Barbara BINIAŚ, Janina GOSPODAREK, Milena RUSIN
University of Agriculture in Krakow, Department of Agricultural Environment Protection
Al. Mickiewicza 21, 31-120 Kraków, Poland
e-mail: binias.barbara@gmail.com

THE EFFECT OF INTERCROPPING OF BROAD BEAN (*VICIA FABA* L.) WITH SWEET ALYSSUM (*LOBULARIA MARITIMA* L.) AND WHITE MUSTARD (*SYNAPIS ALBA* L.) ON THE ENERGY AND THE ABILITY OF SEED GERMINATION

Summary

The aim of this study was to determine the impact of the accompanying plants: sweet alyssum (Lobularia maritima) and white mustard (Synapis alba L.) on the energy and the ability of germination of broad bean (Vicia faba L.) seeds variety Bartek. In the experiment, the analyzed broad bean seeds were obtained from a field experiment, in which it had been grown along with two other plants in varying spacing (the distances between rows were 50, 65 and 80 cm) and in homogeneous cultivation (the distances between rows were 50 cm). Broad bean in a homogeneous cultivation served as a control. In addition, the broad bean seeds from homogeneous cultivation subjected to a standard protection by chemical insecticides were also analyzed. The measurement of the energy and ability of broad bean seeds germination was carried out in the laboratory conditions, in accordance with generally accepted standards. The morphological parameters of seedlings were also evaluated (the length of the root and the above ground parts and the number of the lateral roots longer than 2 mm). There was no significant influence of the neighbourhood of sweet alyssum (Lobularia maritima L.) and white mustard (Synapis alba L.) on the germination energy and ability of broad bean seeds. The neighbourhood of sweet alyssum did not significantly affect the length of the primary root and the above-ground part of the broad bean seedlings and the number of the lateral roots. However the neighbourhood of the white mustard contributed to the increase of the length of above-ground part of seedlings, but only in the highest applied spacing of rows.
***Keywords**: intercropping, broad bean (Vicia faba L.), sweet alyssum (Lobularia maritima), white mustard (Synapis alba L.), energy and ability of seed germination*

WPŁYW UPRAWY WSPÓŁRZĘDNEJ BOBU (*VICIA FABA* L.) ZE SMAGLICZKĄ NADMORSKĄ (*LOBULARIA MARITIMA* L.) ORAZ GORCZYCĄ BIAŁĄ (*SYNAPIS ALBA* L.), NA ENERGIĘ I ZDOLNOŚĆ KIEŁKOWANIA NASION

Streszczenie

Celem badań było określenie wpływu rośliny towarzyszącej: smagliczki nadmorskiej (Lobularia maritima L.) oraz gorczycy białej (Synapis alba L.), na energię i zdolność kiełkowania nasion bobu (Vicia faba L.) odmiany Bartek. W doświadczeniu analizowano nasiona bobu pochodzące z doświadczenia polowego, w którym był on uprawiany współrzędnie z dwoma w/w roślinami w zróżnicowanej rozstawie (odległość między rzędami: 50, 65 i 80 cm) oraz samodzielnie (odległość między rzędami 50 cm). Bób w uprawie jednorodnej stanowił kontrolę. Dodatkowo analizowano także nasiona bobu pochodzące z uprawy jednorodnej i poddanej standardowej ochronie z użyciem insektycydów chemicznych. Ocenę energii i zdolności kiełkowania nasion bobu przeprowadzono w warunkach laboratoryjnych, zgodnie z ogólnie przyjętymi normami. Ocenie poddano również parametry morfologiczne siewek (długość korzenia głównego i części nadziemnej oraz liczbę korzeni bocznych dłuższych niż 2 mm). Nie stwierdzono istotnego wpływu towarzystwa smagliczki nadmorskiej (Lobularia maritima L.) oraz gorczycy białej (Synapis alba L.) na energię i zdolność kiełkowania nasion bobu. Sąsiedztwo smagliczki nadmorskiej nie wpłynęło w sposób istotny na długość korzenia głównego i części nadziemnej siewek bobu oraz na liczbę korzeni bocznych. Z kolei towarzystwo gorczycy białej, ale tylko przy największej zastosowanej rozstawie, przyczyniło się do zwiększenia długości części nadziemnej siewek.
***Słowa kluczowe**: uprawa współrzędna, Vicia faba L, Lobularia maritima L., Synapis alba L., energia i zdolność kiełkowania nasion*

1. Introduction

The intercropping system is one of the oldest and simplest method of protecting plants from pests, diseases or weeds [1]. Adequately carried out cropping enables the natural protection of plants, without the use of artificial means to protect them. The basis for the proper development of plants in the growing intercrop system is associated with a proper selection of plants [2, 3]. Their role is, among others, the preservation of a biological balance in the form of a natural control of the pests of plants [4], the protection against the expansion of diseases, excessive weeds, as well as the deterioration of the soil structure due to the erosion or used monoculture [5, 6]. The solicitude to obtain the best quality seeds is one of the elements of a proper crop [7]. Broad bean is an example of a legume whose consumption increases in recent years. The high protein content, which is an alternative to the animal protein, vitamins and folic acid [8] are the main reasons for which the cultivation of this plant should be increased.

Sweet alyssum (*Lobularia maritima* L.) and white mustard (*Synapis alba* L.) are the examples of plants whose neighbourhood in cultivation brings tangible benefits. The presence of the melliferous plants, which sweet alyssum is an example of, allows to minimize the extent of taking over the main crops by pests [9]. These plants are capable of lur-

ing the natural predators of pests for which the attractant is a plant pollen. The cultivation of white mustard helps to reduce the amount of weeds, inhibits the expansion of fungal diseases and protects from pests of plants [10 – 13]. The introduction of different spacing between the rows in the field has an impact not only on the yield of the main crops. The "visibility" of the companion plants for potential predators of pests, attracted by the visual or olfactory stimuli is an important aspect [14].

The introduction of the above mentioned method of the plants protection is based on the control of pests and diseases on the crop field already during the growth of the plant. During this period, the seeds are also mostly exposed to injury or infection. Damaged, diseased or weakened seed material shows less energy and a lower ability of germination, which at a later stage of plant growth may reduce yield.

The aim of the experiment was to investigate the effect of accompanying plants: sweet alyssum and white mustard on the energy and the ability of germination of broad bean (*Vicia faba* L.) seeds.

2. Materials and methods

The experiment was carried out in laboratory conditions. In the study a broad bean seeds, variety Bartek, were used, which were obtained from a field experiment conducted at the Experimental Station of the Agricultural University in Prusy, near Krakow. The broad bean was grown along with sweet alyssum and white mustard, with the use of the varying row spacing. The shortest distance between rows was 50 cm, the next one - 65 cm and the largest - 80 cm. The homogeneous cultivation of broad bean, in row spacing of 50 cm, served as a control. The seeds originating from the homogeneous cultivation subjected to a standard control, with the use of two chemical insecticides (Decis 2.5 EC and Fastac 100 EC) were also analyzed. Each of the insecticides was used twice. At the time of the appearance of black bean aphids and again, by the end of flowering first inflorescences. Decis 2.5 EC formulation at a dose of 0.25 l / ha was used against *Bruchus rufimanus* Boh. In controlling *Sitona lineatus* L. Fastac 100 EC at a dose of 0.09 l / ha was used. The procedure with the use of this preparation was carried out after the first visible damage caused by pests, and then repeated after 7 days.

The test was conducted in Petri dishes. A filter paper was used as a substrate**.** A healthy and undamaged broad bean seeds were picked. The germination energy was determined after six days, whereas the germination ability after two weeks. During the second observation the length of the above-ground part of each of the seedling root length and the number of lateral roots of length greater than 2 mm was also measured.

The statistical analysis of the results was performed by using Statistica 10.0.PL. The significance of differences between means was tested by the one - way analysis of variance and the means were differentiated using Fisher LSD test at the significance level $\alpha = 0.05$.

3. Results

The vicinity of both plants, sweet alyssum (*Labularia maritima* L.) and white mustard (*Synapis alba* L.), regardless of the spacing, as well as the applied chemical protection, showed no significant effect on the energy of the seed germination of broad bean (fig. 1). The most healthy and properly germinated seeds were recorded in objects: control, chemically protected and where the broad bean grew in the vicinity of white mustard at a spacing of 65 cm.

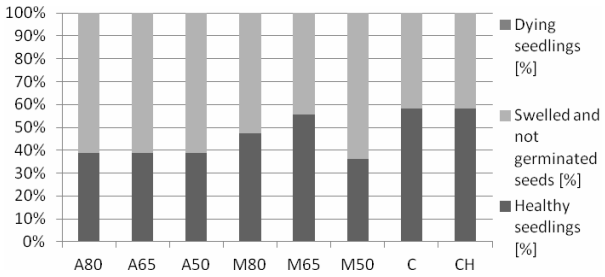

Fig. 1. The energy of germination of broad bean seeds, obtained from a field experiment, based on a intercropping, with sweet alyssum (A) and white mustard (M) used as neighbouring plants, in row spacing of 50 cm, 65 cm and 80 cm and subjected to a chemical protection (CH) in the comparison to the control (C). The statistical analysis showed no significant differences between the objects

In all sites a high germination of seeds was reported, from 85% in the facility with sweet alyssum in the span of 80 cm, up to 100% in objects with a homogeneous broad bean crop (with and without chemical protection) and in the object with white mustard, with a spacing of 50 cm (fig. 2). The differences between objects, however, were not statistically significant. The most of the dead seeds were recorded in objects where seeds came from plots where sweet alyssum and white mustard were the neighbouring plants and broad bean was grown in the highest row spacing (80 cm).

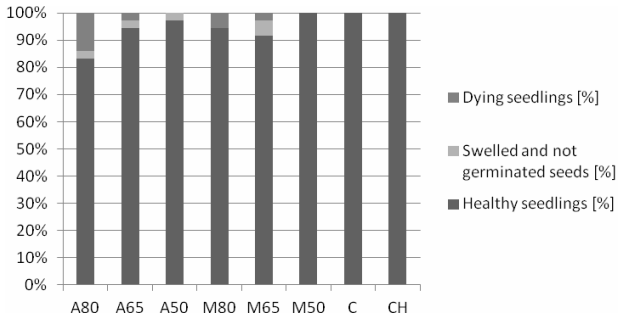

Fig. 2. The ability of germination of broad bean seeds obtained from plants grown in the vicinity of sweet alyssum and white mustard. Symbols as in fig. 1. The statistical analysis showed no significant differences between objects.

The measurements of the length of the primary root of broad bean showed that the vicinity of white mustard used in the largest of the row spacing had the most beneficial effect (fig. 3). A similar effect has been demonstrated for chemically protected object and the object with a vicinity of white mustard, in the smallest of the applied row spacing. Significantly shorter roots were developed by seedlings obtained from objects, where broad beans were grown along with sweet alyssum, with spacing between rows 50 and 80 cm. However, none of the objects differed significantly in comparison with the control object.

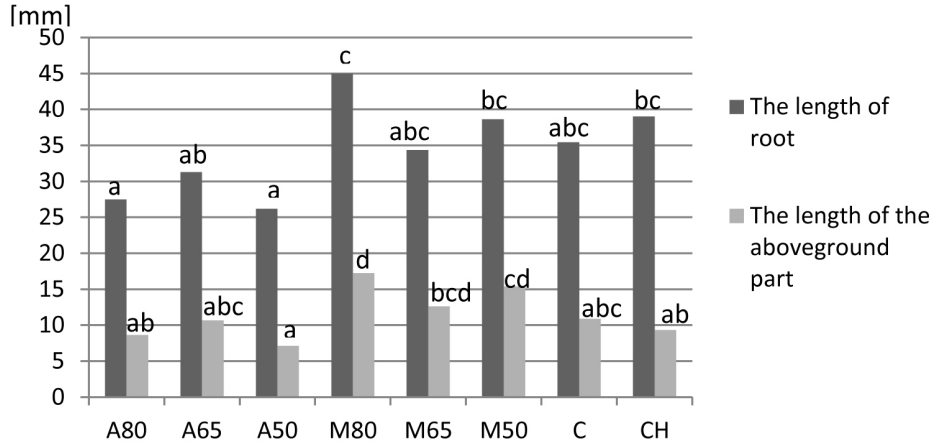

Fig. 3. The average length of roots and aboveground parts of germinating seeds obtained from plants grown in the vicinity of sweet alyssum and white mustard. Symbols as in fig. 1. Values marked with different letters differ significantly at α = 0.05

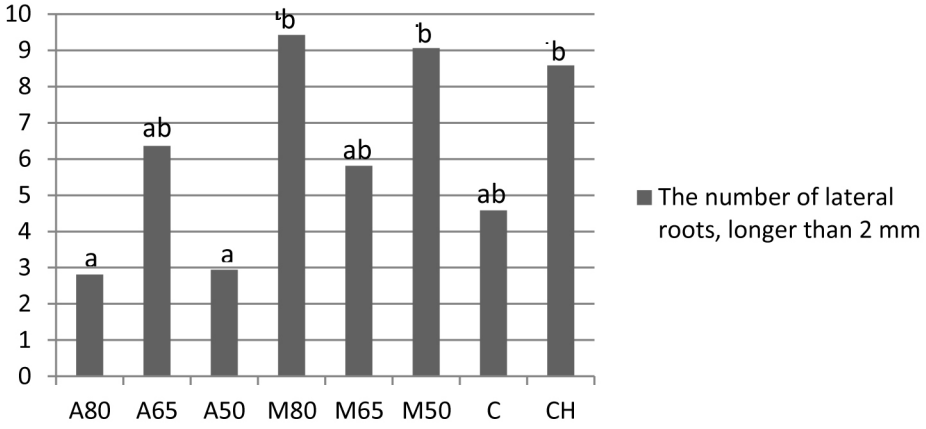

Fig. 4. The average number of lateral roots of germinating seeds obtained from plants grown in the vicinity of sweet alyssum and white mustard. Symbols as in fig. 1. Values marked with different letters differ significantly at α = 0.05

The result of the morphological measurements showed that the longest above-ground parts developed seedlings from seeds obtained from intercrop cultivation, whereas the neighbouring plant white mustard was used and broad bean was grown in the largest spacing (Fig. 3). The difference in this case was significant, both in relation to the control and in relation to the object chemically protected and also to objects where the broad bean was accompanied by sweet alyssum.

The most numerous of the lateral roots were developed by the broad bean seedlings from seeds which came from coordinate cultivation with white mustard in minimum and maximum spacing and from chemically protected object. Significantly less branched were the roots of control seedlings and those from seeds, where broad bean was grown along with sweet alyssum in minimum and maximum spacing used (fig. 4). In relation to the control plant, however, no statistically significant differences were proven.

4. Discussion

The energy and germination ability of seeds is directly affected by their quality [15, 16]. The mechanical damage of seeds or their weakening caused by the activity of pests and diseases, also have a negative impact on their development [17, 18].

Bruchus rufimanus Boh is one of the most serious pests of broad bean seeds. The insects feeding on broad bean seeds is the main cause of reduced energy and ability of plants germination [19]. Control of *Bruchus rufimanus* by non-chemical methods is difficult and does not always bring the expected results. The use of non-chemical preparations (Polyversum HR, Bioczos BR and Biosept 33 SL) tests by Gospodarek et al. [20] did not reduce significantly the number of seeds damaged by *Bruchus rufimanus*. The objects in which Polyversum HR and Vitavax 200 FS preparations were used, are characterized by the increase in seed germination energy. None of the used methods for the protection of broad bean did significantly influence the development of the morphological characteristics of seedlings and their ability to germinate. There is little data on the impact of mixed crops on the extent of seed damage by this pest. Growing naked oat mixed with faba bean had restrictive influence on feeding of both, *Bruchus rufimanus* Boh. and black bean aphid [21]. Research by Szpunar - Krok et al. [22] on a yield of naked oats in the monoculture or in a mixture, however, do not confirm these results. The share of faba bean seeds damaged by *Bruchus rufimanus* Boh. in a mixture with naked oat did not differ significantly from homogeneous crops.

In the available literature, there is a lack of information about the impact of the vicinity of white mustard on these

pests. Previous observations showed the restrictive effect of this plant on the presence of the beet cyst nematode (*Heterodea schachtii* Schmidt). Furthermore, the production of allelochemicals by the roots of white mustard causes the reduction of the weeds abundance [23].

Black bean aphid (*Aphis fabae* Scop.) is another insect having a negative impact on both, the quality of seeds and the crop development. One of the non-chemical methods of controlling this pest is to enrich the colonization of plants with its natural predators. The production of pollen and nectar by flowers of sweet alyssum, has a positive effect on the survival and abundance of parasitic Hymenoptera [9]. The appearance of these insects naturally regulates plants colonization by aphids. The appropriate placement of the plant, through the selection of the appropriate row spacing, is used in the intercrop cultivation in the control of currant-lettuce aphid (*Nasonovia ribisnigri* Mosley) [24]. Sweet alyssum is also used to control the pea aphid (*Myzus persicae* Sulzer) [25].

In our studies the cultivation of broad bean with white mustard in the largest spacing was the most favorable for the development of the above-ground parts of broad bean seedlings. In addition, a stimulating effect on root branching of broad bean seedlings was recorded in two objects, with the neighborhood of white mustard. The phytosanitary impact of white mustard, has the effect of protecting the vegetative and generative parts. The positive impact on the broad bean root branching in the initial stage of their development might be the result of obtained resistance of broad bean to disease, through the phytosanitary impact of white mustard.

Schröder and Köpke [26] undertook research on the effects of safflower (*Carthamus tinctorius* L.) and white mustard (*Synapis alba* L.) on growth of faba bean (*Vicia faba* L.) roots and nitrogen assimilation by the plant. The introduction of the cultivation of white mustard with faba bean, significantly increased the density of roots by the optimum using of soil space. However, decreases of the yield of broad bean, as well as the amount of available nitrogen in the soil, resulting from lower seeding density in cultivation with white mustard, compared to the homogeneous crop was visible.

The significance of the selection of the proper plant spacing on yield and profitability of crop production is mentioned in several studies [27-29]. However, the research on the effects of different row spacing in the cultivation on the ability and energy of seed germination is low. In the study of the effects of the method, time of sowing and row spacing on energy and seeds germination of perennial ryegrass, the greatest beneficial effect has been demonstrated in the widest row spacing (48 cm), from several different sowing distances (12-, 24-, 36- and 48-centimeters). This effect was stated only in the case of the germination energy and it was shown only in the third year of the experiment [30]. The mechanisms of influence of the white mustard and the sweet alyssum are different. Despite this, both of them could help us to protect the broad bean plants [31].

5. Conclusions

1. There was no significant influence of the neighbourhood of sweet alyssum (*Lobularia maritima* L.) and white mustard (*Synapis alba* L.) on energy and germination ability of broad bean seeds.
2. The neighbourhood of sweet alyssum did not affect significantly the length of the primary root and above-ground part of broad bean seedlings and the number of lateral roots.
3. Association of white mustard, but only at the highest applied spacing, contributed to increase the length of the above-ground part of broad bean seedlings.

6. References

[1] Khan Z. R., Ampong - Nyarko K., Chiliswa P., Hassanali A., Kimani S., Lwande W., Overholt W. A., Overholt W. A., Picketta J. A., Smart L. E., Woodcock C. M.: Intercropping increases parasitism of pests. Scientific Correspondence, 1997, Vol. 388, 631–632.

[2] Ofori F., Stern W. R.: Cereal-legume intercropping systems. Advances in Agronomy, 1987, Vol. 41, 41–90.

[3] Wiech K., Kałmuk J.: Uprawy współrzędne sposobem na urozmaicenie agrocenoz i zmniejszenie zużycia pestycydów. Monografia Ochrona Środowiska Naturalnego w XXI wieku - nowe wyzwania i zagrożenia, 2005, 126–137.

[4] Åsman K. , Ekbom B., Rämert B.: Effect of Intercropping on Oviposition and Emigration Behavior of the Leek Moth (Lepidoptera: *Acrolepiidae*) and the Diamondback Moth (Lepidoptera: *Plutellidae*). Entomological Society of America, Population Ecology, 2001, Vol. 30(2), 288–294.

[5] Morse S., Willey R. W., Nasir M.: Modelling the long-term yield effects of compensation in intercropping using data from a field experiment. Experimantal Agriculture, 1997, Vol.33, 291– 299.

[6] [6] Bunescu H., Ghizdavu I., Mihai G., Oltean I., Porca M., Bodiş I.: The control of pests in ecosystems by unchemical methods, Journal of Central European Agronomy, 2003, Vol. 4(1), 7–12.

[7] Górecki R.J., Grzesiuk S.: Fizjologia plonowania roślin. Wyd. UWM, 2002.

[8] Alonso R., Aguirre A., Marzo F.: Effects of extrusion and traditional processing methods on antinutrients and in vitro digestibility of protein and starch in faba and kidney beans. Food Chemistry, 2000, Vol. 68(2), 159–165.

[9] Johanowicz D.L., Mitchell E.R.: Effects of sweet alyssum flowers on the longevity of the parasitoid wasps *Cotesia Marginiventris* (Hymenoptera: *Braconidae*) and *Diadegma insulare* (Hymenoptera: *Ichneumonidae*). Florida Entomologist , 2000, Vol. 83(1), 41–47.

[10] Hemingway J.S.: The mustard species: condiment and food ingredient use and potential as oilseed crops. In: Brassica Oilseeds: production and utilization. Komber, D.S, D.I. McGregor, CAB International, 1995, 373–383.

[11] Wnuk A.: Effect of intercropping of pea with tansy phacelia and white mustard on ccurrence of pests. Folia Horticulture, 1998, Vol. 10(1), 67–74.

[12] Paszkiewicz-Jasińska A.: Wpływ wybranych czynników agrotechnicznych na rozwój gorczycy białej, plon i jego jakość. Cz. II. Wpływ nawożenia azotem i gęstość wysiewu na skład chemiczny nasion gorczycy białej (*Sinapis alba* L.). Oilseed Crops, 2005, Vol. 26(2), 467–478.

[13] Nowakowski M.: Wpływ nawożenia potasem na efektywność działania antymątwikowego i wartość nawozową międzyplonów z gorczycy białej i rzodkwi oleistej przeznaczonych pod buraki cukrowe. Zakład Technologii Produkcji Roślin Okopowych, IHAR Oddział Bydgoszcz, 2007, ss.30.

[14] Brennan E.B.: Agronomic aspects of strip intercropping lettuce with alyssum for biological control of aphids. Biological Control**,** 2013, Vol. 65(3), 302–311.

[15] Szafirowska A.: Availability and quality of vegetable seeds from organic Cultivation on domestic market. Journal of Research And Applications in Agricultural Engineering, 2013, Vol. 58(4), 174–178.

[16] Szafirowska A.: Differences between snap bean cultivars in seed productivity and quality in organic cultivation. Journal of Research And Applications in Agricultural Engineering, 2014, Vol. 59(4), 89–93.

[17] Gospodarek J.: Quality of broad bean (*Vicia faba* L., ssp. Maior) seeds in conditions of soil polluted with heavy metals and subjected to liming. Chemia i Inżynieria Ekologiczna, 2006, Vol. 13(11), 1231–1239.

[18] Chodulska L., Palonka S.: Uszkodzenia nasion bobu (*Vicia faba* L. var. major Harz.) i ich wpływ na kiełkowanie. Bibliotheca Fragmenta Agronomica, 2000, Vol.08, 53–62.

[19] Gospodarek J.: Wpływ żerowania strąkowca bobowego (*Bruchus rufimanus* Boh.) na zdolność kiełkowania nasion bobu (*Vicia faba* L. ssp. Maior) w warunkach gleby skażonej metalami ciężkimi i poddanej wapnowaniu. Progress in Plant Protection, 2007, Vol. 47 (1), 233–237.

[20] Gospodarek J., Boligłowa E., Gleń K., Rusin M.: Quality and quantity of broad bean seeds protected against *Bruchus rufimanus* Boh. with non-chemical products. Progress in Plant Protection, 2013, Vol. 53(4), 850–855.

[21] Ropoek D., Kulig B.: Wpływ uprawy mieszanki bobiku z owsem nagoziarnistym w systemie ekologicznym na występowanie szkodników. Progress in Plant Protection, 2011, Vol. 51(3), 1291–1295.

[22] Szpunar-Krok E., Bobrecka-Jamro D., Tobiasz-Salach R.: Plonowanie owsa nagoziarnistego i bobiku uprawianych w siewie czystym i w mieszankach. Fragmenta Agronomica, 2009, Vol. 26(2), 145–151.

[23] Sawicka B., Kotiuk E.: Gorczyce jako rośliny wielofunkcyjne. Acta Scientarum Polonorum, Agricultura, 2007, Vol. 6(2), 17–27.

[24] Brennan E. B.: Agronomic aspects of strip intercropping lettuce with alyssum for biological control of aphids. Biological Control, 2013, Vol. 65, 302–311.

[25] Patt J.M., Hamilton G.C., Lashomb J.H.: Foraging success of parasitoid wasps on flowers: interplay of insect morphology, floral architecture and searching behavior. Entomologia Experimentalis et Applicata, 1997, Vol. 83, 21–30.

[26] Schröder D., Köpke U.: Faba bean (*Vicia faba* L.) intercropped with oil crops – a strategy to enhance rooting density and to optimize nitrogen use and grain production?. Field Crops Research, 2012, Vol. 135, 74–81.

[27] Markowski P., Rawa T., Lipiński A.: Wpływ wybranych czynników na równomierność dozowania i wysiewu nasion pszenicy kołeczkowym zespołem wysiewającym. Inżynieria Rolnicza, 2008, Vol. 5 (103), 103–109.

[28] Bondyra R., Markowski P.: Wpływ wybranych czynników na nierównomierność dozowania nasion pszenżyta wybranym kołeczkowym zespołem wysiewającym, Inżynieria Rolnicza, 2008, Vol. 2(100), 7–14.

[29] Rawa T., Markowski P., Lipiński A.: Próba określenia wpływu parametrów roboczych kołeczkowego zespołu wysiewającego oraz szerokości międzyrzędzi i prędkości siewu na równomierność dozowania nasion pszenicy. Inżynieria Rolnicza, 2005, Vol. 7, 255 - 263.

[30] Szczepanek M., Skinder Z.: Wpływ czynników agrotechnicznych na jakość plonu nasion życicy trwałej (*Lolium Perenne* L.) w trzyletnim okresie użytkowania. Acta Sci. Pol., Agricultura, 2006, Vol. 5(1), 63–70.

[31] Banik P., Sasmal T., Ghosal P. K., Bagchi D. K.: Evaluation of mustard (*Brassica compestris* Var. Toria) and legume intercropping under 1:1 and 2:1 row - replacement series systems. Journal of Agronomy & Crop Science, 2000, Vol.185, 9–14.

This work was financed from the funds for the University of Agriculture in Cracow statutory activity.