Effectivity of reduced dosages of herbicides to weed constitution of spring barley I

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Abstract. The barley variety 'Ansis' was cultivated in the field at the State Stende Plant Breeding station, 2001–2004, in sod podzolic and sod–gleysolic sand loamy soil with neutral soil response. Average annual dicotyledonous weed infestation level in trial years differed: 106.9 weed plants per m^2 in the year 2001; 213 in 2002; 22.7 in 2003, and 216 in 2004. *Thlaspi arvense* (L.) was the most widespread weed in 2001, 2002 and 2004 trial years, but *Chenopodium* spp. was dominant in 2003–2004, and *Polygonum convolvulus* (L) in 2004. *Lamium* spp. was also widespread in all-trial years, *Viola arvensis* (Murray) in 2001, 2002 and 2004; *Stellaria media* (L.) in 2002 and 2003, and *Capsella bursa–pastoris* (L.) in 2002 and 2004.

The effect of herbicides is usually calculated as decrease in weed number and as decrease of fresh weight of weeds (% to control or % to initial amount). In this article the ratio of one weed's weight after herbicide use to one weed's weight in control is recommended for comparing effectiveness of the doses of herbicides to weeds. The effectiveness of herbicides is estimated as a special factor EfKo. The reduction of herbicide doses to one half or one fourth of recommended dosage usually had no significant effects on weed control.

Key words: herbicide, reduced dosages, weeds

INTRODUCTION

Weeds compete with cultivated plants regarding nutrition elements and other resources within grain-crop sowings. They decrease the quality of production and increase the costs of the initial process of grain treatment. Therefore limiting weed spreading is a very important measure of grain-growing technologies. Currently the most dominant method in the struggle against weed spreading is the use of herbicides (Bourdôt et al., 1996), but as a result, the pollution of the environment is increasing. Research shows that several herbicides influence life functions of warm-blooded animals (mice and rats) (Bellet et al., 2001; Kostka et al., 2002; Sissell, 2002; Pickrell, 2002). Solving the environmental pollution problem is in the centre of attention in the whole world at the present moment, especially in more industrially developed countries. Research on the possibilities of decreasing the amount of herbicides used, including studies of the effectiveness of decreased herbicide dosages, is one of the possible steps in this process (Courtney, 1991; Boerboom, 1992; Mitchell, 1998; Walker et al., 2002). The effectiveness of the use of herbicides, including use of reduced dosages, depending on the time of the day has been investigated (Miller et al., 2003). Investigations on the effectiveness of reduced herbicide dosages have also been carried out over several years in the State Stende Plant Breeding Station in Latvia.

MATERIALS AND METHODS

The barley was cultivated in the field at the State Stende Plant Breeding station, 2001–2004. The barley varieties 'Ansis' was grown in sod podzolic sand loamy and sod–gleysolic soil (Table 1).

Table 1. Soil characteristic, Stende, 2001–2004.

Indices	2001	2002	2003	2004
Pre–plant	Rye	Barley with peace	Spring wheat with peace	Red clover for seeds
pH	5.7 – 5.9	6.0 – 6.6	6.3 – 6.6	5.4 – 5.9
Humus content, g kg^{-1}	20 – 21	20 – 21	23 – 25	14 – 18
P_2O_5, mg kg^{-1}	315 – 319	292 – 390	85 – 92	182 – 199
K_2O, mg kg^{-1}	244 – 249	160 – 179	86 – 51	167 – 180

Conventional cultivation of soil – autumn tillage and pre–sowing cultivation - has utilized the Kuhn cutter. The barley–seeding rate was 400 germinating seeds per 1 m^{-2}. The sowing was done by a sowing machine, Juko 2500, on May 3, 2001; April 23, 2002; May 5, 2003 and April 19, 2004. The field experiment was carried out at random in 4 replicates, plot size 20 m^{-2}. The rate of fertiliser was 666 kg ha^{-1} (N 18: P 9: K 9), applied locally with dissemination. Six (6) different herbicides were used in the field experiment in crop growing stage (GS) 26–29 (by Zadoks) and 3–herbicide dosages in 4 replicates (Table 2). Weed growth stage at the moment of treatment varied from 17 GS (the first true leave) to 30 GS (stem or rosette development) depending upon climate conditions and the kind of weed species (by EPPO Standard).

Table 2. Herbicides and their dosages used on spring barley, Stende, 2001–2004.

Herbicides	Full recommended dosage (1/1)	Half dosage (1/2)	Quarter dosage (1/4)
Tribenuron–methyl (Granstar, 750 g a.i. kg^{-1}, Du Pont de Nemour)	15 g ha^{-1}	7.5 g ha^{-1}	3.75 g ha^{-1}
Amidosulfuron (Grodil, a.i. 75%, Bayer CropScience)	40 g ha^{-1}	20 g ha^{-1}	10 g ha^{-1}
Dicamba + triasulforon (Lintur, a.i. 65.9% and a.i. 4.1%, Syngenta Crop Protection AG)	150 g ha^{-1}	75 g ha^{-1}	37.5 g ha^{-1}
MCPA (MCPA 750, g a.i. L^{-1}, BASF)	2 L ha^{-1}	1 L ha^{-1}	0.5 L ha^{-1}
Dihlorprop–P + mekoprop–P + MCPA (Duplozan Super, 310 g a.i. L^{-1} + 130 g a.i. L^{-1} + 160 g a.i. L^{-1}, BASF)	2 L ha^{-1}	1 L ha^{-1}	0.5 L ha^{-1}
Fluroxypyr (Starane, 180 g a.i. L^{-1}, DowAgro Sciences Danmark)	0.700 L ha^{-1}	0.350 L ha^{-1}	0.175 L ha^{-1}

The fungicides epoxiconozol and fenpropimorph (Tango Super, 84 g a.i. l^{-1} + 250 g a.i. l^{-1}, BASF) 1.25 l ha^{-1} have been used in GS 47–49. Because of an aphids invasion in 2002, insecticide thiametoxam (Aktara, a. i. 250 g kg^{-1}, Syngenta Crop Protection AG) 0.07 g ha^{-1} was used.

The year 2001 was characterised by a wet and warm end of June-beginning of July, but in 2002 drought and a warm end of July was observed. In the beginning of spring, 2003 the weather was moderately warm and dry, but in the middle of June, when moisture provision improved, the growing conditions were optimal. The spring in 2004 was cool and dry; summer, cool and wet.

The recording of annual dicotyledonous weeds was performed in 3 fixed places (recording area 0.25 m^{-2}, n = 12), twice: first ,before treatment with herbicides, and again 4–6 weeks after the treatment,, defining the green mass of each weed species (g).

The Microsoft Excel programme did mathematical analysis of the data. The average mass of the weed (ratio of fresh mass of weeds in the second recording to number of weeds in the first recording) in the control variant (m_{kv}) and in processed variants (m_v) was calculated. One–factor dispersion analysis for the obtained ratio was calculated, using the smallest essential border difference ($\gamma_{0.05}$) and the Fischer criterion (F). The effectiveness of herbicides was estimated as a special factor EfKo (proposed by us), which has been calculated according to the formulae: EfKo = $1 - m_v/m_{kv}$, where m_v = average mass of weed (annual dicotyledonous weeds) on the experimental variant, and m_{kv} = average mass of weed (annual dicotyledonous weeds) on the control variant.

RESULTS AND DISCUSSION

The effectiveness of herbicides can be calculated comparing the number of weeds in processed variants to the number of weeds in the control variant, or as compared to the first registration, if both registrations have been recorded in the same place. It has been elicited that there are no essential differences between these methods of calculation of the effectiveness of herbicides (Kopmanis, 2003).

However, this conclusion can be ascribed only to sufficiently high and sufficiently even weed biomass background. Unfortunately our experiment has been conducted in well-cultivated soils where the level of weed biomass is not very high. It was especially low in 2003, with a result that the invasion of some weed species was rather uneven, both in registration areas and especially by years. Average annual dicotyledonous weeds infestation level in trial years differed: 106.9 weed plants per m^2 in the year 2001, 213 in 2002, 22.7 in 2003 and 216 in 2004. *Thlaspi arvense* (L.) was the most widespread weed in 2001, 2002 and 2004 trial years, but *Chenopodium* spp. in 2003, 2004 and *Polygonum convolvulus* (L) in 2004. Also *Lamium* spp. was widespread in all trial years, *Viola arvensis* (Murray) in 2001, 2002 and 2004, *Stellaria media* (L.) in 2002 and 2003, and *Capsella bursa–pastoris* (L.) in 2002 and 2004. The estimate of the effectiveness of herbicides on the basis of the number of weeds is not objective as such, especially in research where reduced dosages of herbicides have been used. It points only to the effect of total extermination of weeds, but does not show the extent of their stifling. The comparison based on the mass would be more objective. The number of weeds of some species differed considerably on the plots processed with herbicides from the control plots. Therefore, because of the aforementioned unevenness of weeds, such comparison does not provide a full idea of the influence of herbicides and their dosages. This is especially so when analysing each weed species separately. Therefore we considered it to be more objective to estimate by a special coefficient, which shows the mass of one particular plant of weed on the processed plots, in comparison with the same indices on control plots. It was calculated by the methodological formula using the average biomass of weed. The average biomass of weed was used to get coefficient EfKo. It was analysed using ANOVA to determine which differences were significant; mean values were separated by Fisher's protected γ ($P \leq 0.05$). Its values are within the limits of 0 (total lack of effectiveness) to 1 (100% effectiveness), which was used to test the effect of herbicide doses in years 2001–2004 (Table 3).

Table 3. Control of short life dicotyledonous weeds in spring barley, factor EfKo.

Years	Dosages	Herbicides					
		Granstar	Grodil	Lintur	MCPA	Duplosan Super	Starane
2001	1/1	0.66	0.49	0.65	0.76	0.88	0.26
	1/2	0.84	0.13	0.79	0.64	0.86	-0.24
	1/4	0.59	-0.38	0.85	0.79	0.71	-0.46
	$\gamma_{0.05}$	0.400	1.145	0.343	0.345	0.165	1.185
2002	1/1	0.89	0	-0.27	0.70	0.58	-0.47
	1/2	0.58	-0.21	0.17	0.57	0.48	-0.63
	1/4	0.56	-0.23	-0.03	0.30	-0.27	-0.87
	$\gamma_{0.05}$	0.280	0.614	0.934	0.342	0.697	1.525
2004	1/1	0.88	0.79	0.93	0.72	0.77	0.15
	1/2	0.90	0.64	0.88	0.69	0.65	0.07
	1/4	0.93	0.59	0.79	0.49	0.55	-0.09
	$\gamma_{0.05}$	0.080	0.269	0.126	0.255	0.284	0.742

The results essentially differed among years. The main reason could be the meteorological conditions affecting agriculture. Thus in 2001, in damp and cool weather, four of six herbicides used in the tests produced good results. The dosages of these herbicides were not significant. In 2002 spraying was done in warm and dry weather (the average relative humidity was only 49%). Two herbicides, Granstar and MCPA produced good effectiveness. One fourth of the recommended dosage for Granstar this year had essentially less activity than the recommended dosage but, for MCPA, the quarter dose had no essential activity at all. The use of Grodil, Lintur and Starane was ineffective. Goosefoot (*Chenopodium* spp.) was tough, especially in dry weather. 2003 was unfavourable for tests of herbicides, as there was a very small number of weeds. This influenced the data dispersion. As a result only Granstar showed some activity in comparison with control. The best year for our experiments was 2004. It was cool and wet with maximal infestation level of weeds. Five of six herbicides used in the tests produced good effectiveness. The dosages of these herbicides had no importance.

Thus only Granstar expressed itself as a universal herbicide that can be used under different meteorological conditions and is effective when used on a wide spectrum of weeds. In optimum growing conditions of weeds, there was no essential difference in the choice of herbicide. An exception is Starane, because a very specific spectrum of weeds was sensitive to it. Very different activity of Grodil in different years can be explained by the structure of weed species on tested fields, as there were no *Galium aparine* (L.) and perennial weeds, such as *Taraxacum officinale* (Web. agg.) etc., which are not characteristic for grain sowings. So in 2001, the most widespread weeds were *Thlaspi arvense* (L.), *Chenopodium* spp., *Stellaria media* (L.), *Viola arvensis* (L.) Murr., *Lamium* spp., *Spergula arvensis* (L.). In 2002 before treating the sowing with herbicides, six weeds were registered more frequently: *Thlaspi arvense* (L.), *Chenopodium* spp., *Stellaria media* (L.), *Capsella bursa–pastoris* (L.) Med., *Lamium* spp., *Veronika arvensis* (L.). In 2003, four of the most widely spread weed species were *Chenopodium* spp., *Stellaria media* (L.), *Lamium* spp., *Poligonum aviculare* (L.). In 2004 the most widely spread weed species were *Thlaspi arvense* (L.), *Polygonum convolvulus* (L.), *Chenopodium* spp., *Lamium* spp., *Stellaria media* (L.), *Viola arvensis* (L.) Murr.

In the case of very different infestation of annual dicotyledonous weeds year by year, in different types of soils, and depending upon weather conditions, it would be purposeful to investigate separate species of weeds separately. Starane and Lintur were investigated in Study and Research Farm "Vecauce", LUA (Kopmanis, 2004) in this way. Therefore we presented our analysis of control of the most popular annual dicotyledonous weed in 2004 – *Thlaspi arvense* (L.) in this article (Table 4).

Table 4. Control of *Thlaspi arvense* (L.) in spring barley, factor EfKo, 2004.

Dosages	Herbicides					
	Granstar	Grodil	Lintur	MCPA	Duplosan Super	Starane
1/1	1	1	1	1	0.94	0.20
1/2	1	1	1	0.99	0.98	-0.19
1/4	1	0.98	0.99	0.83	0.28	-1.49
$\gamma_{0.05}$	0.000	0.021	0.016	0.099	0.495	1.863

As the data show, five of the six herbicides were very active against *Thlaspi arvense* (L.). There were no differences in activity between recommended and reduced dosages. Only MCPA had somewhat less and Duplozan Super, much less activity using one quarter (25%) of the recommended full dosage, in comparison with using 150% of it. Starane was not effective against *Thlaspi arvense* (L.).

CONCLUSIONS

1. In cases of unevenness of weeds, it is more objective to estimate activity of herbicides by a special coefficient, based on comparison of the mass of one particular plant of the weed on the processed plots with the same indices on control plots.
2. Granstar was found to be the most universal of the examined herbicides and is effective against a wide spectrum of weeds and under different meteorological conditions.

3. There was no essential difference in the choice of herbicides if the growing conditions of weeds were optimal.
4. Overall, there was no difference in activity between recommended and reduced dosages.

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