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WEED CONTROL EFFICACY OF REDUCED HERBICIDE DOSES IN SPRING WHEAT DEPENDING ON WEATHER CONDITIONS

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Abstract: The aim of trials was to determine the efficacy of three doses of herbicides in different weather conditions. There were tested two herbicide groups: hormon type herbicides and sulfonylurea herbicides. Each of the herbicide (Aminopielik Gold 530 EW, MCPA 750 SL, Duplosan Super 600 SL, Granstar 75 WG, Grodyl 75 WG, Lintur 70 WG) was applied in three doses: recommended dose, 1/2 of recommended dose and 1/4 of recommended dose. The herbicides were applied in the tillering stage of spring wheat. In some cases it is possible reducing doses of herbicides but decision about choice of herbicide type and dose should be considered in connection with weather conditions before application.

Key words: hormon type herbicides, sulfonylurea herbicides, reduced doses, weather conditions, spring wheat

INTRODUCTION

Weeds are one of the most harmful reason decreasing crops yield and therefore it is necessary to dedicate a great attention to weed control. From the middle of 20th century until today chemical weed control is the most common method used in agriculture. It is extremely difficult for alternative methods to reach so high standard set by herbicides. However using herbicides for long time did not reduce the weed problem (Dobrzański and Adamczewski 2001)

There is a clear trend to reduce the use of inputs in cereals, including herbicides. Recent concerns over environmental issues have prompted much interest and research into practices, which reduce agrochemical inputs.

Research has shown that reduced doses of herbicide can provide adequate weed control with yields largely unaffected, although the risk of regrowth may be increased (Champion and Froud-Williams 1997).

Some weed species are well controlled by most herbicides and than it is possible to use doses well below the recommended doses, whereas other weed species can be effectively controlled only with higher doses (Jensen and Rydhal 2000).

The environmental conditions during the prespraying period influence plant growth and development (Lundkvist 1997) and they can change the efficacy of herbicides (Kudsk 2001). At the spraying time and after herbicide application, weather conditions affect herbicide retention, penetration, absorption, translocation and activity (Lundkvist, 1997).

Climatic conditions before, at and after herbicide application can change the efficacy of herbicides (Kudsk 2001). Environmental factors, such as light intensity and temperature, may affect as well herbicide activity as metabolism in plants. The weed spectrum and weed growth stage must be considered, when using reduced herbicide doses (Cashmore and Caseley 1995). Many foliage applied herbicides increase activity with increasing air temperature and relative humidity and optimum water supply (Lundkvist 1997).

The effects of environmental factors on foliage absorption are very subtle acting either directly or indirectly on the plant, especially cuticle development. Absorption is generally enhanced by light and penetration is also temperature dependent. High humidity generally favours foliar absorption of herbicides possibly reflecting the increased drying time of spray droplets, enhanced stomata opening and phloem transport. Drought conditions may cause reduced absorption or translocation of herbicide. These environmental factors affect the structure of cuticule and wax. Leaves developing under full sunlight form a thicker cuticule than those expanding in the shade do. Moreover, environmental factors markedly affect the quantity, structure and chemistry of the epicuticular wax (Fletcher 1982).

Herbicide activity is influenced by many complex interactions involving weed flora, growth stage of weeds, environmental conditions and competitive ability of the crop. Under favourable conditions satisfactory weed control can be obtained with doses much lower than the recommended dose while under unfavourable conditions not even the highest dose recommended on the label may provide satisfactory weed control (Kudsk 2001). However, herbicide system may become more sensitive to the influence of weather when the herbicide doses are reduced (Lundkvist 1997). There is much information available about the efficacy of threshold and reduced applications for reducing weed control inputs (Skorda et al. 1995). However, more information is needed on the relation between weed control, reduced doses of herbicides and weather conditions.

The aim of experiments was to determine an influence of reduced doses on biological activity of several herbicides originated from different chemical groups in different weather conditions.

MATERIAL AND METHODS

The experiments were conducted within the framework of co-operation between Institute of Plant Protection in Poland and Danish Institute of Agricultural Sciences. The trials were carried out in the years 2000–2002 in the Experimental Station in Winna Góra. The tested crop was spring wheat cv. Banti, Ismena and Helia.

The spring wheat was sowing with the seeding rate respectively 240 kg/ha, 200 kg/ha and 200 kg/ha.

In the trials six herbicides from two chemical groups were compared. The first group was hormon type herbicides: Aminopielik Gold 530 EW (fluroksypyr 80 g/l, 2,4-D 450 g/l), MCPA 750 SL (MCPA 750 g/l), Duplosan Super 600 SL (mecoprop 130 g/l, dichlorprop 310 g/l, MCPA 160 g/l). The second group was sulfonylurea herbicides: Granstar 75 WG (tribenuron methyl 75%), Grodyl 75 WG (amidosulfuron 75%) and mix of sulfonylurea and hormon type herbicides – Lintur 70 WG (dicamba 65.9%, triasulfuron 4.1%). Each of the herbicide was applied in three doses: recommended dose 1/1, 1/2 of recommended dose and 1/4 of recommended dose. There were three untreated controls in every trial. The herbicides were applied at the growth stage (GS 14–5) of spring wheat. All herbicides were applied with knapsack sprayer at 200 kPa in a water volume of 230 l/ha. Herbicide applications were done: the 4th of May 2000, the 16th of May 2001 and the 10th of May 2002.

Four weeks after spraying, weed plants were collected from 1 m^2 of each plot. Plants were separated by species with the roots and the number and fresh mass was analysed.

Data analysis

The experiments were of a completely randomized block design with three replications. Two factors were estimated: herbicides and doses of applied herbicides. The data were transformed into relative units (untreated plot = 0) in order to compare the efficacy of the treatments. The response data were transformed to relative units within each block. Data of broadleaf weed control were subjected to an analysis of variance and treatment means were separated with least significant difference test (LSD 0.05)

RESULTS

Weather conditions in the year 2000

The 3rd decade of March was warm. Average temperature from decade approximated 5°C and it was about 2°C–3°C higher than average over years. Rainfall sum from decade exceeded average over years. At the beginning of the 1st decade of April was warm but at the end of the decade was colder. Temperature average carried up 6°C and the temperature was similar to average over years. The 2nd decade of April was very warm. At the end of the decade there was noted a temperature characteristic for summertime. Average temperature carried up ± 11°C. This value exceeded an average over years. Decade sum of rainfall exceeded the average over years nearly 10mm. The 3rd decade of April was exceptionally warm as for this season. Average temperature carried up 17°C and it was about 10°C higher than average over years. There wasn't any rainfall. The 1st, 2nd, and 3rd decade of May was sunny and warm and the air humidity was low. The temperature carried up ± 15°C. There wasn't any rainfall in the 1st decade of May. Amount of rainfall was ± 4 mm higher than average over years in the 2nd decade and ± 16 mm in the 3rd decade.

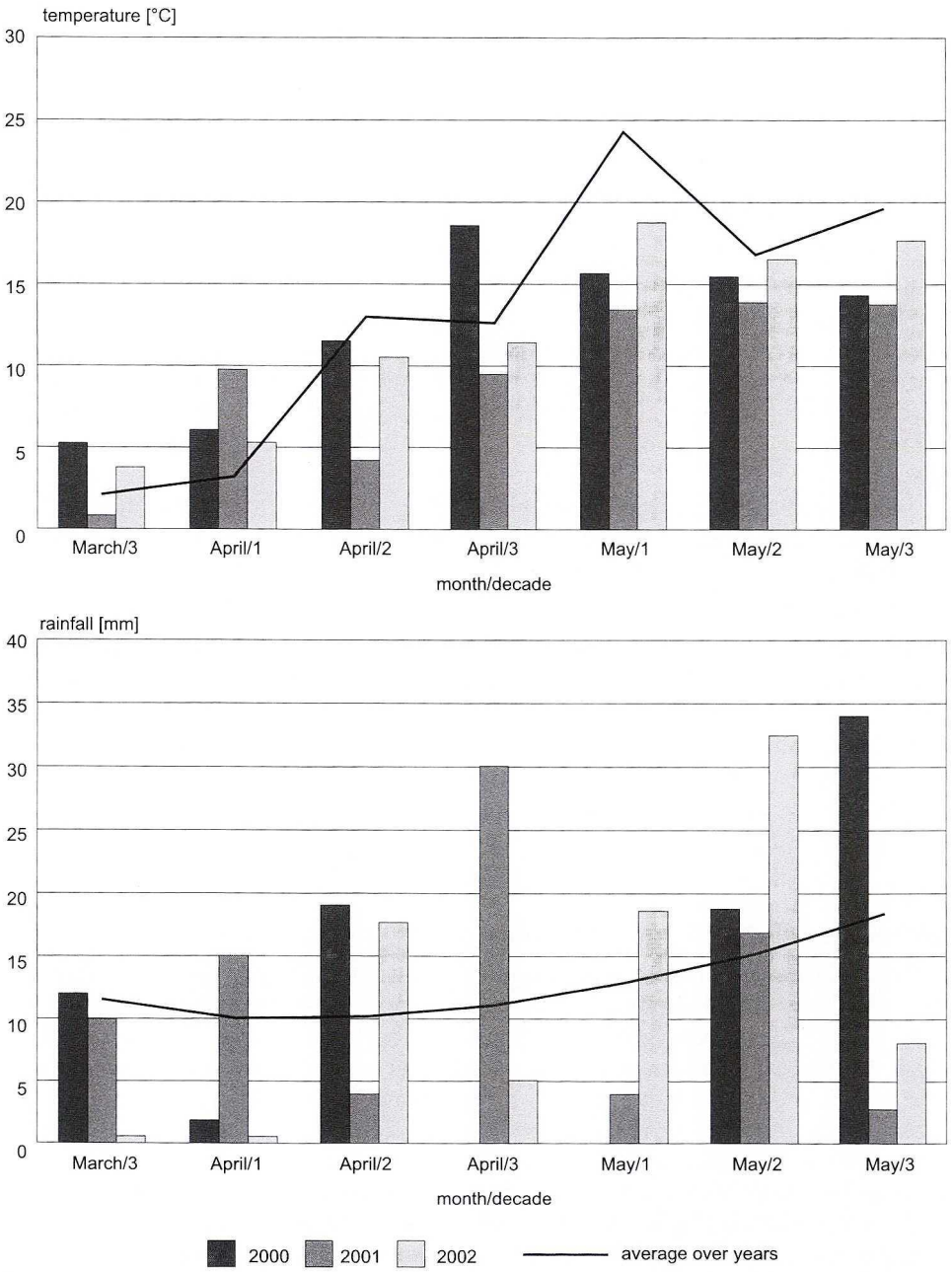

Fig. 1. Weather conditions during the experiments – decade data)

Weather conditions in the year 2001

The 3rd decade of March was cold. Average temperature carried up ±1°C. This value was ±1°C lower than average over years. The sum of rainfall carried up10 mm

and it was similar to average over years. The 1st and 3rd decade of April was very warm. Decade average carried up almost 10°C and it was definitely higher than average over years. The 2nd decade of April was colder. Amount of rainfall was lower about ±5 mm than average over years. There were mostly sunny and warm days in the 1st decade of May. Average of decade carried up 14°C. There was noted little rainfall. In the 2nd and 3rd decade of May average of temperature was similar to the 1st decade. Rainfall amount (±17 mm) was similar to average from many years. However in the 3rd decade the rainfall was lower than average over years.

Weather conditions in the year 2002

In the 3rd decade of March average of decade temperature carried up ±4°C and it exceeded average over years. There was rainfall deficiency. The temperature in the 1st decade of April ±5°C was similar to average over years. Rainfall sum was lower than 2 mm. Significant increasing of temperature over 10°C was observed in the 2nd decade of April. The rainfall exceeded an average over years almost about 9 mm. The 3rd decade of the month was very warm. Amount of rainfall was a half of an average over years. The 1st decade of May was very warm. The temperature was 17°C–18°C. Sum of decade rainfall was higher than average over years. The temperature in the 2nd decade of May (±16°C) was similar to average over years. There was observed a high quantity of rainfall– over 30 mm. This value exceeded average over years. The 3rd decade of May was very warm. The temperature carried up 17°C–18°C. The rainfall was much lower than average over years.

Table 1. Efficacy of herbicides applied in recommended and reduced doses against main broadleaf weed species during 2000 season

Treatments	Dose per ha	CHEAL		AMARE		VIOAR		GALAP		STEME	
		N	W	N	W	N	W	N	W	N	W
Aminopielik Gold 530 EW	1.2 l	90	85	99	61	33	33	100	100	10	67
Aminopielik Gold 530 EW	0.6 l	83	49	53	30	28	7	95	80	95	47
Aminopielik Gold 530 EW	0.3 l	62	43	66	32	56	33	85	67	50	33
Duplosan Super 600 SL	2.0 l	74	64	25	5	55	0	90	75	100	10
Duplosan Super 600 SL	1.0 l	77	74	83	50	44	17	98	80	50	71
Duplosan Super 600 SL	0.5 l	67	51	61	33	16	0	58	63	50	67
MCPA 750 SL	1.0 l	100	75	64	54	31	33	30	44	100	100
MCPA 750 SL	0.5 l	80	49	32	33	32	15	75	35	100	100
MCPA 750 SL	0.25 l	66	63	85	73	51	18	0	72	33	0
Granstar 75 WG	20 g	12	46	56	64	89	74	0	10	100	100
Granstar 75 WG	10 g	29	10	83	67	52	57	87	56	100	100
Granstar 75 WG	5 g	7	20	38	41	28	21	0	47	100	100
Grodyl 75 WG	20 g	37	3	99	93	56	17	97	92	50	67
Grodyl 75 WG	10 g	64	39	94	90	29	0	100	100	70	62
Grodyl 75 WG	5 g	28	16	73	81	30	17	42	22	50	50
Lintur 70 WG	160 g	71	73	85	29	97	93	80	47	100	100
Lintur 70 WG	80 g	43	38	40	33	10	0	66	56	100	100
Lintur 70 WG	40 g	64	43	64	52	74	7	66	53	100	100
Untreated ([No (g)/sq.m]	–	106	(23)	30	(4)	18	(2)	13	(6)	3	(1)

N – number of weeds; W – mass of weeds

Table 2. Efficacy of herbicides applied in normal and reduced doses against main broadleaf weed species during 2001 season

Treatments	Dose per ha	CHEAL		VIOAR		CAPBP		MATIN	
		N	W	N	W	N	W	N	W
Aminopielik Gold 530 EW	1.2 l	65	90	85	94	100	100	50	51
Aminopielik Gold 530 EW	0.6 l	50	77	67	67	100	100	100	100
Aminopielik Gold 530 EW	0.3 l	24	33	73	83	47	41	67	67
Duplosan Super 600 SL	2.0 l	56	83	89	93	100	100	83	98
Duplosan Super 600 SL	1.0 l	56	66	68	71	100	100	46	85
Duplosan Super 600 SL	0.5 l	64	53	43	33	100	100	55	80
MCPA 750 SL	1.0 l	65	61	96	92	67	85	100	100
MCPA 750 SL	0.5 l	35	59	37	80	58	99	26	31
MCPA 750 SL	0.25 l	24	36	38	94	87	92	52	66
Granstar 75 WG	20 g	70	89	100	100	71	99	100	100
Granstar 75 WG	10 g	67	53	79	96	100	100	100	100
Granstar 75 WG	5 g	22	47	87	99	100	100	86	96
Grodyl 75 WG	20 g	40	60	96	99	67	67	100	100
Grodyl 75 WG	10 g	64	65	94	98	87	95	88	98
Grodyl 75 WG	5 g	35	40	66	83	73	75	71	93
Lintur 70 WG	160 g	56	40	66	66	100	100	100	100
Lintur 70 WG	80 g	61	50	100	100	93	99	86	99
Lintur 70 WG	40 g	55	21	100	100	100	100	100	100
Untreated ([No (g)/sq. m]	–	21	(115)	6	(6)	3	(4)	2	(14)

N – number of weeds; W – mass of weeds

Weed infestation and weed control

The field in the year 2000 was naturally infested with *Chenopodium album* (CHEAL) [106 plants/sq. m], *Galium aparine* (GALAP) [6 plants/sq. m], *Amarantus retroflexus* (AMARE) [4 plants/sq. m], *Viola arvensis* (VIOAR) [3 plants/sq. m], *Stellaria media* (STEME) [1 plant/sq. m] (Tab. 1). Drought conditions caused slow plant development. The weeds were less competitive and weak e.g. there were a lot of *Chenopodium album* plants [106/sq. m] but the weeds were very small and fresh mass was small [23.0 g].

In the year 2000 low efficacy of herbicides with WG formulation was observed: Granstar 75 WG, Grodyl 75 WG, Lintur 70 WG. The reason of that was rainfall deficiency during the time before spraying was. The herbicides with WG formulation were harder absorbed in drought conditions. The best efficacy obtained after Aminopielik Gold 530 EW application, especially in the highest dose. Efficacy of Duplosan Super 600 SL and MCPA 750 SL was sufficient but not very well. In some cases there were significant differences between influence of the herbicide doses on weed number and sometimes on weed mass.

The dominant weed species in the year 2001 were *Chenopodium album* (CHEAL) [21 plants/sq. m], *Viola arvensis* (VIOAR) [6 plants/sq. m], *Capsella bursa-pastoris* [(CAPBP) 3 plants/sq. m], *Matricaria inodora* (MATIN) [2 plants/sq. m] (Tab. 2). Weeds were large and overgrown. There was noted a great mass [139 plants/sq. m] and small numbers of weeds [32 plants/sq. m]. Occurrence of weeds in advanced

Table 3. Efficacy of herbicides applied in normal and reduced doses against main broadleaf weed species during 2002 season

Treatments	Dose per ha	CHEAL		VIOAR		STEME		THLAR		GERPU	
		N	W	N	W	N	W	N	W	N	W
Aminopielik Gold 530 EW	1.2 l	69	85	41	54	84	93	100	100	67	66
Aminopielik Gold 530 EW	0.6 l	52	72	29	52	96	95	100	100	67	39
Aminopielik Gold 530 EW	0.3 l	52	77	0	0	81	89	0	0	100	100
Duplosan Super 600 SL	2.0 l	89	96	43	71	100	100	100	100	100	100
Duplosan Super 600 SL	1.0 l	84	94	27	38	88	94	77	75	100	100
Duplosan Super 600 SL	0.5 l	13	49	13	12	81	87	0	0	67	91
MCPA 750 SL	1.0 l	96	99	0	28	69	77	31	81	100	100
MCPA 750 SL	0.5 l	52	70	0	0	57	69	0	35	100	100
MCPA 750 SL	0.25 l	47	73	0	0	0	9	0	0	33	38
Granstar 75 WG	20 g	56	84	0	30	100	100	0	0	33	f0
Granstar 75 WG	10 g	38	53	0	43	100	100	0	0	0	47
Granstar 75 WG	5 g	2	72	0	26	88	98	0	0	33	62
Grodyl 75 WG	20 g	15	71	4	49	49	87	77	60	33	87
Grodyl 75 WG	10 g	34	76	43	63	92	97	31	3	100	10
Grodyl 75 WG	5 g	2	23	0	9	77	83	0	2	67	57
Lintur 70 WG	160 g	53	85	89	94	100	100	100	100	33	36
Lintur 70 WG	80 g	65	72	45	59	92	97	100	100	100	100
Lintur 70 WG	40 g	28	67	17	62	49	89	54	10	67	57
Untreated ([No (g)/sq. m]	–	169	(562)	89	(31)	23	(13)	4	(2)	3	(2)

N – number of weeds, W – mass of weeds

growth stages made weed control more difficult to some herbicides. On the other hand there was observed only slight difference in weed control between full and 1/2 of dose (e.g. *Chenopodium album*). Another weed species – *Viola arvensis* was better controlled than in previous year. Generally Aminopielik Gold 539 EW, Duplosan Super 600 SL, and Granstar 75 WG showed similar efficacy at recommended dose and at 1/2 of normal dose.

In the year 2002 there was noted great number and mass of *Chenopodium album* [169 plants/sq. m and 562.0 g/sq.m] and *Viola arvensis* [89 plants/sq.m and 31.0 g/sq. m] (Tab. 3). The rest of weed species occurred in minority. The fresh mass of all weeds carried up 626.0 g/sq. m. Generally the efficacy of weed control was better than in previous years, especially after using of hormon type herbicides (Aminopielik Gold 530 EW, Duplosan Super 600 SL, MCPA 750 SL) in the highest dose. The main reason of that was probably great amount of rainfall before time of spraying. The level of rainfall was definitely higher than in the previous years of experiment.

In these cases the efficiency decreased along with dropping the rate. But there were some differences between action of these two herbicides. Duplosan Super 600 SL efficacy decreased gradually while efficacy of MCPA 750 SL decreased violently. Sufficient or satisfactory level of weed control recorded after using of herbicide Lintur 70 WG and Aminopielik Gold 530 EW in a full dose and a 1/2 of full dose.

The best *Chenopodium album* control gave two herbicides: Duplosan Super 600 SL and MCPA 750 SL. The 1/2 of dose of Duplosan Super 600 SL was as effective as full

Table 4. Efficacy of broadleaf weed control by recommended and reduced doses of tested herbicides from 2000 to 2002

Treatments	Dose per ha	2000 season		2001 season		2002 season	
		N	W	N	W	N	W
Aminopielik Gold 530 EW	1.2 l	85	94	72	88	67	76
Aminopielik Gold 530 EW	0.6 l	32	71	52	78	51	71
Aminopielik Gold 530 EW	0.3 l	32	41	26	37	44	62
Duplosan Super 600 SL	2.0 l	45	78	63	85	83	95
Duplosan Super 600 SL	1.0 l	58	80	63	70	74	91
Duplosan Super 600 SL	0.5 l	36	47	60	54	13	49
MCPA 750 SL	1.0 l	46	61	71	67	83	94
MCPA 750 SL	0.5 l	0	46	38	56	34	55
MCPA 750 SL	0.25 l	54	33	32	40	32	67
Granstar 75 WG	20 g	41	0	74	91	49	81
Granstar 75 WG	10 g	20	36	66	56	33	54
Granstar 75 WG	5 g	33	0	33	56	0	70
Grodyl 75 WG	20 g	46	24	47	67	16	70
Grodyl 75 WG	10 g	43	73	75	70	15	61
Grodyl 75 WG	5 g	27	13	47	45	2	24
Lintur 70 WG	160 g	61	67	69	50	59	86
Lintur 70 WG	80 g	28	19	21	58	64	72
Lintur 70 WG	40 g	25	58	70	26	28	67
LSD (0,05)for all treatments	–	42,7	48,9	43,2	41,9	47,1	37,9
LSD (0,05) between Herbicides	–	–*	–*	–*	–*	–*	–*
LSD (0,05) between Doses	–	24,7	28,2	24,9	24,2	27,2	21,9
Untreated ([No (g)/sq.m]	–	176	(39)	32	(139)	174	(284)

N – number of weeds, W – mass of weeds
*not significant differences

dose. In the case of MCPA 750 SL 1/2 of dose gave only sufficient (number) and satisfactory (mass) weed control. The best control of *Viola arvensis* (the 2nd numerous weed species in this year) was occurred after Lintur 70 WG application. The rest of herbicides didn't give a satisfactory effect.

The number and mass of weeds were diverse in every year of trials. There was recorded the greatest amount of weeds in years 2000 and 2002. In the year 2001 weeds were almost 80% less than in other experimental years (Tab. 4). The mass of weeds depended on density and amount of rainfall. In the all years of trial the variability analysis indicated uncertain estimation between herbicides but there was recorded a satisfactory reducing of weed mass after application of hormon type herbicides. There weren't statistical differences between herbicides applied in recommended and 1/2 of recommended dose especially for hormon type herbicides.

CONCLUSIONS

The results have shown that in case of some weed species it is possible reducing doses of herbicide to 50% of recommended dose.

There was some evidence that weed size influenced on herbicide dose-response.

Rainfall deficiency limited efficiency of sulfonylurea herbicides compared to hormon type herbicides.

Control of dominated weed species caused compensation of less susceptible weed species.

Decision about choice of herbicide type and dose, should be connected with weather conditions before application and density and type of weeds at application.

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POLISH SUMMARY

SKUTECZNOŚĆ DZIAŁANIA OBNIŻONYCH DAWEK HERBICYDÓW W RÓŻNYCH WARUNKACH POGODOWYCH

W latach 2000–2002 prowadzono w Instytucie Ochrony Roślin w Poznaniu ścisłe doświadczenia polowe w uprawie pszenicy jarej, których celem było porównanie efektywności działania obniżonych dawek herbicydów z grupy regulatorów wzrostu i grupy sulfonylomocznikowych stosowanych w różnych warunkach przebiegu pogody. W doświadczeniach testowano następujące herbicydy: Aminopielki Gold 530 EW, Duplosan Super 600 SL, Granstar 75 WG, Grodyl 75 WG, Lintur 70 WG, MCPA 750 SL. Zabiegi wykonywano nalistnie w fazie krzewienia rośliny uprawnej stosując herbicydy w dawce zalecanej, 1/2 i 1/4 dawki zalecanej. Wyniki doświadczeń pokazały, że jest możliwe zastosowanie herbicydów w dawkach obniżonych o 50%. Wielkość chwastów w momencie zabiegu miała wpływ na skuteczność chwastobójczą obniżonych dawek herbicydów. Warunki pogodowe a zwłaszcza niedobory opadów bardziej ograniczały skuteczność działania herbicydów sulfonylomocznikowych niż herbicydów z grupy regulatorów wzrostu. Zniszczenie dominujących gatunków chwastów (np. *Chenopodium album*) wywoływało kompensację mniej wrażliwych na herbicydy gatunków chwastów. Podejmując decyzję o wyborze herbicydu i wysokości dawki należy wziąć pod uwagę zarówno stan zachwaszczenia jak i przebieg warunków pogodowych.