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# THE EFFECT OF PLANT ARRANGEMENT IN SOYBEAN CROP ON PRESENCE OF MORE IMPORTANT HERBIVORES – PRELIMINARY RESULTS

*Summary*

*The aim of the study was to determinate the effect of soybean plant arrangement on the number and dynamics of the most important herbivores. Preliminary studies were carried out in 2015, at RZD Pawłowice, Poland belonging to Wrocław University of Environmental and Life Sciences. Colonization of plants by herbivores was compared for row spacing 15 and 30 cm and also for seeding rate 50 and 90 seeds per square meter. Plants were directly observed throughout the vegetation season and sweep net was also used for collecting arthropods. It has been demonstrated, that the row spacing has a significant impact on the incidence of herbivorous organisms. Thrips were most numerous group of arthropods that appeared on the soybean plants. A total of 2371 specimens were observed during collecting with entomological net and 1902 individuals during plant observations. Also great number of aphids, flea beetles and caterpillars occurred on soybean plants. Most of these pests inhabited soybean growing in the lower density.*
***Key words**: soybean, pests, plants arrangement, organic farming*

# WPŁYW ROZMIESZCZENIA ROŚLIN W ŁANIE NA WYSTĘPOWANIE WAŻNIEJSZYCH FITOFAGÓW SOI – BADANIA WSTĘPNE

*Streszczenie*

*Celem badań było określenie wpływu rozmieszczenia roślin w łanie na liczebność oraz dynamikę występowania ważniejszych fitofagów soi. Badania wstępne przeprowadzono w 2015 roku w RZD w Pawłowicach należącym do Uniwersytetu Przyrodniczego we Wrocławiu. Porównywano zasiedlenie roślin przez fitofagi przy rozstawie rzędów 15 i 30 cm oraz gęstości wysiewu 50 i 90 nasion na $m^2$. Rośliny były obserwowane bezpośrednio przez cały okres wegetacji, a do odłowu stawonogów wykorzystano również czerpak entomologiczny. Wykazano, że rozstawa rzędów ma istotny wpływ na występowanie organizmów fitofagicznych. Najliczniejszą grupą owadów obserwowanych na roślinach soi były przylżeńce. Łącznie odnotowano 2371 osobników w odłowach za pomocą czerpaka entomologicznego oraz 2072 osobniki w trakcie obserwacji bezpośrednich roślin. Licznie na soi występowały również mszyce, pchełki oraz gąsienice motyli. Większość szkodników w większej liczbie zasiedlała soję rosnącą w mniejszej obsadzie.*
***Słowa kluczowe**: soja, szkodniki, rozmieszczenie roślin, rolnictwo ekologiczne*

## 1. Introduction

Soybean is one of the most important crops in many regions of the world. It ranks fourth place in terms of cultivation area after wheat, rice and maize. Soybean seeds are characterized by high content of protein (approximately 40%) and fat (about 20%). Due to its nutritional properties, soybean is a valuable raw material in animal feed and food production. Most of soybean is cultivated in the United States, Brazil and Argentina. According to FAOSTAT in 2014 [5] cultivation area of soybean in the globe scale exceeded 111 million hectares, of which 0.417 million hectares within European Union. In Europe, more than 80% of soybeans are cultivated in Ukraine and in Russia. The acreage of soybean plantation is also rising in Poland and the demand for its seeds increases every year. In order to increase their own production, the EU members are trying to reduce import of soybean meal from the American countries. A new soybean varieties are created being capable to acclimatize to European climatic conditions and day length. This gives a chance to make soybean production profitable, also in Poland [2, 7]. Soybean is a very valuable plant not only for economic reasons. Like other plants from Fabaceae family, it is capable to nitrogen fixation. The left crop residues enrich the soil with nitrogen, potassium and humify organic matter. This allows reducing nitrogen fertilization. Strongly developed root system builds up the soil structure and slows down its degradation. The yield crop of successive plants might increase up to 15%. Soybean is also a good forecrop for winter crops [3, 9] and excellent plant for organic farming. Organic farming in the case of soybean is particularly important because it provides an alternative to imported soybean GMOs. The main problems, so far reported, are: crops damage caused by birds and forest animals, especially during the soybean germination, and also higher weeds presence in contrast to conventional farming. The weeds number is limited by adjusting the row spacing or using mechanical methods of weeds reduction. Yield crop in organic farming is lower comparing to conventional one. However, as demonstrated by the current data, the ecological system is financially profitable [8, 11]. The pests' occurrence is one of the factors, which affects the profitability of production. The yield crop and its quality could be significantly reduced by herbivores. Both the row spacing and plant density have a great impact on the environmental conditions within the cultivation area. It determines

directly the presence of entomofauna in the field [6]. Specific microclimate of cultivation area is determined by the distribution of plants. Higher plant density prevents the ground surface from heating of and maintains moisture at relatively constant level. The microclimate of particular field area has an impact not only on the yield size and quality of the crop, but also on the occurrence and development of pests, weeds and insects [4, 12]. Entomofauna occurring in soybean plantations in our country has not yet been examined. There is also lack of information in current literature about the effect of the arrangement and density of planting soybean on the occurrence of herbivores. Therefore, the presented studies should be considered as new. The aim of the study was to investigate the numbers and dynamics of the soybean herbivores, depending on the combination of row spacing and the number of seed sown.

## 2. Material and methods

The studies were conducted in 2015, at the Agricultural Experimental Station in Pawłowice (51°10'36.5 N, 17°06'24.9 E), belonging to the Wrocław University of Environmental and Life Sciences, Poland. The occurrence of herbivores was studied on soybean plantation, where Merlin variety was used. Plants were cultivated in 15 and 30 cm row spacing and sowing density 50 and 90 seeds per square meter. The experiment was established in form of randomized blocs with four replications each. The size of plots was 30 $m^2$ (3 x 10 m). Winter wheat was forecrop for soybean. Soybean was sown on April 22$^{nd}$. The following agricultural practices were applied before sowing: harrowing, twice on 15$^{th}$ and 23$^{rd}$ of March; pre-sowing fertilization on April 22$^{nd}$ and herbicide containing metribuzin was applied on April 24$^{th}$ (doses of 0.55 $dm^3$ per ha was used).

Entomological research was conducted in the period from 11$^{th}$ of May to 7$^{th}$ of September. In order to evaluate the occurrence of herbivores the direct observations of plants and collecting insects using entomological nets were carried out. The direct observations were performed on twenty consecutive plants in each plot (in the middle of the plot). Each plant was carefully checked for damage or occurrence of pests. Observations were repeated regularly at weekly intervals. The insect collections using entomological net were performed in three crucial stages of soybean development, i.e. before flowering (BBCH12-49), during flowering (BBCH 54-68) and after the pods establishment (BBCH 70). For each plot twenty strokes with entomological net were performed, in the center of the plot. The Statistica 12.5 program was used to elaborate collected statistical data. The analysis of variance and Tukey's test (Honestly Significant Difference) were conducted for comparison of noted arthropods in different treatments, at significant level of $p \leq 0.05$

## 3. Results and discussion

### 3.1. Direct plant observations

Amongst the herbivores observed on soybean plants the mites, thrips, aphids, flea beetles and butterfly caterpillars were present in large numbers (Table 1). The thrips were the largest group of arthropods feeding on soybean. During the whole vegetation season in total 2072 of these insects were recorded. Most of the thrips occurred on soybean growing in the smallest density, e.g. at a 30 cm of row spacing and density of seeding 50 plants per $m^2$. Other herbivores occurring in large numbers on the plants were: aphids (407 individuals) (mainly *Aphis fabae* Scop. and *Acyrthosiphon pisum* Harris), mites (192 individuals), flea beetles (127 individuals) and the butterfly caterpillars (20 individuals). For flea beetles and caterpillars also a large number of damaged plants, caused by these herbivores were noted. There were 4085 leaves damages, characteristic for the caterpillars, while for flea beetles just 2043. The leaves damages, caused by mites, aphids and caterpillars also occurred most frequently on the plants grown in the smallest density. The variance analysis did not demonstrate any significant differences in the total number of herbivores and damage to the plants during the whole season.

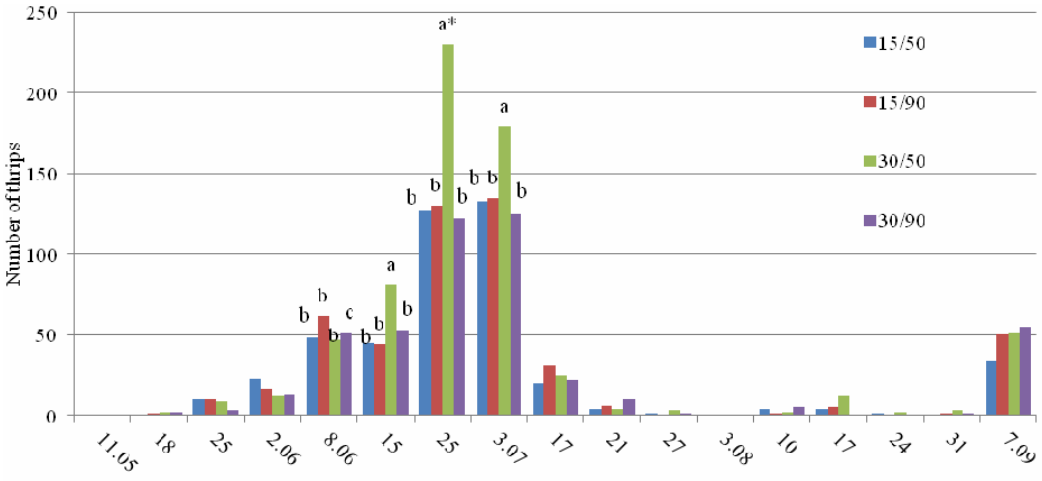
The dynamics of the herbivores occurrence in different treatments of plant arrangement is presented for the most abundant herbivores, i.e. thrips and aphids. The largest settlement of thrips on soybean plants was in June and early July (Fig. 1). In four sessions of observations during this period there were significant differences in their abundance between treatments of the experiment. In a first part of period, i.e. on June 8 significantly more Thysanoptera were recorded (62 individuals) on soybean grown in a 15 cm of row spacing and density of seeding 90 seeds per $m^2$, compared to all other treatments of the experiment. In three subsequent dates (15 and 25 June, July 3) significantly more thrips occurred on soybean grown in the lowest density (spacing of 30 cm, a density of seeding 50 per sq m) (81, 230, 179 individuals respectively) compared to all other treatments. The number of surveyed herbivores on soybean growing in all treatments was low in the early stages of soybean vegetation (BBCH 12-49), i.e. the second half of May and from mid-July to late August.

In the case of aphids, their largest settlement on soybean plants also took place in June and early July. Most of them were reported in June 25$^{th}$, in treatments with the lowest density of plants, i.e. 88 individuals (Fig. 2). The abundance was significantly greater than on soybean grown in a spacing of 15 cm and the density of seeding 90 seeds/$m^2$. For other dates of observation numbers of aphids did not differ significantly between the various treatments of the experiment.

Table 1. Total number of herbivores and plant damages observed on soybean plants
*Tab. 1. Łączna liczebność fitofagów i uszkodzeń obserwowanych na soi*

| Row spacing [cm] | Density of sowing seeds/$m^2$ | Mites | Thrips | Aphids | Flea beetles | Flea beetles - damages | Caterpillars | Caterpillars' damages |
|---|---|---|---|---|---|---|---|---|
| 15 | 50 | 40* | 454 | 110 | 29 | 511 | 10 | 1002 |
| 15 | 90 | 40 | 493 | 62 | 31 | 423 | 1 | 989 |
| 30 | 50 | 77 | 662 | 144 | 23 | 530 | 6 | 1041 |
| 30 | 90 | 35 | 463 | 91 | 44 | 579 | 3 | 1053 |
| Total | | 192 | 2072 | 407 | 127 | 2043 | 20 | 4085 |

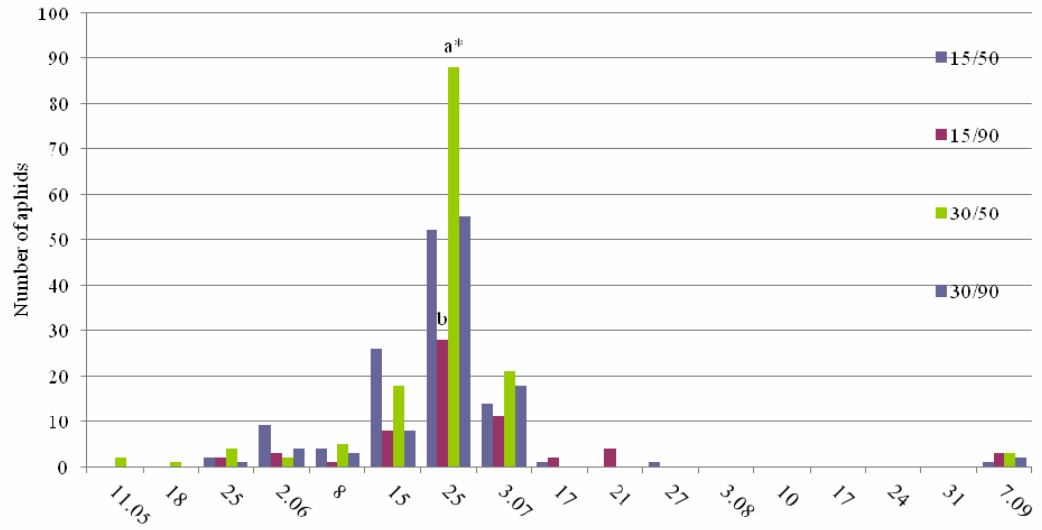
*no significant differences / *brak istotnych różnic *Source: own work / Źródło: opracowanie własne*




**significant differences / *różnice istotne*

*Source: own work / Źródło: opracowanie własne*

Fig. 1. Seasonal dynamics of thrips observed on soybean plants for each of the experimental treatment
*Rys. 1. Dynamika występowania przylżeńców na soi obserwowanych w poszczególnych kombinacjach doświadczenia*




** significant differences / * różnice istotne*

*Source: own work / Źródło: opracowanie własne*

Fig. 2. Seasonal dynamics of aphids observed on soybean plants for each of the experimental treatment
*Rys. 2. Dynamika występowania mszyc na soi obserwowanych w poszczególnych kombinacjach doświadczenia*

### 3.2. Herbivores collected with entomological net

The thrips were the most numerous group of herbivores collected with entomological net, with a total of 2,371 individuals (Table 2). Most of these insects were collected on soybean grown in 15 cm of row spacing and density of sowing 50 seeds per $m^2$ (696 individuals). Aphids occurred less frequently (218 individuals), however, most of these insects were recorded on soybean grown in 30 cm of row spacing and density of seeding 50 units per $m^2$ (67 aphids). Flea beetles and caterpillars, foraging on soybean were collected in a small number in all treatments of the experiment in the growing season. There were no significant differences in the total number of those insects in different treatments of the experiment.

The collections using entomological net were conducted three times during the growing season, in the crucial stages of soybean development. Most thrips were found in the second time of collecting, i.e. at the time of flowering (July 7$^{th}$) (Fig. 3). Within this date significantly more Thysanoptera occurred in the treatment of 15 cm and 50 seeds per $m^2$ (430 individuals) compared to plants grown in the smallest abundance (30 cm and 50 seeds – 287 individuals). During two other days no significant differences were found.

In the case of aphids, in the first time of collecting, i.e. before flowering, the number of these insects was significantly higher in soybean growing at a spacing of 30 cm and the sowing density of 50 seeds per $m^2$ comparing to the treatments with the highest density of plants (spacing of 15 cm and density of sowing 90 seeds/$m^2$). The other two dates of collecting (flowering BBCH 54-68, bonding pods BBCH 70), there were no significant differences in the number of aphids in different treatments.

These studies conducted on soybean shown higher occurrence of thrips, aphids, caterpillars and flea beetles. Also a great number of leaves damages characteristic for flea beetles and caterpillars were noted. Mites, lygus bugs and

sitona weevils were recorded in small number. In other European countries, main soybean pests are: stinkbugs (*Nezara viridula* Linnaeus), mites (*Tetranychus urticae* Koch), butterflies (*Vanessa cardui* Linnaeus, *Etiella zinckenella* Treitschke) and thrips (*Anaphothrips obscurus* Müller, *Frankliniella intonsa* Tang, *Thrips tabaci* Linderman and *Thrips angusticeps* Uzel) [13].

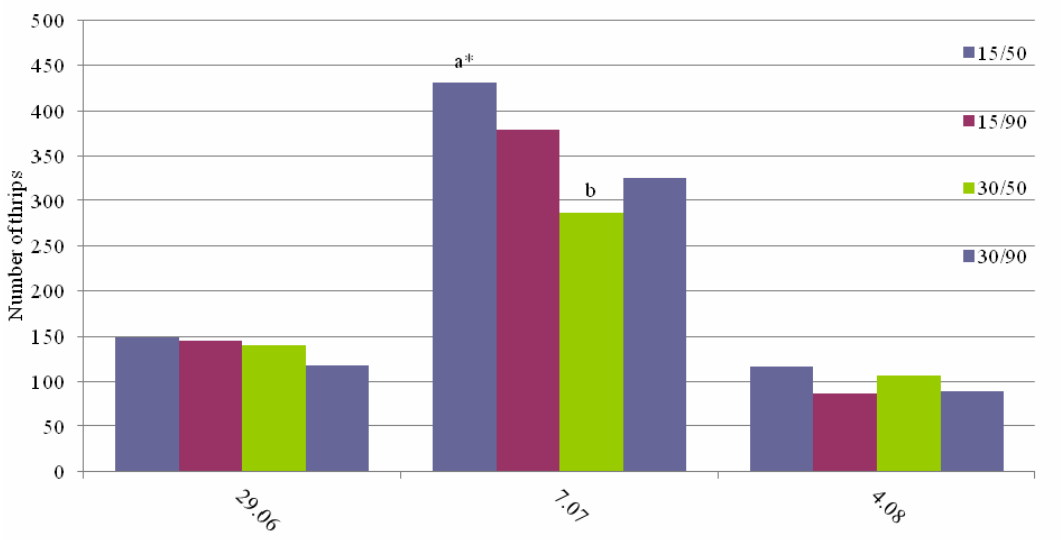
The density of plants is an important factor affecting the plantation microclimate, including access to light and humidity, and thus can affect the occurrence of herbivores. It can be assumed that the reasons of the differences in the occurrence of soybean herbivores in a different plant arrangement will be alike to similar studies concerning other crops.

Table 2. Total number of herbivores collected with entomological net
*Tab. 2. Łączna liczebność fitofagów odławianych za pomocą czerpaka entomologicznego*

| Row spacing [cm] | Density of sowing seeds/m$^2$ | Thrips | Aphids | Flea beetles | Caterpillars | Total |
|---|---|---|---|---|---|---|
| 15 | 50 | 696* | 57 | 6 | 7 | 766 |
| 15 | 90 | 610 | 45 | 4 | 10 | 669 |
| 30 | 50 | 533 | 67 | 5 | 14 | 619 |
| 30 | 90 | 532 | 49 | 7 | 14 | 602 |
| Total | | 2371 | 218 | 22 | 45 | 2656 |

*no significant differences / *brak istotnych różnic

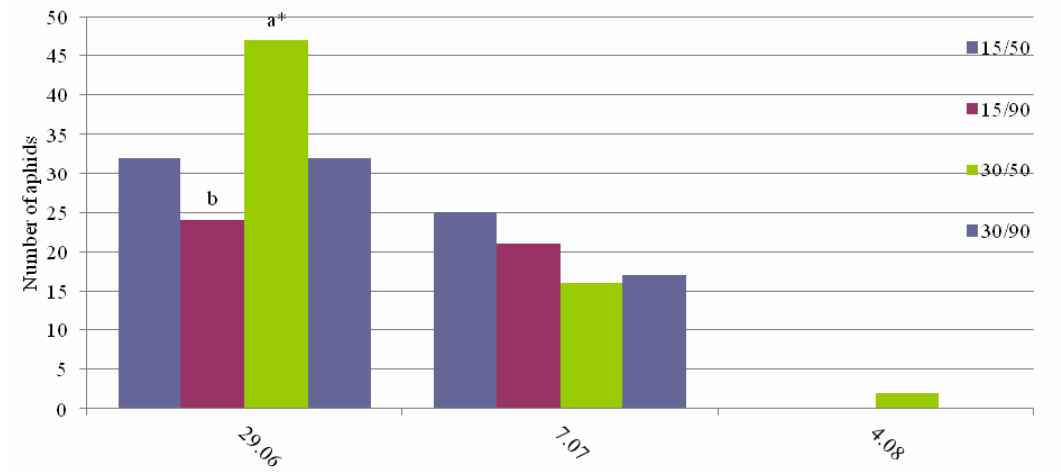
*Source: own work / Źródło: opracowanie własne*




**significant difference / *różnica istotna*

*Source: own work / Źródło: opracowanie własne*

Fig. 3. Seasonal dynamics of thrips collected on soybean plants with entomological net
*Rys. 3. Dynamika występowania przylżeńców na soi odławianych za pomocą czerpaka entomologicznego*




** significant difference / * różnica istotna*

*Source: own work / Źródło: opracowanie własne*

Fig. 4. Seasonal dynamics of aphids collected on soybean plants with entomological net
*Rys. 4. Dynamika występowania mszyc na soi odławianych za pomocą czerpaka entomologicznego*

For example, in cultivating clover, birdsfoot, triticale and oats has been shown that the higher density and lower row spacing cause lower weeds occurring [11]. Weeds occurring in the soybean field also may be colonized by herbivores and be a source of pests spreading. The density can affect the number of branches and number of pods made by plants [1]. It is likely that a change of biometric features of plants by modifying density of the crop affects the microclimate in the plantation area and changes it in a way unfavorable to herbivores. This would explain that, in the experiment conducted in Pawłowice for soybean grown in the highest density (15 cm row spacing and 90 sown seeds per $m^2$), the lowest number of herbivores was noted [1, 10]. In a similar experiment conducted on the oilseed rape Hurej and Twardowski [6], showed that the higher density of this plant reduces the occurrence.

## 4. Conclusions

1. Thrips were most numerous herbivores occurring in soybean field in Pawłowic. Aphids were less numerous (mainly *Aphis fabae* and *Acyrthosiphon pisum*), and also flea beetles, mites, caterpillars and butterflies.
2. Both Thysanoptera and Aphidoidea occurred in greatest abundance on soybean plants from early June to early July, i.e. in the flowering stage.
3. The most herbivores occurred on soybean plants growing in a low density, i.e. the spacing 15 and 30 cm and the sowing of 50 seeds per $m^2$. The number of thrips and aphids on such treatments were significantly higher comparing to the plants growing in highest density.

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