THESES OF DOCTORAL (PhD) DISSERTATION

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Precision cultivation methods Doctoral School

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Prediction of the skip-jack beetles (*Agriotes spp.*) and the wireworms with precision methods

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1. INTRODUCTION, OBJECTIVES

Application of the precision cultivation methods has got spreading function nowadays. We know a lot of coherence related to the pests and the defence against them in the plant protection inside of the cultivation. In the transforming agriculture of our country the pests have swollen powerfully due to the deficit of the organised defence, the parcelled homestead content, the unprofessional defence at all, and the capital shortage. The consequences of these are the irregularity or leeway of the early regular forecasts, and the abandon of the justified soil-disinfections. This is a considerable professional failure that the different production systems prescribed the soil-disinfection obligations that are independent from the knowledge of the real position. The soil-disinfections, that reduce the number of the wireworms living in the soils significantly, have to base on the dates of previous surveys.

In the Hungarian agriculture the precision researches were beginning at the end of the 1990 years. The matter of the precision economy is that with the application of the GPS (Global Positioning System) and the GIS (Geographic Information System) realized technically the possibility of the intervention on a given point of the agro-ecological system.

The damagers of the plants rarely show inside of the given field homogeneous occurrences and damaging, rather typical is for they appearance the heterogeneous spread. The objective of the precision plant protection is the accurate exploration of the damaging organisations, that show varied frame on the production area, and the application of such a protection technology, which follows up the heterogeneous occurrence. In extreme case the damager can not be found on a significant part of the cultivated field, or under the injury threshold only, for that very reason the protection could drop off local. These decisions can bring along considerable savings, and the pesticide load of the environment can significantly decrease.

We can sign the accurate spatial position of the damagers with geographical information identifiers and with time-identifiers we can follow up their temporal and spatial movement. On a given place there is a possibility for the fixing of other facts, in connection with the phenomena (land resistance, water content, weedy). For the temporal and spatial appearance of the damagers of the plants, which belong to the group of the animal organisms, exception of some cases is the quick intensive changing the typical. The most of the actual damager survey methods are not competent for the attending of the precision plant protection, because the enforcement of the methods is time-, device-, and cost consuming, but then again the density of the samples has just representative character. The so-called terricolous insect species living in the soils exist in the major fraction of their development interval under movement limiting circumstances.

Due to the collective egg-laying of the imagos, the margin of the hatched larvae realizes in a limited, local space. From this dilemma follows, that their development is in dependency relation with the available nutrition on the habitat (polifagh nourishment), with the values, which determine the soil quality, especially in regard of the resistance, water content and temperature of the soil.

Objectives of the research:

1. Making a map about the dominance relations of the *Agriotes* species living in the area of Kapuvár. The follow-up of the swarm procedure of the imagos with pheromone traps; the survey of the larvae with territorial square method.

2. Application of geographical information methods for the signing and fixing of the sampling places and for the establishment of the localisations based on the data.

3. Making a map about the local occurrence of the weed-kinds serving as nutrition and examination of the connection between the habitats of the larvae.

4. Solution of the secure and effective survey of the soil larvae, and its mechanisation.

5. Measuring of the soil resistance and water content of the survey places, and the statement of the connection between the components number of the larvae.

6. Statement of the local occurrence of the soil larvae and accordingly designation of the defence area. Evaluation of the effect of the soil disinfections taking the precision solutions into consideration.

7. Statistical evaluation of the data of the experiment and the determination of the connection’s strength.

8. Soil disinfection in the focuses depending on the components number of the wireworm. Determination of the effect of the applied products.

2. MATERIAL AND METHOD

We performed the experiments in 2005, 2006 and 2007 in the area of Himod. The experiments territorial was a field of 35 hectares, where we raised corn in the ear (spring barley), grain maize and sunflower. The sowed cultivated plants were based in heterogeneous humus type fields. There was no soil disinfection on the sample field for 10 years.

We collected the imagos of 5 *Agriotes* components (*A. lineatus, A. ustulatus, A. sputator, A. obscurus, A. rufipalpis*) through 3 years in the swarm season with sexpheromon trap with two types of rotating systems (YATLOR funnel (Yf) and CSALOMON VARb3 with fish-basket). The number of the traps was 8-8 pieces/species. We placed the traps in a 20x20 m binding, which gave us possibility for the inhomogeneous argumentation of the swarm direction regarding to the components number.

The attraction effect of the traps – without capsule change – prevailed under the full interval of the swarm. We applied the traps without change with same objective over 3 years.

We stored dry the species-specific collected skip-jack beetles and identified them based on their morphological marks. We checked the catch frequency of the traps in every 3 day; we drew up minutes about the components number, and made a swarm-curve by species. Taking into consideration that we got some useful species in the traps (big puffing carabid: *Brachynus crepitans*, backspotted smallrunner: *Agonum dorsale*), which consumed the skip-jack beetles, therefore we used at the preservation vinegar-ether for the blast, too.

We solved the survey of the components number of the terricolous larvae with capacity quadrate method, with such processes, that need some technical solutions (forestry pit drill, grabber). We fixed the needed sample field in the territorial of our own homestead. At the survey we fixed the 35 sample sites in every 1 hectare with the help of the Trimple Pathfinder Power geographic information GPS with sub-meter accuracy. This procedure has got more possibilities. On the one hand the sampling is repeatable beside the given coordinates; on the other hand it is possible to undertake other soil examinations on pre-fixed points. We wrote the surveyed dates into a Microsoft Excel table, and we charted it with converting with the ERDAS Imagine 8.5 Professional capacity informant software.

On the spot we verified and garbled the pests living in the soil. We administrated extra the pits done with pit-drill and extra the pits done with grabber. We collected the pests separated per sampling places into foils, which contain 75 % alcohol, then determined their components number, and the generic affiliation. We examined the weed coverage on the experimental fields. The weed-surveys were done with the Balázs-Újvárosi method. For the exploration of further connections we measured the water content and resistance of the soil in the fixed points. As last step of the examinations we compared the efficiency of two soil disinfectants, the Marshal 25 EC and the Force 10 CS, with the help of the Henderson-Tilton formula.

3. RESULTS

Considering the components number of the imagos collected over 3 years we can state that *A. lineatus, A. ustulatus* and *A. sputator* species were dominant in the examined area. In the years 2005 and 2007 the *A. lineatus* was dominant in 2005 and 2007, while *A. ustulatus* in 2006. The component number collected in 2005 passed the number of the caught components in 2006 and 2007. The highest component number had got the *A. lineatus* in 2005, which was 70 % of the total collected 1756 skip-jack beetles. *A. sputator* reached 19 %, *A. obscurus* 3 %, *A. ustulatus* 6 %, the *A. rufipalpis* 2 %. The traps caught altogether 1494 skip-jack beetles in 2006. In the number of the swarming components of the species was derogation, which proved the 55 % dominance of the *A. ustulatus*. The *A. lineatus* has performed with 16, the *A. sputator* with 14, the *A. obscurus* with 8, the *A. rufipalpis* with 7 % participation rate. In 2007 there was captured prominently few imagos. The altogether collected number of the components was 63. One explanation for this can be the singularity of the weather (early rainfall abundance, then droughty period), further the success of the probably for each years concentrated mass relation of the several years developing species.

In 2005 the trash average of the swarming imagos of the *A. lineatus* and *A. sputator* passed the value limit of the 15-25 component numbers. In 2006 the component number of the *A. ustulatus* and the *A. sputator* was in defence determining role. The average data of 2007 didn't sign the necessity of the defence, notwithstanding of the larva population in the soil. This in gross queries the validity of the imago component number referring to the soil-disinfection fixed by FURLAN et al. (1996). The swarming record appeared with less derogation between the 21st and 31st of May. In case of the *A. ustulatus* there wasn't expressed swarming record.

With the responsible survey of the imago swarming, computed with the duration and dominance of the different development of the species, the particular and expensive larva component number exploration will maybe redeemable.

We found during the soil examinations altogether 355 pieces of wireworms. In 2006, relative to the years 2005 and 2007, the number of the wireworms was significantly fewer. With the scoop grabber and forestry pit-drill parallel collected component numbers in 2007 (with grabber 179, pit-drill 87 pieces) surpassed the average of the 3 years.
Among the larvae of the *Agriotes* species was the *A. lineatus* the dominant in every 3 examination years (2005:89 %, 2006: 61,5 %, 2007: 37,9 %). Besides this the proportion of the *A. ustulatus* was also significant, which dominance was with grabber 18,2 %, with pit-drill 19,3 % in the average of 3 years.

The *A. sputator* showed an average dominance, we found its average proportion with the using of grabber 15 %, with pit-drill 10,7 %. The order of the wireworms of the *Agriotes* species, assessed after dominance is (in the average of the 3 years and the grabber-pit-drill): *A. lineatus* (62,8 %), *A. ustulatus* (18,75 %), *A. sputator* (12,85 %), *A. obscurus* (5,75 %).

Our results show that the dominant relations of the wireworms changed in the area of Kapuvár compared with the data of

1960-1970. We found the *A. obscurus*, which was dominant in those years, during our examinations in 2007 only.

Averagely we found wireworms in less of the half of the 35 samplings, which verifies a relatively little constancy values. The constancy of the wireworms under 50 % and their different abundance on the several sampling places confirm their focal location in the soil.

For the statement of the necessity of the soil-disinfection, we drew up a chart, which illustrates the component number of the phytophag wireworm (abundance) found per m^2. On the sampling area we can see, on which region the defence is required. Every time, if we cross the 3-6 pieces/m2 danger threshold value, we have to defence. This threshold could be seen on a 9 hectar area in 2005, on a 2 hectar plot in 2006 and a 21 hectar plot in 2007. So, in this way it is enough to use pesticide on these parts of the area instead of the whole 35 hectars. The distribution of pesticide can be carried out by a sprayer which has a GPS system. If we follow this method it reduces the production costs and less pesticide can be used.

When we examined the two pieces of sampling equipment, we stated that the excavator with a scoop was more effective over the 3 years. More wireworms were collected using this method than using the pit-drill. The reason for this is that the wireworms which were taken together with the soil are not killed.

While we examined the soil samples we also measured how much of the soil was covered with weeds, how much water it contained and how resistant it was. Finally colourful maps were made which are digital models. The supposed component number of the wireworms, the result of the weed-survey, the water capacity value of the soil, and the value of soil resistance were connected with geographical positions.

We stated that the component number of wireworms per m² increases proportionally with the increasing quantity of weeds (horse-thistle- *Cirsium arvense*). The component density of the wireworms is definitely connected with the quantity of weeds ($R^2_{2005} = 0{,}7751$, $R^2_{2006} = 0{,}9357$, $R^2_{2007} = 0{,}7676$). The weed-content of the experimental area was the highest in 2007. It passed the 60 % in 5 sampling areas, which caused the higher number of wireworms (averagely 20,45 pieces/m²). The poliphag nutritive wireworms accept the *C. arvense* as nutritive plant, the development of the larvae is on this weed possible, too.

There is a strong relationship between the component number of wireworms per m² and the water capacity tf% ($R^2_{2005} = 0{,}6789$, $R^2_{2006} = 0{,}7532$, $R^2_{2007} = 0{,}639$). For the life-function of the wireworms are the areas with over 60 % water-content more optimal, while soils with a water-content under 40 % unfavourable. The wireworms live the upper thirsty layers of the soil in vertical direction and they range into the wetter layers, which are deeper as 60 cm, where the survey of them is not soluble. It happened probably in the dry 2006.

The results of the soil-resistance measurements on the sampling areas sign various soil hardness. In some point the figures hardly reached 8-10 * 100 KPa, in the other parts they were higher than 15-17 * 100 KPa. We composed the soil-resistance with the number of wireworms found per m2 and we could state that fewer wireworms were found in the harder heavier soil. It proved that the relationship between soil-resistance and the density showed inverse proportions ($R^2_{2005} = 0{,}3714$, $R^2_{2006} = 0{,}6741$, $R^2_{2007} = 0{,}2478$).

Besides soil-resistance hardness of the ground can be presented by the hardness number used by Arany, whose numbers were between 41 and 58 in the sampling areas. More wireworms appeared in the lighter adobe and clayey adobe sample pits whose hardness number was fewer than 50. It is true that if the AK figures are higher the number of the wireworms becomes smaller in the sampling pits.

There is a strong relationship between soil-resistance and the hardness number invented by Arany, $R^2 = 0,75$. So both figures can be used to determine the hardness of the soil. The density of wireworms is definitely connected with the quantity of weeds, the water capacity and the soil-resistance. This connection was proved by statistical examinations.

Force 10 CS and Marshal 25 EC pesticides were compared. Their effectiveness against wireworms was calculated using the Henderson-Tilton formula, and it was in both cases more than 90 %. Force 10 CS reached 97,5 %, while Marshal 25 EC reached 90,3 % effectiveness. As a result we state that we have to use Force 10 CS pesticide because in this way we can sow seeds safely and they will result in a good crop yield.

We could assign the sample-taking pieces in advance by using geographical information methods, which is also used during precision pest control. So, we can undertake the samplings similarly to the natural conditions (grabber with scoop, forestry pit-drill), and the measuring of the soil (soil-resistance, water capacity). Based on the processed data we can solve the precision treatments. This way we can avoid the homogeneous soil-disinfection, which results a cost-effective and environment-friendly solution.

4. THE LATEST SCIENTIFIC RESULTS

1. We used firstly species-specific sexpheromone traps for the collecting of swarming skip-jack beetles in the area of Kapuvár. According to the catching data we can determine the dominant role of the *A. lineatus*, *A. ustulatus* and *A. sputator* species. From specialized literature we know that *A. obscurus* was the most dominant species in 1960-70.

2. We stated that the swarming records at the *Agriotes lineatus*, *A. ustulatus* and *A. sputator* appeared with small differences in the last decade of May. At the *A. ustulatus* we cannot speak about significant swarming record.

3. Over 3 years of examination was the *Agriotes lineatus* dominant among the larvae of the *Agriotes* species. The dominance of the larvae of *A. obscurus* was low like at imagos.

4. The dominance relations of the wireworms changed compared to the 1960-70 years on the Small Plain. The proportion of the *A. obscurus* decreased, but parallel to this the number *A. lineatus* and the *A. ustulatus* increased.

5. For the soil sampling, which is similar to the natural state, is the most acceptable the grabber with scoop, because we can state safely the number of wireworms, which live in the soil we elevated. It doesn't fracture the wireworms we grabbed out with the soil together.

6. The small constancy of the wireworms and the different abundance experienced on the sampling areas prove their focal location in the soil.

7. We stated a close positive connection between the component number of the wireworms and the weed-content of the soil (horse-thistle) over 3 years.

8. We stated a positive connection between the number of the larvae in soil and the water capacity of the soil. For the life-function of the wireworms are the soils with over 60 % water-content more optimal, while with less than 40 tf% water-content are unfavourable.

9. Based on the hardness by Arany and the values of the soil-resistance are the soil-resistance and the component density of the wireworms are in connection with each other.

10. Having the results and using statistical methods we can show the localisation of the component number of the wireworms and its influences to the quantity of the soil-disinfections.

11. Using a precision cultivation we have to take into consideration the local position of the wireworms, so we can save considerable costs during the production.

5. THE LIST OF SCIENTIFIC ARTICLES AND LECTURES, PRESENTATIONS WHICH WERE CARRIED OUT ABOUT THE TOPIC OF THE DISSERTATION

Scientific articles:

1. **KOVÁCS T.** – KUROLI G. – NÉMETH L. – TÓTH M. (2008): Agriotes species collected by sexpheromone traps in the area of Kapuvár. Plant protection, **44** (10): 495-501.
2. KUROLI G. – **KOVÁCS T.** – POMSÁR P. – NÉMETH L. – PÁLI O. – KUROLI M. (2006): Localisation and seasonal position of wireworms in different soils. Plant protection, **42** (10): 545-551.

Presentations which were published in their original forms:

1. **KOVÁCS T.** – KUROLI G. – POMSÁR P. – NÉMETH L. – PÁLI O. – KUROLI M. (2006): Localisation and seasonal positions of wireworms in soils. Comm. Appl. Biol. Sci, Ghent University, **71** (2b) 357-367.

2. KUROLI G. – NÉMETH L. – POMSÁR P. – PÁLI O. – **KOVÁCS T.** – KUROLI M. (2005): Localisation and seasonal position of wireworms and grubs in soils. 10. Tiszántúli Növényvédelmi Fórum. 18-20th October. Debrecen, 36-52. p.

Presentations:

1. **KOVÁCS T.** - KUROLI G. – POMSÁR P. – NÉMETH L. – PÁLI O. – KUROLI M. (2006): Localisation and seasonal positions of wireworms in soils. 58th International Symposium on Crop Protection. 23rd May, 2006. Gent, 50. p.