Bulgarian Journal of Agricultural Science, 23 (No 6) 2017, 980–987
Agricultural Academy

EFFICACY OF REDUCING LINTOUR DOSES AND BIOCONTROL COMPONENTS FOR AN EFFECTIVE WEEDS CONTROL IN WINTER WHEAT (*TRITICUM AESTIVUM*)

MEISAM ZARGAR; ELENA N. PAKINA; VADIM G. PLUSHIKOV; VALENTIN VVEDENSKIY; MARYAM BAYAT
RUDN University, Institute of Agriculture, Department of AgroBiotechnology, 117198 Moscow, Russia

Abstract

Zargar, M., E. N. Pakina, V. G. Plushikov, V. Vvedenskiy and M. Bayat, 2017. Efficacy of reducing lintour doses and biocontrol components for an effective weeds control in winter wheat (*Triticum aestivum*). *Bulg. J. Agric. Sci.*, 23 (6): 980–987

Herbicides rate cutting is an example of poor application of chemicals that can have potential adverse implications due to rapid herbicide resistance evolution. Three years studies during 2014 – 2016 have examined the combined effect of reducing new generation herbicide lintour doses 0.18, 0.15 and 0.12 kg/ha^{-1} and biological components to control weeds in winter wheat (*Triticum aestivum* L.). Weeds were mainly diminished when herbicide lintour 0.18 kg/ha^{-1} plus biological agents was applied compared with other treatments. Furthermore, satisfactory reducing of dominant weeds such as *Viola arvensis,* species of *Poaceae* and also in some cases, *Stelaria media* were achieved with below-labeled herbicide dose as 0.15 kg/ha^{-1} plus biological agents. Hence, the higher efficacy weed control was desirably obtained with the maximum lintour rate combined to biological agents but the difference was not high compared with dose 0.15 kg/ha^{-1}. The lowest herbicide dose 0.12 kg/ha^{-1} plus biological agents had considerably lower weeds control efficacy on reducing of *Viola arvensis, Poaceae* and *Stelaria media*. It was determined that variation of herbicide doses combined with biological agents influenced yield and yield components, the highest yield (7.8 t/ha^{-1}) was obtained with herbicide rate 0.15 kg/ha^{-1} Plus biological agents.

Key words: wheat; weed suppression; lintour; biological agent; reduced dose

Introduction

Sustainability of cropping system is at risk because of declining productivity growth of wheat and diminishing total factor productivity (Kumar et al., 2013). This might be attributed to multiple factors, involving (1) degradation in the natural resource base, especially soil and water; (2) rising scarcity of labor and water; (3) increasing costs of cultivation; and (4) increasing weed populations and evolution of herbicide resistance. The public concern about environmental safety of herbicides has enhanced interest in developing effective non-chemical weed management strategies. The objective of biological practices in an overall management scheme initially may be supplemental to other approaches (Aldrich, 1984).

In majority of countries, herbicides are the dominant practice used for the weeds suppression; consequently, there have been many examples of the evolution of weed resistant to herbicides (Heap, 2010; Powles and Yu, 2010). Crop protection practices have come under greater scrutiny because of environmental issues related to chemical residues in the soil, water and food, and herbicide-resistant weeds (Ruegg et al., 2007). Biological weed control agents offer alternatives to the use of herbicides that provide new environmental options (Hallet, 2005; Boyetchko, 2005; Boyetchko and Rosskopf, 2006; Bailey and Mupondwa, 2006). Biological weed control is determined as an environment-friendly process, towards targeted weeds (Pleban and Strobel, 1998), biological agents recommended alternatives to the application of chemicals

**Corresponding author*: zargar_m@pfur.ru

that provide new environmental weed control tools (Bailey and Mupondwa, 2006; Boyetchko, 2005; Delfosse, 2004). Thus, Coombs et al. (1999) stated that optimizing biological weed suppression happen in stages, high concentrations and the alteration of formulations are essential to improve biological herbicide (Patzoldt et al., 2001).

Recently, the aim of weed management is to keep the weeds at a desirable level, rather than to keep the crop totally free of weeds (Hamill et al., 2004; Zhang et al., 2000; Bostrom and Fogelfors, 2002). For instance, the combination of *Aphthona* spp. flea beetles and picloram plus 2,4-D increased leafy spurge (*Euphorbia esula* L.) control when compared with either method used alone (Lym and Nelson, 2002; Nelson Lym, 2003; Zargar et al., 2011; Shakouri et al., 2012). Mentioned results suggest that the effect of herbicide-induced stress and beetle herbivory on weed suppression may be dependent on herbicide dose. Combining biological practices with 2,4-DB or glyphosate application was more effective at reducing field bindweed (*Convolvulus arvensis* L.) growth than either tactic alone (Boydston and Williams, 2004). Herbicide resistance, possible adverse impacts of herbicides on the environment, has accelerated the efforts of weed scientists towards the development of integrated weed control strategies (Buhler et al., 2000; Primot et al., 2006).

Desirable weed management can often be obtained by applying herbicides at reduced doses than recommended ones (Fernandez-Quintanilla et al., 2000; O'Donovan et al., 2004; Zhang et al., 2000) while maintaining satisfactory crop yields (Fernandez-Quintanilla et al., 2000; Barros et al., 2005, 2007, 2008). Reduced herbicide rates may control most of the target weeds under proper conditions; however, under less favorable conditions, a higher dose will be required, and in unfavorable conditions even the highest herbicide dose may still give unsatisfactory results (Medd et al., 2001; Mafakheri et al., 2012). The aim of using biocontrol agents as biofungicide and biogrowth regulator in this study was to protect wheat from fungal and bacterial diseases due to improve wheat ability to compete favorably with weeds populations, these agents had anti stress activity to climate changes and chemical components and properties. The main objective of this research was to investigate the efficacy of biological component in combination with reduced doses of new generation herbicide lintour on weeds.

Material and Methods

Description of survey area

Three field experiments in the period 2014 – 2016 were conducted on improving the strategies for post-emergence weed suppression in winter wheat. Experiments performed as an intensive farming technology in the field of Dagestan Agricultural University of Russia. The site was located at 42° 58′ N, 47°28′ E and 130 m altitude. Soil was typically a loamy soil with 1.82% organic matter and a pH of 5.6 in 2014 year. The experimental field was plowed before planting seeds, and the seedbed was prepared by roller harrowing before planting. Disk operation also conducted. Due to changing soil pH, Dolomik powder 5 t/ha^{-1} was added to the soil.

Experimental details and field layout

Biological agents [bioherbicide (3 L/ha^{-1}) + biofertilize & growth regulator (1 L/ha^{-1}) + biofungicide with anti-stress activity to weather conditions and chemical treatments and growth regulator activity (1 L/ha^{-1})] in combination with reduced doses of new generation post emergence herbicide 'Lintour' (0, 0.12, 0.15 and 0.18 kg/ha^{-1}) surfactant 0.5 L/ha^{-1} was mixed to herbicide as a tank mix. Herbicides were applied post-emergence by a knapsack sprayer which had flat fan nozzles. All agents were applied at the early stem stage of wheat. Detailed description of the treatment combinations is given in Table 1a. Other cultural practices were typical of those used for commercial winter wheat production in Daghestan state.

Wheat cv. Nemchinovskaya was planted in twenty ninth of August 2014 and in the second and third year the same variety of wheat was sowed in second and fifth of September 2015 and 2016, using plant densities of 5 million viable seeds per hectare.

Lintour. Formulation of this herbicide: 70 WG contient 4.1% de Triasulfuron et 65.9% de Dicamba 3,6-dichloro-2-methoxybenzoic acid. Lintour is labeled in summer and winter wheat for the control of weeds.

Bioherbicide. Kemi: is a biological herbicide. It contains the microorganism Colletotrichum spp. This bioherbicide

Table 1 a

Treatments combination details in experiments

Treatments	Symbol
lintour 0.18 kg ha^{-1} + Biological agents (biofertilizer&growth regulator+bioherbicide+biofungicide with anti-stress activity)	L1B
lintour 0.15 kg ha^{-1} + Biological agents (biofertilizer&growth regulator+bioherbicide+biofungicide with anti-stress activity)	L2B
lintour 0.12 kg ha^{-1} + Biological agents (biofertilizer&growth regulator+bioherbicide+biofungicide with anti-stress activity)	L3B

can be applied mid and late season when most chemicals cannot be sprayed, the usual rate 3 kg/ha^{-1}.

Biofertilizer. Humi: is a humic fertilizer and growth regulator. It contains humic acid and such ingredients as B, Mo, Co, Cu, S, I, Mn, Zn. This growth regulator helps plants survive stress caused by weather conditions and chemical treatments. It reduces the incidence of damage by pests and diseases and increases the yield. For winter wheat it can be used at the rate of 1 L/ha^{-1}.

Phytosporin. Is a biological fungicide with anti stress activity to weather conditions and chemical treatments and growth regulator activity, consisting of highly active spores of endophyte bacterium Baccilus subtilis (isolate 26D). It is effective against a wide range of fungal and bacterial diseases. Phytosporin is applied by pre-sowing treatment of seeds and spraying vegetating plants. For winter wheat 1 L/ha^{-1} during tillering stage can be sprayed.

Sampling procedure

Weed biomass. The total number of weeds from 0.25 m² area (weed density) of each net plot was counted each year at 12 and 30 days after application of treatments by the use of 50 × 50 cm² quadrate according to the method of European Weed Research Society (EWRS). Also, the whole weeds were dried in an oven at 70º C until constant weight was obtained for dry weight (biomass). The weed density and weed biomass were expressed as number of weeds m² and g m² respectively.

Determined weeds during years experiment were: *Viola arvensis* (Field pansy), *Stelaria media* (Checkweed) and *Poaceae* species.

Biological efficiency of treatments 15 days after application was estimated according to reducing weed biomass compared to the control.

Wheat traits and determined parameters. Crop was harvested from each experimental unit leaving border rows and plot margins, tied into bundles in respective plots. Measure experiments of plants height (cm^{-2}), grains weight per spike of wheat were counted from two randomly selected sites (100 × 100 cm) from each plot and were averaged. Each experimental plot was manually threshed and grain yield was recorded (t/ha^{-1}).

Data analysis

The data were analyzed by an analysis of variance, using the general linear model procedure of SAS Institute (SAS Institute, 2002). Duncan's multiple range test was used for the separation of the means when the F-test revealed an error probability of less than or equal to 5% ($P < 0.05$).

Results and Discussion

Weeds affected by treatments during 2015

Biomass of *Stelaria media* was affected and diminished by each three of treatments properly compared to control, but, it might be due to high sensitivity of *S. media* to lintour even in below labeled doses (Figure 1). Effective application of herbicides at reduced doses depends on some basic factors such as weed sensitivity to applied herbicide. Despite the lowest weeds biomass was achieved with the maximum rate of lintour 0.18 kg/ha^{-1} plus biological agents but it can be possible to recommend intermediate lintour rate 0.15 kg/ha^{-1} plus biological agents as effective on weed control. Scientists (Auskalnis and Kadzys, 2006; Barros et al., 2007; Walker et al., 2002; Bostrom and Fogelfors, 2002) revealed similar results, concluding that significant weed suppression can be obtained with reduced herbicide rates and providing desirable weed control during critical periods. It is not always necessarily to apply full herbicide rate (Talgre et al., 2008) and there can be flexibility regarding herbicide doses depending on the weed spectrum, densities, their growth stage and environmental conditions of the site. Moreover, non-chemical weed management strategies as biological components can have desirable weed control efficacy in combination with chemicals, biological control agents will probably provide long-term benefits to natural areas and biodiversity preservation as long as the potential risks from this approach are fully recognized and addressed (Randall et al., 1999; Zargar et al., 2017). Increasing lintour doses from 0.12 to 0.18 kg/ha^{-1} in combination with biological agents considerably diminished the total weeds biomass (Figure 1).

Reducing herbicide doses in combined with biological components as bioherbicide or some other biocontrol agents in ongoing weed management strategies can be recommended, mentioned pattern in addition to suppress weeds in the proper way can decline environmental pollution, herbicide resistant weeds and ultimately achieve sustainable agriculture, biocontrol agents will not replace chemical herbicides, Indeed, bioherbicides should be combined with other weed management strategies (Medd, 1992). These outcomes also match those found by Weis et al. (2008).

Weeds affected by treatments during 2016

Herbicide 0.18 kg/ha^{-1} plus biological agents were the most effective treatment on diminishing biomass of both *Viola arvensis* and *Poaceae*. *Stelaria media* was affected and reduced by each three of treatments compared to the control (Figure 2). In some studies, applying labeled-doses, achieved a weed control only 20 to 40%, whereas a weed control efficacy of 70% and higher was obtained with herbicide rates as low as 20% of the label recommendation, the same experi-

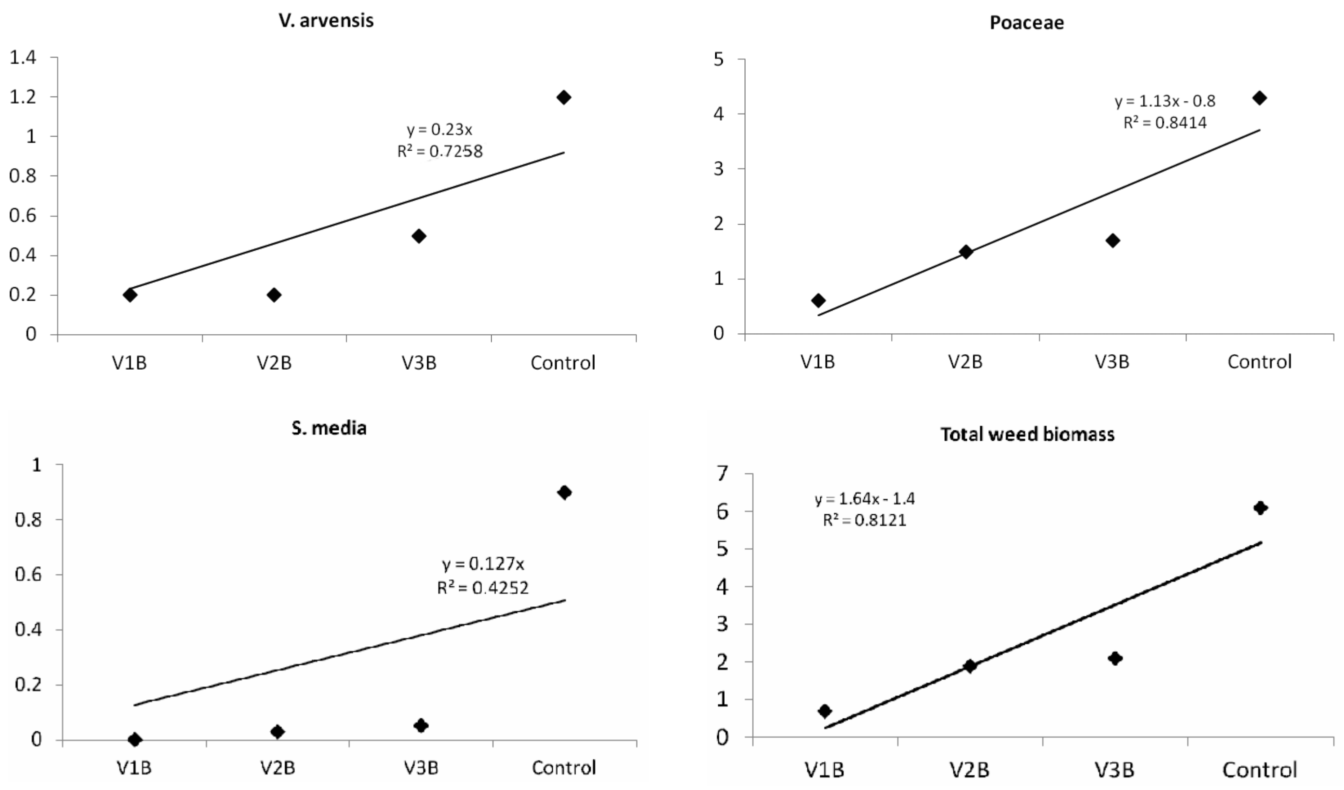

Fig. 1. Effect of reduced doses of lintour belongs with biological agents on reducing weeds biomass 15 days after treatments in 2015 (gr/m^{-2})

ment illustrated that weed control efficacy tended to be lower more at reduced rates than labeled ones, but remained within the 60 to100% range in over 90% of the cases. In more cases, weed control was over 70% at doses between 30% and 60% of the recommended dose (Zhang et al., 2000). Recent studies have demonstrated that low rates of herbicides can result in the evolution of herbicide resistance (Neve and Powles, 2005a,b; Busi and Powles, 2002).

Increasing the herbicide doses from the lowest one to the highest dose '0.18 kg/ha^{-1}'combined to biological agents desirably reduced the total weeds biomass (Figure 2). Modern weed management science emphasizes an ecological approach based on maintaining weed populations below threshold levels rather than eradicating those (Barroso et al., 2009), such findings are in agreement with those described by Talgre et al. (2008). It is not always necessarily to apply full doses of herbicide and there can flexibility according herbicide rates depending on the weed spectrum, densities, their growth stage and so environmental conditions of the site (Talgre et al, 2008).Furthermore, amount of herbicide rate at lower than labeled-doses are appropriate to provide satisfactory weed control without sacrificing crop yields and increasing weed infestation in the following years (Zhang et al., 2000; Boström and Fogelfors, 2002; Auskalnis and Kadzys, 2006; Barros et al., 2007).

Biological efficiency of lintour plus biological agents

Lintour 0.18 kg/ha^{-1} combined to biological agents reduced weeds biomass 86.5% compared to the control, moreover, weeds biomass was properly diminished in comparison with control when intermediate herbicide dose 0.15 kg/ha^{-1} was used (Table 1b). The aim of weed management is to keep the weed population at a proper level, rather than to keep the crop totally free of weeds. Some studies have revealed satisfactory weed control and favorable yields, while herbicides are used at lower than recommended rates (Hamill et al., 2004; Bostrom and Fogelfors, 2002). Hallet (2005) determined that conservation biological method should not be investigated the primary weed management practice but should be considered as a combination of another weed management tools. Similarly, 28% of the cropped area in Canada controls weeds with reduced herbicide doses (Beckie, 2006).

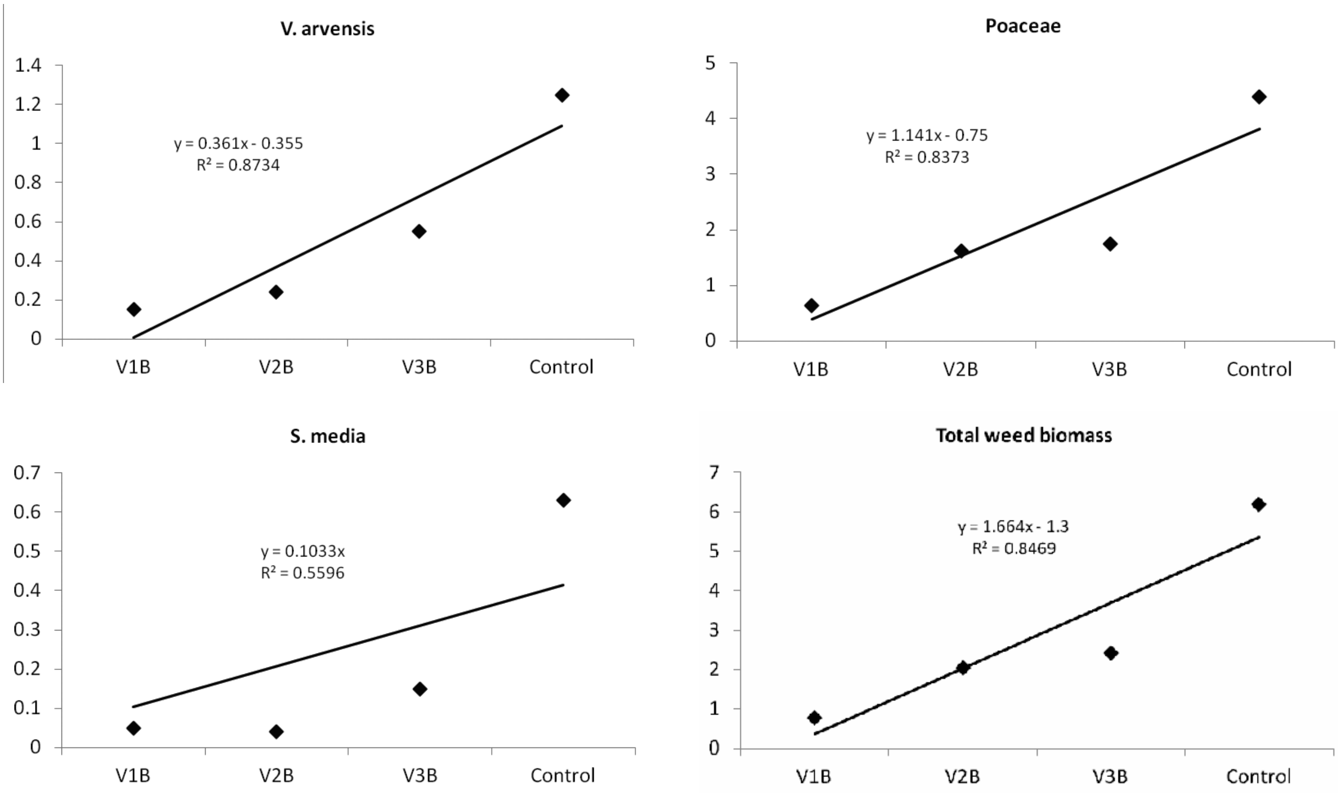

Fig. 2. Effect of reduced doses of lintour belongs with biological agents on reducing weeds biomass 15 days after treatments in 2016 (gr/m^{-2})

Table 1 b
Biological efficiency of lintour in winter wheat 15 days after applications during 2015 -2016

Treatments	Year	Weed dry weight gr/м$^{-2}$	Weed reduction% compared to control
lintour 0.18 kg ha^{-1} + biological agents	2013	0.7	86.5
	2014	0.7	88.7
Lintour 0.15 kg ha^{-1} + biological agents	2013	1.9	79
	2014	0.7	78.2
lintour 0.12 kg ha^{-1} + biological agents	2013	2.1	62.5
	2014	2.2	64.5
Control ‘no application’	2013	6.1	–
	2014	6.2	–

Yield of wheat as affected by weeds competition and treatments during 2015-2016

Grain yield was negatively correlated with weed populations. Wheat grain yield was enhanced with various rates of lintour plus biological agents as compared to control (without treatment). Thus, the highest level of wheat grain yield 7.8 t/ha^{-1} was achieved about intermediate lintour dose 0.15 kg/ha^{-1} in combination with biological agents and the lowest wheat yield 6.8 t/ha^{-1} was obtained in the control (without application) (Table 2).

The increase in grain yield with different herbicide doses might be related to reduce weed-crop competition; such findings are in agreement with those described by Hamill et al. (2004). Fairly acceptable wheat and wheat components and also weeds suppression were achieved with dose of 0.15 kg/ha^{-1} in combination with biological agents that were comparable to results with its label dose. It can be used as a cost effective and environmentally friendly approach to minimize weed pressure. Therefore, the aim of biological weed management is not to eradicate but rather to reduce and regulate weed populations below levels that cause economic injury to the crop.

Although differences between treatments were not significant about grain yield in 2013, but, yield 7.57 t/ha^{-1} was obtained when intermediate dose 0.15 kg/ha^{-1} plus biological components was applied, and the lowest yield 6.51 t/ha^{-1} was achieved in the control (no application)

Table 2
Influence of reduced doses of lintour combined with biological agents on agronomic and morphological traits in 2014-2015

Tratments	2015yr			2016 yr		
	Plant height (cm^{-2})	Grain weight/ spike	Wheat yield (t/ ha^{-1})	Plant height (cm^{-2})	Grain weight/ spike	Wheat yield (t/ ha^{-1})
lintour 0.18kg ha^{-1} + biological agents	98.50a	1.85a	7.31a	102.15a	1.76a	7.18ab
lintour 0.15kg ha^{-1} + biological agents	98.61a	1.86a	7.57a	102.27a	1.57b	7.80a
lintour 0.12kg ha^{-1} + biological agents	95.05b	1.85a	7.55a	97.80b	1.52b	7.16ab
Control 'without application'	92.57b	1.78b	6.51a	96.75b	1.37b	6.80b

Means in columns followed by the same letter are not significantly different at P = 0.05.

(Table 2). Gupta (2004) stated that weeds are the most troublesome of pests that interfere with crops through competition process, resulting in direct losses to quantity and quality of the crop production and indirectly increasing production costs. Therefore, reduced herbicide doses seem to recommend a favorable practice to decline herbicide consumption across the globe. Thus, the application of biological weed management agents recommended alternatives to the use of herbicides that provide new environmental options weed management tools (Boyetchko, 2005; Bailey et al., 2006).

Grain yield of wheat as affected by treatments without biocontrol agents during 2014-2016

Results of three years experiments during 2014 to 2016 related to effect of various lintour doses alone (no biocontrol agents) on winter wheat revealed that wheat yield percentage was desirably enhanced 17.63% compared to the control

Table 3
Grain yield of winter wheat 'Nemchinovskaya' without biocontrol components during 2014-2016

lintour doses	2014	2015	2016	Average	+/– Control	%
0.18kg ha^{-1}	5.91	7.33	7.39	6.87	0.69	11.16
0.15kg ha^{-1}	6.52	7.8	7.51	7.27	1.09	17.63
0.12kg ha^{-1}	5.81	7.2	7.41	6.80	0.62	10
Control 'no application'	5.23	6.8	6.52	6.18	–	–

when intermediate dose of lintour 0.15 kg/ha^{-1} was applied, the lowest yield increasing percentage 10 % was achieved when lintour 0.12 kg/ha^{-1} was used (Table 3).

Economic efficiency of experimental treatments

Experimental technology of weed control practices in winter wheat Nemchinovskaya was high effective according to energetic and economic efficiency. The highest income provided cultural practice with herbicide lintour 0.15 kg/ha^{-1} + biological agents, when net income was 32163 rub./ha and payback 2.02 rub./rub (Table 4).

Conclusion

Weeds were mainly declined when lintour 0.18 kg/ha^{-1} + biological agents was used. Furthermore, satisfactory reducing of dominant weeds such as *Viola arvensis,* species of *Poaceae* and also in some cases, *Stelaria media* were obtained with intermediate dose as 0.15 kg/ha^{-1} + biological agents. The higher efficacy weed reduction was desirably achieved with labeled lintour dose plus biological agents but the difference was not high compared with dose 0.15 kg/ha^{-1} plus biological agents.

Acknowledgments

This paper was financially supported by Ministry of Education and Science of the Russian Federation on the program to improve the competitiveness of RUDN University among the world's leading research and education centers during 2016 – 2020.

Table 4
Economic efficiency of treatments in winter wheat (Nemchinovskaya) cultivation (average for 2014– 2016 years)

Treatments	Grain yield t/ha	Yield price rub./ha	Cultivation cost rub./ha	Conditional Net return, Rub.	Payback rub./rub.
lintour 0.18 kg ha^{-1} + biological agents	6.97	45305	15971	29334	1.84
lintour 0.15 kg ha^{-1} + biological agents	7.40	48100	15937	32163	**2.02**
lintour 0.12 kg ha^{-1} + biological agents	6.83	44395	15911	28484	1.79
Control 'no application'	6.17	40105	15811	24294	1.54

References

Aldrich, R.J., 1984. Weed-Crop Ecology: Principles in Weed Management. *New Breton Publ.*, North Scituate, Mass, 465 p.

Auskalnis, A. and A. Kadzys, 2006. Effect of timing and dosage in herbicide application on weed biomass in spring wheat. *Agronomy Res.*, **4**: 133-136.

Bailey, K.L. and E.K. Mupondwa, 2006. Handbook of sustainable weed management. In: Singh H.P., Batish D.R., Kohli R.K. (eds.) *The Haworth Press Inc,* Binghamton, NY, pp. 431-473.

Barros, J.F.C., G. Basch and M. De Carvalho, 2005. Effect of reduced doses of a post-emergence graminicide mixture to control *Lolium rigidum* G. in winter wheat under direct drilling in Mediterranean environment. *Crop Prot.*, **24**: 880-887.

Barros, J.F.C., G. Basch and M. De Carvalho, 2007. Effect of reduced doses of a post-emergence herbicide to control grass and broadleaf weeds in no-till wheat under Mediterranean conditions. *Crop Prot.,* **26**: 1538-1545.

Barros, J.F.C., G. Basch and M. De Carvalho, 2008. Effect of reduced doses of a post-emergence graminicide to control *Avena sterilis* L. and *Lolium rigidum* G. in no-till wheat under Mediterranean environment. *Crop Prot.,* **27**: 1031-1037.

Barroso, J., D. Ruiz, C. Escribano, L. Barrios and C. Fernandez-Quintanilla, 2009. Comparison of chemical control strategies for Avena sterlis ssp. ludoviciana. *Crop Prot.*, **28**: 393-400.

Beckie, H.J, 2006. Herbicide-resistant weeds: tactics and practices. *Weed. Tech.*, 20: 793-814.

Bostrom, U. and H. Fogelfors, 2002. Response of weeds and crop yield to herbicide dose decision – support guidelines. *Weed Sci.*, **50**: 186-195.

Boydston, R.A. and M.M. Williams, 2004. Combined effects of Aceria malherbae and herbicides on field bindweed growth. *Weed Sci.*, **52**: 297-301.

Boyetchko, S.M, 2005a. Biological herbicides in the future. In: Ivany JA (ed) Weed Management in Transition. Topics in Canadian Weed Science, Vol. 2, Sainte-Anne-de-Bellevue, Quebec. *Canadian Weed Science Society* (Societe Canadienne de Malherbologie), pp. 29-47.

Boyetchko, S.M, 2005a. Weed Management in Transition. In: Ivany J.A. (ed) *Canadian Weed Science Society* (Societe Canadienne de Malherbologie), pp. 29-47.

Boyetchko, S.M. and E.N. Rosskopf, 2006. Strategies for developing bioherbicides for sustainable weed management. In: Singh H.P., Batish D.R., Kohli R.K. (eds.) Handbook of Sustainable Weed Management. *The Haworth Press Inc*, Binghamton, NY, pp. 393-430.

Buhler, D.D., M. Liebman and J.J. Obrycki, 2000. Review: theoretical and practical challenges to an IPM approach to weed management. *Weed Sci.,* **48**: 274-280.

Busi, R. and S. Powles, 2009. Evolution of glyphosate resistance in a Loliumrigidum population by glyphosate selection at sublethal doses. *Heredity*, **103**: 318-325.

Coombs, E.M., P.B. McEvoy, G.L. Piper and B. Villegas, 1999. In: Spencer N., Noweierski R., (ed) 10th International Symposium On Biocontrol of Weeds, *Montana University*, MTUSA, 27.

Delfosse, E.S, 2004. In: Coombs E.M., Clark J.K., Piper G.L., Co Francesco A.F., Corrallis, G.R. (ed) Introduction. Biological Control of Invasive weed. OR: *Oregon State University Press*, pp. 1-11.

Fernandez-Quintanilla, C., J. Barroso, J. Recasens., X. Sans., C. Torner and M.J. Sánchez, 2000. Demography of *Lolium rigidum* in winter barley crops: analysis of recruitment, survival and reproduction. *Weed Res.*, **40**: 281-291.

Gupta, O.P, 2004. Modern weed management. 2nd ed, *Agro Bios*, Jodhpur, India, pp. 18-23.

Hallet, S.G, 2005. Where are the bioherbicides? *Weed Sci.*, **53**: 404-415.

Hamill, A.S., S.E. Weaver, P.H. Sikkema, C.J. Swanton, F.J. Tardif and G.M. Ferguson, 2004. Benefits and risks of economic vs. Approaches to weed control in corn, soybean. *Weed Tech.,* **18**: 723-732.

Heap, I., 2010. The International Survey of Herbicide-Resistant Weeds.
http:// www.weedscience.org. Accessed: January 25, 2010

Kumar, V.S., R.S. Singh., R.K. Chhokar, D.C. Malik and J.K. Ladha, 2013. Weed management strategies to reduce herbicide use in zero-till rice–wheat cropping systems of the Indo Gangetic Plains. *Weed Tech.*, **27**: 241-254.

Lym, R.G. and J.A. Nelson, 2002. Integration of *Aphthona* spp. flea beetles and herbicides for leafy spurge (*Euphorbia esula*) control. *Weed Sci.*, **50**:812-819.

Mafakheri, S., M. Zargar and K. Fakhri, 2012. The best application time and dose of herbicide for optimum weed management in two red bean cultivars. *Indian Journal of Science and Technology*, **5** (1): 1848-1850.

Medd, R.W., 1992. Directions for bioherbicide research. *Plant Protection Quarterly*, **7**: 151-153.

Medd, R.W., J. Van de Den., D.I. Pickering and T. Nordblom, 2001. Determination of environment-specific dose-response for clodinafop-propargyl on *Avena* spp. *Weed Res.*, **41**: 351-368.

Nelson, J.A. and R.G. Lym, 2003. Interactive effects of *Aphthona nigriscutis* and picloram plus 2,4-D in leafy spurge (*Euphorbia esula*). *Weed Sci.,* **51**: 118-124.

Neve, P. and S.B. Powles, 2005a. High survival frequencies at low herbicide rates in *Lolium rigidum* result in rapid evolution of herbicide resistance. *Heredity,* **95**: 485-492.

Neve, P. and S.B. Powles, 2005b. Recurrent selection with reduced herbicide rates results in the rapid evolution of herbicide resistance. *Theor. Appl. Genet.*, **110**: 1154-1166.

O'Donovan, J.T.K., N. Harker, G.W. Clayton., J.C. Newman, D. Robinson and L.K. Hall, 2004. Barley seeding rate influences the variable herbicide rates on wild oat. *Weed Sci.*, **49**: 746-754.

Patzoldt, W.L., P.J. Tranel, A.L. Alexander and P.R. Schmizer, 2001. A common ragweed population resistant to cloransulammet2hyl. *Weed Sci.*, **49**: 485-490.

Pleban, S. and G.A. Strobel, 1998. Rapid evaluation of *Fusarium* spp. as a potential biocontrol agent for weeds. *Weed Sci.,* **46**: 703-706.

Powles, S.B. and Q. Yu, 2010. Evolution in action: plants resistant to herbicides. *Annu. Rev. Plant. Biol.*, **61**: 317-347.

Primot, S., M. Valantin-Morrison and D. Makowski, 2006. Predicting the risk of weed infestation in winter oilseed rape crops. *Weed Res.,* **46**: 22-33.

Randall, J.M., 1999. In: Spencer N., Noweierski N. (ed) A conservation biologist's perspective on biocontrol of weeds. Abstracts of the 10th International Symposium on Biological Control of Weeds. *Montana State University*, Bozeman, MT, USA, 56.

Ruegg, W.T., M. Quadranti and A. Zoschke, 2007. Herbicide research and development: challenges and opportunities. *Weed Res.*, **47**: 271-275.

SAS institute, 2002. The SAS system for windows, release 9.1. *The Institute Cary*, NC, USA.

Shakouri, M.J., A. Varasteh Vajargah, M. Ghasemi Gavabar, S. Mafakheri and M. Zargar, 2012. Rice Vegetative Response to Different Biological and Chemical Fertilizers. *Advances in Environmental Biology*, **6** (2): 859-862.

Talgre, L., E. Lauringson and M. Koppel, 2008. Effect of reduced herbicide dosages on weed infestation in spring barley. *Zemdirbyste-Agriculture*, **95**: 194-201.

Walker, S.R., R.W. Medd, G.R. Robinson and B.R. Cullis, 2002. Improved management of Avena ludoviciana and Phalaris paradoxa with more densely sown wheat and less herbicide. *Weed Res.*, **42**: 257-270.

Weis, M., C. Gutjahr, V. Rueda Ayala, R. Gerhards, C. Ritter and F. Scholderle, 2008. Precision farming for weed management: techniques. *Gesundebpflanzen*, **60** (4): 171-181.

Zargar, M., T. Astrakhanova, E. Pakina, I. Astrakhanov, A. Rimikhanov, A. Gyul'magomedova, Z. Ramazanova and N. Rebouh, 2017. Survey of biological components efficiency on safety and productivity of different tomato cultivars. *Res on Crops*, **18** (2): 283-292.

Zargar, M., H. Najafi, K. Fakhri., S. Mafakheri and M. Sarajuoghi, 2011. Agronomic evaluation of mechanical and chemical weed management for reducing use of herbicides in single vs. twin-row sugarbeet. *Res on Crops*, **12** (1): 173-178.

Zhang, J.S., E. Weaver and A.S. Hamill, 2000. Risks and reliability of using herbicides at below-labeled doses. *Weed Tech.*, **14**: 106-115.

Received August, 5, 2017; accepted for printing October, 30, 2017