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THE EFFECT OF SOIL AND PLANTS COVERING WITH THE POLYPROPYLENE NON-WOVEN ON THE QUANTITY AND QUALITY OF YIELD OF STEM LETTUCE (*Lactuca sativa* L. var. *augustana* Irish)

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Abstract. The aim of study was to estimate the effectiveness of polypropylene woven (PP-17) covers usage in growing of stem lettuce. The seeds of 'Karola' cultivar were sown in non-heated green-house in the middle of March. The seedlings were planted in the last ten days of April at spacing 40 × 30 cm . The plants were grown in the soil mulched with black cover propylene non-woven. Some plants were covered with a transparent propylene non-woven, others remained not covered (control group). A significant effect of polypropylene non-woven usage was found regarding quantity and quality of stem lettuce. The harvest was forced by 4 days earlier (on average) and the increase of marketable yield of stems was 20.9% in comparison with open-field production. The plants grown under covers showed higher unit weight and the diameters of edible stems as well as higher dry weight content and total sugar content including reducing sugar. The mulching of soil with black propylene non-woven did not affect considerably productivity and yield quality of stem lettuce compared to control group (open-field).

Key words: stem lettuce, covers, yield quantity and quality

INTRODUCTION

Vegetables should constitute an important position in human nutrition. It is because of their specific nutritional and biological value. They provide into our diet large amounts of important chemical compounds, such as: vitamins, mineral compounds, easy to digest carbohydrates and lots of other biologically active compounds [Gawęcki and Hryniewiecki 2008].

Compared to Western European countries, there has been a poor assortment of leafy vegetables (e.g. butterhead lettuce, crisphead lettuce, spinach) noted in Poland. One of the little known species is for example asparagus lettuce which was quite popular in

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thirties-fifties of the last century in Cracow region and named 'głąbiki krakowskie' [Stępowska 2004]. Asparagus (stem) lettuce can be consumed raw (stems, young leaves), but also cooked as asparagus or preserved as sour cucumbers.

Because of the simple cultivation, rather short vegetation period and high biological value (carotenoids, vitamins C and E, anthocyans), stem lettuce is worthy of further popularization.

The best planting date for this vegetable is early spring or autumn. In spring cultivation – yield of stems might be accelerated by covering plants.

The aim of conducted experiment was the estimation of the effect of using flat plastic covers on the quantity and quality of yield of stem lettuce cultivated for the early harvest.

MATERIAL AND METHODS

The field experiment was conducted in the years 2006–2008 at the Horticultural Experimental Station in Dołuje near Szczecin. The experiment was set in one-factorial, randomized block design with four replications. Objects of the tested factor were: covering plants with polypropylene non-woven fabric, mulching with polypropylene non-woven fabric and object without covers (control). Plot area was 3.36 m^2 (2.10 × 1.6 m).

For the experiment Polish cultivar 'Karola' was chosen. This cultivar is recommended for spring and autumn harvest, its vegetation period lasts 70–90 days. Stem lettuce seeds were treated with Zaprawa Funaben T at 1 kg dose per 1 kg of seeds, and then sown in the middle of March in unheated glasshouse into the seed trays. Seedlings at cotyledon stage were transplanted into fulfilled with peat substrate pots of 4 cm diameter.

The experiment was performed on black earth soil comprising on average 1.6% organic matter. For all of the years of study as a forecrop basil was grown. Before transplant lettuce planting, field was prepared according to agrotechnique recommended for this species. In autumn, prior ploughing, manure at dose 20 $t \cdot ha^{-1}$ was applied. Mineral fertilization was quantified according to the results of the chemical analysis of the soil samples and supplemented to recommended for lettuce level of 70 mg N, 50 mg P and 150 mg K per 1 dm^3 [Sady 2006]. Before planting multi fertizer HydroComplex was used. Transplants were planted into the field on 25 April (in 2006), 20 April (in 2007) and 24 April (in 2008), in 40 × 30 cm distance. According to the experiment methods, part of the transplants was planted into the soil mulched with black polypropylene non-woven fabric of weight 60 $g \cdot m^{-2}$, while the other part was covered with transparent polypropylene non-woven fabric of weight 17 $g \cdot m^{-2}$. Plots without covers were used as control. Polypropylene non-woven fabric was kept on plants for 3 weeks. After the covers were removed from plants, on all experimental objects biometrical measurements were conducted (plant height, number of leaves, length and width of leaves and diameter of leaf rosette).

Lettuce was harvested several times when the plants attained height about 20 cm. After the harvest the quantity of the total yield (weight of above-ground part of lettuce plants) was assessed. Moreover, there was a marketable yield of stems with rosette of leaves on

top of plants estimated. Also, the mean weight and diameter of stem, and number of leaves of the top part of plants was assessed.

The chemical analysis were carried out in raw plant material. The determinations included the content of dry matter (drying at 105° to constant weight), total sugars (by the method of Luff-Schoorl) and vitamin C as L-ascorbic acid (by the method of Tillmans). The results were subjected to the analysis of variance and the means were separated with Tukey's test at a significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

In the present study it was proved that covering stem lettuce with PP non-woven fabric had a positive effect on morphological features of the plants (tab. 1). Better results according to the plant height, number of leaves, length and width of leaf blade, and diameter of leaf rosette were noted for plants grown under non-woven fabric. However, there were no significant differences assessed in these features between plants grown in soil mulched with non-woven fabric and without any covers. This corresponds with investigation of Błażewicz-Woźniak [2009]. The author found that only black polyethylene foil mulch unlike black PP-50 non-woven mulch had a significant influence on emergence of fennel.

In opinion of Kaniszewski [1994] non-woven fabric mulch unlike foil, allows for water permeation steadily on whole mulch surface and decreases disease development, but in the same time gives worst productivity effects in comparison with foil.

Table 1. Evaluation of selected morphological features of stem lettuce after removing the polypropylene non-woven

Tabela 1. Ocena wybranych cech morfologicznych roślin sałaty łodygowej po zdjęciu włókniny

Manner of the use of covers Sposób stosowania osłon	Years Lata	Height of plants Wysokość roślin cm	Number of leaves Liczba liści	Lenght of leaves Długość blaszek liściowych cm	Width of leaf Szerokość blaszek liściowych cm	Plant diameter Średnica rozety liściowej cm
Covering with non-woven fabric Okrywanie włókniną	2006	27.1	20.5	23.4	8.8	39.1
	2007	23.8	19.2	25.3	8.1	38.0
	2008	25.1	21.5	22.9	8.5	37.9
	mean średnia	25.3	20.4	23.9	8.5	38.3
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	2006	19.7	14.3	18.5	7.7	28.6
	2007	12.8	11.5	18.0	5.8	27.4
	2008	13.7	10.4	13.3	6.0	24.6
	mean średnia	15.4	12.1	16.6	6.5	26.9
Without covers (control) Bez osłon (obiekt kontrolny)	2006	19.5	14.7	19.0	7.9	29.0
	2007	15.1	12.6	18.9	6.3	25.9
	2008	16.5	11.9	15.9	6.8	25.2
	mean średnia	17.0	13.1	17.9	7.0	26.7

Table 2. Harvest progress of stem lettuce marketable yield according to the way of the use of covers
Tabela 2. Przebieg zbioru plonu handlowego sałaty łodygowej w zależności od stosowania osłon

Manner of the use of covers Sposób stosowania osłon	Term of harvest – Data zbioru (2006)									
	13.06		17.06		21.06		25.06		–	
	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	–	–
Covering with non-woven fabric Okrywanie włókniną	34.7	12.36	48.6	18.24	–	–	–	–	–	–
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	–	–	41.7	13.90	34.7	12.90	–	–	–	–
Without covers (control) Bez osłon (obiekt kontrolny)	–	–	38.2	11.00	30.8	10.32	10.9	4.68	–	–

Manner of the use of covers Sposób stosowania osłon	Term of harvest – Data zbioru (2007)									
	03.06		06.06		12.06		15.06		21.06	
	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}
Covering with non-woven fabric Okrywanie włókniną	11.9	4.35	41.7	16.47	29.8	12.72	–	–	–	–
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	–	–	–	–	11.7	3.52	30.0	9.67	38.3	13.91
Without covers (control) Bez osłon (obiekt kontrolny)	–	–	–	–	13.3	4.06	29.8	10.07	36.8	14.07

Manner of the use of covers Sposób stosowania osłon	Term of harvest – Data zbioru (2008)									
	10.06		15.06		20.06		–		–	
	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}	thousand pcs·ha^{-1} tys.·szt·ha^{-1}	t·ha^{-1}
Covering with non-woven fabric Okrywanie włókniną	34.7	14.50	48.6	22.20	–	–	–	–	–	–
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	17.4	6.96	48.6	20.46	13.9	6.08	–	–	–	–
Without covers (control) Bez osłon (obiekt kontrolny)	20.8	6.70	45.1	16.28	17.4	6.32	–	–	–	–

In table 2 the harvest progress of stem lettuce marketable yield according to the way of use of covers was presented. In the first year of the study the earliest yield was collected from objects where lettuce was covered with PP non-woven fabric. From other experimental objects the yield was obtained 4 days later. The last harvest took place on 25 June from the plots where plants were grown without any covers. In the second year, first harvest was conducted on 3 June from the objects covered with non-woven fabric. The first yield from objects where plants were grown in mulched soil and in non-covered field was obtained on 12 June. The last harvest from these objects took place on 21 June. In the last year of the study, the first harvest was done on 10 June, for all experimental objects. At this date, from objects covered with PP non-woven fabric 39.5% of whole marketable yield was obtained, while 20.8% – from mulched objects and 22.9% from control plots.

Table 3. Influence of the manner of the use of covers on the quantity of yield of stem lettuce
Tabela 3. Wpływ sposobu stosowania osłon na plonowanie sałaty łodygowej

Manner of the use of covers Sposób stosowania osłon	Yield – Plon, $t \cdot ha^{-1}$							
	total – całkowity				marketable – handlowy			
	2006	2007	2008	2006–2008	2006	2007	2008	2006–2008
Covering with non-woven fabric Okrywanie włókniną	57.6	63.1	58.9	59.9	30.6	33.6	36.7	33.6
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	43.1	58.1	54.4	51.9	26.8	27.1	33.5	29.1
Without covers (control) Bez osłon (obiekt kontrolny)	48.5	60.4	47.1	52.0	26.0	28.2	29.3	27.8
LSD – $NIR_{\alpha = 0.05}$	1.31	2.64	3.88	3.60	3.66	4.21	2.61	4.49

Mean for the years 2006–2008
Średnio z lat 2006–2008

In each year of the study there was a significant effect of covering method on total yield of stem lettuce, including the marketable yield of edible stems found (tab. 3). On average for the years 2006–2008, an increase of total yield of the above-ground parts of plants (by 15.4%), comparing to the cultivation of lettuce in non-covered field (control object), was proved. For the marketable yield this increase amounted to 20.9%. However, at the same time there were no significant differences found in the case of the yield quantity between objects where soil was mulched with non-woven fabric and in the case of cultivation without covers. These results are comparable with data of Kalisz and Cebula [2001]. The authors obtained better yielding effects in spring cultivation of Chinese cabbage covered with polypropylene non-woven in comparison with soil mulching method and with cultivation in non-covered field. It had a strict relationship with more preferable for Chinese cabbage microclimate under non-woven fabric in comparison with cultivation in non-covered field. Similar research at this area was conducted by Piróg [2009]. The author investigated quantity and quality of fruit yield of cucumber grown in the field according to the use of mulching soil with black PP-50

non-woven fabric and covering plants with Pegaz 17 non-woven fabric. It was proved that effectiveness of use of plastic covers in cucumber cultivation depended on weather conditions. Use of mulching and plant covering with agrotextile, because of the warm weather in May and June of the study years, did not have a significant effect on increase of marketable yield of fruit in comparison with growing cucumber in non-covered field.

Positive effect of soil mulching (with transparent and black foil) on yielding of butterhead lettuce and celery was proved by Siwek and Ambroszczyk [2009]. For lettuce an increase of marketable yield was on average by 36.1% and for celery – by 41.4% in comparison with control object.

Positive effect of stem lettuce covering with polypropylene non-woven fabric was proved also with regard to analyzed in the study quality features of the yield (tab. 4). Plants grown under non-woven fabric covers were characterized by significantly higher mean plant weight including higher weight and diameter of edible stems, in comparison with cultivation in mulched soil and in non-covered field. However, there were no significant differences noted for such characteristics as weight of single whole plant, weight of above-ground part of plants and stem diameter, between growing plants in non-woven mulched soil and cultivation in non-covered soil.

Table 4. Influence on the covered with polypropylene on selected traits of the yield of stem lettuce (mean for 2006–2008)

Tabela 4. Wpływ osłaniania włókniną na wybrane cechy plonu sałaty łodygowej (średnia z lat 2006–2008)

Manner of the use of covers Sposób stosowania osłon	Whole plant weight Masa rośliny g	Weight of above-ground parts g·plant^{-1} Masa części nadziemnej g·roślina^{-1}	Stem weight of leaf rosette g·plant^{-1} Masa łodygi z rozetą liściową g·roślina^{-1}	Diameter of stem Średnica łodygi mm	Number of leaves Liczba liści w rozecie
Covering with non-woven fabric Okrywanie włókniną	840.2	710.9	375.4	40.2	25.2
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	790.1	680.3	323.0	35.8	22.6
Without covers (control) Bez osłon (obiekt kontrolny)	787.9	556.7	313.5	33.7	22.7
LSD – $NIR_{\alpha=0.05}$	48.88	29.97	9.46	3.66	n.s.

n.s. – nonsignificant differences – różnice nieistotne

Filho et al. [2009] recommend for vegetable cultivation use of light weight non-woven fabric. The authors proved in their investigation faster growth rate of lettuce plants and higher yield when this method was used comparing to cultivation in non-covered field. Also, Gimenez et al. [2002] obtained significantly higher biomass leaves of lettuce and spinach grown under flat covers in comparison with cultivation in non-covered field.

Positive influence of plant covering on some morphological features and yielding of fennel and corn salad (from the earliest dates of harvest) was confirmed by Dobromilska [2001], and Rekowska and Słodkowski [2005]. Positive effects of kohlrabi flat covering (perforated foil and polypropylene non-woven) was observed also by Biesiada [2008]. However, significantly the highest early and marketable yield of kohlrabi in spring cultivation was obtained only when plants were covered with non-woven fabric.

In the case of Welsh onion, better results according to the quantity of leaf yield were obtained when plants for a short period of time were covered with perforated foil in comparison with non-woven fabric use [Tendaj and Mysiak 2007].

Except the effect of plant covering on the external quality characteristics of the yield, there were observed the differences in the content of dry matter and also of these chemical compounds which have an influence of the level of biological value of vegetables.

On the base of the results of the conducted experiment (tab. 5) it was proved that significantly the highest content of dry matter (4.99%, on average for the years 2007–2008) and total sugars (2.49% f.w.) was determined in edible parts of plants covered with PP 17 non-woven comparing to other objects. Regarding content of vitamin C, the best results were obtained for plants grown in soil mulched with black non-woven fabric and in non-covered field.

Table 5. The content of selected minerals in stem lettuce (mean for the years 2007–2008)
Tabela 5. Zawartość wybranych składników chemicznych sałaty łodygowej (średnio z lat 2007–2008)

Manner of the use of covers Sposób stosowania osłon	Dry matter Sucha masa %	Total sugars % f.m. Cukry ogółem % św.m.	Reducing sugars % f.m. Cukry redukujące % św.m.	L-ascorbic acid mg·100 g^{-1} f.m. Kwas L-askorbinowy mg·100 g^{-1} św.m.
Covering with non-woven fabric Okrywanie włókniną	4.99	2.64	2.49	6.98
Mulching with black non-woven fabric Ściółkowanie czarną włókniną	4.23	2.02	1.75	8.60
Without covers (control) Bez osłon (obiekt kontrolny)	4.28	1.97	1.72	8.64
LSD – $NIR_{\alpha = 0.05}$	0.469	0.08	0.158	1.57

Capecka et al. [2000] stated the changes in the content of some organic compounds (e.g. sugars, L-ascorbic acid) in radish root according to the type of covers used in their experiment. However, the authors did not proved a constant correctness for the following years of study. It was because of diverse course of temperature and moisture of air and soil during growing this vegetable.

On the other hand, Najda and Dyduch [2006] determined higher amount of flavonoid compounds in celery leaves when plants were grown in soil mulched with black PE foil in comparison with non-woven fabric mulching. The least content of these compounds was assessed in leaves of plants grown in control objects (without mulching).

CONCLUSIONS

1. Covering stem lettuce plants with PP non-woven fabric had a positive effect on the acceleration of harvest and on the quantity and quality of the yield.

2. Use of non-woven fabric for plant covering had an influence on increase of marketable yield of lettuce stems by 20.9% in comparison with cultivation in non-covered field.

3. Plants covered with non-woven fabric were characterized by significantly higher weight of above-ground parts, including higher weight and diameter of stems. Moreover, for this method of cultivation higher amount of dry matter and total sugars was determined with at the same time lower content of L-ascorbic acid, comparing to the method of cultivation in non-covered field.

4. Mulching soil with black non-woven fabric did not have a significant effect on the quantity and quality of lettuce in comparison with control object (non-covered field).

REFERENCES

Biesiada A., 2008. Effect of flat covers and plant density on yielding and quality of kohlrabi. J. Elementol. 13(2), 167–173.

Błażewicz-Woźniak M., 2009. Wpływ osłaniania gleby i roślin oraz terminu siewu na wschody i wzrost dwóch odmian kopru włoskiego w uprawie polowej. Annales UMCS, sec. EEE, Horticultura, XIX (2), 13–20.

Capecka E., Siwek P., Libik A., 2000. Wpływ osłon do przykrywania płaskiego na zawartość wybranych składników w zgrubieniach rzodkwi japońskiej. Annales UMCS, sec. EEE, Horticultura, VIII, 103–109.

Dobromilska R., 2001. Forecrop fennel cultivation in a cold greenhouse and in the field under covers. Veg. Crop Res. Bull. 54, 1, 99–103.

Filho B. G. S., Lobato A. K., Silva R. B., Schmidt D., Costa R. C. L., Alves G. A., Neto C. F., 2009. Lettuce and radish productivity in intercropping systems as influenced by starting time and row spacings. Hortic. Brasileira, 25, 15–19.

Gawęcki J., Hryniewiecki L., 2008. Żywienie człowieka. Podstawy nauk o żywieniu. Wyd. PWN, Warszawa: 323–325.

Gimenez C., Otto R. F., Castilla N., 2002, Productivity of leaf and root vegetable crops under direct cover. Scientia Hortic. 94, 1–11.

Kalisz A., Cebula S., 2001. Direct plant covering and soil mulching in the spring production of some Chinese cabbage cultivars. Growth and yielding. Effect of temperature on premature bolting. Folia Hortic. 13, 1–2, 3–22.

Kaniszewski S., 1994. Reakcja pomidora na kroplowe nawadnianie oraz mulczowanie folią i włókniną polipropylenową. Biul. Warz., 41, 29–38.

Najda A., Dyduch J., 2006. Zmiany zawartości związków flawonoidowych w liściach selera naciowego (*Apium graveolens* L. var. *dulce* Mill./Pers.) w zależności od wieku roślin i ściółkowania gleby. Folia Hortic., 2, 23–27.

Piróg J., 2009. Wpływ ściółkowania i mikroklimatu pod agrowłókniną na plonowanie ogórka w gruncie. Zesz. Probl. Post. Nauk Roln., 539, 567–574.

Rekowska E., Słodkowski P., 2005. Wpływ płaskiego okrycia roślin oraz normy siewu nasion na plonowanie roszponki. Zesz. Nauk AR Wrocław, Rol. 86, 515, 433–439.

Sady W., 2006. Nawożenie warzyw polowych. Wyd. Plantpress, Kraków, 70–71.
Siwek P., Ambroszczyk A. M., 2009. Wpływ stosowania ściółek polietylenowych na opłacalność produkcji sałaty i selera naciowego w uprawie polowej. Zesz. Probl. Post. Nauk Roln., 539, 647–656.
Stępowska A., Rogowska M., 2004. Uprawa sałaty w polu i pod osłonami. Wyd. Plantpress, Kraków.
Tendaj M., Mysiak B., 2007. Plonowanie cebuli siedmiolatki (*Allium fistulosum* L.) w zależności od terminu sadzenia rozsady i stosowania płaskich osłon. Annales UMCS, sec. EEE, Horticultura, XVII (2), 5–10.

WPŁYW OKRYWANIA GLEBY I ROŚLIN WŁÓKNINĄ POLIPROPYLENOWĄ NA WIELKOŚĆ I JAKOŚĆ PLONU SAŁATY ŁODYGOWEJ (*Lactuca sativa* L. var. *augustana* Irish)

Streszczenie. Celem prowadzonych badań była ocena efektywności stosowania osłon z włókniny polipropylenowej w uprawie sałaty łodygowej. Nasiona odmiany ‘Karola‘ wysiano do szklarni nieogrzewanej w połowie marca. Rozsadę sadzono w 3 dekadzie kwietnia, w rozstawie 40 × 30 cm. Zgodnie z założeniami metodyki część roślin uprawiano na glebie ściółkowanej czarną włókniną, część roślin okrywano przezroczystą włókniną oraz sadzono na polu bez osłon (obiekt kontrolny). Rośliny uprawiano na glebie ściółkowanej czarną włókniną, część roślin okrywano przezroczystą włókniną oraz sadzono na polu bez osłon (obiekt kontrolny). Stwierdzono istotny wpływ okrywania roślin włókniną PP-17 na wielkość i jakość plonu sałaty łodygowej. W tym przypadku uzyskano przyśpieszenie zbioru (średnio o 4 dni) oraz wzrost plonu handlowego łodyg o 20,9% w porównaniu z uprawą na polu odkrytym. Stwierdzono również istotnie większą niż w uprawie na polu odkrytym masę jednostkową i średnicę jadalnych łodyg oraz większą zawartość suchej masy, a także cukrów ogółem, w tym cukrów redukujących. Ściółkowanie gleby czarną włókniną nie wpłynęło w sposób istotny na wielkość oraz jakość plonu sałaty łodygowej w porównaniu z obiektami kontrolnymi (pole odkryte).

Słowa kluczowe: sałata łodygowa, włóknina, plon, jakość

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