https://doi.org/10.26898/0370-8799-2022-2-4
УДК: 632.954: 633.15
Тип статьи: оригинальная
Type of article: original

ИЗУЧЕНИЕ ФИТОТОКСИЧНОСТИ ГЕРБИЦИДА ЛЮМАКС В ПОСЕВЕ КУКУРУЗЫ НА ЗЕРНО В УСЛОВИЯХ ЮГА ДАЛЬНЕГО ВОСТОКА

(✉) **Костюк А.В., Ляшенко Е.В.**
Дальневосточный научно-исследовательский институт защиты растений – филиал Федерального научного центра агробиотехнологий Дальнего Востока им. А.К. Чайки
Приморский край, с. Камень-Рыболов, Россия
(✉) e-mail: dalniizr@ mail.ru

Изучена фитотоксичность гербицида Люмакс, состоящего из трех действующих веществ: С-метолахлора, тербутилазина и мезотриона, к гибридной популяции кукурузы П8521. Исследования проведены в Приморском крае в 2020, 2021 гг. на двух фонах: засоренном и чистом от сорняков, который в течение вегетационных сезонов регулярно пропалывали. Гербицид применяли до всходов, в фазы 2–3 и 5–6 листьев кукурузы в нормах расхода 4 (рекомендованная) и 8 л/га (двукратная от рекомендованной). Почва опытных участков лугово-бурая оподзоленная среднесуглинистая, содержащая в пахотном горизонте 3,8% гумуса, Ph 5,0–5,9. Гербицид Люмакс, примененный в фазу 5–6 листьев, в течение вегетационного сезона оказывал фитотоксичное действие на растения и урожайность зерна кукурузы. Существенное снижение урожая зерна отмечено в 2021 г., когда за II и III декады июня и июль выпало всего 35 мм осадков при норме за этот период 187 мм. При применении гербицида Люмакс в фазу 5–6 листьев существенно уменьшилась длина початка, количество зерен в нем, масса початка и зерна с него, а также масса 1000 зерен. Кукуруза более толерантна к гербициду Люмакс при применении в фазу 2–3 листьев и менее – при использовании в фазу 5–6 листьев.

Ключевые слова: кукуруза, гербицид, фитотоксичность, урожайность, толерантность

STUDY OF PHYTOTOXICITY OF LUMAX HERBICIDE IN GRAIN MAIZE CROPS UNDER CONDITIONS OF THE SOUTH OF THE FAR EAST

(✉) **Kostyuk A.V., Lyashenko E.V.**
The Far Eastern Research Institute of Plant Protection – Branch of Federal Scientific Center of Agricultural Biotechnology of the Far East named after A.K. Chaiki
Kamen-Rybolov, Primorsky Territory, Russia
(✉) e-mail: dalniizr@ mail.ru

The phytotoxicity of the herbicide Lumax to the hybrid population of corn P 8521, consisting of three active substances: C-metolachlor, terbutylazine and mesotrion, was studied. The studies were conducted in the Primorsky Territory in 2020 and 2021 on 2 backgrounds: clogged and weed-free which was regularly weeded during the growing seasons. The herbicide was applied before germination, in phases 2-3 and 5-6 of corn leaves at consumption rates of 4 (recommended) and 8 l/ha (twice the recommended). The soil of the experimental plots is meadow-brown podzolized, medium loamy, containing 3.8% humus in the arable horizon, PH 5.0-5.9. The herbicide Lumax, applied in the phase of 5-6 leaves, during the growing season had a phytotoxic effect on plants and corn grain yields. A significant decrease in the grain harvest was noted in 2021 when during the II and III ten-day periods of June and July there were only 35 mm of precipitation, while the norm for this period was 187 mm. When applying Lumax herbicide in the phase of 5-6 leaves, the cob length, the number of grains in it, the weight of the cob and grains from it, as well as the weight of 1000 grains significantly decreased.

Corn is more tolerant to Lumax herbicide when used in the 2-3 leaf phase and less tolerant when used in the 5-6 leaf phase.

Keywords: corn, herbicide, phytotoxicity, yield, tolerance

Для цитирования: *Костюк А.В., Ляшенко Е.В.* Изучение фитотоксичности гербицида Люмакс в посеве кукурузы на зерно в условиях юга Дальнего Востока // Сибирский вестник сельскохозяйственной науки. 2022. Т. 52. № 2. С. 32–38. https://doi.org/10.26898/0370-8799-2022-2-4. EDN GOYADC.

For citation: Kostyuk A.V., Lyashenko E.V. Study of phytotoxicity of Lumax herbicide in grain maize crops under conditions of the South of the Far East. *Sibirskii vestnik sel'skokhozyaistvennoi nauki = Siberian Herald of Agricultural Science,* 2022, vol. 52, no. 2, pp. 32–38. https://doi.org/10.26898/0370-8799-2022-2-4. EDN GOYADC.

Конфликт интересов
Авторы заявляют об отсутствии конфликта интересов.
Conflict of interest
The authors declare no conflict of interest.

INTRODUCTION

The purpose of registration tests is to develop and verify the regulations for the use of pesticides that ensure both efficacy and safety of their application. The preparations must meet the requirements of ecotoxicological safety [1]. Biological safety of plant protection is necessary for adaptive intensification of crop production, its ecologization and biologization. According to the results of protective measures, the consequences of overdoses and accidents with pesticides are predicted [2].

One of the requirements for herbicides in registration trials is the safety of preparations for cultivated plants. It consists in the absence of phytotoxicity of herbicides and in increasing crop yields when using them [3]. The use of the preparation should be studied in specific agrotechnologies and soil and climatic conditions. Currently, such studies have not been conducted in sufficient quantities [4].

There is a close correlation between the impact of a destructive factor and the activity of plant growth processes, which is adjusted by weather conditions. Therefore, the level of initial impact of herbicide and the weather conditions determine the speed of the adaptation process and features of crop yield formation [5].

The modern range of herbicides to protect corn from weeds in the Russian Federation contains more than 200 preparations [6]. In 2016, according to "Agrostat" company in the Russian Federation, 73% of the areas under corn were treated once or more [7]. When developing new herbicides for post-emergence application, the key factor is their selectivity to the crop [8].

In the All-Russian Research Institute of Corn the phytotoxic effects of post-emergent herbicides Meister, Titus Plus, Dublon Super, Stellar, Meister Power have been studied for several years. Visual observations showed no signs of inhibition of corn plants by these herbicides when used at the recommended rates and times of application [9-11]. However, a strong phytotoxic effect on the crop was observed when Meister Power was used in the phase of 8 leaves. The use of herbicide at a later date caused growth retardation, changes in the number of corncobs per plant, corncob weight and grain per corncob [12].

In the Smolensk region, when Titus Plus was applied at temperatures above 25 °C, growth retardation and pinking of corn leaves were observed. Stress exposure to herbicide affected the chemical composition of the feed - a lower content of protein and a higher content of fiber were found [13].

When testing the new herbicide Kreutzer in seed crops of lines and simple hybrids of corn under severe drought conditions with lack of moisture and high air temperatures, an increased manifestation of phytotoxicity on plants at the rate of 0.11 kg/ha was noted [14].

In the Moscow region after the application of herbicide Kelvin Plus in the phase of 7-8 leaves of corn chlorosis and suppression of growth and development were revealed. Subsequently, it reduced the value of the obtained yield relative to the variants with its use in the recommended terms [15].

The Far Eastern Research Institute of Plant Protection used herbicides Dublon Gold, Titus Plus, Meister, Stellar and Adengo at recommended and double recommended rates in corn crops on a clean weed-free background. According to measurements of plant height and green mass, growth and development of corn was slowed down in almost all variants with the application of herbicides. According to their response to the crop, they can be placed in the following descending order: Titus Plus, Adengo, Dublon Gold, Stellar and Meister [16]. It was also found that herbicide Adengo when sprayed in the phase of 5-6 leaves in corn can have a phytotoxic effect on the crop plants and significantly (up to 0.78 t/ha) reduce grain yield [17].

The aim of the research was to study phytotoxicity of Lumax herbicide in the sowing of corn for grain at recommended and double recommended rates in the conditions of the south of the Far East.

MATERIAL AND METHODS

The studies were conducted on the experimental fields of the Far Eastern Research Institute of Plant Protection, a branch of the Federal Scientific Center of Agricultural Biotechnology of the Far East named after A.K. Chaiki, in 2020 and 2021. The soil of the experimental plots was meadow-brown podzolized middle loamy, containing 3.8% humus in the arable horizon, Ph 5.0-5.9.

Climatic conditions in the years of research differed significantly among themselves. Thus, in 2020 in the third ten-day period of May and June, uniform rainfall (145 mm, the norm 106 mm) contributed to the active growth and development of corn plants. Only 70 mm of rain fell in July (with an average of 140 mm). In the first two ten-day periods of September, there was an excess of moisture in the soil (3 times the norm). Precipitation amounted to 35 mm in 2021 during the second and third ten-day periods of June and July, while the long-term average was 187 mm. Daily air temperatures reached 28.1-36.3°C during the second and third ten-day periods of June, and average daily values exceeded the long-term average by 4.6-5.5°C. Precipitation also exceeded the long-term average in August. Precipitation also amounted to only 73.6 mm in August, which was two times less than the long-term average (155 mm).

Agronomic technique of corn cultivation is common for this region on the basis of mouldboard tillage. Corn hybrid population P8521 was sown with the rate of 70 thousand seeds/ha. Mineral fertilizer (dinitroammophoska) in the rate of physical weight of 70 kg/ha was introduced at sowing. The forecrop was soybeans.

The experiments were set up on two backgrounds: weedy and weed-free. The latter plot was regularly weeded during the growing season. Lumax herbicide was applied before sprouts, in phases 2-3 and 5-6 leaves of corn at rates of 4.0 (recommended) and 8.0 l/ha (double of the recommended). Herbicide working solutions were applied by hand-operated boom sprayer designed by All-Russian Research Institute of Phytopathology with working solution application rate of 200 l/ha. The area of experimental plots was 22.5 m^2, repeated four times, and the location was randomized.

In the phases of 10-12 leaves and milk ripeness of the cobs the height of plants was measured and the green mass was counted. For this purpose, 10 plants most typical for each plot were selected. Corn cobs were harvested manually in the phase of waxing ripeness of grain. After drying, they were analyzed (5 pieces from each plot) according to N.A. Maysuryan's method [18]. The remaining cobs were threshed on a stationary threshing machine. To quantify the nature of the direct response of cultivated plants to Lumax herbicide a tolerance coefficient (T) was used, which was calculated according to the formula

$$T = \frac{Yh}{Yc},$$

where Yc is the yield in the weed-free control, expressed in tons per hectare; Yh is the grain yield in the weed-free background with herbicide application, expressed in tons per hectare. Tolerance of corn plants to Lumax herbicide was evaluated by analyzing the results of the experiments laid on the crops infested to a greater or lesser degree. For this purpose, the method of weed harmfulness assessment by

V.S. Zuza[1] was used. Such an assessment involves the calculation of weed harmfulness coefficient Kw, which shows the amount of yield shortfall caused by 1 ton of weed mass. Calculation of the yield shortage at the end of the crop vegetation is carried out by the formula

$$Kw = \frac{\Delta Y}{\Delta W},$$

where ΔY is the difference in yield in the control and the variant where the herbicide was studied, expressed in tons per hectare; ΔW is the difference in the ratio of the weed mass, expressed in tons per hectare. All studies and data processing were performed according to the generally accepted methods [2-4].

RESULTS AND DISCUSSION

In the phase of 10-12 leaves of corn in the control variant, plants grew with an average height of 125 cm and vegetative mass of 357 g (see Table 1). In the variants with application of Lumax herbicide before sprouting and at the phase of 2-3 leaves, the plants were 1-5 cm higher and increased aboveground weight by 3-25 g more than in the control. When using the herbicide in a later phase of development (5-6 leaves), Lumax had a significant phytotoxic effect on the crop. Plants were registered 13-14 cm lower and their aboveground weight was 57-61 g less than in the control.

When recording in the phase of milky cob ripeness, Lumax herbicide continued to negatively affect plants of the crop (height 208 cm, weight 648-670 g) when used in the phase of 5-6 leaves in both rates of consumption. On the herbicide-free version, corn plants reached an average height of 214 cm and built up 702 g of vegetative mass.

Phytotoxic effect of Lumax herbicide (4.0 and 8.0 l/ ha), manifested during the growing season when used in the late phase of 5-6 leaves, had an impact on corn grain yield. In 2 years of research on these variants less grain by 0.40-0.52 t/ha than in the control was received (see Table 2). It should be noted that reliably less of it was collected in 2021 (5.81-6.13 t/ha, the control 6.85 t/ha). Climatic conditions of this year had a significant impact, as mentioned above.

Табл. 1. Влияние гербицида Люмакс на растения кукурузы (среднее за 2020, 2021 гг.)

Table 1. Influence of Lumax herbicide on corn plants (average for 2020 and 2021)

Experiment option	Dosage, l/ha	Treatment time	10-12 leaf phase				Corncob milky stage			
			Single plant height, cm	Single plant herbage, g	Change (+/-) from the control		Single plant height, cm	Single plant herbage, g	Change (+/-) from the control	
					height, cm	herbage, g			height, cm	herbage, g
Control	–	–	125	357	–	–	214	702	–	–
Lumax	4,0	Before sprouting	126	354	+1	–3	214	670	0	–32
Lumax	8,0		130	374	+5	+17	218	722	+4	+20
Lumax	4,0	2–3 leaf phase	126	358	+1	+1	215	678	+1	–24
Lumax	8,0		128	366	+3	+9	216	698	+2	–4
Lumax	4,0	5–6 leaf phase	112	300	–13	–57	208	670	–6	32
Lumax	8,0		111	296	–14	–61	208	648	–6	–54
LSD_{05}			6	31			7	58		

[1]Zuza V.S. Regression analysis in the study of relationships of cultivated plants and weeds. Agricultural Biology. 1974. No. 6. Pp. 838-843.

[2]Spiridonov Yu.Ya., Larina G.E., Shestakov V.G. Methodological guidelines for the study of herbicides used in crop production. Moscow: Pechatny Gorod, 2009. 252 p.

[3]Dospekhov B.A. Methodology of Field Experiment. Moscow: Kolos, 1979. 416 p.

[4]Koronevsky V.A. To the method of statistical data processing of long-term field experiments. Farming. 1985. No. 1. Pp. 56-57.

Табл. 2. Влияние гербицида Люмакс на урожайность зерна кукурузы и элементы ее структуры (среднее за 2020, 2021 гг.)

Table 2. Influence of Lumax herbicide on the yield of corn grain and elements of its structure (average for 2020 and 2021)

Experiment option	Dosage, l/ha	Treatment time	Corncob length, cm	Number of grains per cob, pcs.	Weight, g			Grain yield, t/ha	Tolerance coefficient
					corncob	grain per corncob	1000 grains		
Control	–	–	17,9	536	177	150	274	7,38	–
Lumax	4,0	Before sprouting	17,7	534	168	147	271	7,28	99
Lumax	8,0		17,8	544	174	152	280	7,52	102
Lumax	4,0	2–3 leaf phase	17,4	518	158	138	271	7,09	96
Lumax	8,0		17,5	524	165	144	272	7,26	98
Lumax	4,0	5–6 leaf phase	17,4	516	157	138	268	6,92	94
Lumax	8,0		17,1	494	151	132	265	6,86	93
LSD_{05}			0,5	29	11	10	1,6	0,56	

Laboratory analysis of corn cobs confirmed the yield data. Thus, the length of the cob, the number of grains in it, the weight of the cob and the weight of 1000 grains from the cob were reliably 0,5-0,8 cm, 42 pieces, 20-26 g, 12-18 g and 6-9 g less than the control in the variants of Lumax application during the phase of 5-6 leaves. When applying herbicide in the pre-emergence period at twice the recommended rate of consumption, the above indicators (exceptions: length and weight of the cob) were respectively 8 pcs, 2 and 6 g more, which confirms the resulting yield increase of 0.14 t/ha in this variant.

Calculation of the tolerance coefficient showed that in the variants with Lumax herbicide before sprouting and in the phase of 2-3 leaves of corn the difference in grain yield was within 2-4% in one direction or the other, and when treated in the later phase of crop development (5-6 leaves) the difference reached 6-7% in the downward direction. We can consider that in the first case corn was indifferent to Lumax, and in the second case we can indicate a significant phytotoxic effect on corn.

When conducting experiments on weedy background for 2 years of research on the control (without herbicides) variant 1.12 t/ha of corn grain was received (see Table 3).

There were weeds with a total aboveground mass of 28.1 tons/ha on this plot. Calculation of the coefficient of harmfulness showed that if corn responded equally to all three terms of herbicide application, the increase in yield from them would be proportional to the reduction in the weed mass, then the values of Kw in all three cases would be about the same. However, the actual values of the coefficients are different, so we can assume that corn is more tolerant when Lumax is applied in the phase of 2-3 leaves and less tolerant when it is used in the later phase of development.

Табл. 3. Расчет коэффициентов вредоносности сорняков

Table 3. Calculation of weed harmfulness coefficients

Option	B, t/ha	Y, t/ha	D	D	WHC
Control (without herbicides)	28,1	1,12	–	–	–
Control (manual weeding)	0	7,38	28,1	–6,26	–0,223
Lumax 4,0 l/ha					
before sprouting	12,4	4,46	15,7	–3,34	–0,213
2–3 leaf phase	12,6	4,61	15,5	–3,49	–0,225
5–6 leaf phase	14,1	3,71	14,0	–2,59	–0,185

Note. B – raw weed mass before harvesting; Y – corn yield; WHC – weed harmfulness coefficient.

CONCLUSIONS

1. Lumax herbicide can have a phytotoxic effect on plants and corn yields if the application regulations are not observed (overdose, application in late phases of development). The length of the cob, the number of grains in it, the weight of the cob and grains from it, as well as the weight of 1000 grains decreases.

2. Corn is more tolerant to Lumax herbicide when used during the 2-3 leaf development phase and less tolerant when used in later development phases.

СПИСОК ЛИТЕРАТУРЫ

1. *Петрова М.О., Черменская Т.Д., Долженко В.И.* Развитие исследований в аналитической лаборатории ВИЗР по оценке остаточных количеств пестицидов // Вестник защиты растений. 2020. Т. 103. № 2. С. 87–93. DOI: 10.31993/2308-6459-2020-103-2-13571.
2. *Соколов М.С., Санин С.С., Долженко В.И., Спиридонов Ю.Я., Глинушкин А.П., Каракотов С.Д., Надыкта В.Д.* Концепция фундаментально-прикладных исследований защиты растений и урожая // Агрохимия. 2017. № 4. С. 3–9.
3. *Долженко В.И., Петунова А.А., Маханькова Т.А.* Биолого-токсикологические требования к ассортименту гербицидов // Защита и карантин растений. 2001. № 5. С. 14.
4. *Данилова А.А.* Доступный способ регулирования скорости детоксикации пестицидов в зерновых агроценозах Западной Сибири // Достижения науки и техники АПК. 2016. Т. 30. № 4. С. 33–35.
5. *Дворянкин Е.А.* Продуктивность сахарной свеклы, поврежденной гербицидами гормоноподобного действия в сублетальных и изрежи-вающих посев дозах // Агрохимия. 2021. № 1. С. 49–54. DOI: 10.31857/S0002188121010051.
6. *Маханькова Т.А., Голубев А.С.* Гербициды для кукурузы // Защита и карантин растений. 2018. № 2. С. 37–64.
7. *Колесник С.А., Сташкевич А.В., Кислушко П.М.* Формирование ассортимента гербицидов для защиты посевов кукурузы в Беларуси // Защита и карантин растений. 2021. № 1. С. 18–21.
8. *Захаренко В.А.* Перспективы применения химических средств защиты растений в сельском хозяйстве (по материалам VII Международной конференции «Пестициды-16») // Агрохимия. 2017. № 4. С. 10–15.
9. *Кузнецова С.В., Губа Е.И.* Гербициды для раннеспелых гибридов кукурузы // Защита и карантин растений. 2017. № 7. С. 48–50.
10. *Багринцева В.Н.* Защита кукурузы от сорняков в товарных и семеноводческих посевах // Кукуруза и сорго. 2012. № 1. С. 27–28.
11. *Багринцева В.Н., Кузнецова С.В., Губа Е.И.* Послевсходовые гербициды с почвенным действием для кукурузы // Кукуруза и сорго. 2015. №1. С. 22–26.
12. *Багринцева В.Н., Губа Е.И., Кузнецова С.В.* Эффективность гербицида Майстер Пауэр в зависимости от сроков применения // Защита и карантин растений. 2020. № 3. С. 10–12.
13. *Солнцева О.И., Прудников А.Д.* Действие гербицидов на химический состав корма из кукурузы // Агрохимический вестник. 2019. № 2. С. 65–67. DOI: 10.24411/0235-2516-2019-10031.
14. *Кузнецова С.В., Багринцева В.Н.* Эффективность применения нового гербицида Крейцер // Агрохимия. 2021. № 10. С. 36-44. DOI: 10.31857/S0002188121100100.
15. *Голубев С.А., Маханькова Т.А., Комарова А.С.* Эффективность и безопасность применения гербицида Кельвин Плюс в посевах кукурузы в разных фазах развития культуры // Агрохимия. 2021. № 3. С. 38–44. DOI: 10.31875/S000218121030 08X.
16. *Костюк А.В., Лукачёва Н.Г.* Эффективность применения гербицидов в посевах кукурузы и толерантность культуры к ним // Сибирский вестник сельскохозяйственной науки. 2018. Т. 48. № 1. С. 38–43. DOI: 10.26898/0370-8799-2018-5.
17. *Костюк А.В., Лукачёва Н.Г.* Оценка эффективности и фитотоксичности гербицида Аденго в посевах кукурузы // Сибирский вестник сельскохозяйственной науки. 2020. Т. 50. № 1. С. 40–47. DOI: 10.26898/0370-8799-2020-1-5.
18. *Майсурян Н.А.* Растениеводство: монография. М., 1960. 383 с.

REFERENCES

1. Petrova M.O., Chermenskaya T.D., Dolzhenko V.I. Development of the research to assess residual pesticides in the analytical laboratory of VIZR. *Vestnik zaschity rastenii = Plant protection News*, 2020, vol. 103, no.2, pp. 87–93. (In Russian). DOI: 10.31993/2308-6459-2020-103-2-13571.
2. Sokolov M.S., Sanin S.S., Dolzhenko V.I., Spiri-

donov Yu.Ya., Glinushkin A.P., Karakotov S.D., Nadykta V.D. The concept of fundamental-applied studies of plant and yield protection. *Agrokhimiya = Agricultural chemistry*, 2017, no. 4, pp. 3–9. (In Russian).
3. Dolzhenko V.I., Petunova A.A., Makhan'kova T.A. Biological and toxicological requirements for the range of herbicides. *Zashchita i quarantine rastenii = Board of Plant Protection and Quarantine*. 2001, no. 5, pp. 14. (In Russian).
4. Danilova A.A. Accessible method of regulation of pesticide detoxication rate in cereal agrocenosis of Western Sibiria. *Dostizheniy nayki i tehniki APK = Achievements of Science and Technology of AIC.* 2016, vol. 30, no. 4, pp. 33–35. (In Russian).
5. Dvoryankin E.A. Productivity of beet damaged by hormone – like herbicides in subletal and thinning doses. *Agrokhimiya = Agricultural chemistry.* 2021, no. 1 pp. 49–54. (In Russian). DOI: 10.31857/S0002188121010051.
6. Makhan'kova T.A., Golyubev A.S. Herbicides for corn. *Zashchita i karantin rastenii = Board of Plant Protection and Quarantine.* 2018, no. 2, pp. 37–64. (In Russian).
7. Kolesnik S.A., Stashkevich A.V., Kislyshko P.M. Formation of range of herbicides for the protection of corn in Belarus. *Zashchita i karantin rastenii = Board of Plant Protection and Quarantine.* 2021, no 1, pp. 18–21. (In Russian).
8. Zakharenko V.A. The prospects of application of chemical means of plants protection in Agriculture (on materials of VII international conference «Pesticides-16», *Agrokhimiya = Agricultural chemistry*. 2017, no. 4, pp. 10–15. (In Russian).
9. Kuznetsova S.V., Guba E.I. Herbicides for early and mid-ripening corn hybrids. *Zashchita i karantin rastenii = Board of Plant Protection and Quarantine.* 2017, no. 7, pp. 48–50. (In Russian).
10. Bagrintseva V.N. Maize protection against weeds in commodity and seed-growing crops. *Kukuruza i sorgo = Corn and Sorghum.* 2012, no. 1, pp. 27–28. (In Russian).
11. Bagrintseva V.N., Kuznetsova S.V., Guba E.I. Postemergence herbicides with soil action for corn. *Kukuruza i sorgo = Corn and Sorghum.* 2015, no. 1, pp. 22–26. (In Russian).
12. Bagrintseva V.N., Guba E.I., Kuznetsova S.V. The effectiveness of herbicide Maister Power depending on the timing of application. *Zashchita i karantin rastenii = Board of Plant Protection and Quarantine.* 2020, no. 3, pp. 10–12. (In Russian).
13. Solntseva O.I., Prudnikov A.D. Influence of herbicides on chemical compound of forage from corn. *Agrokhimicheskii vestnik = Agrochemical Herald.* 2019, no. 2, pp. 65–67. (In Russian). DOI: 10.24411/0235-2516-2019-10031.
14. Kuznetsova S.V., Bagrintseva V.N. Effectiveness of the new herbicide Kreutzer. *Agrokhimiya = Agricultural Chemistry.* 2021, no. 10, pp. 36–44. (In Russian). DOI: 10.31857/S0002188121100100.
15. Golubev A.S., Makhan'kova T.A., Komarova A.S. Efficiency and safety of application of herbicide Kelvin Plus an corn at different crop stage. *Agrokhimiya = Agricultural Chemistry.* 2021, no. 13, pp. 38–44. (In Russian). DOI: 10.31857/S000218812103008X.
16. Kostyuk A.V., Lukacheva N.G. Efficiency of herbicide in maize sowing and culture tolerance to them. *Sibirskii vestnik sel'skokhozyaystvennoy nayki = Sibirian Herald of Agricultural Science.* 2018, vol. 48, no. 1, pp. 38–43. (In Russian). DOI: 10.26898/0370-8799-2018-5.
17. Kostyuk A.V., Lukacheva N.G. Estimation of efficiency and phytotoxicity of Adengo herbicide in corn crops. *Sibirskii vestnik sel'skokhozyaystvennoy nayki = Sibirian Herald of Agricultural Science*. 2020, vol. 50, no. 1, pp. 40–47. (In Russian). DOI: 10.26898/0370-8794-2020-1-5.
18. Maisuryan N.A. *Plant growing.* Moscow, 1960. 383 p. (In Russian).

ИНФОРМАЦИЯ ОБ АВТОРАХ

(✉) **Костюк А.В.,** кандидат сельскохозяйственных наук, ведущий научный сотрудник; **адрес для переписки:** Россия, 692684, Приморский край, Ханкайский район, с. Камень-Рыболов, ул. Мира, 42-а; e-mail: dalniizr@mail.ru

Ляшенко Е.В., младший научный сотрудник

AUTHOR INFORMATION

(✉) **Alexander V. Kostyuk,** Candidate of Science in Agriculture, Lead Researcher; **address:** 42-a, Mira St., Kamen-Rybolov, Khankasky district, Primorsky Territory, 692684, Russia; e-mail: dalniizr@mail.ru

Elena V. Lyashenko, Junior Researcher

Дата поступления статьи / Received by the editors 24.01.2022
Дата принятия к публикации / Accepted for publication 13.04.2022
Дата публикации / Published 25.05.2022