THESIS OF PhD DISSERTATION

POSSIBILITIES AND LIMITS OF WEED MANAGEMENT IN HERBICIDE FREE CARROT PRODUCTION SYSTEM

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AIMS

Most weed problems appear during production of those crops of the vegetable crop rotation, which have low competition ability. Crops with slow initial development, like carrot (*Daucus carota* L.) are very sensitive to weedyness.

One of the most important question of an adaptive, environmentally sound plant production system is how we can solve weed control. Organic plant production can not be achieved without successful weed management.

Nowadays most prevalent and almost exclusive tools for plant care are cultivators and harrows. Many thought that with introduction of herbicides these tools are crowded out from production. But practice falsified these statements, because mechanical weed management methods are not only against weeds but also have such positive effects that herbicides can not produce, like soil loosening effect. Beside this with spread of farming with healthy diet and environment protection in view to work out its technology is getting more and more important.

It is also important that the aim is not total demolition of weeds but to control them only until the level that allows also admissible yield of crop and doesn't disturb considerably the production itself.

At the end of 90's Hungary arrived at the decision that until 2006 there will be 300 000 ha organic farming area in the country, because increasing demand for organic products and subsidies would have stir the agriculture to this direction. But to reach this aim research background, technology and later subsidies were missing.

Today with 120 -130 000 ha of certified organic farming area it is totally clear that this aim will materialize only in the far future.

Recognizing the lack of a suitable technology, aims of my research were:

- gathering and comparing non-chemical weed management methods according to the literature,
- developing such weed management strategy that fits into strict terms of organic farming,
- comparing this strategy with a technology based on herbicides,
- testing simultaneously a herbicide-saving method,
- comparing effects of weed management methods on dry matter of carrot roots,
- revealing limits of work sparing weed management.

Carrot was chosen as test crop, because its low weed-suppressing ability and slow initial development, and it is an important vegetable species for healthy diet and so far it is needed to be available in high quantities from organic production.

MATERIALS AND METHODS

The four-year long field experiment was executed at Soroksár, experimental area of Department of Ecological and Sustainable Production Systems of Corvinus University of Budapest from 2000 until 2003.

15 treatment combinations were compared with four replicates. Each of the 60 plots was 10 m long and 2.50 m wide that means 25 m^2 per plot and 1500 m^2 for the whole experiment. The experiment was implemented in a randomised complete block design.

Soil tillage was done until preparing fine seed bed.

The tested carrot (*D. carota*) variety was Nanti. Flat bed production system was chosen from many types of growing systems of carrot mainly because of the available machines. Sowing depth was 3 cm. Carrot was sown in rows with 75 cm row spacing, chiefly because the available weed brush work such wide inter rows. Sowing was done with adjustable portable small seed sowing-machine. Plant-to-plant distance was 3 cm after thinning.

No irrigation was used in the experiment.

The soil type was a chernozem-like sandy soil. Soil forming rock was calcareous sand. Thickness of the humic layer is 30-40 cm. It is a slightly calcareous, mildly alkaline soil.

Data about weather conditions of the examined periods of the four experimental years were compared with average of the past 50 years (1950-2000) with fitting polynomial curve by Microsoft Excel software.

2000 and 2003 were extremely arid and warm. In 2001 the data didn't differ from the average of the last 50 years and 2002 was slightly warmer and more arid than the average.

Treatment combinations of the experiment

1. Untreated/weedy control
2. Herbicide treatment on the whole surface
3. Herbicide treatment on the rows + cultivator treatment in inter rows 1x
4. Herbicide treatment on the rows + weed brush treatment in inter rows 1x
5. Herbicide treatment on the rows + hand hoeing in inter rows 1x
6. Hand weeding in the rows 1x + cultivator treatment in inter rows 1x
7. Hand weeding in the rows 1x + cultivator treatment in inter rows 2x
8. Weed flaming on the whole surface + cultivator treatment in inter rows 1x
9. Weed flaming on the whole surface + cultivator treatment in inter rows 2x
10. Hand weeding in the rows 1x + weed brush treatment in inter rows 1x

11. Hand weeding in the rows 1x + weed brush treatment in inter rows 2x
12. Weed flaming on the whole surface + weed brush treatment in inter rows 1x
13. Weed flaming on the whole surface + weed brush treatment in inter rows 2x
14. Hand weeding in the rows 2x + weed brush treatment in inter rows 2x
15. Hand weeding in the rows 2x + cultivator treatment in inter rows 2x

Control plots remained untreated from sowing of carrot seeds, so natural weedyness after soil preparing was observable here.
Preemergent herbicide treatment (20mL 100 m-2 S-metolachlor (Dual Gold 960 g a.i. L-1) and 20 g 100 m-2 chlorbromuron (Maloran a.i. 50%) was done on the concerned plots.
The used weed brush - working on 4 rows with 75 cm row distance - was built by two Departments, the Agricultural Department (former name of Department of Ecological and Sustainable Production Systems) and Technical Department.
Type of the used cultivator was: ZSMK-6 – working on 6 rows – that is suggested especially for inter row tillage of vegetable production.
Weeding in the crop rows and thinning of carrot was done by hand.
Weed flaming treatment was implemented by a portable weed flamer 2 days before emergence of carrot in 0-2 leaves stage of weeds on the whole surface of the concerned plots.

Samples

- survey of weed cover with BALÁZS-UJVÁROSI method just before and two weeks after each treatments separately in rows and in inter rows of the treated plots
- dry weight of weeds (weeds of the rows were taken from 0,25 m^2 area and ones of the inter rows from 0,5 m^2 area) just before and two weeks after each treatments separately in rows and in inter rows of the treated plots
- survey of soil cover of carrots with BALÁZS-UJVÁROSI method just before and two weeks after each treatments in treated plots
- dry weight of leaves and root of carrots (carrots were taken from 1 rm) just before and two weeks after each treatments in the treated plots

Statistic analysis of data

Collected data were analysed with SPSS 14.0 for Windows Copyright: SPSS Inc., 1989-2005. and MiniStat 3.3 Copyright: Vargha András, 2004. software.

Treatments were closed up into treatment-groups.
Dry matter production data were subjected to analysis of variance (ANOVA).
Weed cover data from one survey were compared with one-way comparison of independent samples in which the software counts with rank means and decides that weed cover data are homogenous or different.
Changes of weed cover in short-term (two weeks after the treatment) and in long-term (from the beginning to the end of the growing season) were analysed by two-way ANOVA.

Method of summarizing the results

Results - evaluated annually and by each survey separately - were summarized with tables in which the treatments or treatment combinations were ranked by line numbers. The highest number was always for the treatment with the best effect. Significant differences were marked beside the rank numbers in the rows of the tables.
To be able to evaluate the effect of treatment combinations on weeds in the rows and inter rows together, rank numbers were summed so the final tables show the effectiveness of the combinations in the rows and in inter rows jointly.

RESULTS

Cover of carrot

Regarding all years of the experiment the highest cover of carrot (*D. carota*) was observable in the flamed **row**s two weeks after weed flaming, so in **short term** this treatment was the best. Flaming two days before the emergence of carrot didn't decrease the cover of carrot significantly in neither of the years of the experiment. That is why we can say that independently of weather conditions preemergent weed flaming does not damage considerably emerging carrot. Beside this in dry years preemergent weed flaming can have negative effect on emergence of carrot that can be attributed to the slight soil-warming and drying effect of flaming.

Observing **long term** effect of **row**-treatments, at the end of the growing season in more humid years carrot showed the highest soil cover in two times hand weeded rows – significantly higher that in untreated control plots. In dryer years this treatment (two hand weedings) gave very bad result that could be because of repeated soil moving caused drying of the soil and with removing of weeds sudden heat stress put back carrot in growing.

After summarising all years of the experiment at the end of the growing season highest carrot cover was observable in herbicide treated rows in most cases. This solution is work-sparing but not environment friendly of a sort and does not allowed in organic farming. Two times hand weeding gave the second best result, but forewent onetime weeding only hardly, so if we see only soil cover of carrot the second hand weeding is worth considering economically.

By examining the effect of **treatment combinations** on carrot cover at the end of the growing season it appears that significant difference can be found among combinations with same row, but different inter rows treatments; so inter row treatments have effect on growing of carrot roots and through this on foliage of carrot even with such wide inter rows.

Under non-irrigated circumstances with average or little bit worse precipitation treatment combination no. 15. could be advised mostly in which rows were hand weeded two times and inter rows were two times cultivator treated.

It did not gain definite proof, that in combination with weed flaming one should choose work sparing method with only one inter row treatment, but as a tendency it is observable that especially in dryer years after flaming inter rows, drying effect of multiple mechanical inter row treatments could influence cover of carrot negatively.

Dry root yield of carrot

Comparing only the **row treatments** one hand weeding of rows had better effect on dry yield of carrot than the also work sparing and environment friendly preemergent weed flaming, so weed management of rows with only one preemergent weed flaming is questionable regarding even the yield.

Dry weight of carrot roots is higher in the rows hand weeded twice than in rows hand weeded only once, but this phenomenon could not be proved statistically, so it can not be stated surely that second hand weeding should be done for the sake of a better carrot yield. Naturally economical aspects also should be considered in this question.

Yield of carrot is decisively influenced by the weedyness of rows during the growing season. Continuous relatively weed free status of the herbicide treated rows gave higher dry matter production of carrot that suddenly decreasing weedyness of hand weeding two times from time to time could not compensate.

By examining the effect of **treatment combinations** it appears that inter row treatments have effect on dry matter production of carrot roots even with such wide inter rows (75 cm), although statistically verifiably difference could not be found in present case. Those inter row treatments that cause soil moving in higher extent and more times like hoeing and cultivator treatment have positive effect on dry matter production of carrot roots.

Beside preemergent herbicide treatment on rows it can be enough to treat the inter rows with cultivator only once because in this combination carrot gives satisfying dry root yield. This combination of methods can be evaluated as herbicide sparing (because herbicide is applied only on rows) and as work sparing (because mechanical inter row treatment is applied only once and by a machine). Hand weeding of rows once and cultivator treatment of inter rows two times could mean a reasonable solution from the point of view of carrot dry yield, and at the same time this is a work sparing combination with leaving the second hand weeding and environment friendly without herbicide treatment.

Combination no. 15 was the best herbicide free method with hand weeding two times in rows and cultivator treatment two times in inter rows, so this combination could be advised principally from the point of view of yield enhancement in organic production.

Total weed cover

Impact of the weather of the different years of the experiment can be unambiguously observed in **short term** effect of **row** treatments. In years with more precipitation weed flaming was better

against the weeds two weeks after treatments than herbicide treatment, so in the case of humid conditions or irrigation possibility flaming can be a good alternative of preemergent herbicide treatment of carrot rows. Under dry circumstances weed flaming was not suitable to replace herbicide.

In **long term** hand weeding two times was definitely the most effective **row** treatment for moderating total weed cover.

Preemergent herbicide treatment decreased total weed cover in rows more effectively than one hand weeding in long term (at the end of the growing season).

At the end of the growing season the preemergent weed flaming of rows - that did not get any other complementary treatment during the year – lost its initial advantage in contrary to the herbicide treatment.

Comparing **short term** effect of the two types of mechanical **inter row** treatment done by machine it is observable that in case of average or little bit more (in 2001) precipitation cultivator treatment can decrease total weed cover more than weed brush. Under extremely dry circumstances any tendency could not be found.

After summarising results of all the four years in short term, cultivator was the better in the inter rows that got only cultivator or only weed brush treatments, so this method could be advised from the two machine made mechanical treatments for weed management of the inter rows.

Looking all the experimental years at once, single weed flaming at the beginning of the growing season did not increased effectiveness of mechanical inter row treatments done only once in short term (two weeks after mechanical treatments) in such extent that doing it - like in this case: once a year - could be advised. In contrary interrow treatment done by machine the second time seemed to be assisted by weed flaming. But since this assistance could not be proven statistically this question needs further research.

Hoeing or cultivator treatment decreased total weed cover more than weed brush. Machine made inter row treatment done two times was always more effective than those done only once, although in case of weed brush this difference is smaller and not significant in none of the years. So weed brush treatment is less reasonable to be done the second time than cultivator treatment.

Cultivator or weed brush treatment combined with preemergent weed flaming is more effective at the end of the growing season – in **long term** – than these treatments without flaming. This difference is statistically verifiable in 2002 in the case of weed brush; so if weed management os **inter row**s is planned to be done by one weed brush treatment it could be worth to be combined with flaming.

Examining **treatment combinations** it is observable that preemergent weed flaming in rows can be only a supplementary method of more complex weed management strategies, which involve

mechanical methods too, because one preemergent weed flaming was not enough to keep rows at least relatively weed-free till the end of the growing season so it increased total weed cover of the whole area.
All the three combinations that were herbicide treated only in the rows and were mechanically treated in inter rows were better after summarizing the four experimental years than those herbicide treated on the whole surface (rows and inter rows). Therefore we can say that the herbicide sparing (only the rows are herbicide treated) weed management methods have grounds in suppressing total weed cover.

Dry mass of weeds

Statement found in literature that dry mass and ground cover of weeds could give mismatching result especially at the end of the growing season was verified by field experiment.

Cover of the six dominant weed species

Effectiveness of four row, ten inter row treatments and fourteen treatment combinations on six weed species chosen according to the literature were compared in flat bed carrot production with wide inter rows and without irrigation.

The applied herbicide combination was effective in short and also in long term against redroot pigweed (*Amaranthus retroflexus* L.), fat-hen (*Chenopodium album* L.) and barnyard grass (*Echinochloa crus-galli* L.); less effective in long term against ragweed (*Ambrosia artemisiifolia* L.) and prostate amaranth (*Amaranthus blitoides* S. Watson) and was not effective at all against couch-grass (*Elymus repens* L.).

From **row** treatments hand weeding two times had the most suppressive effect on **ragweed** (*A. artemisiifolia*); even hand weeding once is more effective than the applied herbicide combination against this species. This seems to support that ragweed is tolerant to the chosen herbicides and that because of its long germinating period long term effect of herbicides is weaker, although this question was not examined separately and the mentioned difference was not significant in any years. Preemergent weed flaming was environmentally friendly and more effective than herbicide treatment of the rows with these agents. However none of these differences were significant. Nevertheless as a tendency it could be stated that weed flaming can be more effective against ragweed in long term than herbicide treatment, because preemergent herbicide

application kept rows more weed-free and ragweed – that is tolerant for these herbicides - had fewer concurrence.

Cultivator treatment is a more effective **inter row** treatment against ragweed than weed brush. Likely strong ragweed plants rode out leaves-rubbing-off effect of weed brush than more forceful soil moving and root cutting effect of cultivator. Comparing mechanical inter row treatments done two times and only once in case of cultivator treatment and hand hoeing treating two times was always better, while in case of weed brush it was worse than treating only once. Since weed brush treatment was not so effective even for first time against ragweed but decreased total weed cover, ragweed was able to strengthen in these plots and resisted more the second weed brush treatment. Beside this against ragweed it is more worthwhile to combine mechanical inter row treatments with preemergent weed flaming if only one (and not two) mechanical treatment is possible during the growing season.

Examining summarized effect of **treatment combinations** on ragweed cover of the whole surface preemergent weed flaming done only once was comparatively effective – in contrast with those observed in the case of total weed cover. This question should be examined with a more specialised research.

In case of ragweed just like in case of total weed cover all the three combinations that were herbicide treated only in the rows and were mechanically treated in inter rows were better after summarizing the four experimental years than those herbicide treated on the whole surface (rows and inter rows). Therefore we can say that the herbicide sparing (only the rows are herbicide treated) and more environmentally friendly weed management methods are reasonable against ragweed in case of this herbicide combination.

It can be stated by single weed surveys that **redroot pigweed** (*A. retroflexus*) appeared later at the experimental area within a growing season than the other significant species mentioned here, so preemergent weed flaming in **row**s and in inter rows with killing first plants of the other species gave advantage to redroot pigweed that kept it later on.

Cultivator treatment is a more effective **inter row** treatment in short term against pigweed than weed brush. Cover of redroot pigweed grew in greater extent in flamed interrows than in those did not get flaming.

Preemergent weed flaming could be effective in long term against this species only if it is not followed by a greater soil movement, because cover of redroot pigweed increased less on flamed inter rows after weed brush treatment – that moved the soil in a smaller extent - than after cultivator treatment that could bring pigweed seeds up from the lower soil layers and make them germinate. Most likely that is why hand hoeing was not so effective against this species as

against the T_4 life form group in general. If redroot pigweed infection is expressed on the area it is worth considering killing emerged pigweed seedlings with another flaming after a mechanical treatment that caused bigger soil movement, so weed seed bank and caused damage of pigweed could be lessened in this way. This could be repeated many times during the growing season in case of wider inter rows.

Two hand weedings were the most effective row treatment against **prostrate amaranth** (*A. blitoides*). Summarizing results at the end of the growing seasons one hand weeding and weed flaming gave worse result in **row**s than untreated control, because could be hardly controlled by these two methods but other species were suppressed in short terms so amaranth could gather ground more.

Preemergent weed flaming combined with one mechanical **inter row** treatment was not effective against prostrate amaranth; while effectiveness of mechanical inter row treatment done twice was increased by weed flaming. It follows that on areas strongly infected with prostrate amaranth preemergent weed flaming is worth to be done in rows or in inter rows alike only if this flaming is followed by supplementary weed management actions as many times as possible during the growing season.

Hand hoeing of interrows was the most effective in suppressing amaranth two weeks after the treatment that could be because this method is more precise. For this species with its lying stems it is easier to gather ground after less precise weed management methods that could be applied less close to the rows.

After doing all inter row treatments at the end of the growing season still the hand weeding was the most effective against prostrate amaranth. Whereas one hand hoeing is not enough to decrease cover of this species adequately, moreover after soil moving explosive emergence of weed seedlings could be observed.

At the end of the growing season the best effect was observed on the whole surface after **treatment combination** with herbicide applied on rows and hand hoeing in inter rows, that was due to hoeing because herbicide treatment of rows was not really effective against this species in long term. Those plants that survived herbicide treatment crept out from rows to inter rows could be killed mostly by the more precise hand hoeing decreasing with this the cover of this species on the whole surface.

Inter row treatments done by machine combined with flaming or without flaming showed such heterogeneous result, on which no tendency could be applied. As far as morphology of this species differs from the other T_4 species in general and it was especially prevailing on the

experimental area it could be worth to start a research that examines in details the questions mentioned here.

Against **fat-hen** (*C. album*) preemergent weed flaming was not an effective **row** treatment in contrary to other dominant species not even in short term. In contrast with my results this species is mentioned in literature as very sensitive to weed flaming. Accordingly it is worth to examine this question with keeping in mind the state of development of the plants.
Leaving rows without any soil moving treatments resulted fewer weed cover increment at the end of the growing season than hand weeding once or two times - when seeds of fat-hen could have brought up from lower layers of the soil - or than preemergent weed flaming that was not effective against this species and gave insuperable initial advantage to fat hen because flaming was - at least short term - effective against weeds of T_4 life form in general.
Inter row treatment with slighter soil moving, the weed brush treatment was more effective against this weed species, than cultivator treatment, while in combination with weed flaming it was the just the opposite, so if combined with flaming cultivator treatment was the better. Even in the case of the second cultivator treatment, it was better than weed brush if combined with flaming. These differences was not significant nor in the case of one or two inter row treatments but it can be evaluated as a tendency. As far as weed flaming was not effective against fat-hen but suppressed the other species, fat-hen could gather ground so more developed plants were cut by cultivator more easily than by weed brush, which could just rubbed off the leaves and plants were able to recover this.
At the end of the growing season inter row treatment done two times in the case of cultivator and also weed brush treatments was more effective than doing them only once. Consistency in effect of weed flaming slurred at the end of the growing season.
Considering **treatment combinations** the one treated with herbicide on the whole surface was the best. Combination with herbicide only on the rows and mechanical treatment in the inter rows were not so effective against fat-hen. So herbicide sparing is not such a good solution against this species.

Preemergent weed flaming in inter rows was not effective against **barnyard grass** (*E. crus-galli*), worsened effectiveness of **inter row** treatments in short and also in long term. Cultivator treatment is more effective against barnyard grass in short and also in long term than weed brush. Inter row treatment with herbicide was the third best at the end of the growing season so it kept from its advantage in long term not like mechanical inter row treatments. If only work and time

consumption is considered, none of the mechanical treatments are worth to be used against barnyard grass.

This is confirmed by the examination of **treatment combination**s too, where the best was the combination with herbicide treatment on the whole surface. Effectiveness of those combinations got herbicide treatment only on the rows were underdeveloped compared to those treated with herbicide on the whole surface, so herbicide sparing solutions are not good against barnyard grass.

Combinations with one hand weeding of the rows were better than those with flamed rows, so work sparing preemergent weed flaming was not enough to suppress this species in the rows. As far as work sparing combinations with herbicide treatment only on the rows were not really effective, work sparing could be reached only at the expense of environment protection (herbicide on the whole surface).

The worst treatment against **couch-grass** (*E. repens*) was herbicide treatment at the end of the growing season after doing all the **row** treatments, that was because the chosen herbicide combination that is especially against weeds reproducing only by seeds. Preemergent weed flaming probably thanks to the same fact was more effective than herbicide treatment, because couch-grass did not gather so much ground that the other weed species sensitive for the herbicides, so it could not proliferate a much as in herbicide treated plots.

In **inter row**s weed brush treatment was the less effective in short term that only rubbed off the leaves from the stems, and those could sprout again more easily. Weed flaming on the whole surface combined with mechanical inter row treatment done by machine suppressed couch-grass more than those without flaming.

Good supplementary effect of flaming could be observed even two weeks after the second inter row treatments and at the end of the growing season. According to this, it would be worth to examine this tendency of supplementary effect of weed flaming for mechanical interrow treatments against couch-grass.

Higher cover of couch-grass could be observed after cultivator treatment that cut more the stems of this species and this resulted in more shoots from more pieces of the stems.

Necessity of starting anew research is supported also by the effect of **treatment combination**s on the whole surface at the end of the growing season where the best result could be observed in plots with flamed rows and flamed then two times cultivator treated inter rows.

Combination with herbicide treatment on the whole surface was one of the worst ones that stand against utilization of the chosen herbicide combination.

In the case of couch-grass much less difference was observable among the treatment combinations than in the case of other emphasised weed species at the end of the growing season, so against couch-grass none of the treatment combinations was especially effective or ineffective.

Correspondence of effectiveness of weed management and dry root yield of carrot

Carrot gave harvestable quantity of yield in the two years with more precipitation. Dry root yield of carrot and effectiveness of weed management of these two years were compared.

Comparing long term effect of hand weeding two times and preemergent herbicide treatment on total weed cover of **row**s and dry root yield of carrot, it is observable that more persistent decline in total weed cover is increasing root yield more effectively. Weedyness during the growing season influences yield of carrot decisively, so even though two hand weedings decreased total weed cover at the end of the growing season, carrot gave more yield on plots treated with herbicide that showed a relatively weed-free state permanently. Same phenomena could be observed in case of ragweed (*A. artemisiifolia*), fat-hen (*C. album*), barnyard grass (*E. crus-galli*) and couch grass (*E. repens*).

Applied herbicides were more effective against redroot pigweed (*A. retroflexus*) and prostrate amaranth (*A. blitoides*) than two hand weedings even at the end of the growing season, so results of these two species are coinciding with those observed with carrot yield.

One hand weeding gave better result than weed flaming regarding total weed cover and also dry root yield of carrot. The same can be observed in the case of ragweed (*A. artemisiifolia*), fat-hen (*C. album*), and barnyard grass (*E. crus-galli*).

In these two years with more precipitation flaming and one hand weeding were equally effective against redroot pigweed (*A. retroflexus*), while flaming was better at the end of the growing season than one hand weeding in the case of prostrate amaranth (*A. blitoides*) and couch grass (*E. repens*).

Environmentally friendly herbicide sparing methods that involve herbicide treatment solely on the rows are also effective in decreasing total weed cover. Those **treatment combinations** with one cultivator treatment or hand hoeing of inter rows had positive effect also on yield of carrot. The same could be observed in the case of ragweed (*A. artemisiifolia*).

Treatment combination with hand weeding of rows two times and cultivator treatment of inter rows two times was one of the best combinations in decreasing total weed cover and increasing dry root yield of carrot. No similar tendency was found during examination of connection of dry root yield of carrot and change of cover of redroot pigweed (*A. retroflexus*), prostrate amaranth

(*A. blitoides*), fat-hen (*C. album*), barnyard grass (*E. crus-galli*), and couch grass (*E. repens*); while the same could be observed in the case of ragweed (*A. artemisiifolia*).

NEW SCIENTIFIC RESULTS

- Higher efficacy of the targeted, more precise methods those considering composition of weed flora was proved in contrast to general weed management methods.

- Efficiency of herbicide-free and work sparing weed management methods was verified.

- Viability of chemical weed management - done only on crop rows and not on the whole surface was proved lowering total weed cover that means a more environmentally friendly and herbicide sparing solution.

- Higher total weed cover diminishing efficiency of hoeing and cultivator treatment, than of brush hoeing was pointed out.

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