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ANALYSIS OF CROPPING PATTERNS OF MEDICINAL AND SPICES PLANTS GROWING ON PRIME ARABLE LAND

ANALÝZA MODELU OSEVNÉHO POSTUPU PRE PESTOVANIE LIEČIVÝCH A KORENINOVÝCH RASTLÍN NA ORNEJ PÔDE

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The research of crop rotation pattern and field homogenization was carrying out during 2000 – 2010 at company Agrokarpaty Plavnica Ltd in Slovakia. The average temperature of the site during growing period is 14.9 °C and a sum of precipitation 438 mm. The fields are situated at 300 – 450 m above the sea level. Total acreage of arable land is 380 ha. Share of medicinal plants varied from 85 ha to 145 ha during evaluated period. The main growing medicinal and spices plants are as follows: *Galega officinalis* L., *Medicago sativa* L., *Hypericum perforatum* L., *Mentha piperita* L., *Melissa officinalis* L., *Calendula officinalis* L., *Fagopyrum esculentum* Moench, *Carum carvi* L., *Achillea millefolium* L., *Agrimonia eupatoria* L., *Matricaria recutita* L., *Plantago lanceolata* L., *Malva mauritiana* L. As a forecrop red clover (*Trifolium pratense* L.), winter wheat (*Triticum aestivum* L.), spring barley (*Hordeum sativum* L.) and oat (*Avena sativa* L.) have been growing. The management practices of “Agrokarpaty Plavnica” are in full compliance with the good agricultural practices (GAP). The high priority is maintenance of soil fertility and sustain of nutrients, mainly nitrogen. The green manure, cover crop, growing of legumes and compost from own productions are used. Two steps for designing have been suggested (i) Field consolidation and homogenisation of field for crop rotations area, (ii) Proposal of crop rotation pattern. The interested area is characterized by low production potential of 8 classes of soil production categories. We have proposed new cropping pattern of 14 fields with total acreage of 180.11 ha with average field 12.87 ha. Share of medicinal and spices plants is 68.27%, share of red clover 14.29% and spring cereals 17.46%. The design of propose crop rotation allows to use organic manure mainly before medicinal plants growing for leaves drug, and incorporation of cover crops for maintenance of soil fertility. Supposed crop rotation pattern complies with basic principles of crop rotation and sustainable agriculture.

Key words: arable land, biodiversity, crop rotation, medicinal plants, spices plants

There is a great demand for medicinal plant in the world market because of its extensive medicinal values and impeccable pharmacological properties. Usage of medicinal plants is expected to rise globally, both in allopathic and herbal medicine. This upward trend is predicted not only because of population explosion, but also due to increasing popularity for natural-based, environmentally friendly products. Also, there has been an increase in the use of natural substances instead of synthetic chemicals because many herbal medicines are free from side effects, easy to obtain, considered healthy, and create income. It is a well-established fact that plant diversity of some medicinal plants is being threatened by unregulated harvesting of natural populations and expansion of urban centres. So it is advisable to cultivate medicinal plants for better quality control of the target bioactive components. This approach also allows the production of uniform plant material at predetermined intervals in the required quantities (Habán et al.; 2008; Singh et al., 2011). Plant materials obtained from wild habitat and by experimental cultivation or farm plantation cultivated as per the modern agricultural guidelines have to be analyzed individually (Asha et al., 2010).

The unique diversity of the Slovak regions in natural vegetation has made our region very interesting for gathering and harvesting plants for medicinal purposes. Slovakia has had a long tradition of using medicinal plants but period of interruptions calls for a restoration of these activities among Slovak farmers (Habán and Otepka, 2006a). The major plantation of medicinal plant was established in 1983 at cooperative Plavnica. There has been strong tradition of

growing medicinal plant at Pieniny mountain area since 17th century. Monastery Červený Kláštor was the centre of healing with medicinal plants.

There is a lack of information concerning agricultural systems of majority of medicinal plants. Incorporation of medicinal plant into crop rotation pattern helps to produce medicinal plant and to increase the biodiversity of agricultural systems (Fazekašová et al., 2011). For new system approaches, the life cycle assessment (LCA) can help improve the agricultural system and crop sequences of medicinal plant growing by Slovak farmers. The evaluation of agricultural systems using LCA, reveals problems with its application due to the heterogeneity of such a system. Nevertheless, LCA has been successfully applied and revealed important results (Horne et al., 2009). Life cycle assessments of different farming systems have been mostly carried out at single crop level. However, farmers optimise their production for a whole crop rotation. Moreover, some emissions like nitrate leaching occur mainly during the fallow periods between crops. It is therefore preferable to compare farming systems in the perspective of a crop rotation (Nemecek et al., 2001).

There is minimum information about forecrop value of main crops and about special crop rotation pattern with dominant share of medicinal plants growing on arable land (Habán and Otepka, 2006b; Habán et al., 2010).

The aim of the study was to analyse and design the special crop rotation pattern of medicinal plant under intensive management practices on “Pieniny” region.

Material and methods

The research of a crop rotation pattern and field homogenization was carrying out during 2000 – 2010 at company “Agrokarpaty Plavnica Ltd“. The company was founded in 1993 dealing with growing of medicinal plants, processing of herbal tea and massage oil. The average temperature of the site is 14.9 °C and sum of precipitation 438 mm during growing period and total year precipitation is 662 mm. The high dose of precipitation is during July – 97 mm and the driest condition is in March – only 31 mm in an average. The coldest month is January (4.4 °C) and the warmest month is July with average temperature of 17.9 °C. Soils are brown and acid with tick soil layer. The soil productive potential was analysed according Džatko (2002). The fields are situated at 300 – 450 m above the sea level. According last updated from 31.12. 2010, total acreage of arable land is 380 ha. Share of medicinal plants varied from 85 – 145 ha during evaluated period.

The main growing medicinal plants are as follows: *Galega officinalis* L., *Medicago sativa* L., *Hypericum perforatum* L., *Mentha piperita* L., *Melissa officinalis* L., *Calendula officinalis* L., *Fagopyrum esculentum* Moench, *Carum carvi* L., *Achillea millefolium* L., *Agrimonia eupatoria* L., *Matricaria recutita* L., *Plantago lanceolata* L., *Malva mauritiana* L. As a forecrop red clover (*Trifolium pratense* L.), winter wheat (*Triticum aestivum* L.), spring barley (*Hordeum sativum* L.) and oat (*Avena sativa* L.) were growing.

Some aspects of LCA have been applied according Horne et al. (2009). For designing of crop rotation pattern, the methodological approaches according Pospíšil et al. (1999) were used. For field homogenisation we merged and split existing fields for designing the space and time rotation with relation to soil quality. The acreage of arranged fields varied 5% about average. For evaluation of soil productivity, fertility and quality of this area, special maps from Soil Science and Conservation Research Institute were used (www.podnemapy.sk).

Results and discussion

The management practices of “Agrokarpaty Plavnica“ are in full compliance with the good agricultural practices (GAP). The high priority is maintenance of soil fertility and sustain of nutrients, mainly nitrogen. The green manure, cover crop, growing of legumes and compost from own production was used.

Due to frequent changes of growing particular medicinal plant there has not been long term a crop rotation pattern yet. For further improvement of yield and quality of production, the elaboration and design of crop rotation are needed. According analysis of ten year period, we have found out positive practices of growing medicinal plants. The medicinal and spices plants were strictly growing only at field with long history of mechanical weed protection. This precondition is very important mainly for tops or harvesting of aboveground biomass (Týr et al., 2009). According literature information a suitable forecrop for medicinal plants are legumes and cereals (Thurzová et al., 1983). According our investigation the suitable forecrop was winter wheat. Spring barley was used for intercropping with clover. Lemon balm (*Melissa officinalis* L.)

positively reacts on goats rue (*Gallega officinalis* L.) as a forecrop mainly due to nitrogen residues. For the same reason the goats rue seems to be good forecrop for common yarrow (*Achillea millefolium* L.). Frequently used forecrop for ramstongue *Plantago lanceolata* L. was red clover. Ramstongue as a leaves drug needs a supply of nitrogen and field without weeds infestation. This is in accordance with Kováč et al. (2003). We have also found out inappropriate crop sequences as follows: two year monoculture of chamomile *Matricaria recutita* L. Chamomile is one year plant and it is out of agro technical rules growing this plant by monoculture manner. Patra et al. (2005) reported that chamomile may follow pulses, such as green gram, pigeon pea, and other summer vegetables. Chamomile can be grown on the residual soil fertility preceding green manuring and crops that are heavily fertilized.

Another shortcoming is growing *Hypericum perforatum* L. after winter wheat, which is according Ruminska (1991) not suitable forecrop. Habán et al. (2008) recommended minimum 3 year interruption for growing pot marigold *Calendula officinalis* L. at the same field for maintenance of quality of drugs. This recommendation was broken several times and pot marigold was growing after one year interruption. *Mentha piperita* L. is usually growing as a monoculture 2 – 4 years and 5 year interaction is needed. We have found out several cases of short rotation. For avoiding such imperfection and for creation of better condition and management practices designing of suitable crop rotation pattern is needed. Sustainability of crop rotation depends also on increasing biodiversity of crop rotation and balance management of organic matter (Kováč and Macák, 2007).

The study shows that the comparison of farming systems may yield misleading results, when performed only at the level of a single crop. The system boundaries should therefore be extended to a whole crop rotation. Differences detected for single crops may be almost fully compensated when the whole crop rotation is considered (Nemecek and Erzinger, 2005).

Two steps for designing were suggested. (i) Field consolidation and homogenisation of field for crop rotations area according soil and land conditions (Vilček, 2004; Fazekášová and Torma, 2007). The area is characterised by 8 classes of soil production categories. T1, T2, T3 – category of field designated for grassland use; OT1, OT2, OT3 category of field potentially use for arable land; O – prime arable land. Only 1 field in category O7 and O6 with the lowest production potential of arable land were identified (Figure 1). The interested area is characterized by low production potential primary designated for extension farming according classification of production categories by Džatko (2002). The 16 fields were analysed and 14 new fields for designing of new crop rotation area were arranged. (ii) Proposal of crop rotation pattern. According methodological approaches from numerous literature sources and own analysis (Pospíšil et al., 1999; Kováč et al., 2003; Macák et al., 2007; Habán et al., 2008) we propose 14 year crop rotation pattern as follows:

- 1. *Trifolium pratense* L. – 12.87 ha. 2. *Plantago lanceolata* L. – 12.87 ha. 3. *Plantago lanceolata* L. – 12.87 ha. 4. *Matricaria recutita* L. – 12.87 ha. 5. *Carum carvi* L. – 4 ha, *Mentha piperita* L. – 2 ha, *Fagopyrum esculentum* Moench. – 3.87 ha, *Calendula officinalis* L. – 1.5 ha, *Malva mauritiana* L. – 1.5 ha. 6. *Carum carvi* L. – 4 ha, *Mentha piperita* L. – 2 ha. *Matricaria recutita* L. – 6.87 ha. 7. spring barely (*Hordeum sativum* L.) – 12.87 ha under seeded with red clover (*Trifolium pratense* L.). 8. red clover (*Trifolium*

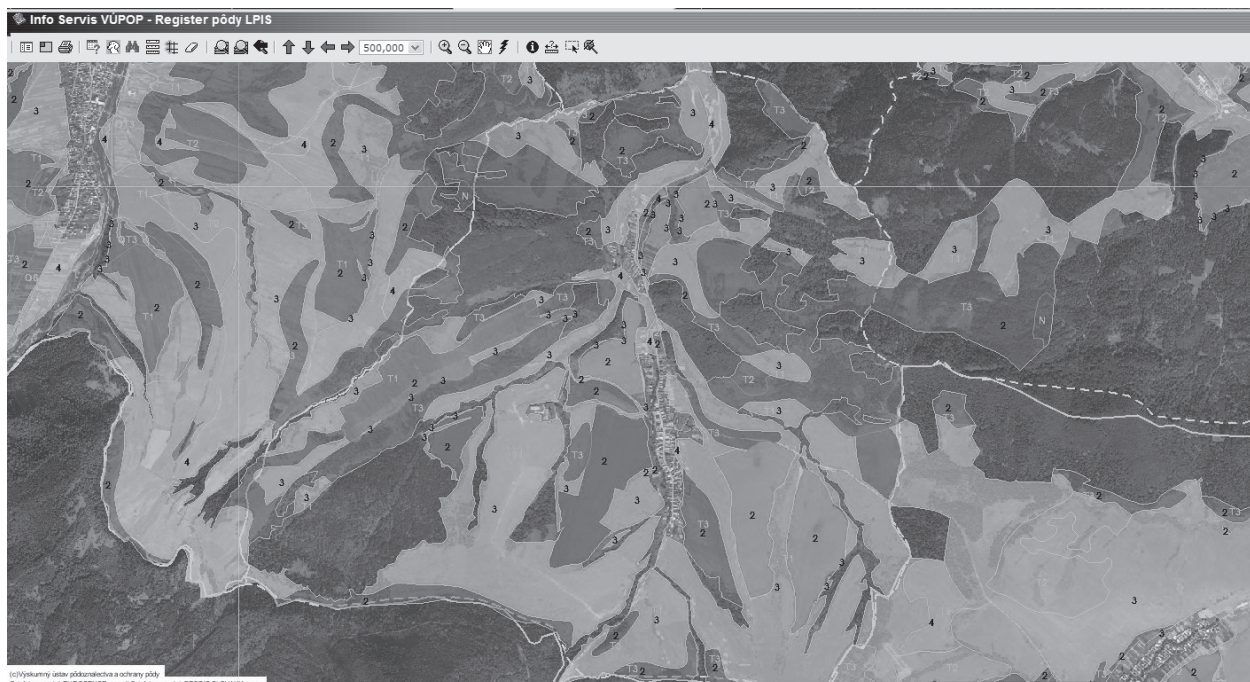


Figure 1 The analysis of production potential of growing area Plavnica – cadastre Šambron
 Source: Soil Register of Soil Science and Conservation Research Institute, 2011
 Thickness of humus horizon (letters: 1 – very deep, 2 – deep, 3 – medium, 4 – shallow) and soil production categories (T – category of field designated for grassland use, OT – category of field potentially use for arable land, O – prime arable land)

Obrázok 1 Analýza produkčného potenciálu pestovateľskej oblasti Plavnica – kataster obce Šambron
 Zdroj: Pôdny portál Výskumného ústavu pôdozvedectva a ochrany pôdy, 2011
 Hrúbka humusového horizontu (písmená: 1 – veľmi hlboký, 2 – hlboký, 3 – stredne hlboký, 4 – plytký) a typologicko-produkčné kategórie (T – kategória pôdy určená na využitie pre trávne porasty, OT – kategória pôdy potenciálne využiteľná ako orná pôda, O – orná pôda)

pratense L.) – 12.87 ha. 9. *Plantago lanceolata* L. – 12.87 ha. 10. *Plantago lanceolata* L. – 12.87 ha. 11. *Hypericum perforatum* L. – 5 ha, *Achillea millefolium* L. – 1.5 ha, *Melissa officinalis* L. – 0.2 ha, *Agrimonia eupatoria* L. – 0.2 ha, *Medicago sativa* L. – 0.2 ha, *Galega officinalis* L. – 0.1 ha, *Matricaria recutita* L. – 5.67 ha. 12. *Hypericum perforatum* L. – 5 ha, *Achillea millefolium* L. – 1.5 ha, *Melissa officinalis* L. – 0.2 ha, *Agrimonia eupatoria* L. – 0.2 ha, *Medicago sativa* L. – 0.2 ha, *Galega officinalis* L. – 0.1 ha and oat (*Avena sativa* L.) – 5.67 ha. 13. *Hypericum perforatum* L. – 5 ha, *Achillea millefolium* L. – 1.5 ha, *Melissa officinalis* L. – 0.2 ha, *Agrimonia eupatoria* L. – 0.2 ha, lucerne (*Medicago sativa* L.) – 0.2 ha, *Galega officinalis* L. – 0.1 ha, *Matricaria recutita* L. – 5.67 ha. 14. spring barley (*Hordeum sativum* L.) – 12.87 ha under seeded with red clover (*Trifolium pratense* L.).

Total acreage of 14 fields of crop rotation is 180.11 ha with average field 12.87 ha. Share of medicinal plant is 68.27%, share of red clover 14.29% and spring cereals 17.46%. The design of propose crop rotation allows to use organic manure mainly before medicinal plants growing for leaves drug and incorporation of cover crops for maintenance of soil fertility. Supposed crop rotation pattern complies with basic principles of crop rotation and sustainable agriculture.

Conclusions

According ten year period of growing medicinal plants in “Agrokarpaty Plavnica” the main findings of the analysis of cropping patterns are as follows: the management practices of “Agrokarpaty Plavnica” are in full compliance with the good agricultural practices (GAP). The high priority is maintenance of soil fertility and sustain of nutrients, mainly nitrogen. The green

manure, cover crop, growing of legumes and compost from own productions are used. The area is characterised by 8 classes of soil production categories. T1, T2, T3 – category of field designated for grassland use; OT1, OT2, OT3 category of field potentially used for arable land and only one field in category O7 and O6 of the lowest production potential of arable land were identified. The interested area can be characterized by low production potential and is primary designated for extension farming according classification of production categories. Total acreage of proposed 14 fields crop rotation area is 180.11 ha with average field 12.87 ha. Share of medicinal plant is 68.27%, share of red clover 14.29% and spring cereals 17.46%. The design of propose crop rotation allows to use organic manure mainly before medicinal plants growing for leaves drug and incorporation of cover crops for maintenance of soil fertility. Supposed crop rotation pattern complies with basic principles of crop rotation and sustainable agriculture.

Súhrn

Výskum modelu osevného postupu a homogenizácie honov bol realizovaný v rokoch 2000 – 2010 v Agrokarpaty s. r. o., Plavnica. Priemerná denná teplota pokusného miesta počas vegetácie je 14,9 °C so sumou zrážok 438 mm. Polia sú situované v nadmorskej výške 300 – 450 m nad morom. Celková výmera ornej pôdy je 380 ha. V hodnotenom období sa liečivé rastliny pestovali na ploche 85 – 145 ha. Pestovali sa hlavne nasledovné liečivé a koreninové rastliny: *Galega officinalis* L., *Medicago sativa* L., *Hypericum perforatum* L., *Mentha piperita* L., *Melissa officinalis* L., *Calendula officinalis*

L., *Fagopyrum esculentum* Moench, *Carum carvi* L., *Achillea millefolium* L., *Agrimonia eupatoria* L., *Matricaria recutita* L., *Plantago lanceolata* L., *Malva mauritiana* L.. Ako predplodiny sa pestovali ďatelina lúčna (*Trifolium pratense* L.), pšenica ozimná (*Triticum aestivum* L.), jačmeň jarný (*Hordeum sativum* L.) a ovos siaty (*Avena sativa* L.). Pestovateľské postupy boli v súlade so správnou farmárskou praxou. Najvyšší dôraz sa kládol na udržiavanie pôdnej úrodnosti a zásobovaniu živinami, najmä dusíkom. Využívalo sa zelené hnojenie, pestovanie leguminóz a aplikácia kompostu z vlastnej produkcie. Boli navrhnuté dva kroky pre modelovanie osevného postupu (i). Priestorová úprava polí a homogenizácia územia osevného postupu (ii). Návrh modelu osevného postupu. Zaujímavé územie je charakterizované nízkym produkčným potenciálom pôdy v 8 typologicko-produkčných kategóriách. Bol navrhnutý model osevného postupu na ploche 180,11 ha s priemernou výmerou honu 12,87 ha. Podiel liečivých a koreninových rastlín bol navrhnutý na úrovni 68,27%, podiel ďateliny 14,29% a podiel jarných obilnín 17,46%. Usporiadanie navrhnutého osevného postupu umožňuje aplikáciu organických hnojív, hlavne pred liečivými rastlinami pestovanými na listovú drogu a pestovanie medzplodín na udržanie pôdnej úrodnosti. Navrhnutý model osevného postupu je v súlade s princípmi striedania plodín a udržateľného poľnohospodárstva.

Kľúčové slová: orná pôda, biodiverzita, osevný postup, liečivé rastliny, koreninové rastliny

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