) and 1.6 g (2.3%) bigger. The fresh mass of grass 'Pūkiai' decreased dramatically at pH 3.5 and at pH 3.3. It was respectively 39.8 g (91.9%) and 40.4 g (93.3%) inferior to control treatment. The least fresh mass was grown by plants growing in substrate with pH 3.3 and 3.5. It was respectively 44.1 cm (93.8%) and 46.9 (99.8%) inferior to control treatment.



A **B**

*P < 0.001

Fig. 1. Percentage of germinated hairy vetch (*V. villosa)* plants sown in different substrates (A), stem height (B) (year *2008).*



A **B**

*P < 0.001

Fig. 2. Fresh mass of hairy vetch (*V. villosa)* above-ground part (A), dry mass of superficial part (B), (year *2008).*

When grass of plants vetch 'Pūkiai' was dried, the greatest amount of dry mass was found in plants grown in substrate with pH 5.8 (Fig. 2, B). Compared to the control treatment, it was respectively 1.3 g (20%) bigger. A similar amount of dry mass was accumulated by plants growing in substrates with pH 5.5. The dry mass of grass 'Pūkiai' decreased dramatically at pH 3.5 and especially at pH 3.3. It was respectively 6.0 g (92.3%) and 6.1 g. (93.8%) inferior to control treatment. The greatest amount of dry grass mass of vetch No.34 was accumulated by plants also in the substrate of pH 5.8 (Fig. 2, B). Here the average dry mass was by 0.6 g (7.7%) larger than in control treatment. No.34 cumulated dry matters comparatively well in substrates with pH 5.5. The minimal amount of dry mass was accumulated by plants growing in substrate with pH 3.5 and especially – 3.3, respectively 6.2 g (95.4%) and 6.4 g. (98.5%) inferior to control treatment.

According to Duke (1981), hairy vetch tolerates soil pH ranging from 4.9-8.2 with a mean of 40 cases being 6.6, and it is reputed to be tolerant of high pH. Hofstetter (1988) stated that the species grows best when pH is from 6.0–7.0. Having analysed our research results, we found that the investigated genotypes grew best in substrates with pH 5.8–5.5. The substrate pH scale is very close to the pH scale found by a Lithuanian scientist (Čiuberkienė et al., 1995) to be best for rye, 5.2–5.5. The hairy vetch in Lithuania commonly grows with rye crops and is even named ‚rye' vetch.

The same stress could react differently upon different genotypes (Cheplick, 2003; Bansal & Nagarajan, 1986). Domesticated vetch 'Pūkiai' exceeded wild vetch No.34 in stem height but trailed in dry matter accumulation. Differences of mineral nutrition between different genotypes are dependent on genetically determined physiological characteristics of the plants (Udovenko, 1995). In the experimental season vetch No. 34 was able to assimilate nutrients better than vetch "Pūkiai".

CONCLUSIONS

The highest hairy vetch seed germination and productivity of above-ground plant parts were observed in the substrates with pH 5.8–5.5. Hairy vetch germination and productivity were most inhibited in the substrates with pH 3.3–3.5. Vetches germinated well and grew in pH within the range 6.5–4.5 and satisfactorily within the pH range 3.5–3.3. 'Pūkiai' and No.34 cumulated dry matters comparatively well in substrates with pH 5.5 and 6.5. The fresh and dry mass of grass 'Pūkiai' decreased dramatically at pH 3.5 and especially at pH 3.3.

The two genotypes of vetches developed under different ecological conditions, therefore, had unequal sensibility to different substrate acidity. Vetch No.34 tolerated substrates with pH 5.8–5.2 better than vetch 'Pūkiai', whereas vetch 'Pūkiai' tolerated substrates with pH 6.5 and 3.3 relatively better than vetch No.34. 'Pūkiai" exceeded in stem height and No.34 surpassed 'Pūkiai' by grass mass.

REFERENCES

Bansal, K.C. & Nagarajan, S. 1987. Reduction of leaf growth by water stress and its recovery in relation to transpiration and stomatal conductance in same potators (Solanum tuberosum L.) genotypes. *Potato Research* **30**, 497–506.

Bernotas, S., Ožeraitienė, D. & Končius, D. The analysis of soil acidify anthropogenical factors.

Agriculture Science **2,** 22–31(in Lithuanian).
Cheplick, G.P. 2003. Evolutionary significance of genotypic variation in developmental reaction norms for a perennial grass under competitive stress. *Evolutionary Ecology* **17**(2), 175–196.
Handbook of Legumes of World Economic Importance. 1981. Duke J.A. (ed.). Plenum Press, New York. 345 pp.
Čiuberkienė, D., Knašys, V. & Čiuberkis, S. 1995. The productivity of crop rotation depending on soil pH and fertilizing intensity on podzolic soils of Western Lithuania. *Agriculture: science works* **44**, 3–16 (in Lithuanian).
Fujii, T. & Araki, H. 2000. Soil properties and tomato growth and yield in no-till and hairy vetch mulch field with sandy and volcanic ash soils. *Bulletin of the Faculty of Agriculture* **52,** 157–168.
Fujii, Y. 2001. Screening and future exploitation of allelopathic plants as alternative herbicides with special reference to hairy vetch. In Kohli R.K., Singh H.P. & Batish D.R. (eds.): *Allelopathy in Agroecosystems.* Food Products Press, Japan. pp. 257–275.
Galambosi, B. & Peura, P. 1996. Agrobotanical features and oil content of wild and cultivated forms of caraway (*Carum carvi* L.). *Essential oil research* **8**, 389–397.
Goar, G.L. 1934. *Vetches and related crops for forage.* Univ. Calif., College Agric., Agric. Exp. Sta., Berkeley, Calif., 336 pp.
Flora Lithuania SSR-IV. 1971. Grigas J. (ed.). Mintis, Vilnius. pp. 448–491 (in Lithuanian).
Hargrove, W.L. 1986. Winter Legumes as a Nitrogen Source for No-till Grain Sorghum. *Agronomy Journal* **78**, 70–80.
Hanano, Y., Fujii, K., Sato, S., Osozawa, S. & Fujihara, S. 1998. Weed control by hairy vetch (*Vicia villosa* Roth.) in Shikoku area-vegetation test and field survey in 1993 to 1997. *Japan Bulletin of the Shikoku national Agricultural Experiment Station* **62**, 45–70.
Hofstetter, B. 1988. Cover Crop Guide: 53 legumes, grasses and legume-grass mixes you can use to save soil and money. *The New Farm* **10**(17–22), 27–31.
Lazauskas, J. & Dapkus, R. 1992. *Selection of crop plants in Lithuania*. 'Mokslas', Vilnius, 250 pp. (in Lithuanian).
Mažvila, J., Adomaitis, T. & Eitminavičius, L. 2004. Aleration of Lithuania soil withouth acidity devoiding liming. *Agriculture. Scientific works* **4,** 3–20 (in Lithuanian).
Mažvila, J., Eitminavičius, L. & Ežerinskis, V. 1996. Acidity and liming of Lithuanian soils. *Agriculture Science* **2**, 13–19 (in Lithuanian).
McLeod, E. 1982. *Feed the Soil*. Organic Agriculture Research Institute, Graton, CA, 290 pp.
Sliesaravičius, A., Petraitytė, N. & Dastikaitė, A. 2004. Ecogeographical distribution and biodiversity of winter wetch (*Vicia villosa* Roth) in Lithuania. Vollmann J., Grausgruber H., Ruckenbauer, P. (eds.): *Genetic variation for plant breeding. Proceedings of the 17th EUCARPIA General Congress*. BOKU, Vienna, Austria, pp. 81–84.
Sheaffer, C.C. & Seguin, P.J. 2003. Forage legumes for sustainable cropping systems. *Crop Prod.* **8**(1–2), 187–216.
Udovenko, G. V. 1995. *Physiological bases of plant selection*. Tome **2**. VIR. Sankt-Peterburg, 293 pp. (in Russian).
Weber, E. & Bleiholder, H. 2001. Phenological growth stages and BBBCH-identitication keys of *faba bean*. In Meier U. (ed.): *Growth stages of mono-and decotyledonous plants*. II edition. Federal Biological Research Centre for Agriculture and Forestry, Berlin ans Brounschweig, Germany, pp. 32–36.
Zhou, X.G. & Everts, K.L. 2004. Suppression of *Fusarium* wilt of watermelon by soil amendment with hairy vetch. *Plant Disease* **88**(12), 1357–1365.