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EFFECT OF REDUCED HERBICIDE DOSAGES ON WEED INFESTATION IN SPRING BARLEY

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Abstract

Herbicide efficacy testing field trials were carried out at the Estonian University of Life Sciences in 2005–2007. The present paper deals with the efficacy of the "I-Taimekaitse (PC plant protection)" decision support system weed control module and with possibilities to use reduced herbicide dosages in chemical weed control. The results from the medium- and high-efficiency weed control models used in the experiment are positive.

Banvel 4S with narrow effect spectrum was of lowest efficiency, even when full doses were used. Sekator OD and Mustang were with wide effect spectrum and their efficiency in controlling any of the weeds was higher than the effect of other herbicides, even if quarter of full doses was used. Full or half doses of Ariane S were successful in controlling most of the herbicides in the experiment.

Key words: herbicide dosage, efficacy, weeds, I-Taimekaitse.

Introduction

Herbicides ensure the preservation of crop and yield, and are recommended in all modern agricultural enterprises. The increased concern for the effect of pesticides on the environment, resistance of weeds to herbicides, and the need to decrease expenses on chemical weed control have brought about the necessity to use herbicides at lower doses. The standard doses recommended by the manufacturers of plant protection products have been set to ensure control efficacy in severe conditions. In most cases, it is not necessary to apply the full doses. According to trials, it is possible to use only 35% of the standard dose of herbicides on spring cereals /Rydahl, 1999; Talgre et al., 2004; Auskalnis, Kadzys, 2006/ without decreasing the yield of cereals or increasing weed infestation. Trials conducted in Poland showed that the mass of most weed species decreased significantly when the herbicide dose was decreased by 50%–75% /Domaradzki, 2003/. Reduced herbicide dosages demand strong and competitive cereals. If the herbicide has been carefully selected and sprayed at the right time, it is always possible to apply lower herbicide doses to strong and competitive cereals /Pallutt, 1999/.

Most selective herbicides will control only a limited spectrum of the weeds dominating in the region. With increasing complexity in local weed infestations, the relevance of using tank-mixtures increases simultaneously. Economic and other interests can also motivate the use of tank-mixtures /Rydahl, 1999/. Herbicide mixtures of different ingredients are effective only if the weed species are sensitive to both herbicides /Kudsk, Streibig, 2003/.

Materials and Methods

Herbicide efficacy testing field trials were conducted in Tartu during the period of 2005–2007. The trials were a randomized block design with three replicates. All herbicides were used at full, ½ and ¼ doses. The tested herbicides are listed in Table 1.

In addition to the herbicides listed in Table 1, two more treatments were added to the trials each year. The treatments were sprayed according to the recommendations of "I-Taimekaitse" – the Estonian decision support system for weed control. Before spraying, weeds were recorded for their corresponding treatments (weed specimens were counted by species, and their developmental stages were determined on 3 x 0.25 m^{-2} plots). The results were inserted into the "I-Taimekaitse" model.

Herbicides were applied when weeds were at 2–6 true leaf stage and cereals at growth stage BBCH 20–22. Weed assessment was made on the individual weed species in 3 x 0.25 m^2 per plot 4 weeks after herbicide application. All weed specimens in all replicates were collected, counted and weighted by species. The unsprayed control treatment was used for comparison.

Efficacy of the herbicides by number and by mass of weeds was calculated by formula:

$E = (M_1-M_2)/M_1*100$

M_1 – weed number or mass per m^2 on untreated plots

M_2 – weed number or mass per m^2 on plots treated with herbicides

Table 1. Tested herbicides

Trade name	Active ingredients	Full dosage
Banvel 4S **	Dicamba 480 g l^{-1}	0.22 l ha^{-1}
Sekator 375 OD	Amidosulfuron 100 g l^{-1} + jodosulfuron-metyl-natrium 25 g l^{-1} + mefenpyrodietil 250 g l^{-1}	0.15 l ha^{-1}
Mustang	Florasulam 6.25 g l^{-1} + 2,4 D 2EHE 452.5 g l^{-1}	0.6 l ha^{-1}
Granstar Preemia 50SX*	Tribenuron-methyl 500 g kg^{-1}	22.5 g ha^{-1}
Ariane S***	Fluroxypyr 40 g l^{-1}; clopyralid 20 g l^{-1}; MCPA 200 g l^{-1};	2.0 l ha^{-1}
Arrat***	Dicamba 500 g kg^{-1} + tritosulfuron 250 g ha^{-1}	130 g ha^{-1}

* – removed 2007, ** – only in the 2005, *** – included in the experiments in 2006

The spring barley was sprayed as follows: in 2005, Lintur 70 WG 118 g ha^{-1} for medium efficacy, and Lintur 70 WG 150 g ha^{-1} for higher efficacy; in 2006, Primus 0.014 l ha^{-1} + Lintur 70WG 114 g ha^{-1} for medium efficacy, and Lintur 70 WG 150 g ha^{-1} for higher efficacy; in 2007, Granstar Preemia 6 g ha^{-1} + Primus 0.07 l ha^{-1} for medium efficacy, and Mustang 0.36 l ha^{-1} + Banvel 0.2 l ha^{-1}for higher efficacy. The article deals with the efficacy of herbicides on the weed mass four weeks after herbicide application.

In 2005, the weather was wet in May, and warm and dry in July. In 2006, the weather was moderately warm and dry. The May of 2007 was wet, whereas June was dry and warm (Table 2).

Table 2. Weather conditions of 2005–2007 (according to the Erika weather station) and the average of 1966–1998* in Tartu (Jaagus, 1999)

Month	Air temperatures °C				Precipitation mm			
	2005	2006	2007	Average*	2005	2006	2007	Average*
April	5.0	6.2	5.8	4.2	22	15	23.4	33
May	10.8	11.9	12.6	11.6	114	34	72.4	55
June	14.4	16.2	16.9	15.1	54	47	28.4	66
July	19.5	18.7	17.3	16.7	22	16	72.2	72

The experimental findings were processed by the correlation analysis method.

Results and Discussion

A total of 14 weed species were registered in the field. The main weed species on the experimental area were *Stellaria media* (STEME), *Thlaspi arvense* (THLAR), *Chenopodium album* (CHEAL), *Galium aparine* (GALAP), *Fumaria officinalis* (FUMOF) and *Lamium purpureum* (LAMPU). In 2007, weed infestation of the experimental area was low – the number of weeds on the unsprayed control treatment was 74 m^{-2} and their mass was 53.3 g m^{-2} (the respective figures for 2006 were 214 m^{-2} , and 473.4 g m^{-2}; and in 2005, 131 m^{-2}, 146.8 g m^{-2}).

The narrow-spectrum Banvel 4 S, which was included in the trial in 2005, had the lowest efficacy. Its control efficacy percentage remained low with most weeds even at full dosages. At quarter doses, it can be used for *Chenopodium album* control, the efficacy being 79%. The control efficacy remained low at the full dose with *Euphorbia helioscopia* (EPPHE), *Viola arvensis*, *Sinapis arvensis* (SINAR) and *Fumaria officinalis*. Consequently, it can be used only in mixtures with other herbicides. The trial conducted in Saku in 2003 also showed that the total efficacy of Banvel 4 S reached up to 40% even at full dose /Uusna, Kastanje, 2006/.

Sekator, Granstar Preemia and Mustang have a wider spectrum, and can be used at reduced doses if the weeds are in their optimum (two to four true leaves) growth stage (Table 3). Granstar Preemia had the most stable efficacy during the trial years, being less dependent on weather conditions as compared to other herbicides.

One of the problematic weeds in spring cereals is *Galium aparine*. Florasulam is an active substance against *Galium aparine* /Singleton-Jones, Bailey, 2001/. Of all the herbicides used in Estonia, Mustang is the one containing florasulam. Earlier trials have shown that lower doses of Granstar Preemia were unable to control this weed species /Talgre et al., 2004/. Ariane S is effective in controlling problematic weeds, such as *Tripleurospermum inodorum* (MATIN) and *Galium aparine*. Even at full doses, Ariane

S proved moderately effective in controlling *Viola arvensis* (Table 3). The efficacy of herbicides is significantly influenced by the climate /Talgre et al., 2004/. Herbicide efficacy is considerably lower in drought conditions as compared to normal plant growth conditions. In 2006, the efficacy of most herbicides remained low as compared to other trial years. With drought, *Fumaria officinalis* cannot be controlled by the reduced doses of Ariane S and Mustang.

Table 3. The efficacy of herbicides used in the trial at different doses for controlling the most widespread broadleaf weeds in 2005–2007

		Granstar		Sekator OD			Ariane S			Mustang		
		2005	2006	2005	2006	2007	2005	2006	2007	2005	2006	2007
VIOAR	1	90	99	98	85	91	45	49	92	72	100	76
	½	86	96	97	80	67	48	44	90	74	84	61
	1/4	98	92	93	65	71	40	35	69	74	93	70
THLAR	1	100	100	100	100	98	99	99	100	100	100	95
	½	100	100	100	100	100	99	98	100	100	100	100
	1/4	99	100	100	98	100	100	98	100	100	100	100
CHEAL	1	100	100	100	90	92	97	100	100	100	100	100
	½	100	100	99	83	74	100	98	100	100	100	100
	1/4	99	100	98	76	100	95	100	100	93	99	97
FUMOF	1	98	100	100	93	93	99	88	99	87	76	97
	½	98	100	97	77	89	97	50	96	96	65	92
	1/4	97	98	93	65	80	50	68	95	78	38	92
GALAP	1	X	100	X	90	98	X	95	97	x	100	97
	½	X	98	X	91	100	X	87	97	X	99	98
	1/4	X	96	x	96	89	x	96	95	X	100	92
LAMPU	1	100	100	100	96	100	100	97	92	80	84	97
	½	0	100	100	93	100	0	79	100	0	75	100
	1/4	0	98	0	93	100	0	79	73	0	80	74
		R=0.19		R=0.29			R=0.29			R=0.2		

The efficacy of herbicide Arrat, which was included in the trial in 2006, proved lower as compared to other herbicides, and decreased considerably with reduced doses (R = 0.41*) (Figure 1).

Weed control conducted in accordance with the Estonian plant protection model "I-Taimekaitse" is based on most widespread weed species and their growth stages. The shorter the weed growth stage, the greater the herbicide efficacy. Other significant parameters include the crop growth stage, the expected yield, and the soil. The prototype helps the user to make decisions concerning spraying, and to make a choice among herbicide effect spectra and price scale.

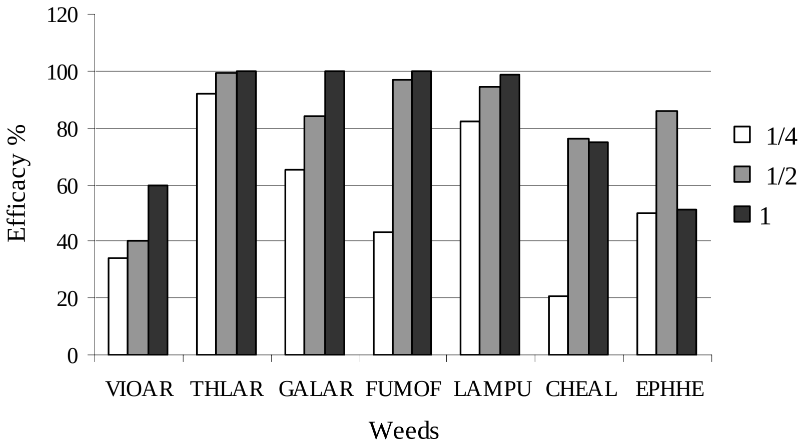

Figure 1. The efficacy of herbicide Arrat in controlling the most widespread weeds in 2006 (R = 0.41*)

New herbicides are continuously added to the "I Taimekaitse" model, and trials have been conducted since 2002 to test the prototype.

In order to assess the efficiency of the recommendations made by the Internet-based plant protection system (www.taimekaitse.eria.ee), a query was submitted to the prototype, which gave an overview of the weed species, their number and growth stages in a field, as well as the crops grown in the field and its soils. In 2005, the prototype's first recommended herbicide was Lintur 70WG with the dose of 118 g ha^{-1} for medium efficacy (expected control 80%), and Lintur 70 Wg with the dose of 150 g ha^{-1} (permitted full dose) for higher efficacy (expected control 95%). The total efficacy of the Lintur doses was >95%, and the recommended herbicide and its doses proved effective in the control of all trial weeds (Figure 2). Lintur control efficacy is 15–25 % lower if the weeds have grown 8 to 12 true leaves for the time of spraying, and have therefore become more resistant to herbicides /Uusna, Kastanje, 2006/.

In 2006, the first recommendation for medium efficacy included a mixture of two herbicides: Primus 0.014 l ha^{-1}+Lintur 70 WG 114 g ha^{-1}; and Lintur 70 WG 150 g ha^{-1} for higher efficacy. Mixtures of herbicides with reduced doses have proven more effective in weed control than single herbicides applied at higher doses (Figure 3).

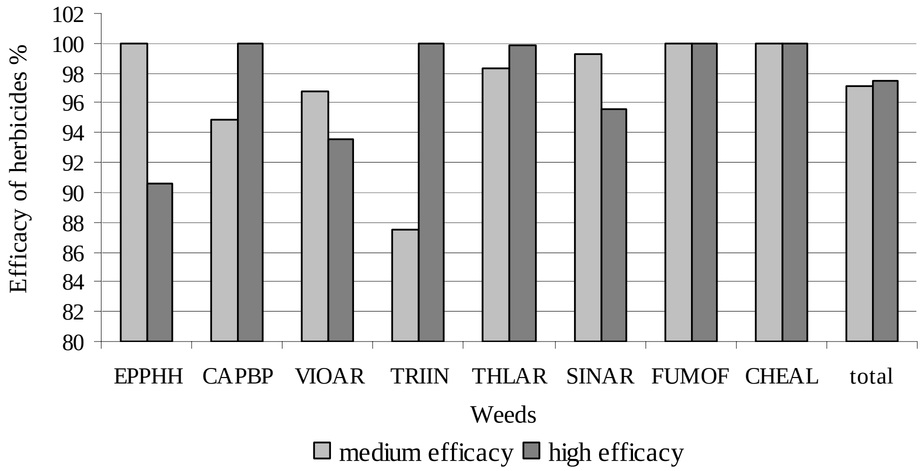

Figure 2. Efficacy of the herbicides in I-Taimekaitse trial in 2005

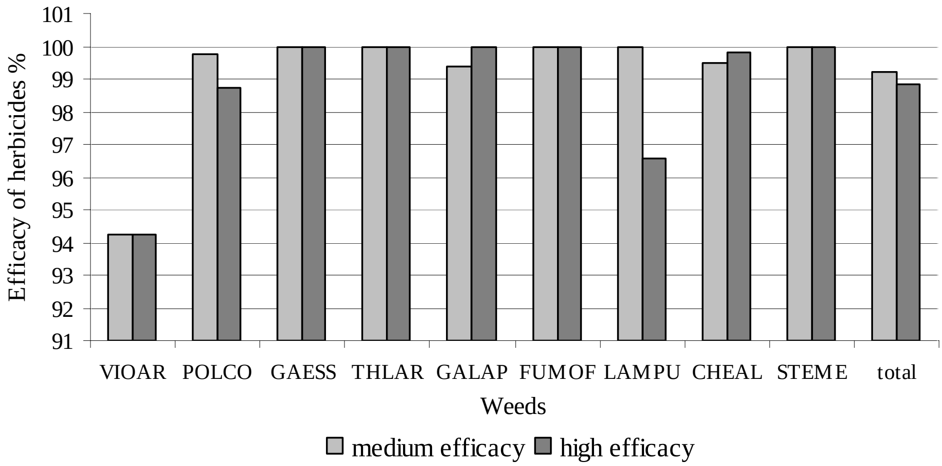

Figure 3. Efficacy of the herbicides in I-Taimekaitse trial in 2006

In 2007, the number of weeds was very low, but there were various hard-to-control species in the experimental field (GALAP, POLCO *(Polygonum convolvulus)*, GAESS (*Galeopsis sp*.)). In accordance with the conditions, the prototype recommended a mixture of herbicides with very low doses: Granstar Preemia 6 g ha^{-1} + Primus 0.07 l ha^{-1} for medium efficacy; and Mustang 0.36 l ha^{-1} + Banvel 0.2 l ha^{-1} for higher efficacy. The expected efficacy was not reached in *Fumaria officinalis* control (Figure 4).

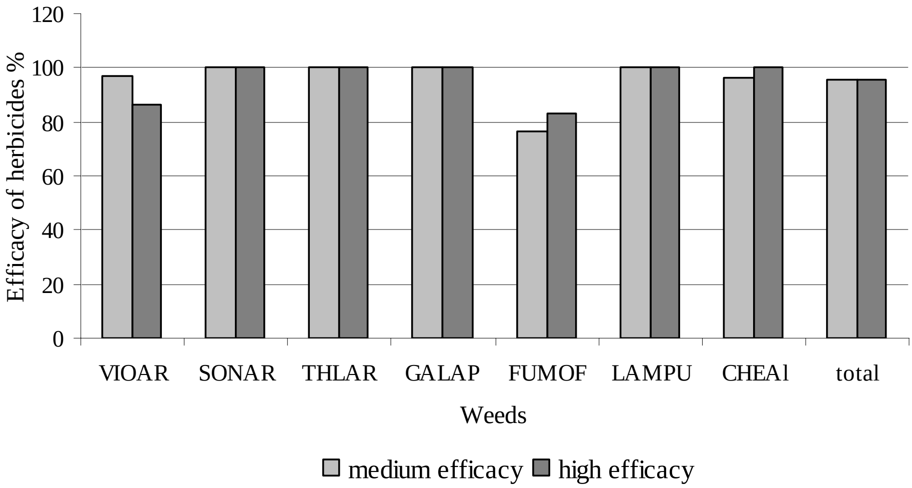

Figure 4. Efficacy of the herbicides in I-Taimekaitse trial in 2007

The recommendations made by the plant protection model "I-Taimekaitse" have proved effective also in trials conducted elsewhere in Estonia. Herbicides can be used also at their third doses for good control efficacy and economically rational result. The efficacy of herbicides was 85–100% in controlling most weed species /Uusna, Kastanje, 2006/.

Conclusions

1. Herbicides can be used at reduced doses on fields if the weed species correspond to the effect spectrum of the herbicide.

2. The plant protection model "I-Taimekaitse" is effective in spring barley and has big potential for optimizing the use of herbicides with reduced dosages according to the needs. In its present form, "I-Taimekaitse" is a system which aids in choosing the optimum control treatments that are also economically most advantageous.

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