Acta Agrobotanica

DOI: 10.5586/aa.1688

Publication history
Received: 2015-09-15
Accepted: 2016-08-20
Published: 2016-10-19

Handling editor
Piotr Sugier, Faculty of Biology and Biotechnology, Maria Curie-Skłodowska University, Poland

Authors' contributions
HG: experiment design, conducting the research; HG, RK: analysis of the results, writing the paper

Funding
The study was carried out as part of task 2.4 under the multi-year (2016–2020) program at the Institute of Soil Science and Plant Cultivation – National Research Institute.

Competing interests
No competing interests have been declared.

Citation
Gołębiowska H, Kieloch R. The competitive ability of *Chenopodium album* and *Echinochloa crus-galli* in maize crops depending on the time of their occurrence or removal. Acta Agrobot. 2016;69(4):1688. http://dx.doi.org/10.5586/aa.1688

ORIGINAL RESEARCH PAPER

The competitive ability of *Chenopodium album* and *Echinochloa crus-galli* in maize crops depending on the time of their occurrence or removal

Hanna Gołębiowska*, Renata Kieloch

Institute of Soil Science and Plant Cultivation – National Research Institute, Orzechowa 61, 50-540 Wrocław, Poland

* Corresponding author. Email: h.golebiowska@iung.wroclaw.pl

Abstract

Small-plot experiments for two levels of infestation (20 and 40 plants per m^2) with *Chenopodium album* L. and *Echinochloa crus-galli* (L.) P. Beav were conducted in the 2009–2011 seasons. In the first variant, the effect of time of weed removal on maize was investigated. Weeds were removed in the following growth stages of maize: one, three, five, and seven leaves, the beginning of stem elongation, and the stage from the fourth to sixth node. The second variant concerned the effect of time of weed emergence on maize and included the same maize growth stages as mentioned above. In both treatments, weed competition was compared to the control – the plot completely free from weeds, as well as to the plot fully covered with weeds. *Echinochloa crus-galli* in the amount of 20 plants per m^2, which were not removed until the five-leaf stage or which emerged immediately after the seven-leaf stage of maize, did not show any competitive effect on the growth and development of maize. *Chenopodium album* was characterized by a similar effect at the same level of weed infestation severity and when not removed until the five-leaf stage as well as in the case of plants that emerged after the seven-leaf stage of maize. Both species present in an amount of 40 plants per m^2 needed to be removed no later than at the three-leaf stage of maize.

Keywords

weed competition; maize; green mass; weed removal; weed emergence

Introduction

Among all cereals, maize is the most susceptible to weed competition. In the first weeks, it grows very slowly and weeds appearing in wide inter-rows strongly compete with maize for water, nutrients, and light. The efficiency of herbicides applied to regulate or control weeds depends, to a high extent, on the knowledge about time intervals in which the competitive activity of weeds in the maize field is strongest [1–3]. The above-mentioned knowledge is also an important and strategic element in integrated weed control programs where manipulating weed populations and reduction in their number below the economic thresholds from early stages of maize development to its harvest are especially emphasized [4]. Therefore, it is necessary to determine the moment by which weeds accompanying the emerged maize will not have contributed to a decrease in maize yield, the length of the required period without complete weed infestation in maize seeds sown as well as since when the growing weeds do not pose a risk to maize growth [5,6].

Currently, in many European countries the highest share in maize infestation with weeds belongs to *Chenopodium album* L. and to *Echinochloa crus-galli* (L.) P. Beav. [7–9]. In the last few years, the threat for maize plantations posed by thermophilous late-germinating species like: green foxtail [*Setaria viridis* (L.) P. Beav.] and yellow foxtail [*Setaria glauca* (L.) P. Beav.] or black nightshade (*Solanum nigrum* L.) in secondary infestation has increased, which is facilitated by climate change – higher temperatures as compared to the mean long-term values and more intensive sunlight, especially in May and June [10]. Weeds are strong competitors for maize, especially in the initial period of maize growth. In the first weeks of the growing period, maize increases its mass merely by 2–3%, while for weeds appearing at the same time in wide inter-rows the above-mentioned parameter ranges 15–18% [11]. *Chenopodium album* or *E. crus-galli* competes with maize for nutrients such as: nitrogen, potassium, or phosphorus, which can lead to a significant decrease in maize yield and in grain quality [12]. Moreover, especially with adverse weather conditions – low temperatures delaying maize emergence and abundant precipitation, a higher level of weed infestation results in a more significant competitive effect of weeds on the crop plant and in a reduction in yield [13,14].

The purpose of the research was to determine the competition period of *E. crus-galli* and *Ch. album* resulting from different times of their removal or occurrence in the maize field as well as their effect on maize plant height and green mass yield according to two levels of infestation intensity.

Material and methods

Small-plot experiments were carried out in three growing periods during 2009–2011 in an experimental field belonging to the Department of Weed Science and Tillage Systems in Wrocław, Poland. The experiments were set up on chernozem soil belonging to very good wheat complex, with an organic matter content of 3.6% and a pH of 6.3. Maize was sown in the third 10 days of April at a row spacing of 0.75 m. After emergence, maize was thinned to leave 13 plants per row. Maize was fertilized with N 152 kg/ha, P 72 kg/ha, and K 80 kg/ha.

The research was conducted in 2 × 2 m plots, in three replications. The examined weed species, i.e., *E. crus-galli* and *Ch. album*, occurred in the experimental plots alone, in the amount of 20 or 40 plants per m^2 after thinning. Weed species that were not the subject of investigation, but occurred in the maize crop, were successively removed just after their emergence.

In the first experiment, the effect of time of weed removal on maize was investigated. The emerging weeds were removed at different growth stages of maize, as follows: one, three, five, and seven leaves, the beginning of stem elongation, from the fourth to sixth node. In the second treatment, time of weed emergence was studied. Seeds of weeds were sown at different times to obtain weed emergence at the above growth stages of maize and weeds were allowed to grow up to green mass harvest.

In both experiments, the competitive effect of *Ch. album* and *E. crus-galli* was compared to the control free from weeds and the treatment where weeds occurred at the one-leaf stage of maize and remained until harvest. The competitiveness of each species was recorded based on plant height and green matter yield. Plant height measurement and green matter harvest were made at the maize tasseling stage. The data were subjected to analysis of variance to evaluate the significance of differences at $\alpha = 0.05$.

Results

The competitive effect of *E. crus-galli* on plant height and yield of maize

Echinochloa crus-galli, in the amount of 20 plants per m^2, accompanying maize from its emergence to five-leaf stage, i.e., BBCH 15, did not have any competitive effect on

Tab. 1 Influence of *E. crus-galli* competition on green matter yield and maize plant height depending on weed removal time.

Treatment		20 plants per m^2		40 plants per m^2	
		plant height (cm)	fresh weight of maize (kg m^{-2})	plant height (cm)	fresh weight of maize (kg m^{-2})
Control	Plots without weeds	283.3 ^{a}	8.12 ^{a}	280.9 ^{a}	8.33 ^{a}
	Weedy plots until harvest	218.3 ^{d}	3.35 ^{d}	235.3 ^{c}	2.10 ^{c}
Maize growth stage	BBCH 10 (one leaf)	285.5 ^{a}	8.55 ^{a}	280.3 ^{a}	7.94 ^{a}
	BBCH 13 (three leaves)	283.5 ^{a}	8.30 ^{a}	280.4 ^{a}	6.66 ^{a}
	BBCH 15 (five leaves)	280.4 ^{a}	7.72 ^{a}	261.5 ^{b}	4.10 ^{b}
	BBCH 17 (seven leaves)	255.0 ^{b}	5.66 ^{b}	260.0 ^{b}	3.82 ^{b}
	BBCH 30 (first node)	252.1 ^{b}	4.30 ^{c}	255.1 ^{b}	3.14 ^{b}
	BBCH 34–36 (fourth–sixth node)	235.5 ^{c}	3.08 ^{d}	255.5 ^{b}	2.30 ^{c}

Tab. 2 Influence of *E. crus- galli* competition on green matter yield and maize plant height depending on weed emergence time.

Treatment		20 plants per m^2		40 plants per m^2	
		plant height (cm)	fresh weight of maize (kg m^{-2})	plant height (cm)	fresh weight of maize (kg m^{-2})
Control	Plots without weeds	283.3 ^{a}	8.32 ^{a}	283.3 ^{a}	8.10 ^{a}
	Weedy plots until harvest	218.3 ^{d}	3.53 ^{c}	218.3 ^{c}	2.95 ^{c}
Maize growth stage	BBCH 10 (one leaf)	233.1 ^{c}	4.10 ^{b}	232.3 ^{b}	3.38 ^{c}
	BBCH 13 (three leaves)	245.6 ^{c}	4.74 ^{b}	238.4 ^{b}	4.25 ^{b}
	BBCH 15 (five leaves)	268.3 ^{b}	4.92 ^{b}	240.5 ^{b}	4.90 ^{b}
	BBCH 17 (seven leaves)	282.6 ^{a}	7.40 ^{a}	242.0 ^{b}	5.22 ^{b}
	BBCH 30 (first node)	285.5 ^{a}	7.60 ^{a}	276.1 ^{a}	8.06 ^{a}
	BBCH 34–36 (fourth–sixth node)	285.9 ^{a}	8.26 ^{a}	280.5 ^{a}	8.21 ^{a}

the growth of maize, which enabled obtaining green matter yield comparable with the treatment without weeds (Tab. 1). At a higher level of weed infestation (40 plants per m^2), it was possible to maintain this species only to the three-leaf stage of maize, i.e., BBCH 13, without a negative effect on further growth of maize. In turn, for both weed infestation levels, when the obtained results were compared to the weedy control, a significant increase in green matter yield was found in the weeded plots before maize reached the seven-leaf stage. Subsequent weeding did not result in yield increase.

When weed species occurred in the maize field from the time of the seven-leaf stage of maize, i.e., BBCH 17, in the amount of 20 plants per m^2 and remained until the harvest time, it did not contribute to a decrease in maize height and green matter yield, while earlier emergence of *E. crus-galli* posed a considerable threat to maize development and growth (Tab. 2). In the case of higher infestation with this weed species, its presence in the maize field was possible without any negative effect on maize yield after maize had reached the first-node stage (BBCH 30). When the emergence of weeds took place earlier, strong *E. crus-galli* competition affected plant growth and a decrease in green matter yield was observed. The emergence of *E. crus-galli* at the one-leaf stage of maize resulted in a yield similar to that of the weedy control, while weeds emerging at the later growth stages were not strong competitors for maize and the yield of maize was significantly higher than for the treatment without weeds.

Tab. 3 Influence of *Ch. album* competition on green matter yield and maize plant height depending on weed removal time.

Treatment		20 plants per m^2		40 plants per m^2	
		plant height (cm)	fresh weight of maize (kg m^{-2})	plant height (cm)	fresh weight of maize (kg m^{-2})
Control	Plots without weeds	287.6 ^{a}	8.10 ^{a}	284.6 ^{a}	7.65 ^{a}
	Weedy plots until harvest	223.9 ^{c}	3.30 ^{c}	228.4 ^{a}	2.30 ^{c}
Maize growth stage	BBCH 10 (one leaf)	288.5 ^{a}	7.90 ^{a}	278.5 ^{a}	7.63 ^{a}
	BBCH 13 (three leaves)	288.6 ^{a}	7.51 ^{a}	278.6 ^{a}	6.99 ^{a}
	BBCH 15 (five leaves)	285.0 ^{a}	7.21 ^{a}	275.0 ^{a}	4.26 ^{b}
	BBCH 17 (seven leaves)	280.6 ^{b}	5.19 ^{b}	247.6 ^{b}	3.02 ^{c}
	BBCH 30 (first node)	275.5 ^{b}	4.44 ^{b}	245.5 ^{b}	2.88 ^{c}
	BBCH 34–36 (fourth–sixth node)	227.1 ^{c}	3.35 ^{c}	227.1 ^{c}	1.85 ^{d}

Tab. 4 Influence of *Ch. album* competition on green matter yield and maize plant height depending on weed emergence time.

Treatment		20 plants per m^2		40 plants per m^2	
		plant height (cm)	fresh weight of maize (kg m^{-2})	plant height (cm)	fresh weight of maize (kg m^{-2})
Control	Plots without weeds	290.6 ^{a}	8.25 ^{a}	288.8 ^{a}	8.05 ^{a}
	Weedy plots until harvest	232.1 ^{b}	3.43 ^{c}	239.8 ^{b}	2.42 ^{d}
Maize growth stage	BBCH 10 (one leaf)	235.6 ^{b}	2.14 ^{c}	235.6 ^{b}	2.11 ^{d}
	BBCH 13 (three leaves)	239.4 ^{b}	3.11 ^{c}	239.4 ^{b}	3.02 ^{d}
	BBCH 15 (five leaves)	241.2 ^{b}	4.98 ^{b}	241.2 ^{b}	4.12 ^{c}
	BBCH 17 (seven leaves)	281.6 ^{a}	7.02 ^{a}	241.6 ^{b}	4.39 ^{c}
	BBCH 30 (first node)	284.6 ^{a}	7.88 ^{a}	244.6 ^{b}	5.38 ^{b}
	BBCH 34–36 (fourth–sixth node)	288.3 ^{a}	8.22 ^{a}	278.3 ^{a}	7.83 ^{a}

The competitive effect of *Ch. album* on plant height and yield size of maize

Chenopodium album, in the amount of 20 plants per m^2 and left in the maize field from its emergence until the five-leaf stage, did not show any competitive activity as far as maize growth and green matter yield is concerned compared to the treatment without weeds. If this weed was left in the plot further, this resulted in a significant decrease in green matter yield of maize (Tab. 3). At higher weed infestation (40 plants per m^2), this species could remain in the maize field without any loss in green matter yield until maize reached the five-leaf stage. Plant height decreased when weeds were left until maize reached the seven-leaf stage. Delayed removal of this weed species led to a considerable decrease in maize yield, compared to the yield obtained from the plot fully covered with weeds. At low weed infestation, an increase in green matter yield was obtained in comparison with the weedy plots when *Ch. album* was removed even in the first-node stage of maize. At higher weed density, they should be removed no later than at the five-leaf stage of maize.

This species, in the quantity of 20 plants per m^2, emerging during the seven-leaf stage of maize and remaining in the field until maize harvest, did not result in decreased maize growth or green matter yield, while earlier emergence of this weed considerably endangered maize growth (Tab. 4). In the case of more numerous occurrence of *Ch. album* in the maize field, its presence was allowed after maize had reached

the first-node stage, while earlier emergence of this weed significantly influenced, in a competitive way, maize growth as well as a highly noticeable decrease in green matter yield was recorded (Tab. 4). Under both low and high *Ch. album* densities, weeds that appeared no earlier than at the five-leaf stage of maize did not affect green matter yield in comparison with the weedy control.

Discussion

In farms with integrated production systems, the decision about removing weed species should be taken on the basis of observation involving weed emergence, the rate of germination and biomass growth. The beginning and end of the critical period of weed competition determine the decrease in corn yield by about 5% [3,15]. The determination of optimal time for the removal of weeds that appear along with maize emergence or those that threaten the maize crop in the second half of the growing period facilitates the decision about the application of herbicides without the risk of damaging maize plants [16–18].

The research, conducted by Rola and Rola [12], on the relationship between maize yield and time for how long *E. crus-galli* is left in a maize field proved that the length of the period during which this weed species occurred in the maize field significantly affected maize yield. In the case of occurrence of *E. crus-galli* until the three-leaf stage of maize, a reduced green matter yield by over 9% is recorded. Further delay in removing weeds resulted in a subsequent decrease in maize yield, while leaving the weeds till maize harvest caused a loss in yield up to 69%. Similar conclusions were drawn by Rusu et al. [19] and Gołębiowska [20] in their research involving the assessment of the competitive effect of *E. crus-galli* on maize plants within their whole growing period. Also LeBlanc et al. [11] conducted a study on the influence of both the presence and lack of *Ch. album* accompanying *E. crus-galli* on maize emergence, growth and yield.

The literature data point to the fact that *E. crus-galli*, in the case of its occurrence in a maize field till maize reaches the five-leaf stage, has no competitive effect during the maize growing period. The removal of the above-mentioned weeds during that time allowed obtaining a pure maize stand, uninhibited plant growth, and a yield comparable to that harvested from the plot without weeds. When the weeds were not removed after the above-mentioned time, a significant decrease in both yield and 1000-grain weight of maize was found [19].

Another research additionally proved the threat that both investigated weed species posed to maize growth and development in the second half of the maize growing period, which led to secondary weed infestation. In order to avoid yield loss, it is possible to allow *E. crus-galli* to emerge in the amount 80 plants/plot after maize plants have produced five leaves, while in the case of *Ch. album*, at the same intensity of infestation, only after seven leaves have been produced by maize. However, at a higher weed infestation level, weeds can be allowed to emerge only after the first node has appeared on maize plants.

As reported in the research by Villasan et al. [21], who attempted to determine the threat posed by leaving these two weed species in a maize field, maize absolutely required a stand free from weeds within the period from 25 to 30 days after its emergence. Since the competition on the part of weeds was highest during that time, maize yield losses due to the above-mentioned competition were 73% in comparison to the treatment without weeds. The findings reported in the research concerning the determination of optimal time for the removal of *Cyperus rotundus*, *Portulaca oleracea*, and *Ch. album* indicated the following period free from weeds: from the three- to seven-leaf stage of maize, at the latest till maize has produced 10 leaves [2,22,23]. It can also be concluded from the literature data that leaving *E. crus-galli* in the maize field for 2–6 weeks after maize emergence negatively affected maize yield, causing a decrease in maize grain yield by 12–69% [12]. This is a proof that in the case of high infestation weeds should be removed from the maize field before it enters the 2–4 leaf stage, i.e., 2–4 weeks after maize emergence at the latest.

Our study proves that at weed density of 20 plants per 1 m^2, it is necessary to completely remove the weeds before maize reaches the five-leaf stage. For a higher weed infestation level, it is required to remove *E. crus-galli* before the three-leaf stage of maize starts. As far as *Ch. album* is concerned, the requirements mentioned above can be met by removing the weeds before maize reaches the seven-leaf stage, while for higher infestation levels – before the five-leaf stage of maize.

In the research carried out by Auškalnienė [1], maize susceptibility to infestation with annual dicotyledonous weed species was compared. To reduce weed competition, higher sowing density was used. During the critical period of weed competition, till about a month after maize emergence, the weeds left in the field caused a decrease in green matter yield of maize by 50% and even more, depending on the intensity of weed occurrence.

The literature data show that different time intervals have been determined from the three-leaf stage of maize until the inter-rows are covered by weeds, depending on the intensity of weed infestation, which proves the absolute necessity of maintaining a weed-free crop stand in order to obtain appropriate plant growth and high crop yield. It is also important to determine time intervals that allow weeds to emerge at later times and do not cause any decrease in maize yield. This research enabled the determination of the above-mentioned time intervals for *E. crus-galli* and *Ch. album*.

Conclusions

- *Echinochloa crus-galli* at the density of 20 plants per m^2, which were not removed until the five-leaf stage or which emerged immediately after the seven-leaf stage of maize, did not show any competitive effect on the growth and development of maize.
- The effect of *Chenopodium album* on maize was similar to *E. crus-galli*.
- Both species present at the density of 40 plants per m^2 needed to be removed no later than the three-leaf stage or they may not emerge after the first-node stage of maize without a significant influence on the decrease in yield.

References

1. Auškalnienė O. Piktžolių konkurencijos kritinis periodas kukurūzų ir vasarinių miezių agrocenozėse. Vagos. 2006;71:7–12.
2. Doğan MN, Ünay A, Boz Ö, Albay F. Determination of optimum weed control timing in maize. (*Zea mays* L.). Turk J Agric For. 2004;28(5):349–354.
3. Ghanizadeh H, Lorzadeh S, Aryannia N. Effect of weed interference on *Zea mays*: growth analysis. Weed Biol Manag. 2014;14(2):133–137. http://dx.doi.org/10.1111/wbm.12041
4. Surawska M, Rzeźnicki B. Ustawodawstwo – projekty ustaw i rozporządzenia z zakresu ochrony roślin. Proceedings: "Racjonalna technika ochrony roślin"; 2010 Oct 6; Poznań, Poland. Poznań: Instytut Ochrony Roślin – Państwowy Instytut Badawczy; 2010. p. 9–17.
5. Sarabi V, Nassiri-Mahallati M, Nezami A, Mohassel MHR. Effect of common lambsquarters (*Chenopodium album* L.) emergence time and density on growth and competition of maize (*Zea mays* L.). Aust J Crop Sci. 2013;7(5):532–537.
6. Sarabi V, Nassiri-Mahallati M, Nezami A, Mohassel MHR. Effects of the relative time of emergence and the density of common lambsquarters (*Chenopodium album*) on corn (*Zea mays*) yield. Weed Biol Manag. 2011;11(3):127–136. http://dx.doi.org/10.1111/j.1445-6664.2011.00414.x
7. Demjanová E, Macák M, Dalović I, Majerník F, Týr Š, Smatana J. Effects of tillage systems and crop rotation on weed density, weed species composition and weed biomass in maize. Agronomy Research. 2009;7:785–792.
8. Głowacka A. Dominant weeds in maize (*Zea mays* L.) cultivation and their competitiveness

under conditions of various methods of weed control. Acta Agrobot. 2011;64:119–126. http://dx.doi.org/10.5586/aa.2011.023

9. Keller M, Böhringer N, Möhring J, Rueda-Ayala V, Gutjahr C, Gerhards R. Long-term changes in weed occurrence, yield and use of herbicides in maize in south-western Germany, with implications for the determination of economic thresholds. Weed Res. 2014;54(5):457–466. http://dx.doi.org/10.1111/wre.12098
10. Kozyra J. Climatic conditions for millet cultivation in Poland. In: Contributions from members on operational applications in agrometeorology and from discussants of the papers presented at the international workshop: "Reducing vulnerability of agriculture and forestry to climate variablity [sic] and climate change" [Internet]. Geneva: World Meteorological Organization, Commission for Agricultural Meteorology; 2004 [cited 2016 Oct 14]. p. 34–35. Available form: http://www.wamis.org/agm/pubs/CAGMRep/CAGM94.pdf
11. LeBlanc ML, Cloutier DC, Legere A, Lemieux C, Assemat L, Benoit DL. Effect of the presence or absence of corn on common lambsquarters (*Chenopodium album* L.) and barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] emergence. Weed Technol. 2002; 16(3): 638–644. http://dx.doi.org/10.1614/0890-037X(2002)016[0638:EOTPOA]2.0.CO;2
12. Rola H, Rola J. Konkurrenz von *Chenopodium album* und *Echinochloa crus-galli* auf mais. Proceedings of the 8th EWRS Symposium "Quantitative approaches in weed and herbicide reseach and their practical application"; 1993 Jun 14–16; Braunschweig, Germany. Braunschweig: European Weed Research Society; 1993. p. 101–106.
13. Bogdan I. The summer rainfall impact to the weediest degree in maize crops. Agricultura-Revistă de Ştiintă şi Practică Agrocolă. 2002;11(3/4):18–23.
14. Frantic T. Interference of *Chenopodium suecicum*/J. Murr and *Amaranthus retroflexus* L. in maize. Weed Res. 1994;34:45–53. http://dx.doi.org/10.1111/j.1365-3180.1994.tb01972.x
15. Rusu T, Gus P, Bogdan I, Moraru PI, Pop AI, Clapa D, et al. Implications of minimum tillage systems on sustainability of agricultural production and soil conservation. Journal of Food, Agriculture and Environment. 2009;7:335–338.
16. Lemerle D, Martin A, Smith A, Verbeek B, Rudd S, Martin P. Breeding for competitive cultivars of wheat. Abstract of the III International Weed Science Congress; 2000 Jun 6–10; Foz do Iguassu, Brazil. Corvallis, OR: International Weed Science Society; 2000. p. 75–78.
17. Guza CJ, Kells JJ. Corn growth and yield as affected by time of weed emergence. Proceedings of the North Central Weed Science Society. 2002;57:140.
18. Fischer DW, Harvey RG, Bauman TT, Hart SE, Johnson GA, Kells JJ. Common lambsquarters (*Chenopodium album*) interference with corn across the northcentral United States. Weed Sci. 2004;52:1034–1038. http://dx.doi.org/10.1614/P2000-172
19. Rusu T, Gus P, Bogdan I, Moraru PI, Pop AI, Sopterean ML, et al. Influence of infestation with *Echinochloa crus-galli* species on crop production in corn. Journal of Food, Agriculture and Environment. 2010;8:760–764.
20. Gołębiowska H. Dynamika występowania flory segetalnej w uprawie kukurydzy na Dolnym Śląsku w latach 1972–2008 i obecne możliwości jej regulacji. Puławy: Instytut Uprawy Nawożenia i Gleboznawstwa – Państwowy Instytut Badawczy; 2011. (Monografie i Rozprawy Naukowe – Instytut Uprawy Nawożenia i Gleboznawstwa; vol 30).
21. Villasana R, Rodríguez AB, Pérez D, Fernández J, Sánchez P, Uranga H. Determinación del período de competencia maíz-malezas. In: Proceedings: III Congreso 2004 Sociedad Cubana de Malezología, Memorias; 2004 Apr 28–30; Habana, Cuba. Wimauma, FL: Asociación Latinoamericana de Malezas; 2004. p. 142–144.
22. Moechnig MJ, Boerboom CM, Stoltenberg DE, Binning LK. Growth interactions in communities of common lambsquarters (*Chenopodium album*), giant foxtail (*Setaria faberi*), and corn. Weed Sci. 2003;51(3):363–370. http://dx.doi.org/10.1614/0043-1745(2003)051[0363:GIICOC]2.0.CO;2
23. Moeching MJ, Stoltenberg DE, Binning LK. Empirical corn yield loss estimation from common lambsquarters (*Chenopodium album*) and giant foxtail (*Setaria faberi*) in mixed communities. Weed Sci. 2003;51(3):386–393. http://dx.doi.org/10.1614/0043-1745(2003)051[0386:ECYLEF]2.0.CO;2

Zdolności konkurencyjne *Chenopodium album* i *Echinochloa crus-galli* w zależności od terminu ich pojawiania lub usuwania w kukurydzy

Streszczenie

Badania realizowano dla dwóch poziomów zachwaszczenia *Chenopodium album* L. i *Echinochloa crus-galli* (L.) P. Beav (20 i 40 roślin/m^2) w warunkach doświadczenia mikropoletkowego prowadzonego w sezonach wegetacyjnych 2009–2011. W pierwszym wariancie badano wpływ terminu usuwania wschodzących chwastów. Chwasty były usuwane w następujących fazach wzrostu kukurydzy: jeden, trzy, pięć i siedem liści, początek źdźbła i w fazach od 4 do 6 węzłów. Wariant drugi dotyczył wpływu terminu pojawienia się chwastów w kukurydzy, usuwanie chwastów następowało w tych samych fazach wzrostu kukurydzy, które stosowano w wariancie pierwszym. Wariant kontrolny stanowiły poletka wolne od chwastów. *Echinochloa crus-galli* w ilości 20 roślin na m^2 które nie zostały usunięte do stadium 5 liści, lub które pojawiały się po stadium 7 liści rozwoju kukurydzy, nie wykazywała żadnego konkurencyjnego oddziaływania na wzrost i rozwój kukurydzy. *Chenopodium album* przy tym samym poziomie nasilenia, nie usuwana do fazy 7 liści lub wschodząca po tej fazie wykazywała podobne oddziaływanie. Oba gatunki chwastów, występujące w ilości 40 roślin na m^2 wymagały usuwania najpóźniej do fazy 3 liści. Brak istotnego wpływu na spadek plonowania kukurydzy związany był z pojawieniem chwastów dopiero w fazie 1 węzła kukurydzy.