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PROTECTION OF THE SOYBEAN CROP AGROECOSYSTEM THROUGH INNOVATIVE TECHNOLOGIES

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Abstract: Soybean is an important economical crop used for human consumption, animal feed and industrial raw material. Also, soybean is succesfully used in crop roatations with the main cereal crops because it's biological nitrogen-fixing capabilities. A great diversity of pests and diseases including nematodes, insects and phytopathogenic fungi are known to affect soybean crop. From plant emergence to grain maturity, pests *Tetranychus urticae* and *Etiella zinckenella*, pseudofungi *Peronospora manshurica* and fungi *Fusarium* sp. and *Botrytis cinerea* can cause economic damage. In this study was evaluated the influence of tillage systems, different types of fertilizers and pesticide treatments on the most economical important diseases and pests of soybean crop in a field experiment at Agricultural Research and Development Station (ARDS Turda) in the climatic conditions of 2020. Teo TD, an early maturing soybean variety created at ARDS Turda, was used for the experiment. Based on the assessments made, soil tillage system, fertilization and control of pests and diseases have differently influenced the downy mildew and *T. urticae* attack. To reduce the attack of pathogens in soybean crop, the best technological option is plowing, balanced fertilization and application of fungicides, either without or in combination with an insecticide. The *T. urticae* populations developed on mineral, organic and green fertilized plants. Integrated control methods must combine agro-technical measures with the application of chemical treatments in accordance with the warning of the appearance of the first adults.

Keywords: *soybean, tillage system, insect pests, Peronospora manshurica*

INTRODUCTION

The soybean crop is one of the most important crops worldwide due to its valuable seed composition with diverse end-user purposes uses (Shea et al., 2019). In order to establish the economic efficiency of different crop technologies, understanding of the health and behavior of plant varieties to phytopathogens and pests attack is of great importance with direct implications on yield (Ivaşcu, 2009). Soybean is attacked by more than 135 pathogens, about 30 of them cause significant losses (Vidić et al., 2013; Faske et al., 2014). Insects that cause damages to soybean crops can affect germination of seeds, plants during emergence, leaves, flowers and pods (Dencescu et al., 1982). Climate change has a significant impact on the abundance and behavior of insects, in most cases increasing aggressiveness on plants. Inappropriate technologies, especially monoculture favor the increase of pest populations (Berca, 2011).

The two-spotted spider mite *Tetranychus urticae* Koch and the pulse pod borer moth (*Etiella zinckenella* Tr.) can cause high damages, with economic importance (Dencescu et al., 1982; Bailey, 2011). TSSM populations increase under hot and dry conditions being one of the main pests of greenhouse crops and also field crops (Abd El-Rahman & El-Keblawy, 2016; Irigaray et al., 2003; Hossain et al., 2006; Bailey, 2011; Lombardi et al., 2015). There are many overlapping two-spotted spider mite generations per year, third and fourth generations are the most dangerous with negative impact on yields (Salehipourshirazi, 2018); late attack has no economic importance.

The use of resistant or tolerant varieties, deep autumn plowing for destroying some hibernating females, optimum plant density and also the control of weeds that are secondary host plants of the pest are the most important agro-technical and biological measures that limit the level of spider populations. The conservative tillage system aims are to ensure that pesticides are used correctly and the increase of agricultural production is done through the intelligent use of natural resources, as well as the rational management of external resources to supplement (minimizing them-fertilizers, pesticides) (Berca, 2011; Yusuf et al., 1999).

Insecticides constitute a large portion of pest management (Shea et al., 2019) but frequent use of them resulted in toxic food residues, environmental degradation, and development of resistance (Kirsch, 1988 cited by Tewari et al., 2014; Shea et al., 2019).

Monitoring with pheromone traps is an important part of Integrated Pest Management programs of many harmful lepidopteran species (Lemic et al., 2016) because trapping information can be used to detect early pest infestation, define areas of infestations, obtain data on biology and ecology of target pest and help in decision making to reduce unnecessary insecticide treatment (Witzgall et al., 2010; Ivaş & Mureşanu, 2013; Damos et al., 2015; Toshova et al., 2017).

The aim of this paper was to evaluate the attack of pathogen *Peronospora manshurica*, and the populations of mite *Tetranychus urticae* and moth species *Autographa gamma*, *Agrotis segetum*, *Amathes c-nigrum* and *Mamestra oleracea* on soybean submitted to the soil tillage system, fertilization and treatments.

MATERIAL AND METHOD

The evolution of soybean diseases, mite *Tetranychus urticae* and moths *Autographa gamma*, *Agrotis segetum*, *Amathes c-nigrum* and *Mamestra oleracea* were evaluated in a polyfactorial experiment (4x4x4) based on a subdivided parcel design with two replications.

The trials were carried out at Agricultural Research and Development Station Turda in 2020. TEO TD, an early soybean variety developed at ARDS Turda was used as a biological material. To achieve the experiment objectives, the following factors were analyzed: (1) diseases and pests control: Copfort (copper) 3 l/ha (fungicide) and Faster (cypermethrin) 100 ml/ha (insecticide) and (2) fertilization: (i) $N_{40}P_{40}$ kg a.s./ha at the same time as the sowing, (ii) organic gülle fertilizer before the sowing + $N_{40}P_{40}$ in the same time as sowing, (iii) green fertilizer, precursory to the soybean crop + gülle before sowing + $N_{40}P_{40}$, in the same time as sowing.

The downy mildew attack was reported in all experimental trials, thus the frequency, intensity and degree of attack for each experimental variant was calculated.

Frequency (F%), represents the relative value of the number of plants or organs attacked (n) reported to the number of observed plants or organs (N) F = n x 100/N. In our case N = the average of leaves per plant and n = average of leaves attacked per plant.

Intensity (I%), represents the percentage in which the plant or organ is attacked or crop loss recorded in a plant or crop per unit area, compared to a healthy crop I% = ∑ (ixf) / N; i and f are the result of notations (Puia, 2005). Based on the frequency and intensity of the attack, the degree of attack, DA% = F x I/100, was calculated for the bacterial blight attack.

The evaluation of moths population was performed using the F-1 type synthetic sex pheromone traps from the "Raluca Ripan" Chemical Research Institute Cluj-Napoca. The presence, abundance as well as establishing flight dynamics which served to warned of the application of chemical treatments (Ivaş et al., 2013).

T. urticae on the leaves of three plants from each plot were collected (Kumar et al., 2013) and the number of motile mites was counted using shaking method: tapping soybean plants onto a white sheet of paper (Cullen & Schramm, 2009; Bailey, 2011).

Experimental data were subjected to analysis of variance (ANOVA) using POLIFACT. Before the analysis of variance, numbers of motile stages of mite were transformed using the formula √x+1 in order to normalize the data (Niu, 2014).

RESULTS AND DISCUSSIONS

In 2020, the influence of tillage practices over the frequency of downy mildew attack in soybean crop was small and non significant (table 1). In all tillage plots the frequency of attack exceeded 50%.

Table 1. The influence of tillage system on *P. manshurica* frequency and intensity

Soiltillage system		Frequency %	Control %	Difference	Intensity %	Control %	Difference
1.	Plowing	54.25	100.0	0,00	1.53	100,0	0.00
2.	Chisel	51.08	94.2	-3.17	1.50	98.1	-0.03
3.	Disk	53.85	99.3	-0.40	1.46	95.9	-0.06
4.	No tillage	51.13	94.2	-3.13	2.62	171.8	1.09***
Fertilizer							
1.	N40P40	44.42	100.0	0.00	1.64	100.0	0.00
2.	N40P40 + gulle	54.65	123.0	10.23***	2.09	127.7	0.45***
3.	N40P40 + green fertilizer	47.33	106.6	2.92	1.68	102.8	0.05
4.	N40P40 + gulle + green fertilizer	63.92	143.9	19.50***	1.70	103.6	0.06
Treatment							
1.	Untreated	56.06	100.0	0.00	2.29	100.0	0.00
2.	Fungicide	53.69	95.8	-2.38	1.32	57.5	-0.97^{000}
3.	Insecticide	53.35	95.2	-2.71	2.02	88.1	-0.27^{00}
4.	Fungicide + Insecticide	47.21	84.2	-8.85^{000}	1.47	64.1	-0.82^{000}
*, ** and *** mean significantly different at p ‹ 0.05, p ‹ 0.01 and p‹ 0.001, respectively							

Intensity is that parameter that has a high influence on the value of the degree of attack; high frequency values with low intensity values will lead to a reduced degree. The attack intensity of *Peronospora manshurica* was influenced by the tillage system. The data presented in table 1 highlighted that the highest value of attack intensity (2.65%) was registered in the no tillage sample, with very significant differences compared to the control sample. The lowest values were found for the sample with the soil tillage system based on disk.

Unbalanced fertilization in soybean crop leads to nutrient deficiency or excess causes the weakness of plants and expose them to the attack of pathogens. Several reports worldwide show inconsistent responses to fertilization application impact on the severity of the disease, both increases and decreases in disease severity being reported when nitrogen fertilization was applied (Veresoglou et al. 2013). The high availability of N can favor obligate parasites, while reducing the severity of the disease of facultative parasites (Dordas, 2008). The severity of the disease can be adjusted by the type of fertilizer and the amount of fertilizer applied; nitrate fertilizers increase the severity of the disease, while ammonium fertilizers decrease it (Huber & Haneklaus, 2007).

The fertilization type differently influenced the frequency of *P. manshurica* attack, the highest frequency of the attack with very significant positive differences compared to the control, was recorded when gulle was applied (Table 1). While increased frequency of the attack (63.92%) in gülle + green fertilizer sample was observed, for the attack intensity, the highest value, with very significantly positive differences compared to the control was obtained when gülle+N40P40 was applied. As a conclusion, if there is any high infection pressure in the area it is not recommended to apply gülle+green fertilizer on soybean crop.

Vegetation treatments are intended to ensure the protection of crops during the growing season, by reducing the attack of pathogens and keeping them below the economic threshold of damage. Analyzing the data in table 1, we can say that the treatment with fungicide and insecticide negatively influenced the frequency of the downy mildew attack, its value being the lowest, with very significant negative differences compared to the control. The treatments during soybean growing season reduced the intensity of the downy mildew attack: very significantly compared to the control, in the samples with fungicide and distinctly negative in the sample when only fungicide was applied (Table 1). As expected, the highest value of the attack intensity (2.29%) was in the variant where no treatment was applied.

For a good understanding of the attack of *P. manshurica* in the four tillage systems, with four samples of fertilization and treatments, the degree of attack was also calculated and presented in Figure 1. The experimental data in Figure 1 highlighted the samples with the maximum values for the degree of the attack: in no tillage soil system, when N40P40 + gülle + green fertilizer was applied and when no treatment on growing season was used (2.74%).

The lowest values of the degree of attack were recorded in all experimental samples in all four soil tillage systems when fungicide was applied.

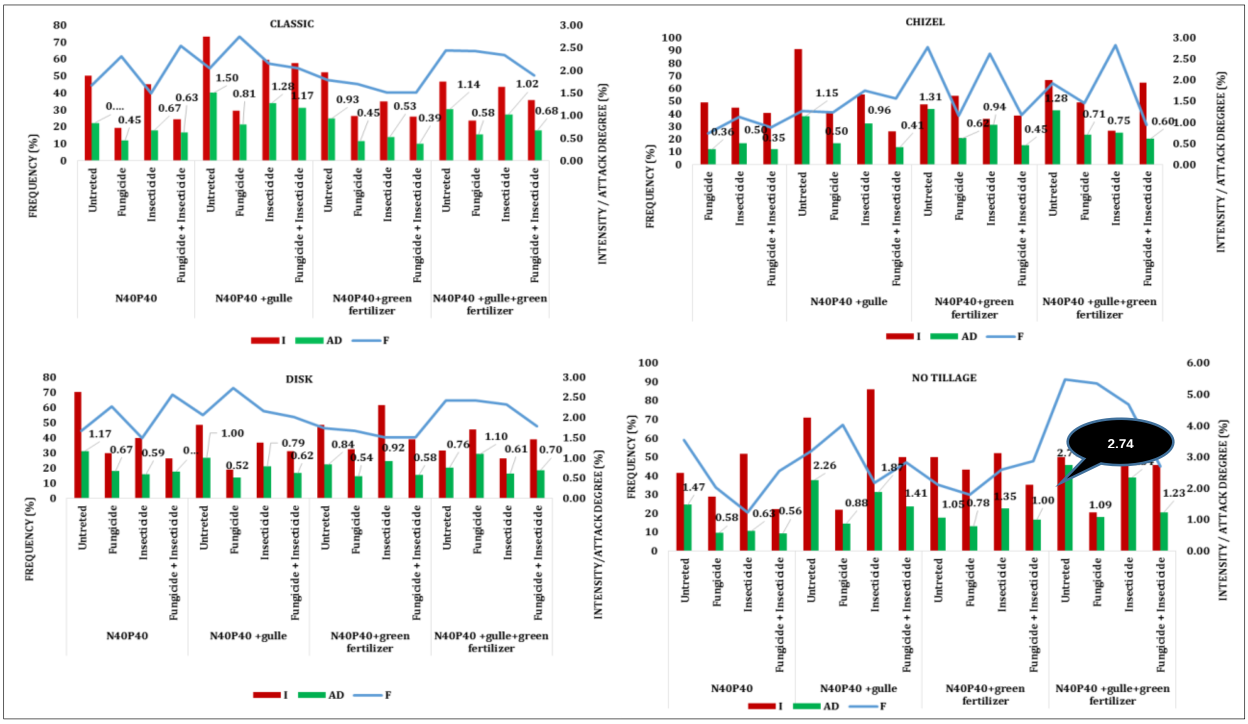

Figure 1. The dregree of attack of *P. manshurica* in four soil systems

For evaluating the pest's numerical evolution in order to identify the differences between populations which requires the application of additional treatments in unconventional systems, the study of the soil tillage system influence is necessary. For the four monitored species, an increase in the number of adults caught in unconventional tillage systems can be observed compared to the classic system (Figure 2). As it is known, autumn plowing destroys some of the soil pests (eggs, larvae, adults) and also the vegetable residues are incorporated in the soil where they are subjected to humidification and mineralization processes.

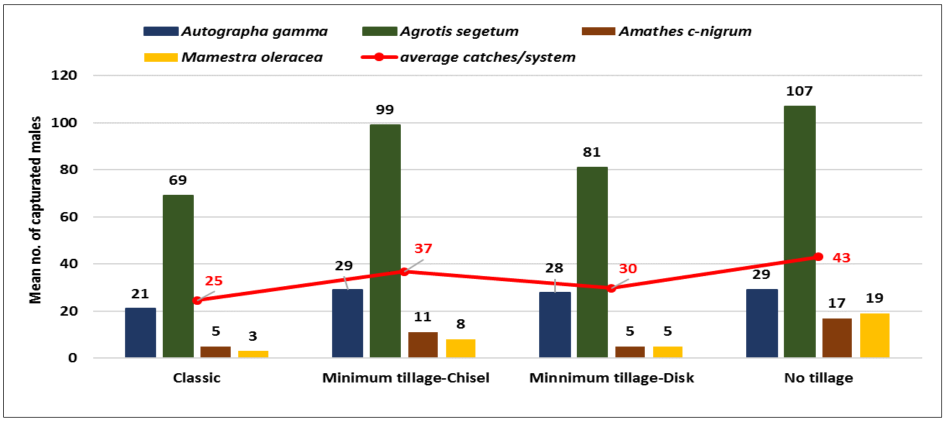

Figure 2. The abundance of the pests Lepidoptera species from soybean crop

The population dynamics of the four species monitored in soybean crop is illustrated in Figure 3.

The silver Y (*A. gamma* L.) began its flight in June. Against the background of an increase in rainfall, a reduction of flight followed, intensifying in the second decade of August, when the first maximum flight was recorded (12 adults in no-tillage). Due to low rainfall, the second flight took place in the first decade of September.

The turnip moth (*A. segetum* Den. & Schiff) had two maximum flights, which were quite close in number; they were registered in early June, and the second in mid-August, in all tillage systems.

The spotted cutworm species dynamics (*A. c-nigrum* L.) was much lower compared to silver Y and turnip moth dynamics. The flight started in May, and at the beginning of June it registered the first maximum flight, then the flight was shorter, and the second flight took place in August. The bright-line brown-eye (*M. oleracea* L.), also present in soybean crop, appeared in field in June, with a small number of adults throughout the monitoring period, most captured individuals registering in no-tillage system.

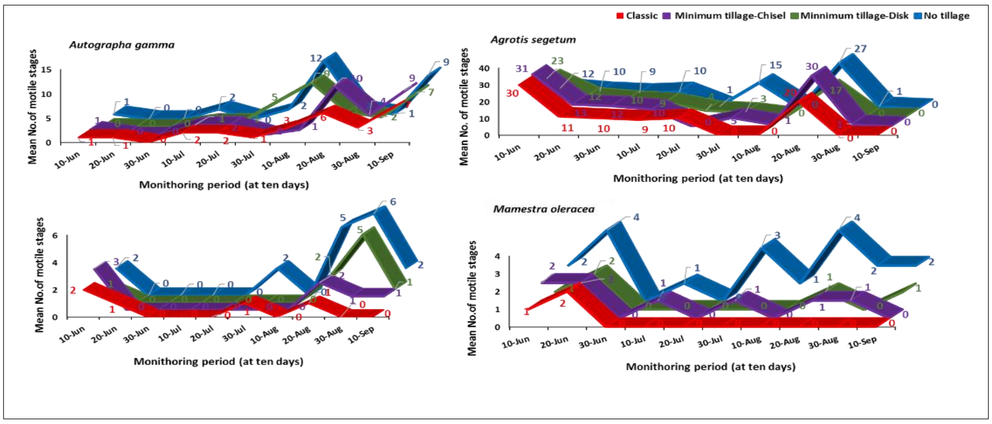

Figure 3. The dynamic of moth flights in soybean crop

In terms of the pests attack on soybean crop in 2020, no dangerous levels were recorded and therefore no significant damages were caused due to the main pests. But from the previous observations, the importance of the biological attack potential of the mite *T. urticae* is known, so its monitoring is an important work. The classic tillage system contributes to the decrease of the population density of this pest, registering the lowest values compared to the unconventional tillage systems. At the samples with no-tillage system, the number of adults spider almost doubled compared to the control sample (classic) with statistically distinctly significant differences.

Several authors have investigated the effect of applying fertilizers on *T. urticae*. Zhang & Xiang (2007) reported that the application of organic fertilizers has led to an increase in the number of this species as well as the production of cucumbers. Other studies have shown that the application of nitrogen or phosphorus fertilizers in soybeans had no effect on the number of the mite (Shabalta et al., 1992). Our experiment reveals that increases in the density of the mite with very significant differences compared to the control was when green fertilizer was applied confirming the previous studies reported differences in pest populations in plants with mineral or organic fertilization.

T. urticae suppression provided by chemicals varies greatly (Hossain et al., 2006). Certain pyrithroids may suppress the mite populations while others may stimulate outbreaks by causing increase in the density of its population (Busvine, 1971). From the data presented in table 2, it appears that the treatment with cypermethrin negatively influences the density of the mite, with very significant differences compared to the control sample. Similar data were reported by Abd El-Rahman & El-keblawy (2016), where cypermethrin was the most effective compound against the motile stages.

Table 2. Number of motile stages of *T. urticae* in soybean crop

	Soil tillage system			
	Classic - Control	Minimum tillage Chisel	Minimum tillage Disk	No tillage
Mean no. of motile mite	2.82	3.07	3.44**	3.56**
	Fertilization			
	$N_{40}P_{40}$- Control	$N_{40}P_{40}$+gulle	$N_{40}P_{40}$+green fertilizer	$N_{40}P_{40}$+gulle+green fertilizer
	2.69	3.01*	3.40***	3.79***
	Treatment			
	Untreated-Control	Cooper	Cypermethrin	Cooper+Cypermethrin
	3.23	3.92***	2.71^{000}	3.03

*, ** and *** Means significantly different at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively

Fungicides use in soybean may further aggravate existing mite infestatations by eliminating mite-killing fungal pathogens (Cullen & Schramm, 2009). Thus, in the experimental sample where Cu was applied, the average number of motile stages was the highest, with very significant differences compared to the control.

CONCLUSIONS

The obtained results have identified innovative technologies that can contribute to the protection of the soybean crop agroecosystem.

Serious attacks of downy mildew *Peronospora manshurica* can occur in soybean crop every year but the frequency and intensity of the disease depends on the grown variety, the source of inoculum and also the applied technology. Plowing combined with a balanced fertilization and fungicides applications (alone or in combination with an insecticide) are necessary to reduce the attack of pathogens in soybean crop.

The largest number of moths caught in the pheromone traps was registered in the no-tillage system. Thus, it is necessary to give more attention in monitoring and treatments application when the economic damage threshold is exceeded in the minimum tillage systems.

Tetranychus urticae population developed on mineral, organic and green fertilized plants. Integrated control methods must combine agro-technical measures with the chemical treatments, in accordance with the warning of the appearance of the first adults.

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