ČESKÁ ZEMĚDĚLSKÁ UNIVERZITA V PRAZE

Ecological requirements of hybrid dock (*Rumex patientia* L. × *Rumex tianschnicus* A. Los) and its potential as a weedy species in comparison with common dock species (*Rumex crispus L. and Rumex obtusifolius* L.)

Thesis extended summary of PhD thesis

PRAGUE 2015

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FAKULTA ŽIVOTNÍHO PROSTŘEDÍ

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Department of Ecology

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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(*Ekologické nároky šťovíku (Rumex patientia L. x Rumex tianschanicus A. Los.) a jeho potenciál jako plevelné rostliny ve srovnání s nejčastěji se vyskytujícími širokolistými šťovíky (Rumex crispus L. a Rumex obtusifolius L.)*)

Extended summary of PhD thesis

Renata Hujerová

Prague 2015

Doktorská dizertační práce **„Ecological requirements of hybrid dock (*Rumex patientia* L. x *Rumex tianschanicus* A. Los.) and its potential as a weedy species in comparison with common dock species (*Rumex crispus* L. and *Rumex obtusifolius* L.) (*Ekologické nároky šťovíku (Rumex patientia L. x Rumex tianschanicus A. Los.) a jeho potenciál jako plevelné rostliny ve srovnání s nejčastěji se vyskytujícími širokolistými šťovíky (Rumex crispus L. a Rumex obtusifolius L.)*)“** byla vypracována v rámci doktorského studia na Katedře ekologie - Fakulta životního prostředí České zemědělské univerzity v Praze.

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Autoreferát byl rozeslán dne: 15. 1. 2015

Obhajoba dizertační práce se koná dne 27. 1. 2015 v 13:00, v místnosti 234 Fakulty životního prostředí České zemědělské univerzity v Praze, Kamýcká 129, Praha - Suchdol.

S dizertační prací je možné se seznámit na Oddělení pro vědu a výzkum FŽP ČZU v Praze, Kamýcká 129, Praha 6 – Suchdol.

CONTENTS

Chapter 1

1.1 GENERAL INTRODUCTION

The energy demand continues to grow and fossil fuels and natural gas is gradually decreasing worldwide. Therefore, in the most developed countries around the world intensifies efforts to find and to use renewable energy sources, where using biomass could represent the possibility. This trend has been joined also by the Czech Republic. Numerous abandoned agricultural lands have occurred after a significant decrease of livestock in the Czech Republic. It is a new challenge for a production of energy crops. A new *Rumex* crop hybrid of *R. patienta* x *R. tianschanicus*, registered as *Rumex* cv. OK-2, has been developed for use as a forage and energy (biofuel) crop. Hereinafter it is referred to as *Rumex* OK-2, but is also known as 'Uteusha' in the Czech Republic (Usťak, 2007) after its Ukrainian breeder, Prof. Uteusha. *Rumex* OK-2 has also recently been introduced into several other European countries, including Germany, Slovakia, Bulgaria and Norway. It has been recorded as having escaped from arable fields into surrounding grassland and has the potential to become a new invasive weedy species (Hujerová, 2010; Pyšek et al., 2012; Hujerová, 2013).

The broad leaves *Rumex* species such as *Rumex obtusifolius* and *Rumex crispus* are considered to be among the most widely distributed weedy species (Holm et al., 1977; Grime et al., 1988; Zaller, 2004; Stilmant et al., 2010; Hrdličková et al., 2011). *R. obtusifolius* is one of the most troublesome weedy species in temperate grasslands because of its avoidance by livestock, high biomass and seed production, perennial character, persistent soil seed bank and its high ability to regenerate from fragmented underground organs (Carves and Harper, 1964; Zahler, 2004). Whereas *R. crispus* is considered to be a serious weed on arable land and in highly disturbed areas because of its short life span and rather monocarpic character (Carves & Harper, 1964; Hejcman et al., 2012a).

The seeds are the main source of regeneration of *Rumex* species (Pino et al., 1995). However, the seeds rarely germinate in dense grass sward. Their development is limited by the presence of areas with bare soil because as a seedlings they have low competitive ability (Carves and Harper, 1967). *In this thesis was evaluated the ability of Rumex OK-2 to*

*spread across the landscape from its original planting fields (**Chapter 2**) and grow and survive in the grassland under different managements (**Chapter 3**).*

Rumex OK-2 is a perennial crop, characterized by high ecological plasticity, cold and winter hardiness, and tolerance to salt and increased humidity (Kosakivska et al., 2008) with strong adaptability to environmental changes (Hou et al, 2014). *R. obtusifolius* can tolerate a high cutting frequency for several years. Therefore, neither two nor three cuts per year are sufficient for its elimination from grassland (Niggili et al., 1993; Hopkins & Johnson, 2002; Stilmant et al., 2010; Hann et al., 2012; Strnad et al., 2012). *R. crispus* has a lower competitive ability in permanent grasslands than *R. obtusifolius* due to its dependence on regular regeneration from seeds and its high sensitivity to regular cutting management (Hejcman et al., 2012a,b; Strnad et al., 2012). Production of belowground and aboveground biomass of *Rumex* OK-2 under different defoliation frequencies was compared with *R. crispus*, *R. obtusifolius* and *R. alpinus* (**Chapter 4**).

R. crispus have short, poor branched root collar, main taproot and some long and branched secondary roots (Hejný & Slavík, 1990). The mature belowground system of *R. obtusifolius* is typified by a stout taproot and a branched stem system above the root collar with a high potential to clonal reproduction (Pino *et al*., 1995). In the seedling year, roots of *Rumex* OK-2 have similar shape and size like parsley. For multi-annual crop, roots are strong, branched and some sectors of the roots can reach a depth of 1.5 to 2.0 m (Usťak, 2007). Production and distribution of belowground biomass at different depths was compared with *R. crispus* and *R. obtusifolius* during vegetation season (**Chapter 5**).

Rumex obtusifolius creates a deep taproot with high storage capacity for assimilates and nutrients. It develops a root-collar with high regeneration ability following disturbance and with a high potential for clonal reproduction (Pino et al., 1995; Strnad et al., 2010). In addition to generative reproduction, *R. obtusifolius* can expand through a phalanx clonal growth strategy, resulting in a dense nest of ramets that can occupy an area of several tens of square meters around the mother plant (Pino et al., 1995). Individual plants can survive in the grassland sward for more than eight years, although a high proportion can die within five years under conditions of low N, P and K availability and no grassland management (Pavlů et al., 2008; Martinková et al., 2009; Hujerová et al.,

2011; Hann et al., 2012; Hejcman et al., 2012a). *R. obtusifolius* well regrows after cutting (Martinková and Honěk, 2001) and therefore does not suffer under a management system of cutting performed twice per year (Strnad et al., 2012). ***Chapter 6*** *is focused on mechanical weeding of R. obtusifolius. This study can be a first step for future comparison of similarities for weeding of Rumex OK-2.*

The objective of the thesis is to answer the following question:
Is *Rumex* OK-2 able to spread outside spontaneously from former field into countryside? What is the dynamic of this spreading?

What is the competition ability of *Rumex* OK-2: germination, emergence and growing under different grassland management?

What are differences in basic growing characteristics between *Rumex* OK-2 and weeds *Rumex obtusifolius*, *R. crispus*, *R. alpinus* under different cutting regimes?

What are differences in aboveground and belowground biomass production between *Rumex* OK-2 and other broad leaved dock weeds *(R. obtusifolius*, *R. crispus*)?

Are there differences of growing dynamics and allocation of belowground biomass in 2 m depth soil profile between *Rumex* OK-2, *R. obtusifolius* and *R. crispus*?

The comparison of growing parameters of *Rumex* OK-2 with the other broad leaves *Rumex* species could help to assess its potential to become a new weedy species. For that reason, we investigated the possibility of *Rumex obtusifolius* mechanical control in grasslands, to answer to following questions: i) How effective is digging of *R. obtusifolius* in 5 and 15 cm performed once or twice for its control in *Agrostis capillaris* grassland? ii) Is no grassland management over five years an effective method for *R. obtusifolius* control?

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Chapter 2

Hybrid of *Rumex patientia* and *Rumex tianschanicus* (*Rumex* OK-2) as a potentially new invasive weed in Central Europe

Abstract

Since 2001 a hybrid of docks *Rumex patientia* × *Rumex tianschanicus* (*Rumex* OK-2) has been grown as a new energy crop in the Czech Republic. It was originally bred as a forage crop plant in Ukraine and then introduced for the same reason to the Czech Republic. In the past five years a successive spreading in the surroundings of the fields of the original plantation was observed. This paper evaluates the results of the two monitoring years (2011 and 2012) at the eastern edge of Prague where *Rumex* OK-2 was established on arable land. In 2011 each plant of the *Rumex* OK-2 was located by geodetic GPS equipment in the study area. In 2012, the presence of *Rumex* OK-2 plants was verified and some newly discovered plants were recorded. By comparison of the two successive years, we have shown successive spreading of *Rumex* OK-2, mainly in man-made habitats. It seems that *Rumex* OK-2 could have an invasive potential. Further detailed study of its biology and ecology is needed.

Citation: Hybrid of *Rumex patientia* and *Rumex tianschanicus* (*Rumex* OK-2) as a potentially new invasive weed in Central Europe. Grassland Science in Europe 18 (2013), 466-468

Autorship: Hujerová R., Gaisler J., Mandák B., Pavlů L. and Pavlů V.

Keywords: energy crop, weed, spreading, *Rumex* OK-2

Chapter 3

Effect of cutting frequency on above- and belowground biomass production of *Rumex alpinus*, *R. crispus*, *R. obtusifolius* and the *Rumex* hybrid (*R. patienta* × *R. tianschanicus*) in the seeding year

Abstract

Rumex species are important weeds in grasslands and on arable land. The *Rumex* hybrid (*R. patienta* × *R. tianschanicus*; cv. OK-2, Uteusha) has been planted as a forage and energy crop since 2001 in the Czech Republic, but its ecological requirements and its potential to become a new weedy species have never been investigated. In 2010 and 2011, we performed a pot experiment to investigate the effect of none, one and two cuts per year on biomass production of *Rumex* OK-2 and common broad-leaved *Rumex* species (*Rumex obtusifolius*, *R. crispus* and *R. alpinus*). The higher cutting frequency can reduce the belowground biomass, but no effect on the aboveground biomass was detected. Flowering in the seeding year was recorded in only 50% of *R. obtusifolius* plants. Nonflowering *R. obtusifolius* plants produced significantly more belowground biomass than flowering plants under no cutting or one cut treatments. The growth response of *Rumex* OK-2 to different cutting treatments was very similar to *R. crispus*. These similarities indicate the weed potential of the hybrid to become a troublesome weedy species, similar to *R. crispus*.

Citation: Effect of cutting frequency on above- and belowground biomass production of *Rumex alpinus*, *R. crispus*, *R. obtusifolius* and the *Rumex* hybrid (*R. patienta* × *R. tianschanicus*) in the seeding year. Weed Research 53 (2013), 378–386.

Autorship: Hujerová R., Pavlů V., Hejcman M., Pavlů L. and Gaisler J.

Keywords: broad-leaved dock, curled dock, monk's rhubarb, grassland management, mowing frequency, *Rumex* OK-2.

Chapter 4

Emergence and survival of *Rumex* OK-2 (*Rumex patientia* x *Rumex tianschanicus*) in grasslands under different management conditions

Abstract

Emergence and survival of *Rumex* OK-2 was studied in the north of the Czech Republic (in experimental garden in Liberec town) in 2013. There were applied three frequencies of cutting: no (0C), one (1C) and three (3C) cuts per year. Seeds of *Rumex* OK-2 were sown into the sward with different microsite conditions (no gap – gap; fertilizers application and no fertilizers application) in each treatment. The following plant characteristics were measured: number of emerged plants, number of surviving plants, plants height and numbers of leaves. Measurements were made three times per vegetation season (middle of June, end of July and end of September) before cutting. Plants of *Rumex* OK-2 emerged more in the treatments with gap. Surviving of *Rumex* OK-2 plants was connected with treatments with gap, especially in the second and the third cutting date.

Citation: Emergence and survival of *Rumex* OK-2 (*Rumex patientia* x *Rumex tianschanicus*) in grasslands under different management conditions. Grassland Science in Europe 19 (2014), 327 - 329

Autorship: Hujerová R., Gaisler J., Pavlů L., Pavlů V. and Hejcman M.

Keywords: weeds, cutting frequency, competition, fertilizers application, gap

Chapter 5

The growth dynamics of belowground biomass of *Rumex crispus*, *R. obtusifolius*, and the *Rumex* hybrid cv. OK-2 (*R. patienta* x *R. tianschanicus*) in the seeding year

Abstract

Broad leaved *Rumex* species are serious weeds on arable land and in permanent grasslands where they can persist on the same area for a long times especially due to well-established belowground systems. The *Rumex* hybrid (*R. patienta* x *R. tianschanicus*; cv. OK-2, Uteusha) has been planted as a forage and energy crop since 2001 in the Czech Republic and it has become a new weedy species, but its ecological characteristics are unknown. In 2010 and 2011 we performed a tube pot experiment to investigate growth dynamics and belowground biomass allocation of *R. crispus*, *R. obtusifolius* and *Rumex* OK-2 during the vegetation season. Biomass production of all *Rumex* species tend to grow from July to September. In the seeding year, flowering was recorded only in one plant of *Rumex* OK-2 and 27.5% of *R. obtusifolius* plants. The proportion of belowground biomass of *Rumex* species in upper 30 cm was about 70-80% whereas only 20-30 % was allocated deeper than 30 cm. The growth dynamics and allocation of belowground biomass of *Rumex* OK-2 was more similar to *R. crispus* than to *R. obtusifolius*. These similarities denote that the weed potential of *Rumex* OK-2 to become a troublesome weedy species, similar to *R. crispus*.

Citation: The growth dynamics of belowground biomass of *Rumex crispus*, *R. obtusifolius*, and the *Rumex* hybrid cv. OK-2 (*R. patienta* x *R. tianschanicus*) in the seeding year. Weed Research (2015), Submitted paper

Authorship: Hujerová R., Pavlů L., Pavlů V., Hejcman M. and Gaisler J.

Keywords: broad-leaved dock, curled dock, *Rumex* OK-2, depth, biomass allocation

Chapter 6

Mechanical weeding of *Rumex obtusifolius* and its effect on plant species composition of *Agrostis capillaris* grassland

Abstract

In grasslands under organic farming, mechanical weeding can be used to eradicate troublesome weed *Rumex obtusifolius.* So far, effectiveness of mechanical weeding together with its effect on plant species composition of *Agrostis capillaris* pasture has never been investigated. Therefore in 2007, we established experiment on pasture heavily infested by *R. obtusifolius*. Applied treatments were grazing by cattle with digging of taproots at the depth of 5 and 15 cm in August 2007 (GD_5O and $GD_{15}O$) and twice in August 2007 and May 2008 (GD_5T and $GD_{15}T$), grazing without weeding (GND) and unmanaged pasture (UND). Ungrazed patches were cut in all treatments with grazing. Cover of vascular plants, species richness and number of *R. obtusifolius* plants were monitored over five years.

In 2011, we recorded 3%, 26%, 28%, 33%, 34% and 77% of *R. obtusifolius* plants from initial number in 2007 in $GD_{15}T$, $GD_{15}O$, GD_5O, UND, GD_5T and GND treatments, respectively. Empty space after removed plants were replaced by nutrient demanding grasses (*Poa pratensis, Poa trivialis, Festuca pratensis* and *Lolium perenne*) and forbs (*Trifolium repens* and *Taraxacum* sp.) with high forage value. No management reduced cover and number of *R. obtusifolius* plants but allowed seed production and spreading of tall weedy species (*Urtica dioica*, *Galium album* and *Elytrigia repens*). There was no effect of weeding on species richness, but species richness decreased from 15 to 9 per 4 m^2 under no grassland management. Repeated digging out at depth 15 cm together with cutting of ungrazed patches is an effective method for control of *R. obtusifolius* in permanent grasslands under conditions of organic farming.

Citation: Mechanical weeding of *Rumex obtusifolius* and its effect on plant species composition of *Agrostis capillaris* grassland. Journal of Pest Science (2015), Submitted paper.

Autorship: Hujerová R., Pavlů L., Pavlů V., Gaisler J., Hejcman M. and Ludvíková V.

Keywords: broad-leaved dock, taproot, digging out, grassland, weed

Chapter 7

SOUHRN (SUMMARY IN CZECH)

Abstrakty v kapitolách 2 – 6 poukazují na přínos jednotlivých studií. V následujících bodech jsou stručně popsány závěry každé studie.

Kapitola 2: Předběžné výsledky za dva monitorované roky (2011-2012) ukazují expanzivní šíření šťovíku *Rumex* OK-2 z původních polí. K největšímu šíření dochází v příkopech podél komunikací a po okrajích polí. Z této studie vyplývá, že by šťovík *Rumex* OK-2 mohl mít invazní potenciál a proto je nutné další studium jeho biologických a ekologických vlastností a jeho strategie rozšiřování a přežívání v krajině.

Kapitola 3: Narušení travního drnu je hlavním faktorem pro uchycení a následné zaplevelení existujícího travního společenstva šťovíkem *Rumex* OK-2. Ačkoli byly rostliny *Rumex* OK-2 v průběhu vegetační sezóny vystaveny vysoké konkurenci existujícího travního drnu, přesto několik z nich bylo zaznamenáno i na konci vegetační sezóny. Tyto rostliny mohou být v příštích vegetačních sezónách důležitým zdrojem semen a mohou podpořit rozšíření *Rumex* OK-2 do okolí. Z této studie vyplývá, že *Rumex* OK-2 má podobné chování jako ostatní druhy širokolistých šťovíků střední Evropy, a proto se dá předpokládat jeho další šíření.

Kapitola 4: Vysoká frekvence sečení může redukovat množství podzemní biomasy, ale vliv na nadzemní biomasu zaznamenán nebyl. Růstová odezva šťovíku *Rumex* OK-2 na různé frekvence seče nebyla příliš odlišná od ostatních studovaných druhů rodu *Rumex*. Při nízké frekvenci seče se produkce podzemní biomasy šťovíku *Rumex* OK-2 nejvíce podobala produkci šťovíku kadeřavého (*R. crispus*). Tyto podobnosti ukazují, že *Rumex* OK-2 by mohl mít potenciál stát se plevelným druhem odpovídající šťovíku kadeřavému. Vzhledem k tomu, že výsledky tříletého pozorování na krajinné úrovni odhalily rychlou expanzi šťovíku *Rumex* OK-2 do okolních travních porostů na území jeho původního pěstování, jeho vysoký potenciál stát se novým problematickým plevelným druhem již byl potvrzen (Hujerová *et al.*, 2013).
Výsledky nádobového pokusu mohou být pouze prvním krokem ke zkoumání ekologických nároků šťovíku *Rumex* OK-2. Budoucí výzkum by

mohl být zaměřen na reakci *Rumex* OK-2 na různou frekvenci seče v souvislosti s konkurencí s jinými rostlinami v polních podmínkách.

Kapitola 5: Produkce nadzemní i podzemní biomasy od července do září u všech sledovaných druhů rodu *Rumex* vykazovala vzrůstající tendenci. Ve vrchních 30 cm půdy bylo situováno 70 až 80% podzemní biomasy, zatímco pouze 20 až 30% podzemní biomasy se nacházelo ve vrstvách hlubších než 30 cm. Kromě kvetoucích rostlin š. tupolistého, pro něhož je kvetení v první sezóně typické, byla zaznamenána i jedna kvetoucí rostlina šťovíku *Rumex* OK-2. Dynamika růstu a rozdělení podzemní biomasy šťovíku *Rumex* OK-2 bylo více podobné š. kadeřavému než š. tupolistém. Tyto podobnosti naznačují, že plevelný potenciál šťovíku Rumex OK-2 by mohl odpovídat š. kadeřavému.

Kapitola 6: Mechanické vyrývání společně se sečením nedopasků je efektivní metodou pro regulaci šťovíku tupolistého (*R. obtusifolius*) v podhorských travních společenstvech s dominantou *Agrostis capillaris*. Dvakrát provedené vyrytí šťovíku tupolistého do hloubky 15 cm bylo nejúspěšnější metodou, která snížila počet rostlin šťovíku tupolistého 97%. Plošky obnažené půdy vytvořené vyrýváním byly obsazeny na živiny náročnými trávami a bylinami s vysokou pícninářskou hodnotou. Ačkoli varianta ponechání ladem snížila počet rostlin šťovíku tupolistého, umožnila produkci semen na přežívajících rostlinách, podpořila rozvoj vysokých plevelných druhů a značně omezila druhovou bohatost cévnatých rostlin.

Chapter 8

8.1 CURRICULUM VITAE

Name: **Renata Hujerová**

Address: Luční 1299, Smržovka, CZ46851

Date of Birth: 29. 7. 1986

Nationality: Czech

Educational background:

2010 – till now	Czech University of Life Sciences in Praque Faculty of Environmental Sciences Study program: Ecology (Ph.D.)
2008 – 2010	Czech University of Life Sciences in Praque Faculty of Environmental Sciences Study program: Applied Ecology (Ing. / MSc.)
2005 – 2008	Jan Evangelist Purkyně University in Ústí nad Labem (UJEP) Faculty of Environment Study Program: Environment Conservation (Bc.)

Professional Appointments:

2012- Czech University of Life Sciences in Prague, Department of Ecology, expert for grassland ecology

From 1.10. 2010 - Czech University of Life Sciences in Prague, Grassland Research Station Liberec

July 2009 - Institute of Crop Production Prague, Grassland Research Station Liberec

July 2007 PLA Administration Jizerské hory

2006 – 2007	Research assistant UJEP

Conferences and training courses:

10. – 12. 10. 2014	Sixth Meeting of PhD students in Plant Ecology and Botany, Research Station "Storczyk" Karpacz, Poland
7. – 11. 9. 2014	European Grassland Federation General meeting 2014- *EGF* at *50: the future of European Grasslands;* Aberystwyth, Wales, U. K.
23. – 26. 6. 2013	European Grassland Federation Symposium 2013 - The Role of Grasslands in a Green Future; Hof Conference Centre, Akureyri, Iceland
30. 11. – 2. 12. 2012	Meeting of Ph.D. students in Plant Ecology and Botany 2012, Podhradí u Ledče n. Sázavou
23. 11. 2011	UCOLIS 2011, Kostelec nad Černými lesy
7. - 9. 10. 2011	Fifth Meeting of Czech, Slovak and Hungarian Ph.D. students in Plant Ecology and Botany; Piesočná, Slovakia
28. - 31. 8. 2011	European Grassland Federation Symposium 2011 in Austria - Grassland farming and land management systems in mountainous regions; Raumberg-Gumpenstein, Austria
6. - 7. 4. 2011	Scientific writing course (A. Hopkins); Praha, ČR
25. - 27. 3. 2011	Meeting of botanical underground; Třeboň, ČR

Participation on projects:

Mobility (2013-2014) 7AMB13PL049 Management of upland grassland in relations to plant species diversity and nature conservation
CIGA 2012: 20124208 Ecological requirements and demands of hybrid dock (*Rumex patientia* L. x *Rumex tianschanicus* A. Los.) and its potential as a weedy species in comparison with common dock species (*Rumex crispus* L. a *Rumex obtusifolius* L.)
IGA 2011 2011421103119 Occurrence, distribution and ecological requirements of the fodder sorrel (*Rumex patientia* x *Rumex tianschanicus*)
NAZV QH 72217 Control of *Rumex* species in grasslands under organic farming, (2007-2009)

8.2 PUBLICATION ACTIVITY

Papers in scientific journals with impact factor:

Hujerová R., Pavlů L., Pavlů V., Hejcman M. and Gaisler J. (2015) The growth dynamics of belowground biomass of *Rumex crispus*, *R. obtusifolius*, and the *Rumex* hybrid cv. OK-2 (*R. patienta* x *R. tianschanicus*) in the seeding year. Weed Research. Submitted paper

Hujerová R., Pavlů L., Pavlů V., Gaisler J., Hejcman M., Ludvíková V. (2015) Mechanical weeding of *Rumex obtusifolius* and its effect on plant species composition in *Agrostis capillaris* grassland under conditions of organic farming. Journal of Pest Science. Submitted paper

Hujerová R., Pavlů V., Hejcman M., Pavlů L. & Gaisler J. (2013): Effect of cutting frequency on above- and belowground biomass production of *Rumex alpinus*, *R. crispus*, *R. obtusifolius* and the *Rumex* hybrid (*R. patienta* x *T. tianschanicus*) in the seeding year. *Weed Research*, 53: 378-386.

Papers in other scientific journals:

Hujerová R., Gaisler J., Pavlů L., Pavlů V. and Hejcman M. (2014): Emergence and survival of *Rumex* OK-2 (*Rumex patientia* x *Rumex tianschanicus*) in grasslands under different management conditions. Grassland Science in Europe 19: 327 - 329

Hujerová R., Pavlů V., Hejcman M., Pavlů L. and Gaisler J. (2013). Effect of cutting frequency on above- and belowground biomass production of Rumex alpinus, R. crispus, R. obtusifolius and the Rumex hybrid (R. patienta × R. tianschanicus) in the seeding year. Weed Research 53, 378–386.

Hujerová R., Gaisler J., Pavlů L. and Pavlů V. (2011): Mechanical weeding of Rumex obtusifolius in organically managed grassland. *Grassland Science in Europe*, 16: 208-210.

Practical methodologies:

Pavlů V., Hejcman M., Gaisler J., Pavlů L. Hujerová R. (2011): Možnosti regulace širokolistých šťovíků v travních porostech v systému ekologického zemědělství. Certifikovaná metodika, VÚRV, v.v.i. Praha.