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ECONOMIC ASPECTS OF AGROCHEMICALS USE FOR WINTER WHEAT IN UKRAINE

Balian A.V.[1], Prysiazhniuk O. I.[2*], Cherniak M. O.[3] and Storozhyk L.I.[2]

[1]National Academy of Agricultural Sciences of Ukraine, 9Mykhaila Omelianovycha-Pavlenka, St., Kyiv, 01010, Ukraine

[2]Institute of Bioenergy Crops and Sugar Beet NAAS, 25 Klinichna St., Kyiv, 03110, Ukraine.

[3]NSC "Institute of Agriculture of NAAS of Ukraine", 2BMashynobudivnykiv, Chabany, Kyiv region, 08163, Ukraine.

*E-mail: ollpris@gmail.com

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ABSTRACT

Winter wheat is an important crop in Ukraine. In 2019, it was grown on 6.65 million hectares. Two factors that can significantly reduce wheat productivity are the wrong selection of fertilizer system and weed control system. The experiments were carried out in the years 2016−2019. The following formulations were used for weed control: Tribenuron-methyl, 750g/kg (20, 30 g/ha); Triasulfuron, 750g/kg (10, 15 g/ha); Prosulfuron, 750g/kg (20, 30 g/ha); Thifensulfuron-methyl, 750g/kg (20, 30 g/ha). Formulations were applied in autumn in the growth stages of winter wheat (BBCH-scale) 7−9, 10−13, 22−25, and in spring in stages 25−26, 27−29, 30−35. The analysis of the areas of cultivation, yield, and export shows that in Ukraine, 24–26 million tonnes of the wheat grain is grown annually, of which 50–72% is exported. Along with the exported grain, 224 thousand tonnes of nitrogen, 80 thousand tonnes of phosphorus, and 53 thousand tonnes of potassium, which equals 382.3 million US dollars, are removed from the soil every year. This means that producers bear the costs of compensation for lost soil fertility through the use of additional fertilizers. To protect crops from dicotyledonous weeds in autumn, it is recommended to use Prosulfuron formulation in the early stages of growth and development of winter wheat (BBCH stages 7–9) at an application rate of 20 g/ha, and Triasulfuron in the stages 10–13 at an application rate of 10 g/ha. If necessary, for spring weed control it is advisable to use Prosulfuron during the restoration of spring vegetation (BBCH stages 25–26), at an application rate of 20 g/ha, or Triasulfuron at a rate of 10 g/ha in stages27–29.

Keywords: Osmosis, Fruits, Preservation, Mass transfer kinetics, extend shelf life, dehydration

INTRODUCTION

Winter wheat is one of the major grain crops grown in Ukraine. Thus, in 2019, it was cultivated on 6.65 million hectares, with a total area under grain crops being 17.4 million hectares. It was followed by maize grown on an area of 5.0 million hectares (State Statistics Service of Ukraine, 2020).

The efficiency of growing crops is determined not only by the demand for products but also depends on the correct selection of components of cultivation technology that ensures a sufficient level of production cost. After all, the technology of growing winter wheat requires the application of mineral fertilizers, fuel, pesticides, and machinery that are imported to Ukraine, and therefore their prices directly depend on the economic situation in the country (Kobuta, 2010; Kobuta *et al.,*2010).

Thus, a significant impact on the growth of wheat production costs has the right choice of fertilizer systems and weed, pests, and disease control systems that are important components of cultivation technology (Kovalchuk & Muliar, 2014; Kucher *et al.,* 2019).

According to many researchers, with the wrong fertilizer system, a farmer can lose 37–55% of the yield. After all, to form a grain yield of 1.0 t/ha, plants need to assimilate in an extremely short time 25–35 kg of nitrogen, 11–13 kg of phosphorus, 20–27 kg of potassium (Ivashchenko, 2002; Lapa *et al.,*2007; Tsykov *et al.,* 2012).

Another important issue is the selection of the correct system of protection of winter wheat from weeds because abundant weed seedlings in autumn significantly suppress winter wheat plants, and wintering weeds remain in the field. Therefore, weeds, if abundant in the field, are able to reduce the yield of winter wheat by 30–45% (Leontiuk, 2015; Melnyk *et al.,*2009; Shevchenko *et al.,* 2004).

Therefore, increasing the economic efficiency of winter wheat cultivation can be achieved through reducing production costs, which can be achieved with the right choice of formulations to protect crops from weeds and with correct timing of treatments (Zhygadlo & Sikachyna, 2008; Zuza & Lotonenko, 2008).

MATERIALS AND METHODS

Experimental studies were carried out in the years 2016–2019at the Bila Tserkva Research and Breeding Station of the Institute of Bioenergy Crops and Sugar Beets NAAS of Ukraine, in the zone of unstable moisture, Right-Bank Forest-Steppe of Ukraine.

The weather conditions during the years of the experiment largely fluctuated and became the most limiting factor in the yield formation in 2017; however, in 2018, soil moisture reserves were restored. Nevertheless, in that year, a negative impact of high temperatures on plants occurred. The best weather conditions for the formation of the winter wheat yield were in 2019.

The soil of the experimental field was typical deep coarse chernozem with a low humus content, medium to light loamy. The thickness of the humus layer was 70–80 cm with the humus content in the layer 0–30 cm of 3.4–3.8%, alkaline hydrolyzed nitrogen of 118–134, mobile phosphorus and exchangeable potassium of 180–208 and 73–91 mg/100 g of air-dry soil. The reaction of the soil solution was weakly acidic and close to neutral.

Winter wheat variety 'Lybid' was used in the experiment. The area of the experimental plot was 32 m^2; accounting area was 25 m^2. The experiment was carried out with four replications.

For weed control, Tribenuron-methyl, 750g/kg (standard) (20 g/ha, 30 g/ha),Triasulfuron, 750 g/kg (10 g/ha, 15 g/ha), Prosulfuron, 750g/kg (20 g/ha, 30 g/ha), and Thifensulfuron-methyl, 750g/kg (20 g/ha, 30 g/ha) were used in autumn and spring treatments. The formulations were applied in the following growth stages of winter wheat (BBCH scale): in autumn in stages 7–9, 10–13, 22–25, and in spring in stages 25–26, 27–29, 30–35.

Sowings were treated using hand sprayer STIHL SG 20 at the operating fluid consumption from 250 to 300 l/ha and a pressure of 2 atmospheres. Sprayings were carried out in sunny weather days at wind speed below 4 m/s (Storchus, 2019).

RESULTS AND DISCUSSION

Export orientation of grain crops plays a significant role in the formation of the balance of basic nutrients. After all, 24–26 million tonnes of wheat grain is grown annually in Ukraine, with the minimum production volumes occurring only in the years with extremely unfavourable weather conditions (such as 2010, 2012, and 2013). In general, annual export of wheat grain ranges between 10 and 20 million tonnes, i.e. 50–72% of the gross yield (Table 1).

Thus, the volume of wheat grain export also affects the level of soil nutrient provision. Along with exported grain, 224 thousand tonnes of nitrogen, 80 thousand tonnes of phosphorus, and 53 thousand tonnes of potassium, which equals 382.3 million US dollars, are removed from the soil every year. That is, given the average long-term export of grain is 10.8 million tonnes, nutrients for 35.3 US dollars per tonne of grain are exported annually.

Besides, many farms do not have an integrated system of weed control, pest control. The use of formulations of dubious origin for wheat protection has become more frequent. Thus, in Ukraine, the volume of imports of the companies producing analogues of herbicides increased to 55 thousand tonnes, while imports of transnational companies amounted to 29 thousand tonnes. Meanwhile, in previous years, the gap was only 10 thousand tonnes in favour of the supply of analogues of recognized formulations.

Indicators of economic efficiency of winter wheat with the autumn herbicide treatment are presented in Table 2.

Among the studied formulations, the cheapest is Tribenuron-methyl. Thifensulfuron-methyl and Triasulfuron are medium expensive and Prosulfuron is the most expensive. However, the differences in the price of the formulations does not significantly affect profitability, as the application rate of 10−30 g/ha has little effect on the total production costs.

The maximum profitability (241 %) was obtainedin the treatment with Tribenuron-methylcarried out in the stages (BBCH-scale) 10−13 at an application rate of 20 g/ha. Increased application rate in the same stages resulted in 2 % lower profitability.

The use of Triasulfuron for protection against dicotyledonous weeds in the stages 10−13 at an application rate of 10 g/ha ensured profitability of 243%; meanwhile, increased rates of the formulation applied in the same stages resulted in only 6% lower profitability.

When applying herbicide Prosulfuron in the early stages of growth and development of winter wheat (BBCH 7−9) at an application rate of 20 g/ha resulted in the profitability of 243%, which was the best result in the experiment.

However, the use of herbicide Thifensulfuron-methyl in stages 10−13 at an application rate of 20 g/ha ensured the profitability of 240%, while an application rate of 30 g/ha resulted in only 235% profitability.

Shown in Table 3 is the economic efficiency of winter wheat cultivation with the spring application of herbicides.

For the application of herbicide Tribenuron-methyl in stages 27−29 at a consumption rate of 20 g/ha profitability of 216% was obtained; however, an increased rate of the formulation provided 4% lower profitability.

When control of dicotyledonous weeds was performed with Triasulfuron applied in stages 27−29 at an application rate of 10 g/ha, the profitability was 216%, while at an increased rate of the formulation the profitability was 212%.

Application of herbicide Prosulfuron in the stage of springrestoration of vegetation (BBCH 25−26), at a rate of 20 g/ha allowed to obtain profitability of 218 %, which was the best result in the experiment.

With the application of herbicide Thifensulfuron-methyl in the stages27−29 at an application rate of 20 g/ha, we obtained 214% profitability, while an application rate of 30 g/ha led to only 210% profitability.

By analogy with the autumn timing, the application of higher rates of all herbicides under study in the spring was less effective compared to the optimal application rates.

CONCLUSIONS

In Ukraine, 24–26 million tonnes of wheat grain is grown annually, and 50–72 % of the harvested grain is exported. Accordingly, annual irretrievable removal of nitrogen is224 thousand tonnes, phosphorus 80 thousand tonnes, and potassium 53 thousand tonnes, which equals 382.3 million US dollars.

Prosulfuron and Triasulfuron-based formulations proved to be the most effective in the autumn treatment aimed at protecting winter wheat sowings from dicotyledonous weeds. To obtain maximum economic

Table 1. Volumes of production, export, and irreversible removal of nutrients with wheat grain

Year	Harvested grain (million tonnes)	Grain export (million tonnes)	Content of nutrients in exported grain, (thousand tonnes)				Costs of exported nutrients(million US dollars)
			Nitrogen	Phosphorus	Potassium	Total	
2008–2009	25.8	12.7	262.9	94.0	62.2	419.1	448.4
2009–2010	20.8	9.3	192.5	68.8	45.6	306.9	328.4
2010–2011	16.8	4.3	89.0	31.8	21.1	141.9	151.8
2011–2012	21.6	5.4	111.8	40.0	26.5	178.2	190.7
2012–2013	15.7	7.2	149.0	53.3	35.3	237.6	254.2
2013–2014	22.3	10.0	207.0	74.0	49.0	330.0	353.1
2014–2015	24.1	8.6	178.0	63.6	42.1	283.8	303.7
2015–2016	26.5	10.9	225.6	80.7	53.4	359.7	384.9
2016–2017	26.0	15.6	322.9	115.4	76.4	514.8	550.8
2017–2018	26.7	15.1	312.6	111.7	74.0	498.3	533.2
2018-2019	27.6	20.0	414.0	148.0	98.0	660.0	706.2
Total	–	–	2465.4	881.3	583.6	3930.3	4205.4

Table 2. Economic efficiency of winter wheat cultivation with autumn herbicide treatment (average), 2017−2019

Formulation	Application rate and growth stage of wheat	Yield (t/ha)	Costs of the technology(UAH/ha)	Costs of growing(UAH/ha)	Production costs(UAH/t)	Profitability (%)
Control (no herbicide treatment)		5.23	525.4	1004.1	100.5	191
Tribenuron-methyl, 750g/kg (standard)	20 g, BBCH 7−9	5.61	527.1	1077.8	93.9	204
	30 g, BBCH 7−9	5.75	528.0	1103.5	91.9	209
	20 g, BBCH 10−13	6.62	527.1	1271.9	79.6	241
	30 g, BBCH 10−13	6.58	528.0	1264.3	80.2	239
	20 g, BBCH 22−25	6.19	527.1	1187.7	85.2	225
	30 g, BBCH 22−25	5.91	528.0	1135.3	89.3	215
Triasulfuron, 750g/kg	10 g, BBCH 7−9	5.70	528.3	1094.9	92.7	207
	15 g, BBCH 7−9	5.76	529.7	1106.9	91.9	209
	10 g, BBCH 10−13	6.67	528.3	1281.2	79.2	243
	15 g, BBCH 10−13	6.54	529.7	1256.2	81.0	237
	10 g, BBCH 22−25	6.22	528.3	1193.8	85.0	226
	15 g, BBCH 22−25	5.94	529.7	1140.2	89.2	215

Formulation	Application rate and growth stage of wheat	Yield (t/ha)	Costs of the technology(UAH/ha)	Costs of growing(UAH/ha)	Production costs(UAH/t)	Profitability (%)
Prosulfuron, 750g/kg	20 g, BBCH 7–9	6.77	536.1	1300.9	79.1	243
	30 g, BBCH 7–9	6.01	541.4	1155.0	90.0	213
	20 g, BBCH 10–13	5.82	536.1	1117.6	92.1	208
	30 g, BBCH 10–13	5.94	541.4	1140.4	91.2	211
	20 g, BBCH 22–25	5.76	536.1	1106.6	93.0	206
	30 g, BBCH 22–25	5.79	541.4	1110.9	93.6	205
Thifensulfuron-methyl, 750g/kg	20 g, BBCH 7–9	5.67	530.4	1088.4	93.6	205
	30 g, BBCH 7–9	5.71	533.0	1096.6	93.3	206
	20 g, BBCH 10–13	6.62	530.4	1271.0	80.1	240
	30 g, BBCH 10–13	6.51	533.0	1250.5	81.8	235
	20 g, BBCH 22–25	6.18	530.4	1187.4	85.8	224
	30 g, BBCH 22–25	5.94	533.0	1140.3	89.8	214

Table 3. Economic efficiency of winter wheat cultivation with spring herbicide treatment (average), 2017–2019

Formulation	Application rate and growth stage of wheat	Yield (t/ha)	Costs of the technology(UAH/ha)	Costs of growing(UAH/ha)	Production costs(UAH/t)	Profitability (%)
Control (no herbicide treatment)		4.67	525.4	896.3	112.6	171
Tribenuron-methyl, 750g/kg (standard)	20 g, BBCH 7–9	5.05	527.1	969.8	104.4	184
	30 g, BBCH 7–9	5.13	528.0	985.5	102.9	187
	20 g, BBCH 10–13	5.93	527.1	1139.4	88.8	216
	30 g, BBCH 10–13	5.83	528.0	1119.8	90.5	212
	20 g, BBCH 22–25	5.54	527.1	1063.5	95.2	202
	30 g, BBCH 22–25	5.27	528.0	1012.2	100.2	192
Triasulfuron, 750g/kg	10 g, BBCH 7–9	5.06	528.3	971.5	104.4	184
	15 g, BBCH 7–9	5.14	529.7	987.5	103.0	186
	10 g, BBCH 10–13	5.95	528.3	1142.9	88.8	216
	15 g, BBCH 10–13	5.85	529.7	1123.1	90.6	212
	10 g, BBCH 22–25	5.55	528.3	1065.7	95.2	202
	15 g, BBCH 22–25	5.31	529.7	1019.5	99.8	192

Formulation	Application rate and growth stage of wheat	Yield (t/ha)	Costs of the technology(UAH/ha)	Costs of growing(UAH/ha)	Production costs(UAH/t)	Profitability (%)
Prosulfuron, 750g/kg	20 g, BBCH 7−9	6.09	536,1	1169.2	88.0	218
	30 g, BBCH 7−9	5.38	541.4	1034.0	100.6	191
	20 g, BBCH 10−13	5.22	536.1	1003.3	102.6	187
	30 g, BBCH 10−13	5.29	541.4	1016.1	102.3	188
	20 g, BBCH 22−25	5.12	536.1	983.1	104.7	183
	30 g, BBCH 22−25	5.21	541.4	1000.8	103,9	185
Thifensulfuron-methyl, 750g/kg	20 g, BBCH 7−9	5.05	530.4	969.6	105.1	183
	30 g, BBCH 7−9	5.12	533.0	983.8	104.0	185
	20 g, BBCH 10−13	5.92	530.4	1137.5	89.5	214
	30 g, BBCH 10−13	5.83	533.0	1119.4	91.4	210
	20 g, BBCH 22−25	5.51	530.4	1058.1	96.3	199
	30 g, BBCH 22−25	5.25	533.0	1008.3	101.5	189

profitability, herbicide Prosulfuron it is recommended to apply in the early stages of growth and development of winter wheat (BBCH 7−9) at an application rate of 20 g/ha. HerbicideTriasulfuron should be applied in the stages BBCH 10−13 at an application rate of 10 g/ha.

If necessary to control dicotyledonous weeds in spring, herbicide Prosulfuron is recommended for treatment during the spring restoration of vegetation (BBCH 25−26) at a rate of 20 g/ha (profitability 218 %), or Triasulfuron in stage BBCH 27−29 at a rate of 10 g/ha, which ensures 216% profitability of the cultivation technology.

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