

SZENT ISTVÁN UNIVERSITY

**Alternative methods of weed control in
plantations**

**Abstract of the PhD. thesis
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Antecedents and aims of work

Today, due to the increase of the environmental burden and contamination the environmental protection has become a central issue in all aspects of agriculture. After our joining to the European Union the role of environment-friendly production technologies have been more appreciated. The European Union's food safety strategy and the slogan at the same time is "from the farm to the table". For the Hungarian agriculture and farmers one of the most important tasks is to produce goods for the international and the domestic market that have high quality, competitive and meet the requirements of the EU criteria. This is a guarantee for both the dealer and the seller and on the other hand, for the consumer that the product has been produced in accordance with the human health and environmental standards. (ROSZIK 2003)

It cannot be disputed that during the current grape growing without continuous plant treatment economical production is not possible. Beside regular insecticides and antifungal treatments nowadays – mainly due to work organization reasons – chemical protection against weeds is associated more often. Currently, the number of approved herbicides is relatively high in case of vineyards but the desired results only occasionally achieved by their usage. Among the possible reasons it should be highlighted that not well chosen herbicides that do not pay attention to the weed composition of the land and other features are used. If such materials (herbicides) are used without the desired effect, then the activity is considered as unreasonable environmental protection. It should be emphasized, however, that the excessive use of mechanical cultivation may also cause unwanted effects (erosion, deflation).

Due to the increasing environmental protected lands and the regulations regarding ecology and integrated wine production introduced in Hungary at the end the of the nineties and since then it has been continuously developing (SZŐKE 2006a; b) beside the known mechanical, covering plants and the chemical weed controlling methods studies regarding the effectiveness and the usability of soil covering have been launched.

The comprehensive test of soil coverings is also supported by the fact that the mountain viticulture has changed after the regime change. The quality vine farms engaged large areas of high-slope hillsides. During the socialism due to the quantitative view so-called "skirt" areas were preferred, but since the early nineties the high-lying areas have been emphasized. The centuries-old experience and the thinking of the ecological needs of the grape resulted in this process . On the hillside areas erosion and efficiency problems mean a serious risk in the

mechanical and chemical weed control, which makes the satisfactory weed control difficult in many cases. The plant covering (putting under grass) method cannot be treated as a good solution from the line management point of view. These changes of the professional aspects implied researches regarding soil covering methods. First, the effect of soil science and crop management was a priority (Varga 1997; NÉMETH et al. 2006) and later the role of weed control was also started to be addressed (NÉMETH et al, 2000).

In my thesis I introduce the weed floristic and effectiveness researches with different weed control methods done at Eger and Tokaj wine regions. In addition, besides studying wine cultures strawberries were also included in the research, where the weed control effectiveness of different soil covering methods were evaluated. The reason for this was to examine in what areas the straw covering can be used.

My study aims to compare the effectiveness of straw coverings with the effectiveness of the commonly used weed control method (s). Beside the effect of straw covering on the weed coverage it is also essential that how the treatment influences the richness of species and the distribution of different forms. During the evaluation it was an important issue that how long the straw placed can effectively preserve the effectiveness against weed, so after how much we need to renovate the straw covering.

During my investigation I considered as important targets the followings:

- Survey the weed flora of the different areas.
- Survey the number of the weed species (pcs) and their covering values (%).
- Determination of the dominant weed species under different weed controls.
- The effect of different weed controls on the number of weed species and the distribution of the covering values of the different species.
- Statistical analyses of the evaluation of the effects of weed controls on the weed coverings (%).

Material and methods

Research circumstances

In my thesis I studied at three sites the effect of soil covering methods on weed species and the effectiveness of weed control. In case of the grapes I studied two locations, the vineyards of Eger Grape and Wine Research Institution in the Kőporos experimental vineyard table (1999-2000), and in vineyard of the Tokaj- Hétszőlő Winery (2006-2008). I also did researches at the Papp-Farm Ltd. at Nyírtass at the strawberry plantations (2000-2001). During the tests in Eger three weed control methods were compared, namely the straw covering, the grass covering and the mechanical soil management. I evaluated the straw covering and mechanical weed control in Tokaj at the Hétszőlő Winery. At the Papp-Farm Ltd. at Nyírtass the straw covering and black foil covering weed control methods were analyzed in case of strawberries.

My aim with researches was to describe the different weed species on different cultivations and to define the percentage of the weed coverings in the different survey dates. For my researches I used the direct covering percentage estimation method suggested NÉMETH és SÁRFALVI (1998). The sample taking was repeated four times every occasion. Beside the weed species of sampling locations I also noted the weed species were not found in the sampling locations. I used 1 m² randomly selected squares for the sampling and the definition of the weed cover was done by estimation. The definition of each weed species was done based on the works of UJVÁROSI (1973) and NÉMETH (1996).

In the case of the different researches I separately analyzed the whole weed cover and the changes of the number of the weed species depending on the weed control methods and cultivations. In addition, these data were grouped in accordance with their life form. During the specification of the life form of each weed species the classification method of MÁTHÉ (1940, 1941) and UJVÁROSI (1973) was used.

Statistical methods

Statistical comparisons were carried out in the vineyards and strawberry cultivation in order to compare the soil management methods. The analysis was based on the comparison of the whole weed coverings from every sampling point at the sample taking times. In the case of the weed species statistical analysis was not done because the recordings did not only cover the weed species of the sampling area but the species appearing in only threads at field level.

They well demonstrate the richness of the board, but distort the results of the statistical analysis.

The statistical comparison was done in one or two steps for the studied parameter (weed cover). The results of all the survey series (Eger: vine weed control, Tokaj: vine weed control, Nyírtass: strawberry weed control) were treated and analyzed separately. First, in the case of cases showing difference several analyses of variance was run by taking into consideration the treatment, the year and the sample taking date (month or date). The homogeneity of variances was checked by Levene-test. With the probe used it can be shown that how the factors of the analyses are important in the modeling of the cultivation examined or the locations and if they have perceptible effect on the weed covering values. In the case of the data for the cultivation of Eger the covering values of the *Stellaria media* was not taken into account because at the first sample taking time its significant appearance considerably distorted the average of the entire weed covering results.

At the soil covering tests done in Tokaj the data did not show normal distribution, this was investigated by a simple statistical test. Then I applied transformation for the weed coverings and the statistical probes were run by the natural logarithm of the values of the coverings. The aim of the transformation is to make the data set normally distributed. The advantage of the logarithmic transformation is that it preserves the order of sequence. It is in this case the logarithmic transformation failed, because in many cases was the straw covering 100 percent effective. Since the severe variables variance could not be used because the weed covering values were not normally distributed, and even after the logistic regression I did not get a normal distribution, so Fisher-Snedecor test of the one-way analysis of variance was used (SAJTOS és MITEV 2007). With the method as an independent variable it can be defined whether there is a significant difference between the different treatments, years tested and the sample taking months from the point of the changing of the weed covering. In this case during the analysis only one independent variable (treatment, month, year) and a dependent variable (% of weed covering) could be compared.

The statistical tests in all cases were performed at the 95% confidence level using SPSS 19 software package. In the presentation of the results in the tables obtained from the program I used the English labels of the program.

Results

The results of the Eger soil covering experience

In Eger the soil covering experiments showed that the use of straw covering was an effective solution for weed control in vineyards. It reached the similar efficiency than the mechanical and grass weed control but after application's fourth year its effect worsened.

In the study, the number of weed species due straw covering did not decrease, but on the other two treatments reached higher values. The cultivation methods had no significant effect on the sequence of weeds. On the areas with mechanical weed control (disking) the dominant weed species were the *Stellaria media*, the *Amaranthus retroflexus*, *Cirsium arvense* and *Convolvulus arvensis*. On the grassy area and on the area covered with straw had the same order.

By using boxplot representation for the weed cover data it can be seen that within the year in the case of straw covering weed cover increases can be detected, while in the case of the mechanical and grassing weed control decreasing trend can be observed (Figure 1).

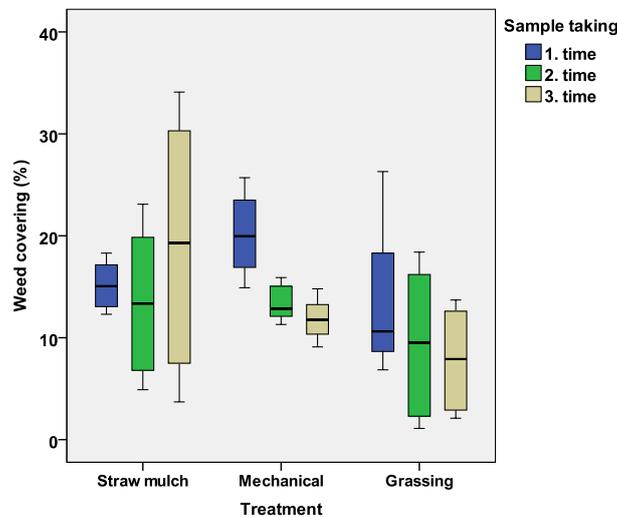


Figure 1.: Average weed covers in the Eger vineyards in the sample taking times

In introducing the impact of the years it can be seen that there is an increase in the straw covering. In the case of the mechanical cultivation there is no significant difference between the years, but in the grassy field there is a significant decrease in the second year (Fig. 2).

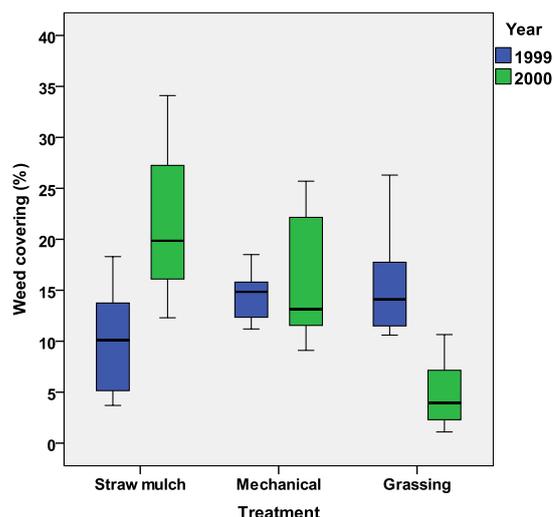


Figure 2.: Average weed covers in the Eger vineyard based on the years studied

The statistical analysis showed that the straw covering after the third treatment year is significantly better at weed controlling than the other two processes. In the fourth year after the application this treatment was significantly the weakest among the applied treatments.

Results of the straw covering research at Tokaj Hétszőlő vineyard

Examining the effectiveness of the cultivation methods of the Tokaj Hétszőlő vineyard I came to the conclusion that after a year that the straw placed the number of the weeds increased by comparing the mechanical treatment but in the second year it was higher. From the point of weed covering values the difference between the straw treatment and the mechanical cultivation was not significant. However, it appeared clearly that on the covered area from the application the weed covering value increased proportionally. This could be best seen in the second year after the application (2007).

The results are shown on boxplot showing within a year treatment had an effect on the changing of the covering values (Fig. 3). The first two survey dates (5 and 6 months) resulted in almost the same in both treatments. Within a year changes it could be seen a growth after the June survey. In the examined period at the time of the surveys the straw covering had better effect than the mechanical treatment.

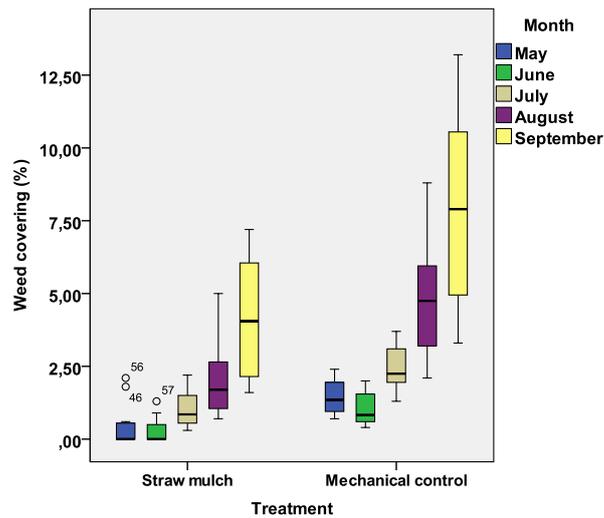


Figure 3.: The changing of the weed coverings during the survey period at the Tokaj Hétszőlő vinery.

The Figure 4. introduces the effect of the weed control methods on the weed covering. The effect of straw covering after the application years (2006 and 2008) when compared to the mechanical treatment showed one to two per cent lower than the average values, while in the second year of treatment (2007), the covering became almost the same but in the case of straw covering there is a higher dispersion which represents an increase in cover of the values.

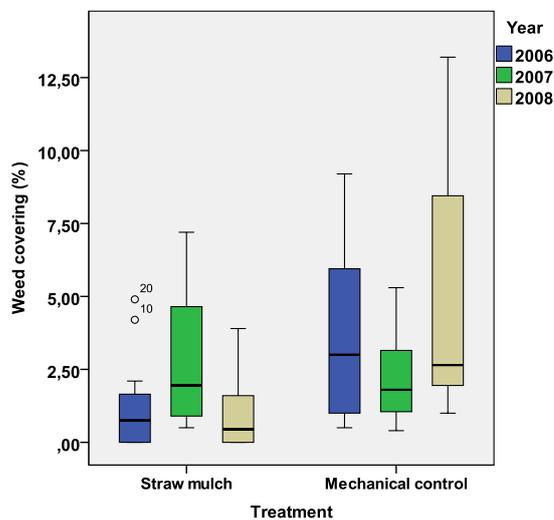


Figure 4.: The changing of weed coverings in the years studied in the Tokaj Hétszőlő vineyard

After analyzing the soil cover methods of the strawberry I realized that the applied black foil and straw covering methods had adequate effectiveness on weed controlling. After the statistical analyzing of the weed covering values it can be seen that only the survey time had

significant effect on the values. In the number of weed species between the two treatments no difference could be realized.

Describing the covering values we see that if we move ahead in the dates the covering values increase in the case of both methods. In the case of the straw management for all tests in the time the values were higher than in the case of black foil cover (Figure 5).

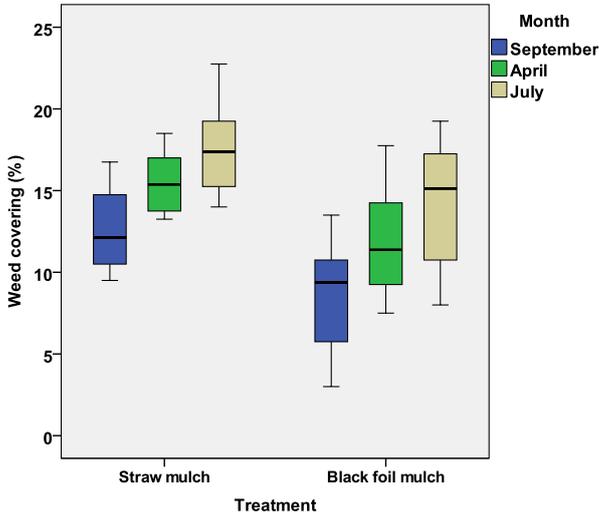


Figure 5.: The changing of the average weed covering in the strawberry fields during the survey time

The Figure 6. shows the effect of the years, where the differences are clearly visible. Between the first and second year a decrease of the emerging weed cover can be seen in both the straw and foil coverings. The difference between the treatments over the years according to the comparison showed a similar variation as the previous figure. The black foil cover resulted a 3-4 percent lower covering.

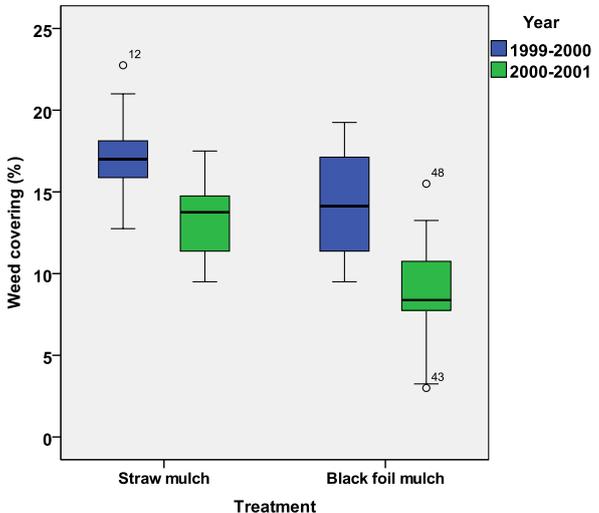


Figure 6.: The changing of the average weed covering in the survey years in strawberry fields

Analyze of the results of the straw covering

Analyzing the complex effect of the straw covering I found that on the studied area such weeds appeared that are not common on that area. As an example the *Triticum aestivum* can be mentioned at the Eger Vineyards and the *Abutilon theophrasti* at the Tokaj Vineyards. I found that the using of the covering brought new weed species and this should be taken into consideration in the future.

My research supported that the straw covering can be effective in the weed control of the plants. The results achieved and the statistical probes also proved the effectiveness of the treatment. The renewal of the straw layer in case of hilly lands should be done in every 2.-3. year and in case of flatland in every 3.-4. year in order to be effective. The straw covering cultivation method can be a good treatment for the environmental friendly weed control for the ecological or for the integrated plants.

New scientific results

1. I found that the straw covering in case of hillside vineyards can provide adequate protection against weeds for two years. During this period the coverage values of the investigated areas have not reached 10 percent.
2. The straw covering applied in graveyards do not have negative effect on the variety of the weed species because the number of the weeds described from the second year exceeded the number of species on mechanical or covered areas. In Eger that meant between 17 and 38 species in the test period in case of straw covering, while in the grassy area it was between 16 and 24 species, in case of mechanical weed control it was 3 and 12.
3. In case of straw covering on the treated lands such weeds appeared that are not common. As an example the *Triticum aestivum* can be mentioned at the Eger Vineyards and the *Abutilon theophrasti* at the Tokaj Vineyards Based on this we have to draw the conclusion that by applying the covering new weed species appear in the land that should be taken into consideration during the cultivation.
4. The results of the weed control of the straw covering proved the assumption that in graveyards and strawberry fields the weed control can be carried out without using herbicides and exaggerated mechanical cultivation.
5. In case of the weed control of the strawberry the straw covering offers an adequate weed control because after the treatment the average covering value altered between 10,5% and 19,62%. The black foil covering had better effect (5,93%-17,12%) in the studied period but the straw covering was also adequate because it was above 80% in every case.
6. By ranking the weed species at the vineyards I proved that in case of straw covering the G₃ species and the Therophyta (in spring T₁, T₂, in summer and winter T₄) are the most frequent in the studied period.
7. In case of straw covering in vineyards and strawberry there are more than the average perennial Hemikryptophyta species than in case of the grassing or the mechanical cultivation.

Conclusions and suggestions

After evaluating the results of the researches as the base of my thesis several suggestions and conclusions can be drawn based on the results achieved.

Evaluating the results of the covering experiments at the Eger vinery area based on the obtained data it can be stated that the straw covering treatment after three years of the application can still control the weeds growth. The decrease of the effectiveness of the treatment can be only detected at the end of the second year which was the fourth year after the straw covering application. It can be stated that if the vineyard is located in an nearly flat area and the slope is less than 5 percent, then the renovation of the straw covering is required only after three years. The applied 15 to 20 cm thick layer of straw is able to provide adequate weed control during this period.

If we analyze the weed species in the area it can be clearly seen that the straw covering has a more favorable effect regarding the number of weed species than the mechanical method because the number of species appeared was always higher in each survey occasion. These results confirm the finding of MIKULÁS (2000) that the mechanical treatment reduced the number of species presented in that area. The results, however, is contradicted by MIHÁLY (2005) findings, who experienced significant decline in species richness compared to the mechanically treated areas. The previous reduction of the species may be explained by the fact that many professionals also said that the *Solidago* species have significant allelopathic effect that could cause germination inhibition.

The comparison based on the weed species shows that there is a great difference in the coverage ratio of the relative values. It can be said that perennial species are dominant in all the three treatments. It can be observed in the case of the perennial species that between the first and last study time in case of the mechanical treatment so significant deviation cannot be realized but in the case of the straw covering there is a significant rise in the covering values as time goes by. The rise of the covering value can be well followed in the case of the G₃ species where within two years the coverage value of the species from 1,8 percentage raised to 12,25 percentage. This increase was mainly due to the fact that the area was untouched so there was not restraining effect on the perennial weeds that could break through the covering. The increase of the covering values of the strengthens the results of NÉMETH et al (2000) who mentioned that the usage of covering method is not effective enough against aggressive perennial weeds.

Based on the significant weeds rank after the treatment it can be seen that the dominant weed species in case of the mechanical treatments are: the *Stellaria media*, the *Amaranthus retroflexus*, *Cirsium arvense* and *Convolvulus arvensis* were significant in case of the grassy and straw covered area as well. The presence of these species is partly in accordance with the results of DELLEI (2000) done in the vineyards of Eger and Mátralja. Contrary to DELLEI (2000) we did not find the *Aristolochia clematitis* which appeared in the nineties in the vineyards of Eger. I mentioned as important species the *Conyza canadensis*, *Lactuca serriola* and *Tragopogon dubius* appeared in the areas studied as well, but they reached significant covering only in a few cases. In case of the straw covering it can be noticed that not only the weeds appearing at the mechanical treated areas had higher coverings but the *Veronica hederifolia* and the *Tripleurospermum inodorum* as well.

If we analyze the results of the Tokaj treatment we can see that in case of steep slopes the wearing out and thinning of the covering is more intensive than in the case of flatland or more moderate slopes.

The results of my research unequivocally support the effectiveness of the straw covering that was examined by other authors earlier (VARGA 1997, NÉMETH et al. 2000, MÁJER and VARGA 2003, MIHÁLY 2005). I treated as new observation the regularity that appeared as a relation between the number of weed species and the time passed after the treatments. Based on this I drew the conclusion that in comparison with the mechanical treatment in case of the straw application the number of the weeds reduced a little but in the second year it was higher than in the mechanically treated areas.

Regularly repeated characteristics in the covered areas that the covering values within a year show a continuous rising in Tokaj. There was only one exception, the year 2007 when at the time of the second survey I found lower value than in the previous time.

From the frequency of the surveys if we evaluate the monthly surveys it can be seen that among the different survey times there was a difference among the covering values. If we examine the data from the point of weed species we may realize that the May and June weed list and the August and September weed list do not show much difference. The difference in the case of the common list is 1-2 species. By knowing this it can be said that for the vineyard weed survey the three aspects survey is enough as described in the professional literature (UJVÁROSI 1973) because it offers a full picture about the possible weed flora.

Analyzing the effectiveness of the soil covering methods used in strawberry fields I found out the straw covering and black foil covering were adequate. The straw covering has a disadvantage from the cultivation technology point of view because in the first year the

application during the flowering time is at the same time is the peak period in spring. Taking into consideration the results of the two years in case of the strawberry fields in order to reduce the usage of herbicides I would advise to cover the lines with black foil and the ridges should be covered with straw. With this without chemical and mechanical weed control the areas' weed control can be ensured. Another advantage of the combined treatment is that during the establishment of the plants till its termination (at the age of 3 or 4) the effective and environment friendly weed control can be ensured.

In accordance with the professional literature (MIHÁLY 2005, PUSZTAI 2010) the straw covering proved to be an effective treatment. Against the weeds the whole covering was effective but the thickness of the cover layer strongly affected the effect. In the case of the organic cover the layer's thickness is continuously changing and the place within rows and the inclination have a significant effect on the erosion's level. The straw covering is tend to become spotted that causes heterogenic weed killing effect. During the application it is important to ensure the appropriate thickness of the covering because based on the rhythm of the erosion and the decomposition the cover layer should be renovated in every second or third year. Among the weed species expect among the T₄-types deep germinating or on the surface the *Conyza canadensis* which is able to germinate even in the covering layer the treatment is effective. The treatment was appropriate even in the case of more aggressive species. In case of the perennial weed species it had little effect so on those areas which are strongly affected by G₁ or G₃ types the treatment cannot be satisfactory. Bearing this in mind I would advise that in all cases before applying the straw covering spraying against perennial weeds or in economical farms exhausting cultivation should be used to ensure the perennial-free area.

This weed control method might be advisable at vineyards near protected environments or on lands where erosion or deflation is common. I strongly advise the straw covering method for ecological and integrated vineyards.

If we esteem the possibilities of the extension of the organic covering methods we can see that significant enlargement cannot be counted in the near future. I see several restrictions in the extension of such coverings (organic manure, reed, mulch, composts) as follows:

- High establishment cost. This should be countered against the cost of the 2 or 3 year cultivation but typically the farmers compare this cost with a single cultivation or in a better case with the cultivation cost of one year.
- Because of the energetic usage of the biomass the prices of the raw materials increases the quantity of the covering material reduces. It is real danger that

because of the increasing energy prices the agricultural and forestry side products (straw, bark, etc.) that used to be available at a low price will be more expensive.

- Lack of special machines that can place the coverings fast and cheaply.
- The results of the covering cultivation are not known widely among the farmers or they strict to the decades old methods. With different marketing activities the reputation of the covering cultivation can be improved.

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