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USE OF ACTIVE SUBSTANCE DEPENDING OF THE FORMULATION OF PLANT PROTECTION PRODUCTS APPLIED WITH AGRICULTURAL SPRAYERS. A CASE STUDY OF WINTER WHEAT IN POLAND

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ABSTRACT
The study into the use of an active substance per hectare was performed to examine the matches of plant protection products applied by agricultural sprayers, containing the same active substance but with a different formulation. The doses of fungicides and herbicides registered in Poland to protect winter wheat against two economically important pests were analyzed. On the basis of the results it is difficult to draw any definite conclusions regarding the influence of formulation on the dose of active substance used per hectare. In some cases, use of a different formulation may be connected with the different amount of an active substance used per hectare. However, the results strongly differed depending on the analyzed active substances. It seems that more cases should be examined to determine whether there are any discernible patterns.

INTRODUCTION

In agriculture and food production numerous studies regarding overall safety (Kazimierczak et al. 2016, Melski et al. 2011) and residues in crops (Szpyrka et al. 2017, Jankowska et al. 2016) are performed. The fertilization and other aspects of plant cultivation influence the crop (Bereś 2016, Pikuła and Rutkowska 2014, Hurej et al. 2017, Zarzyńska et al. 2017, Matyjaszczyk 2011), but the public is especially concerned by the pest management, particularly chemical pest control.

From chemical point of view pesticides (plant protection products) are usually mixtures of active substance(s) and other components (solvents, emulsifiers, safeners, synergetics, adjuvants etc), introduced on the market in different formulations. The component of plant protection product that acts against the pest is the active substance. The aim of the other components is, generally speaking, enabling the safe and effective use of the active substance. From the point of view of environmental safety however it is not only the content of the active substance, but also the formulation and the form of application that counts (Doruchowski et al. 2017, Hoesel et al. 2017, Parafiniuk et al. 2015). Integrated pest management (IPM) – obligatory in all European Union member states from the beginning of 2014 emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems. The professional user should keep the use of pesticides and other forms of intervention to levels that are necessary; among others by reduced doses, reduced application frequency or partial applications (Directive 128/2009).

The aim of this paper is to answer the following question: If and how does the formulation of plant protection products affect the dose of active substance used per hectare?

MATERIAL AND METHODS

Research into the Polish register of plant protection products in May 2017 was carried out. The study was performed using fungicides and herbicides registered for the protection of winter wheat (the most important Polish crop as regards the cultivation area) against the same pests. The selected pests were powdery mildew (*Blumeria*

graminis) in case of fungicides and lamb's quarters (*Chenopodium album*) in case of herbicides. The both pests are economically important in winter wheat production in Poland. All products on the market were analyzed. Only formulations registered to be applied with agricultural sprayers were considered.

The objective of the research was to find matches of plant protection products applied with agricultural sprayers, containing the same active substances and registered for protection of winter wheat against the selected pests in different formulations. To calculate the amount of an active substance per hectare it was estimated (following the methodology of Matyjaszczyk (2017)) that the products were applied according to the maximum recommended dosage.

RESULTS

During the research it was noted that the occurrence of products which contain identical active substances for winter wheat protection in different formulations was not uncommon. In the course of the research it became evident that several matches of products with different formulations are registered to control the selected pests in winter wheat. The details are presented in Table 1 (herbicides) and Table 2 (fungicides). It was found that among fungicidal active substances fulfilling the search criteria only one: tebuconazole was registered in different formulations. For the herbicides six cases fulfilling the search criteria were found: four active substances solo plus two combinations of two different active substances.

The results as regards the dose used per hectare are the following:

- All herbicides matching the search criteria were registered in two different formulations, the only fungicide was registered in three different formulations.
- For one active substance, namely herbicide metsulphuron methyl identical maximal dose was recommended, regardless of the trade names of the products and the formulation.
- For both herbicidal combinations of active substances different maximal doses were recommended in different formulations, however recommended dose of one active substance was higher, while of the second – lower. Since it is very difficult to compare quantitative use of different active substances, therefore in both cases it is difficult to draw any conclusions regarding the quantitative use of active substance per hectare.
- For two active substances, herbicide MCPA and fungicide tebuconazole the maximal recommended dose depended rather on the product, that on the formulation. In both cases majority of products on the market, regardless of the formulation were registered in identical dose: for MCPA 750g/ha, while for tebuconazole 250 g/ha. However for MCPA one product was registered in significantly higher dose 900g/ha and for tebuconazole three products were registered in slightly higher dose 258 g/ha and one in significantly higher dose 312,5 g/ha.
- For two active substances: herbicides tribenuron and fenoxaprop-P the formulation seems to influence the maximal dose of active substance recommended per hectare. In case of fenoxaprop-P the registered dose is higher in formulation EW than in formulation EC and the difference is below 10%. For tribenuron results are not so clear because several different doses is registered

under different trade names, however generally speaking the recommended dose was higher in formulation SG, than in formulation WG.

Table 1. Comparison of matches of herbicides containing the same active substance in different formulations registered for protection of winter wheat against *Chenopodium album*, registered in Poland in May 2017.

Active substance	Formulation*	Product trade name	Dose	Content of active substance	Total use of active substance
MCPA	SL	Premier 300 SL	3 l/ha	300 g/l	900 g/ha
		Agritox 500 SL, Premier 500 SL	1,5 l/ha	500 g/l	750 g/ha
		Agroxone Max 750 SL, Ceridor MCPA 750 SL, Chwastoc Professional 750 SL, Dicoherb 750 SL, Premier 750 SL	1 l/ha	750 g/l	750 g/ha
	EC	Chwastoc AS 600 EC	1,25 l/ha	600 g/l	750 g/ha
2,4-D+dicamba	EC	Aminopielik D Maxx 430 EC	1,5 l/ha	376 g/l+54 g/l	564 g/ha+81 g/ha
	SL	Aminopielik Super 464 SL, Dicopur Top 464 SL, Tayson 464 SL	1 l/ha	344 g/l+120 g/l	344 g/ha+120 g/ha
thifensulfuron-methyl+metsulfuron-methyl	WG	Chenkar 750 WG, Ergon 750 WG, Looma 750 WG, Vima-Tifenmet	75 g/ha	682 g/kg+68 g/kg	51,15 g/ha+5,1 g/ha
	SG	Concert SX 44 SG	150 g/ha	400 g/kg+40 g/kg	60 g/ha+6 g/ha
		Finish SX 40 SG	75 g/ha	333 g/kg+67 g/kg	24,97 g/ha+5,02 g/ha
metsulfuron-methyl	WG	Coma 20 WG, Finy 200 WG, Pike 20 WG, Winnetou 20 WG	30 g/ha	200 g/kg	6 g/ha
	SG	Galmet 20 SG, Primstar 20 SG, Superherb 20 SG	30 g/ha	200 g/kg	6 g/ha
tribenuron	WG	Lumer 50 WG	30 g/ha	500 g/kg	15 g/ha
		Cuckoo 750 WG	25 g/ha	750 g/kg	18,75 g/ha
		Helgran 75 WG, Naxel 75 WG, Nuance 75 WG, Pleban 75 WG, Ranga 75 WG, Sabata 75 WG, Tribe 75 WG, Viking 75 WG	20 g/ha	750 g/kg	15 g/ha
	SG	Granstar SX 50 SG	35 g/ha	500 g/kg	17,5 g/ha
		Toraya 50 SG, Triben Super 50 SG, Trimax 50 SG, Tristar 50 SG	40 g/ha	500 g/kg	20 g/ha
fenoxaprop-P	EW	Fantom 069 EW, Foxtrot 069 EW, Norton 069 EW, Puma Uniwersal 069 EW, Pumex 069 EW, Rumba 069 EW	1,2 l/ha	69 g/l	82,8 g/ha
	EC	Fenoxinn 110 EC, Herbos 110 EC, Monarchi 110 EC	0,7 l/ha	110 g/l	77 g/ha

**A key to formulation codes: SL (soluble concentrate), EC (emulsifiable concentrate), WG (water dispersible granule), SG (water soluble granule), EW (emulsion, oil in water)*

Table 2. Comparison of matches of fungicides containing the same active substance in different formulations registered for protection of winter wheat against powdery mildew, registered in Poland in May 2017.

Active substance	Formulation *	Trade names of products	Dose	Content of active substance	Total use of active substance
tebuconazole	EC	Brasifun 250 EC, Mystic 250 EC	1 l/ha	250 g/l	250 g/ha
	EW	Clayton Tabloid EW, Darcos 250 EW, Domnic 250 EW, Erasmus 250 EW, Furtado 250 EW, Helicur 250 EW, Kosa 250 EW, Orius Extra 250 EW, Riza 250 EW, Sokolov 250 EW, Sparta 250 EW, Syrius 250 EW, Tarcza Łan 250 EW, Tebu 250 EW, Tebusha 250 EW, Toledo 250 EW, Trion 250 EW, Troja 250 EW, Tyberius 250 EW	1 l/ha	250 g/l	250 g/ha
		Tarcza Łan Extra 250 EW	1,25 l/ha	250 g/l	312,5 g/ha
	SC	Ambrossio 500 SC, Venturo 500 SC	0,5 l/ha	500 g/l	250 g/ha
		Bounty 430 SC, Spekfree 430 SC, Starpro 430 SC	0,6 l/ha	430 g/l	258 g/ha

** A key to formulation codes: EC (emulsifiable concentrate), EW (emulsion, oil in water), SC (suspension concentrate)*

CONCLUSION

On the basis of the results, it is difficult to draw any definite conclusions regarding the influence of formulation on the dose of active substance used per hectare. The collected data show that in many cases for the same active substance and formulation different maximal doses were recommended to control the same pest in the same crop, it may however depend on the recommended growth stage of application, which was not considered. In some cases, use of a different formulation may be connected with the different amount of an active substance used per hectare. However, the results strongly differed depending on the analyzed active substances. Probably more cases should be examined to determine whether there are any discernible patterns.

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