NEW POSSIBILITIES OF WEED CONTROL IN WHEAT

Maria Markovic[1], Nada Protic[2], Rade Protic[3], Snejana Jankovic[4]

ABSTRACT

This paper presents a model for weed control in wheat and discusses the degree of effectiveness of herbicides and their selectivity within the system of management and that of an integrated protection of field crops on a regional and global basis. The problem of resistant weeds is made simpler and is easily solved by rotating crops and herbicides with different modes of activity, as well as by introducing proper agricultural measures, new specific herbicides for combating ruderal and problematic weeds in wheat. In such a way, emerging and spreading of resistant weeds is prevented through the system of rotation of wheat, sugar beet, soybean, maize and soybean.

Key words: herbicides, rotation, weeds, wheat.

INTRODUCTION

The lack of knowledge concerning the biology of weeds and crops in the rotation, not understanding the ways and mechanisms of the weed action, inadequate agricultural practices and inappropriate selection of herbicides brought ruderal weeds to the agricultural land. At present the following weeds dominate in wheat: *Cirsium arvense, Abutilon theophrasti, Rubus caesius, Lathyrus tuberosus, Erigeron canadensis, Ambrosia artemisifolia, Ambrosia vulgaris, Xanthium strumarium* and *Iva xanthifolia*. All this is affected the amount and quality of the yields, profits and efficiency in wheat production.

Ruderal weeds are spreading, damage is great, coping with them is complex and requires competent experts to develop the optimal models to control weeds, since the problem is serious and difficult.

MATERIAL AND METHODS

The weed community that invades wheat includes winter-spring ephemera, winter and winter-spring, early spring and summer weed species. Esentially, it is formed by the early spring and summer weeds. Predominant weeds having a short vegetative period are: *Stellaria media, Capsela bursa-pastoris, Veronica* spp. and *Lamium amplicaule*.

Among the early spring weeds, more important are: *Chenopodium album, Amaranthus retroflexus* and *Polygonum aviculare*. The group of dense species includes *Papaver rhoeas, Consolida regalis, Galium aparine, Fumaria officinalis, Ranunculus arvensis* and *Bifora radians*. The following weeds belong to geophytes: *Cirsium arvense, Convolvulus arvensis, Lathyrus tuberosus* and *Rubus caesius* throughout the year and *Sorghum halepense* at the end of spring and on stubble fields during summer. Ruderal elements in wheat, in a narrower sense, are *Datura stramonium, Urtica urens, U. dioica, Xanthium strumarium, Polygonum aviculare* and *Convolvulus arvensis* (Kojic and Janjic, 2000; Vrbnicanin and Kojic, 2000).

Fortunately the predominant in living form are the terophytes, in terms of the number of species and the number of individual plants. In the wheat crop, a frequently occurring geophyte is *Cirsium arvense*, as a result of unsuitable soil cultivation and inadequate choice of herbicides. It prevails in wheat crops on all areas suitable for wheat growing where it establishes a pure community. *Ambrosia artemisifolia* belongs to the adventive floral element (Vrbnicanin and Kojic, 2000), and as a thermophile species it develops during the second half of spring and in summer. *Iva xanthifolia* is a very competitive weed by its robustness and seed production and, luckily for us, it is encountered in large numbers only in the South Srem, on the fields where the rotation of herbicides and crops was left out. *Xanthium strumarium* is a typical ruderal weed and a very harmful one either to stubble crops or row crops. From the group of cosmopolite and early spring weeds that grow on the soils rich in nitrogen the following are to be mentioned: *Polygonum lapathifolium, P. persicaria* and *Bilderdykia convolvulus*. In a similar way, *Ambrosia artemisifolia* and *Abutilon theophrasti* are the weeds of warm climate and dry zones, so today they play an important role among wheat weeds, as is also

[1] Timings, Beograd, Serbia and Montenegro
[2] EKO-LAB, P. Skela, Beograd, Serbia and Montenegro
[3] Institute for plant protection and environment, Beograd, Serbia and Montenegro
[4] Institute for science application in agriculture, Beograd, Serbia and Montenegro

the case with *Erigeron canadensis (*Kojic and Janjic, 2000).

RESULTS AND DISCUSSION

Overview of herbicides used to control weed in wheat and on stubble fields

A global consumption of pesticides in Europe amounts to 318 active substances where the respective quantities are: herbicides – 48%, insecticides – 25%, fungicides – 20%, others – 3% and growth regulators – 2%. Besides, among the new pesticides, the use of herbicides rises to 59%, while that of fungicides and insecticides reaches 22% and 19% respectively (Markovic et al, 2000).

The key herbicide groups are imidazolinones, urea sulfonyl and propionic acid. In the further development of herbicides new active substances are favoured, products are improved and new practices in plant production are promoted.

Table 1. Herbicides for controlling weeds after sowing and before emergence of wheat

Agent (formulation)	Content of active matter	Dosage (l/kg/ha)	Weeds narrow-leaved + broad-leaved
Stomp 330 (EC)	330 g/l pendimetalin	5-6	+
Tolurex 50 (SC)	500 g/l chlorotoluron	3-5	+
Prazlin 21 (FC)	210 g/l nitrophene	8-10	+

Herbicides that are used after sowing and before crop emergence are not traditionally used in Serbia and Montenegro. These are herbicides utilized in Europe and the USA. Pendimetalin inhibits the formation of microbutyl and causes the death of plants after germination, emergence or when weeds are in the cotyledon phase and that of the first 3 - 4 pairs of leaves.

Weeds absorb it through roots and leaves. It is ineffective in checking *Datura stramonium, Xantium strumurium* and *Solanum nigrum.* The other two herbicides are used to a lesser degree because chlorotoluron is insufficiently effective on *Galium* spp., *Veronica* spp., *Bifora* spp., *Papaver rhoeas* and *Viola arvensis,* whereas nitrophene circulates slowly in plants (Tables 1 and 2).

Table 2. Herbicides controlling broad-leaved weeds after emergence of weeds and wheat

Agent (formulation)	Content of active matter	Dosage (l/kg/ha)	Phase of application (BBCH scale)	Weeds	
				annual	perennial
Stomp 330 (EC)	330 g/l pendimetalin	5-6	11-21	+	-
Maraton	250 pendimetalin + 125 g/l isoproturon	4.0	12-21	+	+
Granstar 75 WG)	750 g/kg tribenuron methyl	0.015-0.020	13-32	+	+
Lintur 70 (WG)	659 dicamba Na-salt + 41 g/kg triasulfuron	0.15	14-29	+	+
Timkor (SL)	588 g/l 2.4-D-dimethyl-ammonium	1.5-2.5	25-30	+	+
Maton (EC)	600 g/l 2.4-D-2 ethylheksil ester	1.0-1.5	25-30	+	+
Esteron (EC)	850 g/l 2.4-D-2 ethylhexyl ester	0.8-1.2	25-30	+	+
Mustang (SE)	300 g/l 2.4-D-2 ethylhexyl ester + 6.25 g/l florasulam	0.4-0.6	21-32	+	+
Primus (SE)	12 g/l florasuram	0.1-0.15	21-32	+	+
Lancet (SE)	450 g/l 2.4-D (DMA) + 80 g/l fluroxipir-butoxipropyl	1.0-1.2	29-31	+	+
Sekator (WG)	12,5% iodosulfuron-methyl-sodium + 50 g/kg amido Sulfuron + 125g/kg mefenpir-diethyl	0.15-0.3	13-39	+	+
Cambio (SL)	330 g/l bentazon-sodium salt + 99 g/l dicamba Na-salt	1.0	13-29	+	+
Basagran DP (SL)	364 g/l bentazon Na-salt + 271 g/l + dichlorprop-P-potassium	3.0	20-31	+	+
Laren (WG)	600 g/kg metsulforon methyl	0.01	21-32	+	+
Starane 250 (EC)	250 g/l fluroxipir-meptil	0.6-1.2	13-39	+	+
Grodyl (WG)	750 g/l amidosulfuron	0.02-0.04	12-37	+	+
Duplosan KV (SL)	600 g/l mekoprop (DMA)	2.0	25-31	+	+

Optica combi	300 g/l mekoprop (DMA) + 300 g/l MCPA	1.5-2.0	25-30	+	+
Korovicid kombi (SL)	554 g/l mekoprop (DMA) + 207 g/l 2.4-D (DMA)	4.0-5.0	25-30	+	+
Banvel univerzal (SL)	344 g/l 2.4-D(DMA) + 120 g/l dicamba (DMA)	0.6-0.8	25-30	+	+
Orbit (EC)	200 g/l cinidon-ethyl	0.25-0.37	21-32	+	+

Only the herbicides based on pendimetalin can be applied before and after the emergence of crops and weeds, while still exerting a wide spectrum of effects on narrow-leaved and broad-leaved weeds. By adding isoproturon (Maraton) the spectrum is widened to *Avena* spp., *Poa* spp., *Hibiscus* spp., *Vicia villosa*, *Anthemis arvensis* and *Erigeron canadensis*. In the early phases of the wheat plant growth, herbicides based on tribenuron methyl are utilized (Granstar 75 DF), which is a mixture of triasulfuron and dicamba (Lintur 70). Tribenuron methyl combats very well *Agrostema githago, Bifora radians, Matricaria* spp., *Stellaria media, Veronica* spp., *Anthemis arvensis,* weeds from the *Brassicaceae* family and a large part of the weeds affected by 2.4-D, if they are applied in weeds in the emerging phase of both the cotyledon and the first pair of leaves. By delaying the use of herbicides the death of weeds is slowed down and is prolonged to a period of 20 - 40 days. The other herbicides are most suitable for treating wheat in the period from the end of tillering until the emergence of the first or second node (Markovic et al., 1994, 1995).

The weed control on stubble fields is accomplished through the chemicals based on glyfosat. This measure is justifiable only in case when perennial weeds, such as sorghum, thistle and black berry, are frequent (Table 3).

Table 3. Herbicides controlling weed on stubble fields

Agent (formulation)	Content of active matter	Dosage (l/kg/ha)	Annual weeds	Perennial weeds
Roundup (SL)	480 g/l glifosatis opropylmonium	6-12	+	+
Uragan system 4	360 g/l glifosat trimezium + 240 g/l alkylpoly glycoside	2-8	+	+

Criteria for the selection of herbicides

The basic criteria for selecting herbicides to control weeds in wheat are the spectrum of activity and effectiveness, their physical and chemical characteristics, season and mode of application, phytotoxicity and their effect on useful organisms. This means the rotation of crops and herbicides, the use of herbicides with different and synergistic ways of action having also the suitable characteristics of selectivity and toxicity, so that endangering the environment is avoided (Markovic et al., 1996).

Weed control management is conditioned by social and economic factors. Choosing the strategy and the model to control weeds is an essential issue in the case when the factors involved are those that affect the occurrence and the intensity of growth of certain weed species. A late elimination of weeds in the case of their occurrence earlier in autumn or spring can reduce yield by more than 20%, thus imposing either the selection of the herbicides such as pendimetalin, chlorotoluron, nitrophene, isoproturon before the emergence of crops or triasulfuron with dicamba and tribenuton methyl after the emergence and during tillering phases of wheat. (Tables 4 and 7).

Table 4. Spectrum of activities of herbicides applied immediately before or after wheat emergence

Weeds	Stomp 330 E	Maraton	Prazlin 21	Tolurex 50 SC
Avena fatua	-	+	-	-
Setaria glauca	+	+	-	-
Setaria viridis	+	+	-	-
Echinochloa crus-galli	+	+	-	-
Digitaria sanguinalis	+	+	-	-
Alopecurus myosuroides	+	+	-	-
Apera spica venti	+	+	-	+
Poa spp.	-	+	+	+
Sinapis arvense	+	+	-	-
Thlaspi arvense	+	+	-	-
Amaranthus retroflexus	+	+	+	-
Capsella bursa-pastoris	+	+	-	-
Chenopodium album	+	+	-	-
Matricaria spp.	+	+	-	+
Galinsoga parviflora	+	+	-	-
Chenopodium album	-	+	-	-
Galium aparine	+	-	-	-
Lamium amplexicaule	-	+	+	-
Portulacia oleracea	+	-	+	-
Polygonum spp.	+	+	+	+
Raphanus raphanistrum	-	+	-	-
Ranunculus spp.	+	-	-	-
Hibiscus trionum	+	-	-	-
Stachus annua	+	-	-	-
Solanum nigrum	-	-	+	-
Atriplex patula	+	-	+	-
Urtica urens	-	-	+	-
Veronica persica	+	+	+	-
Papaver rhoeas	+	+	-	-
Stelaria media	+	+	-	+

Since 1940 until recently, wheat growers have relied on the herbicides from the 2.4-D group, on the amino or Na-salts at the beginning,

on esters later on. In some time intervals, their use was limited because the resistant weed species were favoured. By introducing esters the amounts applied were reduced and the spectrum of activities was extended to *Veronica* spp., *Matricaria chamomilla, Fumaria officinalis, Lamium purpureum, Viola tricolor* and *Bilderdykia convolvulus* but not to *Galium aparine*, which still limits the application of 2.4-D in wheat (Table 5).

Table 5. Broad-leaved weed species sensitive and resistant to 2.4-D herbicides

Sensitive weeds	Resistant or poorly controlled weeds
Sinapis arvensis	*Galium aparine*
Thlaspi arvense	*Matricaria chamomila*
Capsella bursa-pastoris	*Matricaria indora*
Vicia cracca	*Bifora radians*
Centaurea cyanus	*Stelaria media*
Helianthus annuus	*Lathyrus tuberosus*
Amaranthus retroflexus	*Abutilon theophrasti*
Chenopodium album	*Daucus corota*
Chenopodium hybridum	*Datura stramonium*
Atriplex patula	*Hibiscus trionum*
Salvia verticilata	*Solanum nigrum*
Cichorium intybus	*Xantium strumarium*
Daucus carota	*Polygonum amphibium*
Erigeron canadensis	*Polygonum lapathifolium*
Ranunculus arvensis	*Polygonum persicaria*
Rumex spp.	*Viola tricolor*
Sonchus asper	*Anthemis arvensis*
Urtica urens	*Fumaria officinalis*
Melilotus officinalis	*Mentha arvensis*
Galinsoga parviflora	*Mentha longifolia*
Geranium dissectum	*Veronica hederifolia*
Cirsium arvense	*Veronica persica*
Taraxacum officinale	*Bilderdykia convolvulus*
Sambucus ebulus	*Convolvulus arvensis*
Plantago major	*Lamium purpureum*
Consolidia regalis	*Myosothis arvensis*
Papaver rhoeas	*Rubus caesius*
Raphanus raphanistrum	*Euphorbia* spp.
Lepidium draba	
Sysimbrium sophia	
Agrostema githago	
Brassica nigra	
Diplotaxis muralis	
Anagalis arvensis	

The problem concerning *Galium aparine* is successfully dealt with by introducing the herbicides based on fluroxipir, florasulam, dicamba, cinidon-ethyl and amidosulfuron (Starane, Mustang, Banvel, Orbit, Grodyl, Sekator) (Table 6). Fluroxipir belongs to the group of the indoleacetic acid, the most selective and effective herbicides for controlling *Bilderdykia convolvulus, Galium aparine* and *Stellaria medea* in wheat. Florasulam inhibits ALS. Highly selective, it is absorbed through the root and leaves; in regard to fluroxipir its spectrum of activity is wider and is extended to the weeds from the families *Brassicacea* and *Matricaria* spp. Dicamba regulates the growth of plants, and depending on the type of auxin, it affects *Ambrosia artemisifolia, Galium aparine* and *Polygonaceae.* Cinodonethyl inhibits protorfinogen oxidase while killing *Galium* spp., *Stellaria media, Xanthium strumarium, Veronica* spp. and *Lamium purpureum*. And finally, amidosulfuron is a specific herbicide for fighting *Galium aparine, Bilderdykia convolvulus* and *Anagalis arvensis* (Janjic, 2000).

The weed control management should be directed to the selection of herbicides and the simultaneous use of smaller quantities of several active substances having various mechanisms of action; its objective is to improve the effectiveness of herbicides on weeds and to upgrade their selectivity on crops. Through a wise application of herbicides a universal weed control is accomplished, and, at the same time, the appearance of resistance of weed species to herbicides is prevented and the damaging effects of residues on the environment are avoided (Table 7).

Metsulfuron methyl is a systemic urea sulfonyl herbicide which acts on broad-leaved weeds through the root and leaves, by stopping the cell division on root tips and plant shoots. Symptoms of their action are manifested by the change in colour, necrosis, and the death of tissue after 2-3 weeks. It is one of the most effective herbicides in controlling *Cirsium arvense, Bifora radians, Daucus carota, Phacelia tanacetifolium, Vicia* spp., *Viola* spp., *Rumex* spp., *Urtica urens* and *Taraxacum officinale.*

The right model for controlling weed in wheat is based on the application of the optimal amounts of herbicides on a given plot of land and a system of rotation of crops, agricultural measures and herbicides in a way that will prevent the growth of seeds in weeds through the use of active sub-

stances with various mechanisms of activity. That is how *Ambrosia artemisifolia* is successfully controlled in wheat with the herbicides based on 2.4-D or with dicamba and through the system of crop rotation, utilizing atrazine or linurone in maize, klopiralide and desmedifam with fenmedifam in sugar beet, imazetapir and metribuzin in soybean and acetochlore with fluorochloride in sunflower.

Table 6. Spectrum of activity of specific herbicides in wheat crop

Weeds	Primus 0.15	Grodyl 0.04	Starane 1.2	Orbit 0.35 ml/ha	Banvel 480 S 0.5 l/ha
Galium aparine	+	+	+	+	+
Stellaria media	+	-	+	+	+
Matricaria spp.	+	-	+	-	+
Polygonum persicaria	+	-	-	-	+
Polygonum lapathifolium	+	-	+	-	+
Polygonum aviculare	-	-	+	-	+
Bilderdykia convolvulus	+	+	+	-	+
Sinapis arvensis	+	+	-	-	+
Thlapsi arvense	+	+	-	-	+
Capsela bursa-pastoris	+	+	-	-	+
Anagalis arvensis	-	+	-	-	+
Convolvulus arvensis	-	-	+	-	+
Rubus spp.	-	-	+	-	-
Taraxacum officinale	-	-	+	-	-
Rumex crispus	-	-	+	-	-
Urtica dioica	-	-	+	-	-
Calystegia sepium	-	-	+	-	-
Ranunculus repens	-	-	+	-	+
Helianthus annuus	-	-	+	-	+
Solanum nigrum	-	-	+	-	+
Aristolochia clematitis	-	-	+	-	-
Datura stramonium	-	-	+	-	+
Abutilon theophrasti	-	-	+	-	-
Ambrosia artemisifolia	-	-	+	-	+
Myagrum perfoliatum	-	-	+	-	+
Fumaria officinalis	-	-	+	-	+
Consolida regalis	-	-	-	+	+
Veronica hederifolia	+	-	+	+	+
Xanthium strumarium	-	-	-	+	+
Papaver rhoeas	-	-	-	+	+
Lamium purpureum	-	-	+	+	+

Tabela 7. Degree of effectiveness of herbicides on dominant weed species in wheat in the phase starting from the six-seventh leaf until the emergence of the first node

Weeds	Mustang 0.6 l/ha	Lancet 1.2	Sekator 0.3	Lintur 0.2	Laren 0.01
Polygonum persicaria	+ + + + +	+ + +	+ + + +	+ + + + +	+ + + +
Datura stramonium	+ + + + +	+ + + + +	+ + + +	+ + + +	O
Xantium strumarum	+ + + + +	+ + + + +	+ + + + +	+ + + + +	O
Ambrosia artemisifolia	+ + + + +	+ + + + +	+ + + +	+ + + +	O
Galium aparine	+ + + + +	+ + + + +	+ + + + +	+ + + + +	O
Cirsum arvense	+ + +	+ +	O	+ + + +	+ + + + +
Sinapis arvensis	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
Bilderdykia convolvulus	+ + + + +	+ + + +	+ +	+ + + + +	+ + + + +

Convolvulus arvensis	O	O	O	O	O
Amaranthus retroflexus	+ + + + +	+ + + + +	+ + + + +	+ + + +	+ + +
Abutilon theophrasti	+ + + +	+ + + +	+ + +	+ + + +	O
Solanum nigrum	+ + + + +	+ + + +	+ + +	+ +	O
Chenopodium album	+ + + + +	+ + + + +	+ +	+ + +	+ + + ++
Ranunculus spp.	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + +
Matricaria chamomila	+ + +	+ +	+ + + +	+ + + +	+ + + + +
Rubus caesius	O	+ +	O	+ +	O
Consolida regalis	+ + + + +	O	+ +	+ + + +	+ + + + +
Papaver rhoeas	+ + + + +	O	+ + + + +	+ + + + +	+ + + + +
Stellaria media	+ + + +	O	+ + + +	+ + + + +	+ + + + +
Veronica persica	+ + + + +	O	+ + + + +	+ + + +	+ + +
Lathyrus tuberosus	O	O	O	O	O

Legend:
+ + + + + Effectiveness of herbicides is total; + + + Effectiveness of herbicides satisfies; + + Effectiveness of herbicides is unsatisfactory

In a similar way *Iva xanthifolia* and *Xanthium strumarium* are controlled in wheat and sugar beet, while in sunflower klomazon is used, nikosulfuron or rimsulfuron are applied in maize and imazetapir or bentazon in soybean. The cosmopolite species *Polygonum persicaria* and *P. lapathifolium* can be eliminated over a few years using florasulam and chlortoluron in wheat, nikosulfuron and atrazin in maize, acetochlore and oxifluofen in sunflower, imazetapir and fomesafen in soybean, dimeten amid with the existing herbicide combinations in sugar beet. In this way weeds are under man's control, there is no occurrence of persistent or resistant weeds and a production without losses of yield in amount or quality is realised (Markovic et al., 1996).

CONCLUSIONS

Weed control in wheat is solely performed by the application of herbicides and appropriate agricultural measures along with the use of herbicides for dominant weed species in the system of rotation of field and vegetable cultures.

The most reliable solution to the problem of weed in wheat is to prevent the germinating and spreading of resistant weeds. The problem is made simpler through the system of crop rotation and by the introduction of specific herbicides based on fluroxipir, amidosulfuron, florasulam and cinidon-ethyl, depending on the occurrence of problematic weeds.

In the system of management and an integrated wheat protection, a model of weed control is established on a regional and global basis for a period longer than 5 years, thus implying fundamental changes in the introduction of new technologies, transgenic cultivars and new herbicides.

REFERENCES

Janjic, V., 2000. Znacaj ruderalne akvaticne flore i potreba za njenim suzbijanjem. VI Kongres o korovima, Banja Koviljaca: 40-51.

Kojic, M., Janjic, V., 2000. Razvoj herbologije u Jugoslaviji. VI Kongres o korovima, Banja Koviljaca: 9-18.

Markovic, M., 1995. Uticaj herbicida i njihovih rezidua na biološke ososbine ozimih sorti pšenice. XI Savetovanje agronoma i tehnologa, Beograd.

Markovic, M., Konstatinovic, B., Mandic, R., 2000. Stepen efikasnosti i selektivnosti herbicida u kukuruzu. VI kongres o korovima, Banja Koviljaca.

Markovic, M., Protic, R., Pavlovic, S., Martic, M., 1994. Uticaj herbicida na biomasu i visinu prinosa pšenice. III kongres o zaštiti bilja, Vrnjacka banja.

Markovic, M., Vasin, S., Protic, R., Martic, M., 1996. Uticaj herbicida na biološke osobine pšenice. V Kongres o korovima , Banja Koviljaca: 524-529.

Vrbnicanin, S., Kojic, M., 2000. Biološko i ekološko proucavanje korova na podrucju Srbije. VI Kongres o korovima, Banja Koviljaca: 19-35.