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EFFECTIVENESS OF DIFFERENT METHODS OF WEED MANAGEMENT IN CHINESE CABBAGE (*BRASSICA RAPA L.*) AND TRANSPLANTED LEEK (*ALLIUM PORRUM* L.)

Summary

The studies were conducted in the years 2012-2014 at the Research Institute of Horticulture in Skierniewice and aimed to compare the effectiveness of different weeds management methods useful for organic production of Chinese cabbage and transplanted leek and to determine their impact on the yield of the crops. The effectiveness of such methods as mechanical treatments, mechanical treatments with biostimulator Asahi SL, the usage of mulches (black non-woven polypropylene and biodegradable films) and hand weeding was compared. The weeds control, number and biomass of weeds and secondary weed infestation were determined during the experiments. The plants height and the yield of Chinese cabbage and transplanted leek and additionally the physiological indices such the chlorophyll content in the leaves, were measured also. The best results of weeds control were achieved in the crops weeded by hand and grown in the soil covered with mulch. The mulches completely reduced the weeds in Chinese cabbage and by 98.9-99.5% in transplanted leek. After mechanical treatments the weeds control at the rate of 95.7-97.6% was noted. The reduction of weeds affected positively the yield of the crops. The highest yield from the plots covered by polypropylene and biodegradable films were obtained.. In Chinese cabbage the tendency in changing the chlorophyll content in the leaves was similar in all objects, except the plants weeded by hand, in which was slightly lower before harvest. In all objects the chlorophyll content before harvest was higher than in the check.
Key words: *Chinese cabbage, leek, weed control, mechanical treatments, mulch*

EFEKTYWNOŚĆ WYBRANYCH SPOSOBÓW REGULOWANIA ZACHWASZCZENIA W UPRAWIE KAPUSTY PEKIŃSKIEJ I PORA Z ROZSADY

Streszczenie

W latach 2012-2014 w Instytucie Ogrodnictwa w Skierniewicach przeprowadzono badania, celem których było porównanie efektywności wybranych metod ochrony przed chwastami, przydatnych w ekologicznej uprawie kapusty pekińskiej i pora z rozsady oraz określenie ich wpływu na plonowanie roślin. Porównywano efektywność takich metod jak: odchwaszczanie mechaniczne, odchwaszczanie mechaniczne z zastosowaniem stymulatora wzrostu Asahi SL, ściółkowanie gleby czarną włókniną ściółkującą (PP) i czarną folią biodegradowalną oraz pielenie ręczne. W badaniach przeprowadzono obserwacje stopnia zniszczenia chwastów, określono ich liczbę i masę, oceniono zachwaszczenie wtórne. Wykonywano też pomiary zawartości chlorofilu w liściach kapusty pekińskiej, określono wysokość roślin i wielkość plonów. Bardzo dobre zniszczenie chwastów otrzymano w obiektach pielonych ręcznie i ściółkowanych wybranymi materiałami. Włóknina i czarna folia całkowicie ograniczały zachwaszczenie w uprawie kapusty pekińskiej, a w uprawie pora z rozsady zredukowały je o 98,9-99,5%. Pielenie mechaniczne niszczyło chwasty na poziomie 95,7-97,6%. Ograniczenie zachwaszczenia pozytywnie wpływało na plonowanie kapusty pekińskiej i pora z rozsady. W obu gatunkach najwyższe plony uzyskano ściółkując glebę włókniną i czarną folią. W kapuście pekińskiej zmiany w zawartości chlorofilu w liściach wykazywały podobną tendencję we wszystkich obiektach, z wyjątkiem poletek pielonych ręcznie, w których przed zbiorem zanotowano obniżenie tego wskaźnika. W czasie zbioru we wszystkich obiektach zawartość tego barwnika w liściach była wyższa niż w kontroli.
Słowa kluczowe*: kapusta pekińska, por, odchwaszczanie, zabiegi mechaniczne, ściółkowanie*

1. Introduction

One of the important and inseparable elements of vegetable production technology is to protect against weeds. Their greatest impact on crops is marked at the beginning of the growing season, and the harm is maintained throughout the growing season. Weeds delay the maturation of plants, making them difficult to harvest and cause a reduction in yield [8]. In many years of research Dobrzański et al. [8] showed that the average weight of weeds is mainly dependent on atmospheric conditions. During the growing season, the threat of weeds is greater in organic farming than in other systems of cultivation, as the crops grow more slowly and cover the spacing between rows [5]. The mechanical control of weeds is mainly used in the organic production of vegetable crops. Currently there are modern machines and weeders, with ever greater precision, enabling to control the weeds close to the rows or even in the rows of crops. Mechanical treatment carried out in timely and favorable conditions, can form the basis of plant protection against weeds or complement other methods. Another way to reduce the weed infestation is mulching the soil with impermeable materials, which limit the access of light, e.g. black foil, polyethylene or polyvinyl chloride having a thickness of 0.03-0.05 mm or non-woven polypropylene having a basic weight of 50-60 g/m^2. The mulches form the physical barriers preventing access of light, which may partially or completely prevent the invasion of weeds

[18]. A disadvantage of mulching is its high cost and the need for removal from the field after harvest, as residue or leftovers may persist in the environment. Biodegradable foil produced from plant starch, is completely decomposed into water and carbon dioxide under the influence of soil microorganisms. Its use is particularly recommended in organic agriculture [2], wherein the foil may only be used for one growing season.

2. Material and methods

The studies were carried out at the Research Institute of Horticulture in Skierniewice on pseudopodsolic soil over loamy sand (1.3-1.5% of organic matter, pH-6.8). Experiments in transplanted leek were assumed during the growing seasons of 2012-2013 and in Chinese cabbage between the years 2012 and 2014. The effectiveness of weed management methods such as: mechanical treatments, mechanical treatments with biostimulator Asahi SL, the usage of polypropylene and biodegradable foil as mulches and hand weeding was compared. The field trials were set up in a completely randomized block design with 4 replications. The plot size with mechanical treatments was 12,15 m^2, with mulches 5,4 m^2 and hand weeded 9 m^2. Leek transplants cv. Porbella were planted on 24.05.2012 and 21.05.2013 and Chinese cabbage transplants cv. Bilko on 31.05.2012, 14.06.2013 and 10.06.2014. Black plastic foil and non-woven polypropylene (basic weight 50 g/m^2) was applied by hand, immediately prior to planting, and the seedlings were planted in drilled holes, cut in the appropriate row spacing corresponding to the spacing of the places not mulched. Growth stimulator Asahi SL was used at a dose of 0.5 l/ha, three times, at intervals of three weeks from planting. It was applied by pressurized air wheel sprayer, equipped with "Tee Jet" 110-02 VS nozzles, giving spray volume of 220 L/ha. Mechanical treatments were carried out using a tractor with a suspended weeder hoe "EcoPielnik EP-4", equipped with traditional weeding elements (ploughshare and angled blades) with finger and torsion elements. In transplanted leek, 2-3 mechanical treatments were carried out on seedlings (after 26-31, 48-49 and 73 days of planting), and 1-2 treatments in Chinese cabbage (after 14 days and 19-20 days of planting), depending on the emergence of weeds and crops conditions. The impact of weather conditions on the effectiveness of weed management methods was analyzed in the experiments. During the experiments, the mean daily air temperature at a height of 2 m above the ground and rainfall in mm were specified.

In experiments the weeds control, number and fresh biomass of weeds and secondary weed infestation were evaluated. In transplanted leek the weeds control were assessed 38-39 days after planting and the number and fresh biomass of weeds 47-49 days after planting. In Chinese cabbage these parameters were evaluated, respectively, 21-30 days and 30-42 days after planting. Secondary weed infestation in leek was evaluated after 147-153 days of vegetation and in Chinese cabbage after 66-77 days. Plants height was evaluated after 70-75 days after leek planting and 54-73 days after cabbage planting. During the growing period the chlorophyll content in cabbage leaves was measured, also. The measurements were carried out by using chlorophyll meter SPAD-502 (Soil and Plant Analysis Development) on 19-21, 26-28, 33-35, 41-42, 47-49, 54-56 and 60-63 days after planting. Chinese cabbage heads were harvested at maturity stage, between 61 and 87 days after planting. Leek was harvested once on 151-154 days after planting, and total and marketable yield were determined. The significance of differences between means was evaluated by analysis of variance, using the Newman-Keul's test, at a significance level $\alpha = 0.05\%$.

3. Results and discussion

In the experiments in leek and Chinese cabbage the dominant weed species, such as: shepherd's-purse (*Capsella bursa-pastoris* L.), field pennycress (*Thlaspi arvense* L.), common lambsquarters (*Chenopodium album* L.), smallflower galinsoga (*Galinsoga parviflora* Cav.), henbit deadnettle (*Lamium amplexicaule* L.), false chamomille (*Matricaria inodora* L.), common groundsel (*Senecio vulgaris* L.), yellow charlock (*Sinapis arvensis* L.) and common barnyardgrass (*Echinochloa crus-galli* L.) were observed. The fresh weeds biomass in leek amounted to 25.4 t/ha, on 47-49 days after planting, and in Chinese cabbage 0,8 t/ha, on 30-42 days after planting.

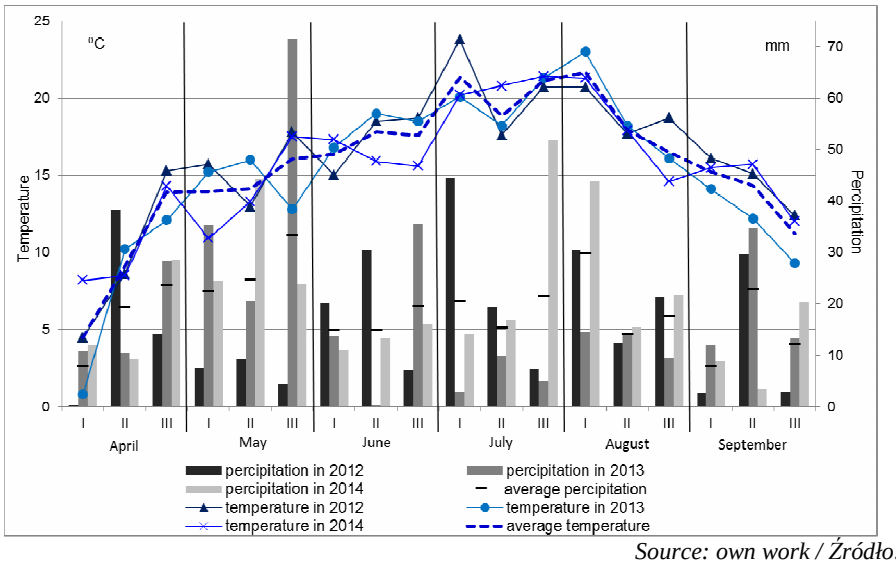

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Fig. 1. Weather conditions in the years 2012-2014, during conducting experiments in transplanted leek and Chinese cabbage
Rys. 1. Warunki pogodowe w latach 2012-2014, w czasie prowadzenia doświadczeń w uprawach pora z rozsady i kapusty pekińskiej

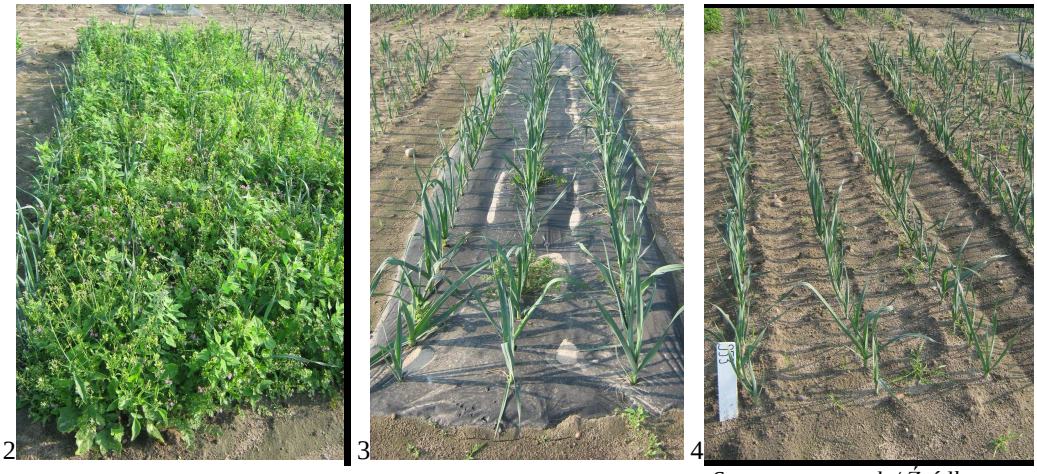

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Fig. 2-4. The influence of soil mulching with non-woven polypropylene and mechanical treatments on weed infestation in transplanted leek

Fot. 2-4. Wpływ ściółkowania gleby włókniną i zabiegów mechanicznych na zachwaszczenie pora z rozsady

The results showed high effectiveness of different methods used for reduction of weeds infestation in vegetables crops. The complete control of weeds on the plots weeded by hand was obtained. This method allows to remove the weeds from the rows and even from interrows. However, this method is labour intensive and even impossible to use on large areas. In addition, the care should be taken not to damage the root system of cultivated plants while weeding [7]. Leek grown from transplants usually requires from 3 to 5 mechanical cultivation between the rows, and much labor for hand weeding. However, there is the need to carry out 1-3 mechanical treatments between the rows in Chinese cabbage and cauliflower and the manual labour required for those crops is about 150-250 hours per ha [10]. In addition, the manual weeding effect is short-lived, and soon there are more weeds.

The high level of weeds control in the mulching plots was observed also. Non-woven and black plastic foil completely reduced the weed infestation in Chinese cabbage and in transplanted leek reduced them by 98.9-99.5%. Chinese cabbage, which is characterized by rapid growth and short growing season, quickly covered the surface of the holes in the plastic foil and non-woven polypropylene, in which the growth of weeds was completely inhibited. During growing season of transplanted leek there were individual weed species in the holes in mulches, in vicinity to the plants due to upright habit of the crop and the number of weeds does not exceed 1.8 per m^2. In both years of the studies in this crop, in the holes of the plastic foil and non-woven polypropylene, species such as: common lambsquarters, shepherd's-purse, smallflower galinsoga and henbit deadnettle were observed. In 2012, the high temperatures noted in late April and early May, during the weeds germination, resulted in slightly higher weeds infestation, so in the holes in the non-woven and black plastic foil there were such species as: field pennycress, common crowfoot, yellow charlock and common barnyardgrass. Dobrzański and Anyszka [9] reports that weeds can emerge in the holes of the plastic foil or can pierce it, especially when there are species forming raised and rigid stems like horsetail (*Equisetum arvense* L.). The weeds infestation in the holes of the plastic foil depends mainly on the crop shape, weather conditions and the seed bank accumulated in the soil.

Table 1. The influence of weed management methods on the overall weeds number and biomass of Chinese cabbage and transplanted leek (means for 2012-2014)

Tab. 1. Wpływ metody ochrony przed chwastami na liczbę i masę chwastów ogółem w uprawie kapusty pekińskiej i pora z rozsady (średnie z lat 2012-2014, Skierniewice)

Weed management method	Overall weeds number		Overall weeds biomass		Secondary weed infestation (%)
	no./m^2	%	g/m^2	%	
	Transplanted leek				
Mechanical treatments	56,3	34,8	77,5	3,1	7,5
Mechanical treatments + Asahi SL 3x0.5L/ha	41,6	25,7	106,1	4,2	9,1
Polypropylene mulching	1,8	1,1	-	-	0
Biodegradable foil mulching	0,8	0,5	-	-	-
Hand weeded	0	0	0	0	0
Check	161,9	100	2537,5	100	17,7
	Chinese cabbage				
Mechanical treatments	13,4	13,0	9,6	11,6	1,1
Mechanical treatments + Asahi SL 3x0.5 L/ha	13,0	12,6	20,3	24,6	0,8
Polypropylene mulching	0	0	-	-	0
Biodegradable foil mulching	0	0	-	-	0
Hand weeded	0	0	-	-	0
Check	103,4	100	82,5	100	1,7

Source: own work / Źródło: opracowanie własne

The positive impact of a biodegradable plastic foil mulching to reduce weeds in celeriac, head cabbage and tomatoes are confirmed by Dobrzański and Anyszka [9]. However, the authors point out, that biodegradable foil very well reduces weed infestation, but does not control them completely. In research carried out in celeriac [11], black plastic foil and biodegradable foil mulching reduced weeds infestation by 99.8-99.9%. The high effectiveness of soil mulching, in both non-woven and black foil in respect of vegetable crops including peppers [4, 6], celeriac [12] head lettuce [16] as well as snap beans and red head cabbage [12] has been reported by many authors.

Mechanical treatments substantially limited the weeds. In table 2 the efficiency of various weed species control by this method is presented. Despite of high weeds control, their effects were short-lived (Tab. 2). Mechanical weeding causes the emergence of new weeds. Secondary weed infestation in leek mechanically weeded was amounted to 7.5%. In Chinese cabbage the mechanical weeding was more effective than other methods because it was done until the time when the plant covered the soil surface in the inter-rows. Due to the rapid growth of cabbage and tight covering the inter-rows by leaves of this crop, the germinating weeds did not have favorable conditions for the growth. Mechanical treatment has a beneficial effect on soil micro-organisms and improves soil aeration, but it shouldn't be done without reason because it can lead to degradation and drying the soil and accelerate the mineralization processes of organic matter. Additionally, it can cause damages to the crops and spread diseases [7].

The leaf greenness index measured by SPAD 502 chlorophyll meter, is associated with the content of chlorophyll in leaves. Chlorophyll is present in all organisms in which there is a process of photosynthesis. The content of this pigment in the leaves indicates the intensity of plant growth and life processes in the crops during the growing season [3]. In the study the plants of Chinese cabbage in its early stages (up to 33-35 days from planting) had a similar chlorophyll content in the leaves and similar dynamic changes. After this period, the reduction of chlorophyll content in most of the sites was determined, which continued up to 54-56 days after planting, and its increase was recorded during harvest. The increase in chlorophyll content was observed already after 47-49 days from planting in Chinese cabbage weeded mechanically, while in the check and on the plots weeded manually, a decrease of chlorophyll content was observed until harvest (Fig. 5).

Table 2. The influence of mechanical treatments on weeds in Chinese cabbage and leek (means for 2012-2014)
Tab. 2. Wpływ zabiegów mechanicznych na zachwaszczenie kapusty pekińskiej i pora (średnie z lat 2012-2014, Skierniewice)

Weed species	Chinese cabbage		Transplanted leek	
	weeds control (%)	soil cover (%)	weeds control (%)	soil cover (%)
Capsella bursa-pastoris (CAPBP)	99,5	1,6	88,9	5,8
Thlaspi arvense (THLAR)	100	1,0	99,0	2,4
Chenopodium album (CHEAL)	95,3	6,2	92,3	18,1
Galinsoga parviflora (GASPA)	97,8	3,6	94,7	5,1
Lamium amplexicaule (LAMAM)	99,6	1,9	98,0	2,3
Sinapis arvensis (SINAR)	100	1,3	100	5,3
Senecio vulgaris (SENVU)	100	0,9	97,8	3,3
Matricaria inodora (MATIN)	98,7	0,3	92,8	41,7
Echinochloa crus-galli (ECHCG)	90,0	9,9	81,8	2,4

Source: own work / Źródło: opracowanie własne

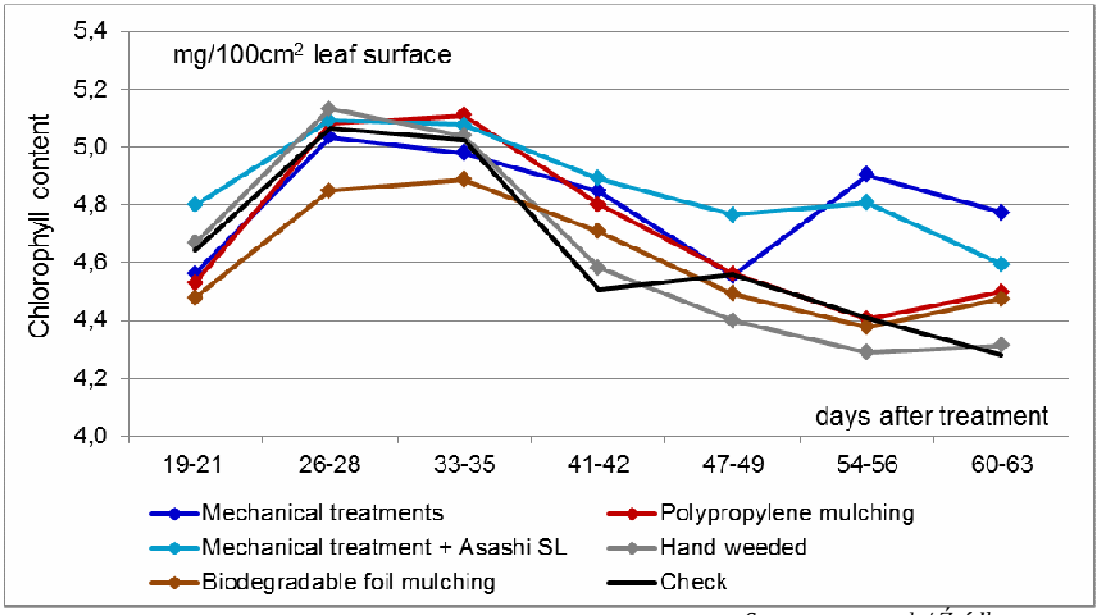

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Fig. 5. The influence of weed management methods on greenness index of Chinese cabbage leaves
Rys. 5. Wpływ metod ochrony przed chwastami na indeks zieloności liści kapusty pekińskiej

In leek the increase of plant height under the influence of weed management methods was stated. The highest leek plants were obtained in the plots with soil mulching and they were higher by 21.2% than in the check, while under the influence of mechanical weeding, the plants were lower than the mulched plots, but higher by 8.7% than in the check (Tab. 3). In Chinese cabbage the differences were lower, but there was a tendency of increasing the plant height by 2.0-6.9%, depending on the method of weed control. The highest plants were observed in the plots with mulches (Fig. 4-7). The positive effect of mulching on the growth of head lettuce was noted in the Wierzbicka study [17]. Mulching the soil with black plastic foil or non-woven polypropylene has a positive effect on microclimate in the root zone of plants [2, 14, 18]. In the studies of Locher et al. [16] carried out on pepper, the use of a black mulch resulted in increasing soil temperature at 1.2-1.4^{o}C at a depth of 10 cm, in comparison to the un-mulched soil. Favorable conditions for the growth of plants being grown in soil mulched with black plastic foil or non-woven also contributed to increase the degree of soil cover before harvest, both by the leek and cabbage plants. The high soil cover by Chinese cabbage at harvest, was also observed in sites mechanically weeded.

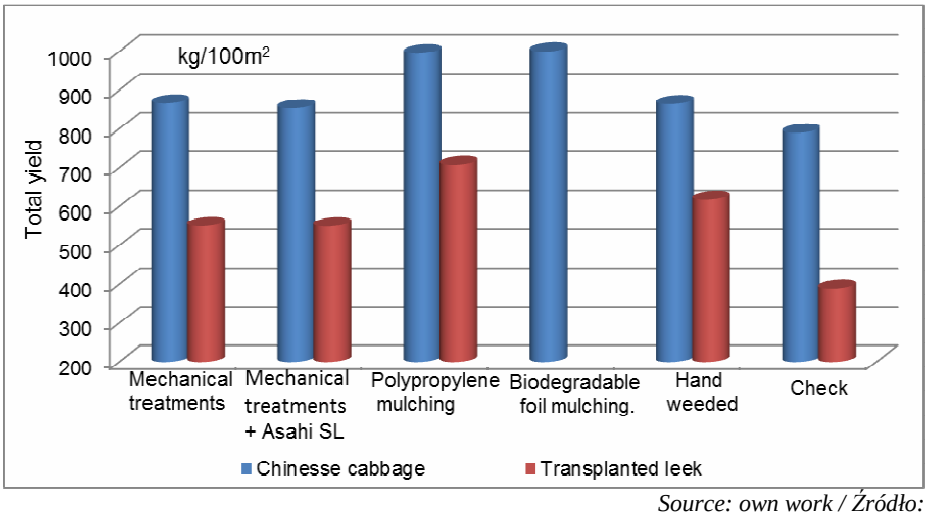
Source: own work / Źródło: opracowanie własne

Fig. 6-9. The influence of soil mulching with non-woven polypropylene on the height of crops
Rys. 6-9. Wpływ ściółkowania gleby włókniną na wysokość roślin uprawnych

Table 3. The height of plants of Chinese cabbage and transplanted leek and secondary weed infestation, depending on weed management method (means for 2012-2014)
Tab. 3. Wysokość kapusty pekińskiej i pora z rozsady oraz pokrycie powierzchni gleby przed zbiorem, w zależności od metody ochrony przed chwastami (średnie z lat 2012-2014, Skierniewice)

Weed management method	Plants height (%)		Soil cover by the crop, before harvest in %	
	Chinese cabbage	Transplanted leek	Chinese cabbage	Transplanted leek
Mechanical treatments	31,8	70,0	91,0	75,9
Mechanical treatments + Asahi SL 3x0.5 L/ha	31,2	68,6	90,9	72,8
Polypropylene mulching	32,4	76,5	86,3	83,0
Biodegradable foil mulching	32,6	-	91,3	-
Hand weeded	31,1	73,4	89,7	81,0
Check	30,5	63,1	87,3	62,8

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 10. The influence of weed management methods on the yield of Chinese cabbage and transplanted leek
Rys. 10. Wpływ różnych metod ochrony przed chwastami na plonowanie kapusty pekińskiej i pora z rozsady

The reduction of weeds infestation positively affected the yield of Chinese cabbage and leek. In both species the highest yields were obtained by mulching the soil with non-woven and black foil. In cabbage cultivation the yield was higher by 26-35.3% than in the check, and in leek by 81.9-88.0%. The beneficial effect of black mulches on the yield of vegetable crops was also confirmed by other authors, including head cabbage [9], celeriac [9, 11], celery [1], pepper [15], eggplant [13] or zucchini. The lowest yield was obtained from sites weeded mechanically, and it was higher than from the check in Chinese cabbage by 1.1-9.7%, and in transplanted leek by 41.4-41.6%.

4. Conclusions

1. In both vegetable crops the complete weeds control was obtained in hand weeded plots and in Chinese cabbage grown in the soil mulched with non-woven polypropylene and black biodegradable foil.
2. Mechanical treatment substantially limited the weeds number, but their effects were short-lived and lead to the re-emergence of weeds.
3. Chlorophyll content in the leaves of Chinese cabbage was similar across all sites.
4. The plants of leek grown in the soil covered with mulch were the highest in the experiment.
5. The highest yields were obtained from mulching the soil and the lowest from sites with mechanical treatments.

5. References

[1] Adamczewska-Sowińska K., Kołota E.: Yielding and nutritive value of field cultivated eggplant witch the use of living and synthetic mulches. Acta Sci. Pol., Hortorum Cultus, 2010, Vol. 9 (3), 191-199.

[2] Adamczewski K., Dobrzański A.: Znaczenie i możliwości wykorzystania metod agrotechnicznych i niechemicznych do regulowania zachwaszczenia w ekologicznej uprawie roślin. W: Poszukiwanie nowych rozwiązań w ochronie upraw ekologicznych. (E. Matyjszczyk red.). Poznań: IOR, 2008, 221-241.

[3] Anyszka Z., Dobrzański A.: Wpływ herbicydów na niektóre ekofizjologiczne wskaźniki wzrostu i zawartość chlorofilu w liściach roślin warzywnych. Prog. Plant Protection/ Post. Ochr. Roślin, 2004, Vol. 44 (2): 580-583.

[4] Anyszka Z., Golian J., Kohut M.: Porównanie efektywności różnych metod ochrony przed chwastami papryki (*Capsicum annum* L.) w uprawie polowej. Prog. Plant Protection/Post. Ochr. Roślin, 2012, Vol. 52 (4), 879-884.

[5] Babik I., Babik J., Jończyk K., Koreleska E., Rogowska M., Sobolewski J., Stalenga J., Szafirowska A.: Produkcja roślinna w gospodarstwie ekologicznym. W: Wdrożenie produkcji ekologicznej i marketing jego produktów szansą rozwoju gospodarstw rolnych i regionów. Materiały szkoleniowe, Skierniewice, 2010, 55-58.

[6] Buczkowska H.: Wpływ ściółkowania na zachwaszczenie w uprawie papryki polowej. Zesz. Probl. Post. Nauk. Roln., 1999, Vol. 466: 157-163.

[7] Dobrzański A., Adamczewski K.: Perspektywy wykorzystania nowych narzędzi i maszyn do regulacji zachwaszczenia w integrowanej i ekologicznej produkcji roślinnej. Prog. Plant Protection/Post. Ochr. Roślin, 2006, Vol. 46 (1), 11-18.

[8] Dobrzański A., Anyszka Z., Pałczyński J.: Biomasa chwastów w zależności od gatunku roślin warzywnych i sposobu uprawy. Pamiętnik Puławski, 2003, Vol. 134, 51-58.

[9] Dobrzański A., Anyszka Z.: Zastosowanie ściółki z folii biodegradowalnej do regulowania zachwaszczenia w integrowanej i ekologicznej uprawie warzyw. Nowości Warzywnicze 2006, 43: 75-80.

[10] Dobrzański A.: Wpływ ochrony przed chwastami na technologię produkcji, jakość i wartość biologiczną warzyw. Materiały XXXI Sesji Naukowej IOR, 1999: 125-133.

[11] Golian J., Anyszka Z., Kohut M.: efektywność wybranych sposobów regulowania zachwaszczenia w uprawie selera korzeniowego (*Apium graveolens* L. var. Rapaceum (Mill.) Gaud.). Journal of Research and Applications in Agricultural Engineering, 2012, Vol. 57 (3).

[12] Kohut M., Anyszka Z., Golian J.: Zmiany w zachwaszczeniu i plonowanie wybranych gatunków warzyw w zależności od metody ochrony przed chwastami. Journal of Research and Applications in Agricultural Engineering, 2013, Vol. 58 (3), 255-260.

[13] Kołota E.: Wpływ zabiegów agrotechnicznych na plonowanie cukinii uprawianej z siewu. Mat. z XVIII Spotkania Zespołu Herbologicznego KNO PAN, 2001, 76-79.

[14] Locher J., Ombódi A., Kassai T., Dimeny J.: Influence of coloured mulches on soil temperaturę and yield of sweet pepper. Europ. J. Hort. Sci., 2005, 70 (3): 135-141.

[15] Siwek P., Ambroszczyk A.M.: Wpływ stosowania ściółek polietylenowych na opłacalność produkcji sałaty i selera naciowego w uprawie polowej. Zesz. Probl. Post. Nauk. Roln., 2009, Vol. 539, 647-656.

[16] Wierzbicka B., Kuskowska M., Majkowska J.: Wpływ stosowania osłon na stan zachwaszczenia w polowej uprawie sałaty. Mat. z XVIII Spotkania Zespołu Herbologicznego KNO PAN, 2001: 98-102.

[17] Wierzbicka B.: Wpływ metod uprawy na plon i zachwaszczenie sałaty masłowej odmiany Nochowska. Mat. z XVII Spotkania Zesp. Herbologicznego KNO PAN, 1999, 90-94.

[18] Woźnica Z.: Metody walki z chwastami. W: Herbologia. Podstawy biologii, ekologii i zwalczania chwastów. (M. Krupa red.). Poznań: PWRiL, 2008, 87-127.