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Review

Achievements and problems in the weed control in common wheat \((Triticum Aestivum \textit{L.})\) and durum wheat \((Triticum Durum \textit{Desf.})\)

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Abstract. Herbicides combinations and tank mixtures of herbicides with adjuvants, fertilizers, growth regulators, fungicides, insecticides, are more effective than when applied alone on wheat crops. Their combined use often leads to high synergistic effect on yield. Many authors present data from which it is clear that durum wheat differs from common wheat in their reaction to some herbicides, herbicide combinations and herbicide tank mixtures. A serious problem in wheat is Bromus arvensis \textit{L.} due to their resistance to most antigramineous herbicides. In recent years effective herbicides to fight against them have emerged, but their number is still too limited. A problem is the persistence of some herbicides used in the predecessors on succeeding crops, which is directly related to the weather conditions during their degradation. Contrary opinions are published on some issues due primarily to the different conditions under which the experiments were conducted and the biological characteristics of the tested cultivars. Most of the information on these subjects refers mainly to common wheat and only a limited amount of it is for durum wheat. A serious problem is also the volunteers of Clearfield canola \((Brassica napus \textit{L.})\), Clearfield and Express sun sunflower \((Helianthus annuus \textit{L.})\). They have resistance to herbicides different from that of conventional canola and sunflower hybrids. A problem is also volunteers of coriander \((Coriandrum sativum \textit{L.})\) and milk thistle \((Silybum marianum \textit{Gaertn.})\). There is yet no information in the scientific literature as to control of these volunteers.

Keywords: wheat, herbicides, weed control, productivity, grain quality

Introduction

The use of herbicides leads to large changes in the number and the species composition of weeds in wheat agrophytocenoses. Chemical weed control is associated with a significant improvement in plant health of wheat crops (Lizanko et al., 1988; Valenti and Wicks, 1992; Rapparini et al., 1994; Clay et al., 1995; Grundy et al., 1996; Markovic et al., 1998 and 2000; Kostrzewska, 2000; Michel, 2001; Jedruszczak et al., 2004; Zewdie and Rungait, 2005; Buczek et al., 2007; Kieloch et al., 2008; Stashinskis, 2008; Nakayama et al., 2010; Gupta et al., 2011; Smajlagić and Đikić, 2011; Lobkov et al., 2012).

The aim of this paper is to review the achievements and problems in the weed control in common wheat \((Triticum aestivum \textit{L.})\) and durum wheat \((Triticum durum \textit{Desf.})\) crops and the roles of herbicides and their mixtures on common and durum wheat productivity, quality characteristics of the grain and sowing characteristics of the seeds.

Weed control in common and durum wheat crops

Abtali et al. (1995) investigated the effectiveness of herbicides Topic (clodinafop-propargyl), Grasp (tralkoxydim), Scorpio Super (fenoxaprop-ethyl) and Iloxan (diclofop-methyl), applied at the end of tillering of wheat and 4-6 leaf weeds. They provide 100% control of Avena fatua \textit{L.} and Avena ludoviciana Durien. These four antigramineous herbicides do not cause phytotoxicity in wheat plants, even with higher doses of treatment. The yield of wheat is increased significantly when compared to all the herbicides weeded controls, but no difference between the individual herbicides.

Herbicide Axial (pinoxaden) has high efficiency against gramineous weeds and good selectivity for common wheat, durum wheat and barley (Campagna and Ruegg, 2008). Herbicide Derby Super (aminopyralid + florasulam) has an excellent efficacy against annual and perennial broadleaved weeds (Dalla Valle et al., 2008). Pasquini et al. (2006) reported about efficacy of Granstar (tribenuron-methyl) against these weeds. Herbicides imazamethabenz, diclofop-methyl, tralkoxydim, fenoxaprop-P-ethyl and clodinafop-propargyl are most efficient against wild oat species (Tiebaset al., 1999). Imanat (2002) found that herbicides Topic and Logran are most efficient at higher soil and atmospheric humidity.

The high efficiency of the herbicide Hussar max (mesosulfuron + iodosulfuron) against gramineous and broadleaf weeds is reported by Ceconi et al. (2000) and Cittar et al. (2002). According to Montemurro et al. (2006) iodosulfuron + mesosulfuron (Atlas) is more effective than metribuzin (Zenkor), 2,4-D + metosulam (Sound) metosulam (Eclipse) and herbicide mixture propargi-clodinafop (Topic) + tribenuron-methyl (Granstar). Soroka et al. (1999) reported that the herbicide Zirol destroys all broadleaf weeds which are resistant to hormone similar herbicides 2,4-D and 2M-4X. Weed control with herbicide Marathon in autumn is more effective than herbicides Cougar and Hussar Turbo (Tsuganov and Potarenko, 2011). The results obtained from Bassi et al. (2002) showed supplement to the spectrum of broadleaf weeds controlled by the tank herbicidal mixture carfentrazone-ethyl + tribenuron-methyl, and no antagonism in the control of gramineous weeds by combining the new herbicide carfentrazone-ethyl with fenoxiprop-ethyl and clodinafop-propargyl.

Due to the poor efficacy of antigramineous herbicides to Bromus ssp., Hamal et al. (1996, 1996a and 1998) recommend the
chemical combat of these weeds to be combined with soil cultivation. These results were confirmed by Kelley et al. (1998), according to whom the fight against these dangerous weeds of wheat should focus on the predecessors. The seriousness of the problem with Bromus spp. is reported by Koscelny et al. (1996) and Koscelny and Peper (1997). Tityanov et al. (2009) found higher efficacy of the herbicide Palace (piroxasulam) against Avena fatua L., Alopecurus myosuroides L., Lolium multiflorum L. and Bromus arvensis L. Efficiency does not change with the introduction of the Palace as a tank mixture with Derby Super (florasulam + aminopyralid). Weak antagonism in the tank mixture Palace + Mustang (florasulam + 2,4-D ester) and strong antagonism in the tank mixture Palace + Herboston (2,4-D amine salt) were reported.

There are no symptoms of phytotoxicity at any of the variants. Herbicide Attribut, due to systemic action destroys the roots of the perennial wheat weed Agropyrum repens L. rather than the annual gramineous weeds Alopecurus myosuroides L., Apera spica-venti P.B. and Bromus arvensis L. (Ammon et al., 2000). Soukop et al. (2000) found that the herbicide mixtures of sulfonylurea herbicides with hormone-similar herbicides do not have higher effect on Cirsium arvense Scop. and other perennial broadleaf weeds compared with separate application of these herbicides. Fenoxaprop-ethyl (Puma Super) tralkoxydim (Grasp) and diclofop-methyl (Iloxan) are highly effective against Avena ludoviciana Durien., but izmatzetabenz (Acer) is not effective against this annual gramineous weed (Montazeri, 1994).

Common and durum wheat productivity

Adamczewski and Paradowski (2004) studied the biological efficacy of herbicides Attribut (propoxycarbazone-sodium) and Aprios (sulfosulfuron) and found that the addition of adjuvants to both herbicides has a positive influence on the herbicide effect and increases the yield of wheat grain. The lowest grain yield was obtained after the use of herbicides Attribut and Aprios without adjuvants. Adjuvants Adbios, Aero, Atpolan and Obiras increased most the efficacy of the tested herbicides. Ammonium nitrate used as adjuvant showed the weakest effect. Attribut herbicide is more efficient in the control of gramineous weeds in comparison with Aprios. On the other hand, Aprios controls better the broadleaf weeds. Both herbicides have long persistence. After application of Attribut (propoxycarbazone-sodium) winter oilseed canola, spring oilseed canola and sugar beet must be grown. After using Aprios (sulfosulfuron) winter oilseed canola should not be grown; however, spring oilseed canola and sugar beet can be grown.

Markovic (1990) investigated the influence of some herbicides: Glean, Racer, Banvel D, Monosan, Racer + Banvel D, Granstar, Granstar + Glean, Harmony, Chisel, Dicuran, Granstar + Banvel D, Buktrl, Satis, Starane, Glean + Racer imported in phase after sowing before emergence of wheat and in 3–4 leaf stage in autumn. Efficiency and selectivity of herbicides and their combinations depend on weather conditions, their period of application and the stage of development of the crop. Similar results were reported by Ogjanovic and Lomovic (1994).

Callens et al. (1996) reported about increase the efficacy of herbicides Puma Super and Topic with the addition of adjuvants. The effect is the best with the addition of the adjuvant Atplus. The combination of antigramineous herbicides Puma Super and Topic with antibroadleaf herbicide Buktlrl increased grain yield by 58% to 107% depending on the level of weed density (Hassan et al., 2003 and 2008). The tank mixture of herbicides Puma Super + Sectors also has high efficacy against gramineous and broadleaf weeds (Gorbacheva et al., 2011). In tank mixtures Puma Super and Topic with Arelon there is synergism with regard to gramineous weeds (Khan et al., 2002 and 2003).

Ahmed et al. (1993), Khan and Noor-ul-Haq (1994 and 2002), Khan et al. (1999 and 1999a), Hashim et al. (2002), Cheema and Akhtar (2005) and Sangi et al. (2012) report about high herbicidal efficacy of herbicides Arelon, Graminon, Tribunil, Buktrl, Dicuran, Tolcan and Dozanex. The increase in grain yield is due to the increase of the productive tillering, the grains number per spike and the 1000 grains weight. The efficacy of the mixtures of these herbicides with hormone-similar herbicides is commented by Marwat et al. (2002 and 2005) and Mueen-ud-Din and Ahmad (2011). The combination of the herbicides Arelon and Zencor affords higher grain yields compared to their separate application (Khan et al., 2006).

Bartolini et al. (2002) and Buccii et al. (2006) investigated the phytotoxicity in some common wheat cultivars by the influence of herbicides and herbicide tank mixtures: isodosufuron + fenoxaprop-ethyl, tralkoxydim, clodinafop-propargiil, fenoxaprop-ethyl, fenoxaprop-ethyl + diclofop-methyl, fluoroxypr + clopyralid + MCPA and tribenuron methyl + fluoroxypr. The results show that all the investigated variants have good tolerance to the investigated common wheat cultivars. Some mixtures have weak phytotoxicity, but it does not lead to a reduction in grain yield. These variants have good tolerance and a large number of durum wheat cultivars (Rapparini et al., 1998, 2000 and 2002; Geminiani et al., 2006). Antigramineous herbicides Iloxan, Grasp, Topic and Puma Super, which are completely selective to common wheat, showed higher phytotoxicity to durum wheat (Bell 1999). Camele and Rana (1995) also reported that durum wheat is characterized by higher sensitivity to some herbicides compared to the common wheat.

Amidosulfuron, carfentrazion-ethyl, fluoroxypr, florasulam and ciklosulfuron have high efficacy against Galiun aparine L. Metosulam, metsulfuron-methyl, tribenuron-methyl and rikolinofen show less effect against this weed (Covarelli, 1998; Covarelli and Stagnari, 2002). Chlorotoluron, chlorbromuron, dicamba and bentazon exhibit high selectivity for the most common wheat cultivars (Dadari et al., 1990). Korres et al. (1999) have reported that isoproturon and chlorotoluron in different wheat cultivars cause damage of varying degrees. Damage from these two herbicides decreased with increasing plant density of 1 m². Isoproturon reduces grain yield in the susceptible cultivars due to the lower grades of 1 m². Tralkoxydim decreases yield less because of less impact on the yield components (Kumar et al., 1997). According to Kulshresta et al. (1999) in resistant wheat biotypes the isoproturon is degraded completely 8 days after treatment. In sensitive biotypes it degrades for more than 18 days. Dastghieb et al. (1994) found that 48 hours after treatment cultivars resistant to chlorosulfuron degrade more than 90% of the herbicide and the sensitive ones – about 40%.

Hormone-similar herbicides Lontrel 418 C (MCPP + 2,4-D), Morogal (MCPP + MCPA) and Monosan C (2,4-D + MCPA), introduced in stem elongation stage of the wheat lead to a reduction in grain yield, spike length, number of spikelets and grains per spike and plant height. When introduced in tillering stage, such a reduction is not found (Bozino, 1996). Glusac and Malasavic (1994) and Marinkovic et al. (1997) also reported the decrease in yield by treatment during stem elongation stage. Herbicides Puma Super in treatment at the stem elongation stage do not reduce grain yield, but herbicide Asert reduces grain yield (Helm et al., 2000). Puma Super causes phytotoxicity in some wheat cultivars. The combination Puma Super + Asert reduces phytotoxicity as compared with their separate treatments (Liu et al., 1994).
Rola et al. (1999) found that many wheat cultivars are sensitive to herbicides Glean and Stomp applied after sowing before germination; herbicide Dicuran applied in autumn in third leaf stage and herbicide Arelon applied in spring in tillering stage. However, most of the cultivars investigated by these authors are tolerant to these herbicides. Wheat and maize resistance to the herbicide chlorotoluron is determined by the dominant condition of a particular gene and sensitivity – by the recessive condition of this gene (Yang and Wu, 1994).

Quality characteristics of wheat grain

Baerg et al. (1996) reported about antagonism between diclofop-methyl (Iloxan) and tribenuron-methyl (Granstar). Tribenuron hinders diclofop translocation in wild oat meristem tissues. Brzozowska and Brzozowski (2002) found that leaf treatment with the combination of herbicide Granstar (tribenuron-methyl) and urea increased the amount of grain yield, but reduced the protein content of the grain of the common wheat. However, combined treatment of herbicides Arelon (isoproturon), Partner (isoproturon + diflufenican), Dublet (isoproturon + bromoxynil + MCPA) and Agmol Kombi (cypermethrin + MCPA) with urea increases the yield and quality of the wheat grain (Tanveer et al., 1999). Combined use of dicamba and metoluron with urea ammonium nitrate (UAN) also increases the yield and grain quality (Wicks et al., 1995).

Efficacy and selectivity as one of the most important parameter for assessment of the effect of chemical treatment against weeds has been investigated for a large number of herbicides and herbicide combinations by many authors (Wybieralski and Wybieralska, 1984; Salarzai et al., 1999; Rapparini et al., 1997, 1998, 2000, 2004; Lukyanyuk and Gaytyukevich, 2007; Chemuha and Dolzenko 2009; Shehzad et al., 2012).

In investigation of herbicides Puma Universal, Secator and Hvastox Extra, Cacak-Pietrzak et al. (2008) found that a higher dose of Secator reduced grain yield and gluten quality in the two cultivars of common wheat. Stashinskis (2001, 2001a) reported higher increase of quality indicators in spring wheat cultivars in the compared weeded control than in the winter wheat cultivars with the use of herbicides Lintur, Secator, Ariana and Duplozan Super. The reasons for this are the different stages of development of the plants of both wheat species and most natural competitiveness of winter conventional canola and sunflower hybrids. A problem is also volunteers of Clearfield canola (Brassica napus L.), Clearfield and Express sun sunflower (Helianthus annuus L.). They have resistance to herbicides different from that of conventional canola and sunflower hybrids. A problem is also volunteers of coriander (Coriandrum sativum L.) and milk thistle (Silybum marianum Gaertn.). There is yet no information in scientific literature to control these volunteers.

Conclusions

Literature review demonstrates the views of the quoted authors who formulated a series of laws. Chemical control has emerged as the most efficient method of weed control. Herbicide combinations and tank mixtures of herbicides with adjuvants, fertilizers, growth regulators, fungicides, insecticides, are more efficient than when applied alone in wheat crops. Their combined use often leads to high synergistic effect on yield. Many authors present data from which it is clear that durum wheat differs from common wheat in their reaction to some herbicides, herbicide combinations and herbicide tank mixtures.

Without claim to be exhaustive in literature review it should be noted that a serious problem in wheat is Bromus arvensis L. due to their resistance to most antigramsimous herbicides. In recent years effective herbicides have been introduced to control them, but their number is still too limited. A problem is the persistence of some herbicides used in the predecessors on succeeding crops, which is directly related to the weather conditions during their degradation.

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