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Review paper

THE IMPORTANCE OF WEED FLORA MAPPING IN THE REGIONS OF SERBIA

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This paper presents results obtained in weed mapping. Results presented in the international literature are surveyed and compared with results gained in weed mapping in our country. As weed mapping implies permanent data collecting and analysing, it results in an accurate perception of the spatial distribution of certain weed species within a particular region. An occurrence of new - invasive, resistant and especially economically important weeds can be established by confirmation of the distribution and infestation intensity of dominant weed species in different regions. In such a way, quarantine regions would be formed more easily. Furthermore, weed control would be also easier. Changes caused by various agricultural practices would be timely determined by monitoring weed flora of a particular region. Therefore, mapping is the safest base for selection and organisation of control measures. Weed flora mapping within the integrated weed management provides possibilities of planned weed control with the reduced herbicide application.

Key words: Weeds, weed mapping, methods in weed mapping

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INTRODUCTION

Due to its specific geographic position Serbia is characterised by a great climatic diversity. Climatic, orographic and geological heterogeneity of a territory provides abundance and diversity of pedological covers (ANTONOVIĆ *et al.*,1965). STEVANOVIĆ and STEVANOVIĆ (1995) stated that climatic and pedological diversity, as well as a vegetation and ecosystemic picture of Yugoslavia was an actual mosaic in which in a very small area interchanged almost all zonal types of climate, soil and biome of Europe. All this presents enormous natural resources that provide, among others, biological diversity of weed flora.

Weeds of different biological groups with specific traits and often different susceptibility to herbicides develop on the same area. The weed association composition is not permanent in one area and it is prone to changes in dependence on climate, soil type, altitude, and in relation to that on a season (AJDER, 1997; VRBNIČANIN *et al.*,1998).

On the other hand, the composition of weed species of a particular habitat changes under conditions of crop growing practices and other agricultural measures taken in order to increase crop yields, such as: selection of crops, tillage, crop density, type and time of herbicide application (KOJIĆ and ŠINŽAR, 1968; VIDENOVIĆ and STEFANOVIĆ, 1994; VIDENOVIĆ *et al.*, 1997; ŠINŽAR and STEFANOVIĆ, 1997; STANOJEVIĆ *et al.*, 1996, 2000; STEFANOVIĆ *et al.*, 2000).

It has been proven that permanent application of the same measures in agriculture would result in disturbance of the agroecosystem. In such a way, the intensive herbicide application, very often accompanied with lack of knowledge on biology and ecology of weeds, results in new problems among which occurrence of weed flora with a greater distribution of grass, perennial, resistant and invasive species are the most important (ŠAINOVIĆ and KOJLANDŽINSKI, 1978; KOJLANDŽINSKI and ŠAINOVIĆ, 1982; AJDER, 1992a, 1992b; KOJIĆ *et al.*, 1993; ŠINŽAR and STEFANOVIĆ, 1993; ŠINŽAR *et al.*, 1997, 1998). Due to it, efficient and economic weed control is practically inconceivable without permanent and detailed studies on weed flora of various regions. The concept of making floristic maps of arable areas is very important for determination of an exact distribution of certain weed species in a particular region.

This paper presents weed flora mapping in the world on the basis of literature data and makes comparisons with this issue in our country.

THE IMPORTANCE OF WEED FLORA MAPPING

A detail presentation of the distribution of certain weed species is a first prerequisite to have an exact insight into the spatial distribution of particular taxa. Making maps is summarising gathered data on the weed species distribution. The importance of representation of summarised data in the form of floristic maps is manifold. Beside the determination of dominant species, weed mapping also provides a timely discovery of new (invasive) species

(SHELEY *et al.*, 1996, 1998; ZAMORA *et al.*, 1989), as well as, infestation and distribution of resistant biotypes of weeds (AIGLE *et al.*,1980; MORISON *et. al.*, 1989; HOLT and LEBARON, 1990; STEPHENSON *et al.*, 1990; BECKIEE *et al.*, 1999; HASHEM *et al.*, 2001). New techniques provide the determination of phenolic stages of crops (LASS and CALLIHAN, 1997), and also a perception of crop damages caused by herbicides (LYM and MESSERSMITH, 1988). All this makes planning of activities and agricultural practices easier (KNEŽEVIĆ *et al.*, 1997; MULUGETA *et al.*, 2001; PIKE *et al.*, 1991). Therefore, weed flora mapping within the integrated weed management provides possibilities of planned weed control with a reduced herbicide application and simultaneous environmental protection.

Monitoring of weed flora requires permanent gathering and analysing of data on the arable area. The technique of data collection and their preciseness changes. The aim, i.e. purpose of mapping has an important role in making maps. Weed mapping beside theoretical has great practical values, as pointed out to by many authors (MARSHALL, 1988; WILSON and BRAIN, 1990, 1991). Such a representation of a spatial distribution of particular taxa indicates the regions in which a given weed species has ecological optimum, and therefore, the locations where it presents the greatest problem in plant production by which is planned and rational control of such weed species created (KARADŽIĆ and STEFANOVIĆ, 2000).

A Universal Transverse Mercator (UTM) map is most often used in flora mapping and due to it this map has become a standard for studies with which the distribution of certain taxa in a particular region should be presented (KARADŽIĆ *et al.*, 1998). According to precisely established principles, basic zones of geographical longitudes and latitudes are designated on UTM maps. The principal longitudinal zones are bordered with meridians which divide the world into 6° geographic areas each of which is given a unique identification from 1 to 60. Latitudinal zones on UTM grid zone maps start with 80°S and end with 72°N. There are areas between these zones that are into segments of 8°. The areas designating latitude are marked from C to X with the exceptions of letters I and O. Such defined principal zones are covered by a pattern of 100,000-meter squares. Each square is numerically identified. The universality of the UTM map is in the fact that the basic quadrangles can further be divided into smaller quadrangles (50m x 50m, 10m x 10m, 5m x 5m, 100m x 100m) which are also numerically identified.

Different scales of the UTM maps can be used depending on the objectives themselves, i.e. on the distribution of taxa which should be presented. KARADŽIĆ *et al.* (1998) states that the optimal scale to present rare and endangered species was 5x5 km, while STEFANOVIĆ (1987) in her study "Weed Infestation of Maize Crops in North-eastern Serbia" presented the distribution of 20 most frequent weed species - edificatory associations of Panico-Galinsogetum, Polygonum convolvulo-avicularis and Hibisco-Eragrostietum on the UTM gridded map of 2km x 2km scale.

SOME RESULTS ON WEED FLORA STUDIES IN THE WORLD

Monitoring of weed infestation of arable areas of various regions has been performed with smaller or greater precision and with different goals. CHANCELOR (1985) pointed to changes of weed flora in England on an arable field cultivated for 20 years. According to seed bank analyses CHAUVEL *et al.* (1989) pointed to changes of weed infestation parameters in dependence of environmental factors. Based on 267 screens SAAVEDRA *et al.* (1989) presented a survey of weed flora of different crops in Spain. WILSON and BRAIN (1991) monitored the distribution of black-grass (Alopecurus myosuroides) within cereal fields in England. ANDERSEN *et al.* (1991) presented the distribution of 37 weed species in Danish fields, while WILLARD *et al.* (1990) presents the distribution of cogon grass (Imperata cylindrica) in Florida. SHELY *et al.* (1998) presented the distribution of knapweed (Centaurea spp.) in western parts of the USA.

Collecting the data on the infestation intensity of different weed species on arable areas that were cultivated in many countries world-wide resulted in making maps of dispersal of certain weed species. In respect to weed flora mapping, THURSTON (1954) presented the distribution of wild oat according to the analysis of collected seed. The same author, based on literature data, presented the distribution of this species in the world (THURSTON and PHILIPSON, 1976).

There are several approaches in data gathering for making maps. When complete areas are screened, the descriptive estimates of infestation are used (species is present/absent, or infestation is strong, medium or weak) and qualitative description of weed infestation is obtained. When a partial screening of weed infestation is performed on certain sites (samples) by counting plants of each species, a quantitative description of weed infestation is obtained. This method is equipment and time consuming and therefore it is more expensive, but also obtained data can be immediately used (weeds can be counted, mapped and treated within a few days).

A spatial distribution of weeds is hardly ever uniform. Many studies of the weeds spatial distribution on arable areas pointed to the fact that the majority of species occur in groups, i.e. patches (MARSHALL, 1988; WILSON and BRAIN, 1990; WALLINGA, 1995; CHRISTENSEN *et al.*, 1996; NORDMEYER *et al.*, 1996, 2002; ASSEMAT and LONCHAMP, 2002). Since occurrence of weed patches is considered a common phenomenon on agricultural areas, weed parches reduction in one field is a more recent approach to monitoring of a weed distribution over a single area (REW *et al.*, 1996). REW and COUSENS (2001) emphasised the importance of monitoring of the partial weed distribution in arable areas and pointed out to advantages of the reduced herbicides application, i.e. the application only to sites where it was necessary but not in the whole field. Such a herbicide application is financially more beneficial and at the same time it is more ecologically justified. PERRY et al. (2002) studied stability of weed (such as Avena fatua and Bromus sterilis) patches and indicated their variability and in relation to this indicated the need to repeat screening once in two years. It had been theoretically proven that weed patches were the most important part of weed population in a field, especially in competition with crops. Furthermore, many other authors stated that data on the weed distribution obtained in such a way provide new possibilities in weed control (NGOUAJIO *et al.*, 1998; LAMIEUX *et al.*, 2002; GERHARDS et al., 2002; SOGAARD and HEISEL, 2002; SWETNAM *et al.*, 1998; ASSEMAT and LONCHAMP, 2002). The authors explicitly pointed to the fact that the treatment of weed patches resulted in the herbicides application reduction within agroecosystems with significant ecological and economical benefit.

Collecting data on weed plants can be performed in larger or smaller areas or in particular parts of fields, with greater or smaller precision and in detail. A weed estimation within greater or smaller quadrangles, depending on the objectives of studying, is recommended within a precision agriculture concept (ASSEMAT and LONCHAMP, 2002). Beside traditional collection of data by counting each species per m^2 and visual scores, in recent times techniques of aerial photography (NORDMEYER *et al.*, 1996), videography (HICKMAN *et al.*, 1991; MITCHALL *et al.*, 1996; SWETNAM *et al.*, 1998) and other sensitive digital techniques have been used. Instruments for satellite positioning, such as a geographic information system (GIS) and global positioning system (GPS) are of a great help (LASS and CALLIHAN, 1997). Different designations are used for the weed infestation estimation (WILLARD *et al.*, 1990).

The significance of such studies was confirmed by a long-term botanical project for mapping of vascular plants performed under the auspices of the government. Studies and monographs on the weed distribution in a certain region are a result of organised work on data collecting. A monograph issued in 1981 for needs of agricultural experimental stations of the US North and Central States is often cited. Beside the description of each species, the publication includes also maps of their distribution (LUND, 1981).

Quadrangles of 50 x 50 km were used in botanical studies, but they can also be smaller (25 x 25 km). These quadrangles can be arranged in different ways on permanently designated areas of the given field. MARSHALL (1988) used permanently set quadrangles of 0.25 m^2 in his studies, while NORDMEYER *et al.* (1996) estimated 201 points set at the distance of 40 x 40 m in the filed of 2.1 ha. Sample points can also be located in randomly chosen field parts.

In recent times the mathematical simulation models, with different aims and purposes, have been used (MORISON *et al.*, 1989; ALLEN *et al.*, 1996; BECKIE et al., 1999a, 1999b; WOOLCOCK and COUSANS, 2000). MARSHALL (1988) noted that the model for prediction the weed distribution in arable areas had been developed with the aim to improve information on population dynamics of weeds. The use of such a model provides the treatment of only infested areas. Furthermore, computer methods of three-dimensional presentation of climatic data are used with a view to improve plant production technology, which is useful in the additional and partial application of herbicides (GERHARDS *et al.*, 2002; LAMIEUX *et al.*, 2002). In relation to the stated, BELDE et al. (2002) suggested modelling of the weed spatial distribution and noted the advantages of the partial herbicide application as an integral part of integrated weed management strategies. Also, data can be analysed and processed by geostatistical methods of interpolation, such as kriging or metapopulation models of data transformation (HEISEL *et al.*, 1996).

Moreover, in countries neighbouring to ours, it has been done more within the filed of weed mapping than in our country. For instance, mapping was established in Bulgaria as early as 1963 (KOLEV, 1963; FETVADŽIEVA, 1973), and in Slovakia in 1978 (KUHN, 1978). The collection of data on the distribution of populations resistant to atrazine was organised in Hungary in 1986 (SOLYMOSI and KOSTYAL, 1985). TOTH (1995) noted that extensive studies with the aim to develop a weed control programme and to be used in field screening of weed populations had stared in 1980. The same author used a 1-4 scale where 1 is 100% field infestation with a weed of a given species; 2 is 75% field infestation with a weed of a given species; 3 is 50% field infestation with a weed of a given species and 4 is 25% field infestation with a weed of a given species. STANKIEWICZ et al. (2001) presented a map of the distribution of black nightshade (*Solanum nigrum*) in Poland.

PREVIOUS RESULTS IN WEED FLORA MAPPING OBTAINED IN OUR COUNTRY

Studies on weed flora and vegetation have been performed in a great number of regions. The majority of these studies are related to floristic composition, life form, syntaxonomy and synecology (KOJIĆ *et al.*, 1975, 1983; ŠINŽAR, 1967; STEFANOVIĆ, 1984; STEPIĆ, 1984; OGNJANOVIĆ *et al.*, 1986; ŠINŽAR *et al.*, 1992; ŠINŽAR *et al.*, 1997b; VRBNIČANIN, 1997; VRBNIČANIN *et al.*, 1998; KOJIĆ and VRBNIČANIN, 1999; VRBNIČANIN *et al.*, 2002a, 2002b). Some authors pointed out to the occurrence of new species in our country. ŠAINOVIĆ and KOLJANDŽINSKI (1981); KOLJANDŽINSKI and ŠAINOVIĆ (1982) detected adventive species, such as common ragweed (Ambrosia artemisiifolia), giant ragweed (Ambrosia trifida) and marsh-elder (Iva xanthifolia) in Vojvodina. ILIJANIĆ and TOPIĆ (1986) from Croatia, former Yugoslavia, indicated to the invasion of dallies grass (*Paspalum dilatatum*).

There are botanical projects for vascular plants mapping in our country (STEVANOVIĆ 1992). The plant distribution in Serbia is presented for only 78 species whose range of distribution is well known. Due to problems related to field material collecting, the greatest number of data used in mapping is ether of literature or herbarial origin. Data were collected from various local and regional floras, floristic and phytocenolic studies, horological supplements, books of proceedings, reprints of journals and manuscripts of original scientific papers (STEVANOVIĆ *et al.*, 1995; FABRI and JOVANOVIĆ, 2000).

However, little work has been done in Yugoslavia on recording the spatial distribution of weed flora of certain regions on UTM maps. Furthermore, there are only a few papers related to mapping of weed associations and most distributed weed species. HORVAT *et al.* (1950) made the most significant contribution to weed flora mapping in southern Balkan countries based on the conventional approach. KOVAČEVIĆ (1972) mapped some agricultural estates in Croatia and at the same time made vegetation maps of those fields. According to the similar principle Topic presented the most distributed weed species within the continental part of Croatia (TOPIĆ, 1982, 1986, 1993). In Serbia, ŠAINOVIĆ and KOLJANDŽINSKI (1978) mapped the distribution of marsh-elder (Iva xanthifolia), a new species in our regions. Based on 184 screenings of north-eastern Serbia, STEFANOVIĆ (1987) mapped the distribution of 20 dominant weed species in maize crops, while STEPIĆ (1984) mapped weed associations in wheat crops of north-western Serbia on the basis of 90 screenings. Since then, similar studies have not been performed in our country. The reasons for such modest results, are first of all, of a financial, but also of an organisational character.

Unfortunately, all previous studies lacked a clearly established method for weed flora mapping. To that effect, KOJIĆ (1980) suggested a unique method for weed mapping for the territory of former Yugoslavia, which was a modification of German geobotanical school (HILBIG, 1974). The principal modification of this method was that the estimate included not only the degree of permanency but also abundance of weed species according to the approach of Braun-Blanquet school. A scale developed in such a way is as follows: estimate I - a species is detected in 1-20% of screenings; II - a species is detected in 21-40% of screenings; III- a species is detected in 41-60 % of screenings; IV- a species is detected in 61-80% of screenings and V- a species is detected in 81-100% of screenings.

Prior to the computer age, making floristic and vegetation UTM maps was a lengthy and painstaking work. Due to the modern technique and computers, software packages are applied in biomonitoring. A programme package "FLORA" is one of such software packages designed by phytoecologists working at the Institute of Biology "Siniša Stanković" in Belgrade, (KARADŽIĆ *et al.*, 1998). This software programme is intended for biomonitoring and quantitative ecology. "Flora" is designed in a way that two types of data can be input: floristic and vegetation ones. For the needs of flora mapping and making floristic maps, the following data are input in the communication space: scientific name of species (Latin name), location of its detection, geographicall longitude and latitude, altitude, exposition, sloppiness, then a date when a species was detected, literature reference in relation to cited data and the degree of species endangerment. Furthermore, the programme converts polar into UTM co-ordinates. This software programme uses a Microsoft Access data base, although it can use other types of data bases such as Excel FoxPro, etc.

Considering that all data have exactly determined geographic co-ordinates, i.e. georeference coordinates, on the UTM map, a distribution of certain species (or their subunits), i.e. higher taxonomic units such as associations, alliances, orders or classes, can be accurately presented. This software programme makes grids from 10 x10km to 500 x 500 m. In such a way a spatial distribution of weed species is established, i.e. the distribution of weed associations on the UTM map is made.

KARADŽIĆ and STEFANOVIĆ (2000) pointed out to the role of mapping in precise and efficient weed control with the reduced herbicide application within the agroecosystem. The UTM maps with a scale of 2 x 2km are stated as an example. Areas in which a given weed species has its ecological optimum, and thereby locations (crops) in which more intensive weed control is necessary, can clearly been observed on such maps.

WHICH ACTIVITIES SHOULD BE TAKEN?

Considering the importance of permanent monitoring of weed infestations of arable areas, with the aim of their mapping, it is necessary to initiate an organised work within this field. In 1980, KOJIĆ indicated that mapping in Yugoslavia should have been done in the unique way and at the same time this author recommended the method (KOJIĆ, 1980). The author noted that inventorying is the first and the necessary task in weed flora studying, which requires the accurate determination of species. This is the initial and harder part of the work that cannot be omitted. There are several ways to determine weeds. The easiest way of determination is to have a whole intact plant, i.e. a sample with leaves, root and flower. The fresh plant is always easier determined than the wilted or dry one. Weed flora mapping is directly ensued after weed species inventorying.

A descriptive and detailed survey on the distribution of particular weed species represents a solid base for both, theoretical studies and practical application in weed control. Mapping of weed plants distribution can be performed with a different degree of precision. As already stated, there are different estimates and designations that can be used in this purpose. KOJIĆ (1980) suggested to make phytocenolic screenings according to Braun-Blanquet method, i.e. 20 each in both small grain crops and row crops. At the same time, the author presented the map of the distribution of wind bent grass (Apera spica-venti) in the region of Halle, where a 1-5 scale was used.

It is our opinion that the distribution of species in Serbia could be presented over geographic regions. The territory of Serbia is divided on the maps of range of distribution according to quadrangles of UTM grids of the 10x10-km scale (STEVANOVIĆ, 1992). Such a grid absolutely suits the goal to be achieved.

Weed infestation of arable areas can be esteemed by the 1-4 scale that also was used by FETVADŽIEVA (1973). It is our opinion that this scale due to its simplicity is acceptable:

1. species is individually detected and covers 5% of the area;
2. species is rarely detected and covers 5-25% of the area,
3. species is often detected and covers 25-50 % of the area,
4. species prevails and covers over 50% of the area.

Data collected in the fields will be stored according to the agreement in certain locations (institute, faculties) and then, maps of the distribution of certain species would be made by the use of the computer programme "FLORA".

In order to develop methods, preliminary studies on mapping weed flora in maize crops have been initiated in two regions - Sombor and Stig. Results on these floristic screenings and the survey of species distributions on UTM maps were presented at the panel meeting on plant protection. Authors pointED out to determined differences in the distribution of certain weed species (STEFANOVIĆ *et al.*, 2002).

INSTEAD OF A CONCLUSION

A weed flora composition of any area changes in dependence on climate, soil type, altitude, and is also prone to seasonal changes. On the other hand, the composition of weed species changes in dependence on measures taken in agriculture: tillage, crop density, crop type, type and rates of applied fertilisers, herbicides, etc.

An exact insight into the spatial distribution of certain weed species, as well as, reliable data on the occurrence one new (invasive) resistant, and especially economically important weeds, would be obtained by the determination of the distribution and intensity of weeds, especially of dominant weed species. In such a way, quarantine regions would be established more easily, and control measures would be taken more successfully. Biomonitoring means a permanent collecting and analysing of data of a certain region. In such a way, mapping represents the safest base for selection and organisation of weed control measures.

Considering that monitoring of weed flora changes is a strategic need of any society on both, global and local levels, it should be thought of a multidisciplinary project to be established with the aim to form a data bank that would encompass information necessary to oversee and predict structural and functional changes within various types of the agroecosystem.

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ZNAČAJ KARTIRANJA KOROVSKE FLORE U SRBIJI

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Izvod

Sastav korovske flore jednog staništa se menja u zavisnosti od klimatskih promena, tipa zemljišta, nadmorske visine, a podložan je i sezonskim promenema. S druge strane, sastav korovskih vrsta se menja i u zavisnosti od mera koje se preduzimaju u poljoprivredi (način obrade zemljišta, gustine gajenja, vrste useva, vrste i količine primenjenih đubriva ili herbicida i dr.). Kartiranjem korova jednog područja dobio bi se tačan uvid prostornog rasporeda pojedinih vrsta korova. Utvrdivanjem rasprostranjenosti i intenziteta zastupljenosti dominantnih vrsta korova raznih područja konstatovala bi se pojava novih, invazionih, rezistentnih, a naročito ekonomski značajnih korova. Tako bi se lakše formirala karantinska područja, a i lakše preduzimale mere borbe sa njima. Biomonitoring podrazumeva permanentno prikupljanje i analizu podataka na određenom području. Na taj način kartiranje predstavlja najsigurniju podlogu za izbor i organizaciju mera suzbijanja.

Imajući u vidu da je praćenje promena korovske flore strateška potreba svakog društva, kako na globalnom, tako i lokalnom nivou, trebalo bi razmišljati o formiranju multidisciplinarnih projekata koji će imati za cilj formiranje banke podataka u kojoj će biti sadržane informacije neophodne za sagledavanje predvidenje strukturno-funkcionalnih promena u različitim tipovima agroekosistema.

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