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Abstracts

3rd EWRS Workshop on Physical Weed Control

**Wye College, UK
23-25 March 1998**

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Abstracts, addresses and further information about the physical weed control working-group are available on http://www.microtec.net/~clodan/main.html
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Photograph of some of the participants
of the 3rd EWRS Workshop on Physical Weed Control

Courtesy of
Howard Lee
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Abstract

In 12 field experiments at different locations during 1995-1997 the effect of pre-emergence harrowing in silage maize was observed in interaction with different herbicide doses. In 2 experiments at a sandy soil the effect of sowing time and false seedbed in interaction with the weed control system was investigated.

Pre-emergence harrowing 1-3 (mean 2) times had a variable effect on the density of the weeds. In general weed emergence was greatly reduced at the time of crop emergence but only 30% (mean) at the time of herbicide application. In 3 of 12 experiments the effect the harrowing on the density at spraying time was neglectable or even positive. The most important and consequent effect of pre-emergence harrowing was the reduction of the size of the weed at the time of herbicide application (mean 12 cm tall versus 6 cm tall, maximum 25 cm tall compared to 10 cm tall).

The most important effect of sowing time proved to be the reduction of labour for weed control after late sowing in some years (till 50% less treatments for mechanical or combined mechanical-chemical control). Delaying sowing time resulted had a slight variable effect at the density of early emerging weed species and a bigger but very variable (positive or negative) effect at the density of late emerging species.
False seedbed preparation (± 3 weeks before sowing) clearly decreased the density of early emerging species. The effect at late emerging species varied a lot between different years for late emerging species (5 times increase till 5 times decrease).

For a better understanding of the effects integration of knowledge on the germination biology of the different species is needed. However delay sowing and false seedbed did reduce remaining weed biomass especially after mechanical control strategies.

Slurry application to improve mechanical weed control in cereals

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Abstract

Weed control in organic farming is not only a matter of replacing a sprayer with a spring tine harrow. Often no single method is sufficient to ensure a high and stable weed control level. Instead several control methods have to be included into a weed control strategy. This presentation focuses on slurry application as a factor to manipulate the growth of crops and weeds. The idea is to improve the competitive ability of the crop by placing the nutrients beside and below the crop seeds. Most weed seeds germinate in the upper soil layer (0-3 cm), whereas most crops are sown in the depth of 4 to 8 cm. Hence nutrients placed below the crop seeds are more available to the crop than to most weeds. Fertilizing the crop and starving the weeds are expected to make the crop more resistant to weed harrowing, to improve crop competition against surviving weeds and to increase nutrient utilization. In 1996 and 1997, three experiments with oat and barley were carried out to study the interactions between weed harrowing and slurry application (injection relative to broadcasting). Both slurry injection and weed harrowing caused weed biomass reductions. Slurry injection improved the effect of weed harrowing significantly in 1996, but not in 1997, partly due to large experimental variations. These were caused by problems with new equipment for slurry application, attacks from nematodes, and variation in weed pressure within the experiments. Despite of this the combination generally improved the total control. Slurry injection generally increases the yield on coarse sand soil, but not on sandy loam soil. Low nutrition level in the upper soil layer increases the effect of slurry injection on crop growth, and at the initial level on coarse sand is normally low due to nitrate leaching during the winter.

In a single competition experiment in 1997 it was found that slurry injection increased the competitive ability of oats against a range of densities of superficially sown rape on sandy loam soil. At weed (rape) densities above 500 plants per m^2 slurry injection increased oat yield by 50% compared to broadcasted slurry. The results stress the importance of integrating methods for weed control in organic farming. There are still many aspects to be studied and optimized, but no doubt nutrient placement add to an improved weed control.

Reference:

Rasmussen, K., J. Rasmussen and J. Petersen (1996). Effects of Fertilizer Placement on Weeds in Weed Harrowed Spring Barley. Acta Agriculturae Scandinavica. Sect. B: Plant and Soil Science. 46:192-196.

Influence of crop rotation, tillage and herbicide use on population dynamics of weeds in winter cereals

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Abstract

The development of concepts and methods of integrated weed management for an economically and ecologically justified restriction of weed growth, requires field-based research in long-term trials. The influence of crop rotation, stubble tillage and herbicide use in cereals on weed population dynamics and weed competition on cereals is tested in a long-term experiment, which has been running since 1985. Some modifications made in the experimental design in 1993 have allowed to study also the effect of conservation tillage on weed infestation and weed-caused yield losses in winter cereals.

The results demonstrate that crop rotation is a key factor for the degree of weed infestation and for the intensity of herbicide use. A well-balanced crop rotation with cereals proportion of about 50 % can limit the occurrence of broad-leaved weeds and grass weeds, especially *Apera spica-venti*, *Alopecurus myosuroides* and also *Agropyron repens*.

Stubble tillage and in particular shallow ploughing can frequently control perennial weeds like *Agropyron repens* and *Cirsium arvense* without any additional use of a special herbicide. But the effectiveness of stubble tillage against annual weeds is only about 20 %.

Whether conservation tillage increases or decreases the weed density in winter cereals depends on crop rotation and preceding crop. If cereals are grown permanently, conservation tillage promotes above all grass weeds, such as *Alopecurus myosuroides, Apera spica-venti, Bromus spec.*and voluntary cereals, but also some broad-leaved weeds (e.g. *Matricaria inodorum*). If cereals are grown after leaf crops (potatoes, sugar beet, maize), conservation tillage decreases initial weed density by about 40 to 50 %.

The influence of crop rotation and soil tillage on weed infestation is weakened, but not completely eliminated by situation-related use of herbicides. But also the intensity of herbicide use in previous crops influences weed emergence in the following crops. Herbicide use over many years reduces the initial weed infestation in following crops by 30 to 60 %.

In crop rotation with a high cereals proportion, conservation tillage can result in an increase of herbicide input by about 25 %.

Integrated weed management by using cultural and mechanical control methods in combination with situation-related herbicide use prevents durably weed-caused yield losses and the selection of special weed species.

Reference:

PALLUTT, B.: Population dynamics and competition of weeds depending on crop rotation and mechanical and chemical control measures in cereals. Brighton Crop Protection Conference - Weeds - 1197-1204, 1993.

Winter annual legumes for use as cover crops in vegetables

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Abstract

Weed suppression is one of several benefits achieved by including a cover crop in a cropping system. A manifold of studies have indicated less weed suppression in cropping systems with plant residues than in systems with living mulch (Brandsæter 1996). However, a serious problem in living mulch cropping systems is yield depression because of competition. Different ways have been suggested to overcome the competition problem in such cropping systems. The classical attempts to reduce competition in these systems have focused on chemical or mechanical suppression of mulch growth or screening for less competitive cover crops. Experiments at our institute (Brandsæter 1996) have shown that the competition in a white cabbage-spring sown living mulch (white clover and subclover) system was considerable. A considerable increase in cabbage yield was achieved by rototilling between the rows 6 weeks after transplanting. The cover crops did not reduce weed biomass or number of weeds early in the season compared with monoculture, but weed biomass in late summer was less in living mulch. Less insect damage and increased green manure effects the subsequent year were additional benefits. However, this experiment showed the need for finding more suitable species/cultivars for living mulch systems. The goal for our screening experiments, which include so-called winter annual legumes, is to find cover crops with a ‘synchronized’ onset of maximum vegetative growth to avoid damaging competition. Winter annual legumes sown in late summer grow vegetatively during autumn, become «dormant» in winter and resume vegetative growth the following spring. Later in the spring or early summer the plant flowers, senesces and dies. Because of this unique life cycle a main crop transplanted into the senescing mulch (e.g. subclover *Trifolium subterraneum* L.) would be able to use all available water and nutrients. Another approach to using a winter annual legume as a cover crop requires sowing the cover crop, e.g. hairy vetch (*Vicia villosa* Rath.) in the autumn and mowing it immediately before transplanting the main crop in the spring. A requirement for developing cover crop systems with winter annual legumes is to find species and cultivars which are adapted to the local climate and latitude. Therefore, our study was initiated to investigate the following aspects of winter annual legumes: winter hardiness, biomass accumulation and time of termination of vegetative growth, canopy height, regrowth ability after mowing, time of flowering and senescing, ability for rapid ground coverage and weed suppression. Preliminary experiments have shown that hairy vetch is a promising cover crop in cabbage.

Reference:

Brandsæter, L.O. (1996). Alternative strategies for weed control: Plant residues and living mulch for weed management in vegetables. *Agricultural University of Norway, Doctor Scientiarum Theses* 1996, **25.**

Soil covering with grass in apple orchard in Hungary

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Abstract

It was needed to find some soil covering techniques to protect the soil against the compactness caused by the heavy machinery and against the soil losses mainly on the hillsides and on sandy soils. In this work we have to avoid the competition among the ground covering agents or mixtures and the trees themselves. The common method of tilling the whole surface by disking or particularly by rotary hoeing in the season seems to be worthy of controlling the weeds, but it increases the evaporation and energy demands.

6 plant mixtures were tested from the total 13 in the first year as soil covering in apple orchard on sandy soil with the control of natural “self seeding” as mowed weedy surface. The other mixtures are constructed of widely known grass species and/or legumes or a special Hungarian born natural mixture from Hortobágy region.

Measurements were soil moisture and compactness analysis, carried out by a special Hungarian instrument connected to a PSION data recorder in each plots and ground cover percentage in connection with the plant species.

The tendency of the compactness was the highest in case of fibrous root lawn grass based mixtures (Szarvas No. 1.- No.2.) and lowest if we had tested rhizome rooted grasses (*Festuca rubra* or *Poa pratensis*). Surprisingly the weedy control had usually a low or sometimes the lowest compactness.

The moisture content of the soil did not show any significant difference among the tested ground cover mixtures in upper layer of the soil. The only difference was found in the main level of the tree roots area. After the hot summer period the best type was *Festuca rubra* + *Trifolium repens* mixture and the worst was Szarvas No. 1. mixture, while the Hortobágy mixture gave intermediate result.

The relative ratio of monocotyledonous plants was lower in the control plots than in the other treatments. The cover percentage of monocotyledonous plants in the treatments was stable in the last 3 years of this study, except in control plots, where significant difference was found between the years and it was different from all the other cover plots.

Finally we found that the covering can protect moisture losses in orchards, but it can be successful only with dry tolerant local species in connection with their weed controlling effect, because they can suppress the water prodigal annuals as *Amaranthus retroflexus* L. etc. Hortobágy mixture seems worth to be combined with some other species or let it combined with the local weed flora.

Session 1 Cultural methods and their interactions with direct weed control measures

Organizer: D.T. Baumann (CH)

Summary and concluding remarks

In session 1 weed control aspects of cultural methods were discussed. The effects of crop rotation, tillage, seedbed preparation, nutrient placement and the use of cover crops have been presented in four contributions. On top of that two poster presentations dealt with photocontrol of weeds and weed suppression in apple orchards using grass soil cover. The perspectives and limitations of cultural methods have been reviewed to introduce discussion groups on strategic cultural methods (e.g. crop rotation), cultural methods previous to the crop cultivation (e.g. soil tillage, seedbed preparation) and cultural methods during crop cultivation (e.g. nutrient management, cover crops, etc.).

Pallutt presented the results of a long-term experiment carried out to study the effects of crop rotation, stubble-tillage and herbicide use on grass and broad-leaved weeds. He showed that a balanced crop rotation with 50% cereals together with stubble tillage, such as shallow ploughing was efficient to control different perennials and to limit the occurrence of grass weeds. Conservation tillage resulted in an increased herbicide input in crop rotations with high cereal proportions.

Van der Weide and Bleeker presented data on the effect of seeding time, false seedbed and pre-emergence harrowing for weed control in maize. The timing of seedbed preparation and seeding was very important with respect to weed suppression and selectivity of mechanical post-emergence treatments. There was no constant effect of pre-emergence harrow treatments applied as false-seedbed technique. Pre-emergence harrowing, however, clearly interacted with the possibilities to reduce herbicides or the for ongoing mechanical control by reducing the size of the weeds.

The effect of nutrient application on weed control was poorly investigated so far. Rasmussen, however, showed that the placement of nutrients in the soil affects the selectivity of mechanical post-emergence treatments. Slurry deliberately placed close to the crop rows using slurry injection increased the competitive ability of oats against weeds. These results stress the importance of integration of cultural methods for weed control in organic farming systems where herbicides are not available.

Brandsæter showed in his contribution that although interesting effects on weed and pest control and green manuring were found, the competition in a white cabbage-spring sown living mulch system was considerable. The results showed the need for finding more suitable species/cultivars for living mulch systems. Experiments have shown that so-called winter annual legumes may be a way to overcome the competition problems. However, a requirement for developing living mulch systems in vegetable crops is to find species and cultivars which are adapted to the local climate and latitude in combination with different approaches for regulating the growth of the cover crops.

Baumann gave an overview on the perspectives and limitations of cultural methods such as crop rotation, maximizing soil cover, optimizing crop growth, tillage, timing of preventive weed control measures and sanitation aspects in production systems. He stated that preventive methods are not exploit in practice for weed control, that using preventive methods would reduce the necessity for direct control considerably and hence improve the economics of a weed management strategy. He finally concluded that therefore preventive cultural methods should be a mayor topic of the working group.

Based on these statements three working groups discussing on strategic cultural methods, methods previous to the cultivation and cultural methods during the cultivation drew the following conclusion:

- Preventive cultural methods are very important in an integrated weed management strategy. From the past there is information available on the effect of preventive cultural methods, however, it needs to be reviewed and summarized.

- Experiments on cultural methods should focus on the interaction between preventive and direct measures. Cultural methods often require expensive long-term experiments (e.g. crop rotation experiments) which again stresses the necessity of a comprehensive review on available information.

- All cultural methods contributing to a weed management strategy should be discussed within the working group „Physical Weed Control“. However, overlap with subjects of other EWRS working groups should be avoided.

Perspectives and reality about physical weed control in row crops

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Abstract

The major objective of physical weed control in row crops is to reduce or even eliminate expensive and time-consuming hand-weeding of weeds growing in the rows (in-row weeds). Weeds between the crop rows can normally by controlled satisfactorily by inter-row cultivation.

Physical weed control against in-row weeds still constitutes a significant challenge to weed research, although some encouraging results have been achieved recently (Melander, 1998). Mechanical control methods for post-emergence usage, such as weed harrowing, torsion weeding, brush weeding, finger weeding, and rotary hoeing, have all demonstrated low selectivity in sown row crops. In most situations, mechanical weeding can only be done when the crop plants are big enough to withstand mechanical treatment and it may take several days to reach that stage.

On the other hand, weed harrowing has been very useful in transplants, such as cabbage and celery, meaning that weed control can be done without hand-weeding at all. It would be worth studying whether this techniques could be further rationalized in order to make it less expensive and thereby more adaptable to other row crops.

Since selectivity is such a decisive factor to the success of mechanical post-emergence weed control, several investigations have been carried out recently, (or are currently running), to study whether the selectivity can be improved, when mechanical post-emergence weeding is combined with cultural methods and/or physical control methods conducted pre-emergence of the crop, such as false seedbed techniques, pre-emergence harrowing, flaming and soil cultivation in darkness.

Positive effects of the false seedbed techniques need generally to be better documented and soil cultivation in darkness have demonstrated very variable and unpredictable results. Pre-emergence harrowing have shown some perspective results that in some cases were comparable to flaming. Both weed number and weed size were reduced considerably. However, aspects such as crop tolerance and optimal time of treatment are worth studying more thoroughly in future research. Flaming in slow germinating crops seems to be a basic and necessary treatment. Otherwise physical post-emergence weeding would be impossible in most situations. In spite of the fact that both pre-emergence harrowing and flaming normally reduce weed size, no investigations so far have revealed any synergistic interactions with mechanical post-emergence weeding.

High technology, such as automatic/sensor guided systems for the steering of e.g. hoes, brush weeders, or torsion weeders, would mean a major step forward for physical weed control in row crops and such systems might be available within a few years. Weed control by mulching with e.g. paper is another aspect worth emphasizing, as this could lead to an almost 100% weed control through most of the growing season. But the techniques need to be further improved.

Reference:

Melander B. (1998). Interactions between soil cultivation in darkness, flaming, and brush weeding when used for in-row weed control in vegetables. *Biological Horticulture and Agriculture, (in press).*

Finger weeders for future intra-row weed control?

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Abstract

Intra-row weeds and weeds close to the crop plants cause a problem in mechanical weed control, especially for organic farmers. High-tech and low-tech solutions are possible.
The finger weeder seems to be a promising low-tech option.

High-tech solutions

High-tech solutions are largely limited by plant detection and traveling speed. At least 3 options are available:

1) Detection by image analyzing.
2) Reorganizing tactile thinners into tactile hoes with drilling in rectangles, counting of contacts and new electronics, offers limited possibilities. This is caused by the low traveling speed (2.5 km/h) as the discs have to be activated in front of each cross-row of crop plants, a short application method (2-3 weeks), dust and the fact that weeds close to plants can not be controlled mechanically.
3) Similar possibilities, but with a strongly improved design, are found in the rotating hoe. Detection is carried out by 3 infrared light sources and 3 photoelectric cells per row. As the distance between the crop plants is rather constant, the location of the crop plants per row can be determined by means of a FFT-computer program.

The disc with (two) knives rotating at 1000 rpm. is retarded to 800 rpm. at the location of crop plants and so the spring loaded knives are retracted. Detection allows a traveling speed of about 10 km/h. The speed allowed by the knives is not known yet.

Low-tech solutions

Low-tech solutions that also control weeds close to crop plants mechanically are brush- and finger weeders. Brush and finger weeders could be used most effectively for de-ridging of hoe-ridged row-crops.

4) Brush weeders are working well in loose soil, small weeds at a rather low speed of <5 km/h.
5) Finger weeders can work easier within crop rows, because of their shape, also on heavier soils and with some crust on top of the soil. They work also relatively easily in wide spread crops, are ground driven, work best at high speed (>10 km/h), are easily adjustable and relatively cheap.

Finger weeders combined with hoe-ridgers can work 100% of the soil surface.

References:

Kouwenhoven, J.K., 1997. Intra-row mechanical weed control possibilities and problems. Soil Tillage research 41: 87-104.
Kouwenhoven, J.K., Wavers, J.D.A. and Post, B.J., 1991. Possibilities of post-emergence mechanical weed control in sugarbeet. Soil Tillage Research 21: 85-95.

Strategies for optimizing physical weed control in organic and integrated farming

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Abstract

The main influence parameters on the feasibility and success of physical weed control are weather, soil conditions, size of the weeds and the function principles and the operation limitations of the weeders. The economic evaluation of machines or strategies for physical weed control demands information about labour and investment costs, treated area, cropping or weeding result and so on. Many of these date are site (soil and weather), crop or machine specific. The use of specific machines may be limited by soil and weather conditions, weed size, crop sensibility and so on. Machines with wide limits and high capacity will be preferable.

According to these necessities a new mechanical weeder was outlined and transferred into a prototype (spit-hoe Weihenstephan). The design of the implement is a combination of cutting and digging tools with rotating tools. Wide duckfoot shares cut the weed roots and throw up the soil; rotating spring tines remove the soil from the weed roots. Moreover, an optimized thermal weeder has been developed. It improves working velocity as well as reduces energy (gas) consumption dramatically.

The prototypes were investigated in experiments. It could be proved that the limitations of the optimized implements are less than the limitations of the conventional implements. Even in bad conditions, bigger weeds were destroyed completely. The improvements of the new thermal weeder could also be proved in doubling the working velocity and reducing energy consumption by up to 75% as compared to an open burner.

For the economic evaluation of the technical optimizations a mathematical model was developed which helps to evaluate weed control strategies for site (soil and weather), crop or machine specific conditions. Supported by this model, the expected labour requirement and cost for farms of different sizes that are using physical weed control can be calculated. Moreover the necessary machine equipment of specific farms can be estimated (or minimized).

Resistance against uprooting in carrots (*Daucus carota*) and annual weeds - a basis for selective mechanical weed control

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Abstract

Trials were carried out in order to investigate possibilities to achieve selectivity in mechanical weed control. The influence of soil type, uprooting angle and development stage on the uprooting force of some annual weeds and carrot were studied. *Spergula arvensis* L., *Urtica urens* L.,*Chenopodium album* L. and carrot (*Daucus carota* L.) were sown in soil bins filled with four different soil types. The plants were uprooted when they had two true leaves. Soil type significantly influenced the uprooting force needed by all four species. The forces required to uproot *U. urens* and *C. album* differ significantly between peat and loamy sand. In loamy sand *Capsella bursa-pastoris* (L.) Med., *Stellaria media* (L.)Vill , *Chamomilla suaveolens* (L.) Pursh Buch. and *Viola arvensis* Murr. could all be uprooted by less force than it took to uproot carrot. The uprooting angle (0°, 45° and 90°) had no significant influence on the uprooting force for carrot at the studied developmental stage. *C. album*, *S. arvensis*, *U. urens*, *Matricaria inodora*, *Thlaspi arvense* L. and carrot could all be uprooted by less than 1 N when they had two true leaves. Carrots demanded higher uprooting force than the weeds at the three studied early developmental stages. This indicates that is should be possible to develop selective mechanical weed control methods.

Reference:

Fogelberg, F. and Dock Gustavsson, A.-M. (1998) Resistance against uprooting in carrots (*Daucus carota*) and annual weeds - a basis for selective mechanical weed control. Weed Research **38,** 183-190

Experiences with mechanical control and low herbicide doses in carrots

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Abstract

At the Agricultural Department of the University of Horticulture and Food we started a weed control experiment in carrot in 1995. The main aim of the experiment to study the effect when reducing herbicide inputs and of non-chemical treatments. The other aim was to construct and test a weed brush.

We compared the following treatments and their combinations: herbicide application overall, band spraying, flame weeding, harrowing, cultivator or brush weeding, hoeing and hand weeding.

The herbicides we used were metalochlor and chlorbromuron at their recommended doses.

We have counted the number of emerging carrot plants and weeds and later the weed coverage and fresh and dried weight were assessed every 10 day, in the rows and between the rows separately.

Concerning the rows we had measured the labour requirement of weeding in 4 different time, the regrowth of weeds after weeding, and is there any difference between the labour requirement of weeding in the rows if we have used cultivator or weedbrush?

In 1995 we have constructed a brush-weeder in co-operation with the Technical Department of our University. The main difference between the other types of brushes and the brush, developed by us was steel fibres between the plastic ones. Because the flexibility of the steel fibres is different from that of the plastic fibres, the former is cleaning the latter. The working depth of steel and plastic fibres is different, because the steel fibres are less flexible than the plastic ones. The steel fibres work better, have less impact on the soil surface, and reduce the amount of dust, which is often one of the biggest disadvantage of this machines.

Automatic machine guidance

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Abstract

With an automatic guidance system it is possible to increase driving velocity, to reduce labour demand and to improve the quality of the physical weed control by smaller security distances to the crop row which also decreases hand weeding.

The main components of an automatic guidance system are the sensor unit and the controller. As sensoring is being investigated at various research stations the controller and the technical guidance implement are the main research topics in Weihenstephan.

The controller has to deal with a complicated situation, for example soil structure, driving velocity, tractor movement and stones influence the reaction of the system to a given control-output. Therefore a closed control loop has been chosen instead of simple 2 or 3 step controllers.

The experiment were carried out on the test track with ground bed. It could be proven, that a closed control loop increases guidance accuracy considerably in comparison to a 2 step controller. If the driving velocity is used to adapt the control algorithm the result can even be better.

At the moment investigation are carried out, to incorporate an automatic self adaption of the controller to optimize the control result independently from the operator. For this self-adaption a mathematical model for the expected movement of the controlled implement is used. The comparison of the expected movement with the actual movement is the main input factor into the adaption of the mathematical model.

Physical weed control options in automatic/sensor guided systems

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Abstract

Automatic vision systems for weed and crop and precise guidance systems may soon be available for implementation in machinery for physical weed control. Organic farming systems aim to produce e.g. beets and vegetables. In organic beets different inter-row hoeing methods (e.g. torsion weeder) can normally control intra-row weeds when the beet crop has 4–6 leaves. But in earlier growth stages labour-intensive manual intra-row hoeing is the only weed control option at the moment. Hence, the prospect of automated physical weed control within the row has lately gained interest. At the Danish Institute of Agricultural Sciences a Ph.D. project concerning this issue will be initiated spring 1998 (Fig. 1). The project will apply studies in weed ecology as a basis for developing and timing physical methods to control in-row weeds in organic beets (Fig. 2). Physical methods (C) that take into account the processes of competition in time (germination beet/weed – B1 versus B2) and space (distance between weed and beet – A) (Fig. 2). This knowledge is essential in order to specify an automated weeding machine. Furthermore, the knowledge achieved will hopefully help reduce or eliminate the need for manual intra-row hoeing in organic beet production thereby promoting its share of the organic crop production.

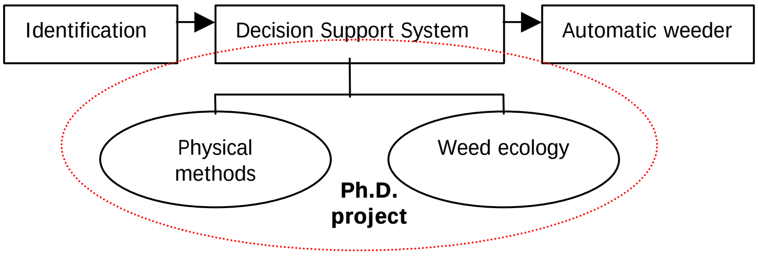

Fig. 1. Components of the future Ph.D. project.

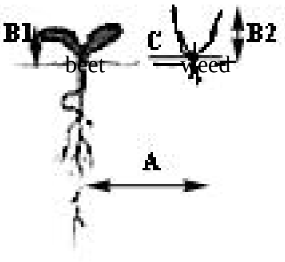

Fig. 2. Spatial (A), temporal (B1 vs. B2) and control (C) aspect.

Many interesting and workshop relevant questions arise:

1. How close to the crop plant do we need to control?
2. This question will be the first to address in the project, in order to specify physical control equipment. If the answer is ‘very close’ (e.g. < 1cm) or ‘close’ (e.g. > 1 and < 5 cm), then what physical weed control systems would be usable in an automatic weeder?
3. Are known systems like inter-row hoeing, torsion and brush weeding or flaming applicable?
4. Or do we need to find alternative methods like cutting, beating or defoliating with e.g. water, iron beater, air, laser treatment etc., that are easier to guide?
5. What is the state of affairs in EWRS?

Mechanical intra-row weed control techniques in row crops

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Different methods for mechanical in-row cultivation are presented and discussed.

A. Inter-row cultivators

Cultivates between rows. Intra-row action by soil covering if plant protectors are removed. Precision guidance needed if cultivation close to the rows.

1. Non-powered
- Ordinary row crop cultivator with sweeps/goose foot shares
- Hillers etc.

2. Non-powered - rotating
- Rolling cultivator (Howard Roll-culi, etc.)
- Basket weeder (Buddingh, USA)

3. Powered - rotating
- Brush weeder (Bärtschi-Fobro, Switzerland, horizontal axis)
- Rotary tilling cultivator

B. Intra-row cultivators

Cultivates close to or in the rows. In-row action by uprooting and covering. Precision guidance.

1. Non-powered
- Torsion weeder (Bezzerides, USA; Moteska, Sweden)
- Spring hoe weeders (Bezzerides, USA)

2. Non-powered - rotating
- Rubber finger weeder (Buddingh Model C, USA; Kress, Germany)

3. Powered - rotating
- Brush weeder (Thermec, Sweden, vertical axis)

C. Weed harrows / tine weeders

Cultivation both inter and intra-row. Action by uprooting and covering. No precision guidance.

1. Non-powered
- Weed harrows (spring-tine harrow/flex-tine weeder, chain harrow, etc.)

2. Non-powered - rotating
- Rotary hoe (several makes)

In addition, hand weeding, inter-row cultivators and weed harrows can be used for ‘cross cultivation’, selectively or non-selectively.

The choice of method depends on several factors including crop, weeds, production system, farm size, available labour and money.

Possibilities of finger weeders

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Abstract

Orientation in the Netherlands in 1997:
in vegetable crops (beans, leek, plated seed onions, planted celery, lettuce and carrots)
two types of soil (clay and sand)
row distance 35, 50 and 75 cm.

Results:
Finger weeder seems useful in a lot of crops.
Minimum row distance should be 50 cm.
Efficacy seems better on clay than sandy soil.
In most crops more selective than harrow.
In combination with a hoe decrease of hand weeding in biological systems is possible.

Questions:
Comparison of efficacy of this weeder with other ‘new’ weeders at different soils
Does it influence yield and quality of different crops?
Is it possible to adjust this weeder for smaller row distances?
Which is the optimale timing, driving speed and adjustment?

Photocontrol of weeds: the seasonal variation in weed reduction of night-time soil cultivation

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Abstract

The German scientists Hartmann and Nezadal published in 1990 a pioneer study where they showed that if all soil cultivations were performed during night instead of day, the weed coverage was greatly reduced. Following studies by e.g. Jensen (1992, 1995), Andersen (1992), Ascard (1994), Scopel et al. (1994) and Niemann (1996) have also shown that weed emergence can be reduced by night-time soil cultivation (this performance is also known as: photocontrol of weeds, night-time harrowing or dark-harrowing). However, there was no effect of night-time treatment in studies by Post (1992) and in some experiments an increase of weed emergence in night-time treated plots was observed (Niemann,1996). This variation in weed emergence can only partly be explained, eg. by seed size (Ascard, 1994) or dry weather conditions (Post, 1992). Thus, we can not predict the result of a night-time soil cultivation, which is a major drawback for its practical application.The aim of this study was to investigate: i)seasonal changes in weed control effect of night-time soil cultivation, ii) changes in weed control effect due to the number of soil cultivations.

Soil from three fields with similar soil type in southern Sweden was placed in plastic boxes in autumn 1994 and kept outdoors untill treated. In April, May and June 1995 boxes of each three soils were placed in a climate chamber with natural daylight while in in August, September and October only soil from two of the fields was used. One half of each box was then cultivated in daylight and the other half during night. Weed counting was performed one month after cultivation.

The results showed that the weed control effect varied from a maximum of about 30 % in May to a minimum of less than 5 % in October. Treatments in April and August gave less effect compared to the May treatment, but resulted in a better effect than the cultivations performed in June and September. The number of cultivations (1, 2 or 3 harrowings) did not have any significant influence on the weed control effect or the number of emerged weeds.

These findings indicate that the treatment time of the year has a great importance on the weed control effect of night-time soil cultivation and therefore can, at least partly, the varying results from previous studies in Europe and the USA be explained. The number of harrowings influenced the weed reduction but no definite trend was found between the number of cultivations and weed emergence. It is clear that the effect of night-time soil cultivation is dependent not only of the light environment, thus there is a need of further investigations of the interactions between eg. soil type, season, number of cultivations and light environment.

References:

A list of references cited is available on request

Good weed control in sugar beets with green methods - a realistic alternative or a dream?

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Abstract

"Green methods" are defined as "methods using little or no input of herbicides". Alternatives to this definition are given. Principle ways to reduce the use of herbicides are:

1. Reducing the over all rate expressed as kg a.i./ha

2. Replacing herbicide treatments with non-chemical other weed control measures

3. Directing the herbicide use to the beet row or possibly the single weed

Integrated and non-chemical strategies for weed control in sugar beets were evaluated over a 3 year period. Several combinations of chemical and mechanical weed control were evaluated in terms of weed control, sugar yield, labour input, costs and energy requirement.

In conclusion, today's mechanical in-row cultivation offers the potential to reduce but not to replace the use of herbicides in sugar beets on a larger scale basis.

Studies into the fundamentals of flaming

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Abstract

Flaming has several advantages. However, it has the disadvantage of polluting the environment with carbon dioxide. For this and also for economic reasons, it should be of primary interest to cases where other non-chemical methods are not satisfactory and the energy efficiency should be improved. This paper deals with three basic laboratory investigations regarding energy efficiency and two basic dose-response experiments in the two cases where flaming is of greatest interest in practice. The laboratory investigations comprised the effect of flames on plants, temperature distribution within the flames, and also design, adjustment and practical use of the equipment. Calculation formulas are developed and relationships established within and between each of the laboratory investigations and - to some extent - between those and the field trials.

The main conclusion of the laboratory experiments on effect of flames on the plants is a confirmation of the energy equation: *Energy = (Temperature time constant)* as also is true for these very high temperatures, and further that, at low temperatures, more energy is needed to kill plants than at high temperatures. High temperatures are achieved by keeping a short distance between the burner and the plants. But increased gas throughput only raised the temperature at distances larger than 10 cm from the burner muzzle. The experiments on improving flaming equipment show that the treatment time may be considerably lengthened, and the temperature at the ground considerably improved, by using long and low cowers provided that the burner gets air enough for complete combustion.

Temperature measurings in the airborne flames showed that the round burners, gave far higher temperatures at 30 cm distance to the plants and at 22,5 burner angle than did the flat burners. On the other hand, the round burners have far narrower flames than the flat ones both at short distances and larger angles. In ordinary flaming under cover long flames are favourable, while in selective in-the-row flaming short, wide and thin flames are favourable. Burners mounted under a cover, normally are far more effective than open ones. But the the particular operation of selective flaming with wide, flat, open and inclined burners is also efficient. Then the flame hits the ground at only 8 to 10 cm distance from the burner muzzle and we only want the about 20 cm long, 'hot core' in the flame sweep for forming the flamed band along the plant row. The great width of the hot core from two flat burners following each other, gives a long bandforming, contemporary flamed rectangle and thus a long treatment time.

Dose-response investigations into selective flaming in various crops

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Abstract

The two above institutions have carried out field experiments on the dose-response relationship in selective flaming after setting or transplanting in onion sets, several *Brassicas*, the two celerys, beetroot, swedes, *Melissa officinalis* and *Mentha x piperita*

The flaming was carried out ten to twenty days after setting or transplanting as soon as the weeds emerged to having grown four permanent leaves and again after two to three more weeks. These flaming doses were applied: 0, 30, 50, and 70 kg of gas/ha actually being flamed, in some cases also 90, 100, and 110 kg/ha. In all cases but one, a manual flaming cart with inclined unshielded burners was employed. The first treatment in onion sets at Ås in 1991 was carried out using a tractor mounted flamer with a long, low shield . The effect of the flaming on both the weeds and the crop plants was recorded by assessment, and in some cases by counting and weighing. The assessing took place a few days after the flamings, in some cases followed by a re-assessment about 30 days later.

The effect on weeds and crop plants was clearly increasing with increasing doses. On the weeds the increase however, diminished for dosees above 70 kg/ha. For the crop plants, assessments generally show the highest rate of damage for the first flaming, mostly due to burn patches. The second flaming caused less damage, and the late assessment showed another picture. For smaller doses, the crop plants were restrained by the now taller weeds. Besides, the middle-dose crops had increasingly recovered from burns. Therefore, the dose-respons curves at this late stage assessment are rather similar to the yield curves.

All the vegetable crops responded favourably to selective flaming. Of the herbs, only the *Mentha* in the first year of growth came well off. Dose-response curves for yield and/or late assessment of the crop plants culminated at doses 50-90 kg of gas per hectare flamed. An exception was the set onions curves from Ås, culminating already at 30 kg/ha as compared to 70-90 kg/ha in Hordaland. The main reason probably was that shielded flaming gives no protection to the "heart leaves" of the crop plants, as the inclined flat burners method do. The growth was somewhat retarded by the doses 50 and 100 kg/ha. Damages from flaming under a shield were even more prominent in the *Mentha* crop. In the first year of growth, when flaming with inclined open burners was practicable, the *Mentha* came well off with doses up to 50 kg/ha. In the second year of growth, however, its ground-covering mode of growing demanded the shielded flame method to be used. Especially in cauliflower and stalk-celery, the results were somewhat uncertain.

Physical changes in the weed plant in thermal weed control

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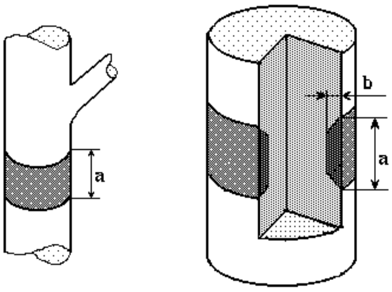
Abstract

The authors suggest the use of thermal-water knife and present theoretical substantiation of the former. Air is not the most efficient transfer of heat, and can be successfully substituted by steam. In order to save heat energy the thermal method of the weed plant injury is expedient to he changed to the heating of that part of the weed plants organs which is of vital importance.

Thermal injury of the weed plant stem biological functions, e.i. 2-5 mm belt affected by high temperature, thus forming a thickness ring of injured tissues around the stem (picture 1) is sufficient to kill the plant.



Picture 1. Ring of thermally injured plant tissues:
a-width of the injured ring;
b-thickness of rings of injured tissues

This method of plants-weeds destruction can be called the thermal knife.

Thermal balance of the plant tissues injured by thermal knife, can be made and commonly expressed by the following equation.

$$dq = \alpha F \tau dt = mcdt + rdw$$

$$q = \alpha(t_1 - t_2)F\tau = mc(t_a'' - t_a') + rw\tau$$

Here q-warmth, involved in the heating process, J; a- the coefficient of heat transfer, W/(m^2·K); t_1 and t_2- temperatures of the fluid and surface of the heated plant correspondingly,^{o}C; F - surface area of the injured ring in the plant, m^2; τ- duration of heating, s; m- mass of the thermally injured ring in the plant,kg; c- specific heat of plant tissues,J/(kg·K); t'_a, t''_a -temperature of plant ring before and after the heating correspondingly, ^{o}C; r- heat of evaporation, J/kg; w-evaporated moisture, kg/s.

The analysis of thermal balance equation makes it possible to chose economically rational heat trans fer for weed control.

References:

Ascard Johan. (1988). Thermal Weed Control in Flame Treatment: A Useful Method for Row-cultivated crops and Haulm-Killing in Potatoes, 29 th Swedish Weed Conference, Uppsala 27-28 January 1988 Vol 1. Reports 194-207.

Holmoy, R. og Storeheier, K.J. 1993 Selective flaming in the plant row and basic investigation and developments of flamers Non Chemical Weed Control, Communications of the Fourth International Conference I.F.O.A.M. Dijon (France) July 5th - 9th, 1993: 157 - 162.

Sirvydas A.P.,Termoenerginiai procesai augaluose ir jų aplinkoje, Kaunas-Akademija 1993, p.318

Laboratory assessment of crop tolerance to selective flaming

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Abstract

In selective flaming, flames are directed to hit the crop row at soil surface at the base of the crop plants. However, the soil surface is often uneven, and flamers do not follow the soil surface nor the crop row exactly. As a consequence, the flames do not always hit where they are intended. Flames that unintentionally heat the upper parts of the crop plant may damage it, but in field conditions it is difficult to separate flaming injury, weed competition and impact of other factors on crop yield. To overcome these difficulties, we developed a laboratory method which enables researchers of thermal weed control to assess crop tolerance to selective flaming.

Two burners were mounted on a trolley on steel rails. They were directed at an angle of 40° from both sides towards the crop plant. The burners were alternately mounted, 20.5 cm apart. Propane dose was adjusted by changing the velocity of the trolley. Temperature measurements: K-type thermocouples were mounted on a vertical steel bar in 2.5 cm intervals to show the vertical heat distribution of the flame. The steel bar with thermocouples was mounted in line with the test plants.

The flame height was adjusted to hit the vertical center line of the crop i) at soil level, ii) at middle of the height of the crop plant, or iii) at the top of the crop plant. Crop plants for the laboratory test were grown in pots, one plant per pot. We flamed four plants, with 50 cm intervals, during one pass, and had three "replicates". Thus twelve plants received each treatment. After flaming the plants were grown for further 14 days. The fresh weight of the plants were recorded.

We have tested cabbage and red beet tolerance to flaming with this method. We used two growth stages of each crop species, recording number of leaves, average height of the plants, and thickness of the stem and leaf of randomly selected plants.

The method can be used to determine whether there are susceptible plant parts, that do not tolerate misdirected flames, i.e. is the exact directing of the flame essential to avoid crop damage. Also, the feasible dose at each growth stage may be assessed with this method. When several dose levels are used in the laboratory test, it is possible to estimate the dose-response relation at the given growth stages and flame directions.

Selective flame weeding in maize, sunflower and soyabean

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The effects of flame weeding on three of the main spring-summer crops cultivated in Italy - sunflower (*Heliantus annuus L.*), maize (*Zea mays L.*) and soyabean (*Glycine max (L.) Merr.*) - and on three of the most important and diffused macrotherm weeds - velvetleaf (*Abutilon theophrasti L.*), common amaranth (*Amaranthus retroflexus L.*) and cockspur grass (*Echinocloa crus galli L.*) - were evaluated in controlled condition. The tests were carried out, by means a test bench, in different stages of development of the plants comparing 20 different treatments obtained by the combination of 5 different driving speeds (from 1 up to 9 km h^{-1}) and 4 LPG pressures (from 0.1 up to 0.4 MPa).

CROPS. After flaming plant damage was evaluated according to the methodology proposed by EWRS for herbicides (modified). Afterwards the plants were transplanted and commonly cultivated. At harvesting stage grain yield of all the treated plants and of an untreated control were determined. There were no significant differences in yield between the different flame treatments and the untreated control in the crops. Plant damage observed after flaming in many cases did not influence grain yield, that was on the contrary influenced by LPG pressure.

In maize and sunflower pressure affected deeply grain yield in both the stages of development; as a matter of fact with the highest value of pressure (0.4 MPa) was obtained the lowest grain yield. In soyabean this effect was less evident.

On the other hand, the use of different driving speeds did not seem to affect grain yield. Moreover, the stage of development in which flaming caused the lowest damage seemed to be 4 true leaves for sunflower and maize, while there were not significant differences for soyabean.

WEEDS. The results of the tests carried out on the three different species emphasized that weed control is closely influenced by both the LPG pressure and the driving speed. In this respect, weed control always decreased as the driving speed increased and increased with the increase of LPG pressure. This trend is less evident for common amaranth in the first two stages of development in which a control of 100% was achieved independently from LPG pressure and driving speed.

As a matter of fact weed control is significantly influenced by LPG consumption per hectare for all the three tested plants.

The weed that showed higher problems to be controlled by flaming was cockspur grass, particularly in the first stage of development. Moreover for velvetleaf and common amaranth there was a clear trend to increase the resistance to flame treatment as the stage of development increased (according to the results obtained in previous experiment for rape), while cockspur grass showed the highest resistance in the first and the lowest in the last stage of development.

Technical investigations of 12 m finger harrow - variations in working intensity across the working width

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Abstract

When using finger harrow it is very important to obtain good selectivity all over the field. Therefore, it is essential to be able to examine the performance of each individual finger in order to obtain information about the dependency of the soil structure and the suspension of the harrow. Extensive development work is made to obtain high capacity in physical weed control. The working width of finger harrows is increased considerably, so that thereby it becomes the same as for field sprayers. One of the reason for that is that many farmers use both finger harrows and field crop sprayers to decrease the consumption of pesticides. For that purpose it is very important that the same working width can be optained with both applications systems. For field crop sprayers there are existing a lot of standardised measurement methods (ISO, CEN), so that the farmer can be sure that he can obtain a good result in the field. Such methods doesn't exist for finger-harrows. The purpose of this project has been to study whether a uniform mechanical soil treatment across the direction of travel can be achieved with 12 m finger-harrows. To fulfil the purpose with the project it was necessary to develop a technical method for measurement of the working intensity across the working width. The measurement method was based on the fact that an equal working intensity across the driving direction can only be obtained if the individual fingers of the harrow provide the same quality of work. Each finger should then work with the same intensity or the same deflection from the neutral position. Measurements were made on five fingers in the centre of the harrow, five fingers at the end of the harrow and five fingers between this to measurement areas. The system was based on strain gauge measurement. A Strain gauge is a slight electrical resistance, witch can be directed towards the harrow finger. By use of strain gauge one can measure the deflection of the harrow fingers, and when this is done sufficiently accurate, the movements of the fingers can be calculated. A strain gauge was placed on each finger , and the signals were delivered via a 16 channel mechanical multiplexer to a CR-10 measurement - and control module unit. The signals were transmitted to a computer, where the calculations were made. The results shows that the individual fingers work with different intensities and are highly varying form the middle to the end of the harrow.

Also, due to the stochastic interaction in the soil, the working intensities of the individual fingers in each link differ a lot. Furthermore the result show that the strain gauge method can be used to measure the working intensity across the forward direction. The variations in intensity from the individual fingers can be reduced by using controlling systems and/or by manually optimising the single link in the finger harrow to the soil structure.

References:

Høy, J.J. and Nielsen, J.J.; Landskontoret for Bygninger og Maskiner, Lund, I.; Forskningscenter Bygholm and Rasmussen, J.; Forskningscenter Flakkebjerg. (1997): Langfingerharver - sammenlingning mellem forskellige harvetypers tekniske virkemåde og deres selektive virkemåde ved ukrudtsharvning i korn. Erhvervsfinansieret Planteavlsfforskning -og udvikling. Landbrugets Rådgivningscenter, 37 p.

Lund, I. (1996): Langfingerharvens tekniske virkemåde. NJF-Teknik - Seminar nr. 268. 6 p.

Does harrowing affect the incidence of leaf diseases in winter wheat?

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Abstract

To control cleavers in cereals mechanically it is often recommended to treat the crop rather late during the growing period. What kind of side-effects to crop health can occur due to this application? Field experiments were carried out in 1994 and 1995 on a loamy clay soil. Experimental layout was a randomised block design with four replications. Winter wheat cultivars either a susceptible variety (cv. Kanzler) or a mixture of three less susceptible varieties were harrowed with different intensity. Applications were conducted as follows:

0 No treatment, herbicide application only
1 Harrowing one time at end of tillering (DC 29)
2 Harrowing two times: begin and end of stem elongation (DC 32 and 39)
3 Harrowing three times (DC 29, 32 and 39)

Two examples are given from powdery mildew and leaf rust to demonstrate different response of the two pathogens (Fig. 1). Incidence of mildew was not affected by increase of harrowing intensity, however the level of infection was rather low. Extent of rust infection showed an obvious response to the weed control treatments. More frequent and late applications favoured leaf rust.

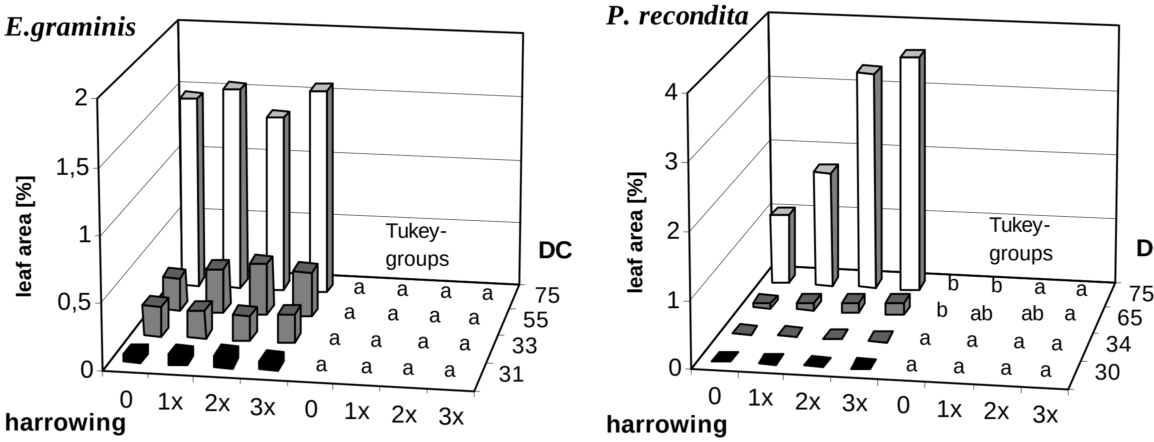

Figure 1: Impact of harrowing intensity on the incidence of powdery mildew (*E. graminis*) and leaf rust (*P. recondita*). Means of three upper leafs and all varieties. Tukey-grouping between treatments at each growth stage ($p < 0,05$).

Significant interactions between intensity of harrowing and wheat variety occured in 50% of the experiments. Incidence of leaf rust in the susceptible variety Kanzler increased with more frequent harrowing as well as grain yield decreased. In the less susceptible mixture of varieties no response due to more frequent use of harrow was observed. It is concluded, that yield depressions due to harrowing may depend on higher infection of fungal diseases indirectly.

Leaf damages occured when harrowing was carried out late in the growing season. Before DC 37 new leafs are produced quite soon after application, so there is no need to care too much for them. For the three upper leafs calculations showed a relation between damages and incidence of rust in cv. Kanzler. The infection of rust is normally not promoted by wounds. Therefore it can be assumed a induction of pre-disposition for infection in the susceptible variety.

Reference:

J. Kakau, M. Sievert, H.-H. Steinmann**.** Auswirkungen mechanischer Unkrautbekämpfung im Winterweizen auf den Befall mit Blattkrankheiten. **-** Z. Pflanzenkrankheiten und Pflanzenschutz, Sonderheft XVI, 705-712, 1998. (in german, english summary)

Experimental tests of weed control by means of finger harrowing in durum wheat

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Abstract

Past research on mechanical weed control in winter cereals has often given contrasting results. The present study aimed to investigate on the effects of tine adjustment and number of passes of a finger-harrow on yield of durum wheat and weed control in different tillage systems in a two-year period (1995-96). The tests were carried out at the Centro Interdipartimentale di Ricerche Agro-Ambientali E.Avanzi? of the University of Pisa on a loam soil. A 12 m wide operative machine equipped with eight small modular frames elastically connected to the main frame was always used to perform finger harrowing on ploughed and untilled soil. The implement was coupled to two different FWD tractors (48 kW and 74 kW). Four tine adjustments (-30 E, -15E, 0E, +15E with respect to the normal to soil surface in the driving direction) were factorially combined with two treatment intensities (one or two passes) and compared to in conventional tillage and no-tillage. The mechanical weeding was compared to the conventional post-emergence chemical weed control and an unweeded control.

The mechanical results emphasised that, as tine inclination increased - both on ploughed and untilled soil - also working depth, fuel consumption, drawbar pull, pulling power and tractor slippage increased, while driving speed and work-chain productivity decreased. These characteristics were also clearly influenced by soil moisture and plasticity. However, the use of the finger harrow was generally connected with low energy and power requirements and high timeliness.

The quality of work of the weeding harrow was different for the eight different treatments both in ploughed and untilled soil. In both 1995 and 1996 the better results (high weed control and reduced crop damage), were obtained performing double treatments in both tilled and untilled soil. Although the best yield results were achieved with herbicide application, the most effective tine adjustment was + 15E on ploughing and -30, -15 on no tillage in 1995, while in 1996 there were no relevant differences among the different tine adjustments used.

Yield of finger-harrowed durum wheat was comparable to that obtained with herbicide use only in 1996, whereas in 1995 it was often even lower than that of the unweeded control, especially in conventional tillage.

Differences in crop yield and weed control between years and tillage systems were independent of initial weed density and depended mainly upon composition of the weed community, differential effect of finger-harrowing on selected weeds (especially on bullwort and canarygrass) in the two tillage systems and seasonal conditions. Overall, the effect of tine adjustment and treatment intensity on crop and weeds within a given tillage system was not very high.

In conclusion, the high working productivity and the low cost of the finger harrowing make this method competitive with the conventional application of herbicides and suitable for an integrated or even only physical management of weed control in durum wheat, although there is a clear need of further research work to assess the more effective adjustments in different soil types and operative conditions.

Targeting spring-tine weeding and inter-row hoeing in winter wheat by means of the critical period of weed competition.

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Abstract

Presently, there is little information on the optimum timing for mechanical weed control in terms of its ability to control weeds and produce a crop yield benefit. To identify the optimum timing for weed control, it seems appropriate to identify the time or period when weeds are likely to exert their greatest competitive effect on the crop and/or when the crop can least tolerate weed competition viz. the critical weed free period. The identification of this period will allow farmers to target weed control for maximum crop benefit.

The critical period represents the time interval between two separately measured components: the maximum weed-infested period or the length of time that weeds which have emerged with the crop can remain before they begin to interfere with crop growth; and the minimum weed free period or the length of time a crop must be free of weeds after planting in order to prevent yield loss. These components are experimentally determined by measuring crop yield loss as a function of successive times of weed removal or weed emergence, respectively.

Two experiments were conducted at Elm Farm Research Centre between 1994 and 1996 with the aim of identifying the critical weed free period in an organically grown winter wheat (Triticum aestivum L.) crop. The experiment conducted in 1994-95 demonstrated that no yield benefit will be obtained if weed infestations are low, hence the critical period cannot be the sole criterion for a weed control strategy. The experiment conducted in 1995-96, however, had a considerably larger weed infestation, which mainly comprised Tripleurospermum inodorum Schultz Bip. and Alopecurus myosuroides Huds. The identification of the critical weed free period was dependent on the imposition of an acceptable yield loss. If a 10% yield loss gives a marginal benefit compared with the cost of weed control, the critical period will begin in early November and finish in late March. Weed control, therefore, must be implemented either before and/or during this period to ensure maximum benefit to the crop.

The exact timing of weeding will depend on the method of weed control used. For example, spring-tine weeding is most effective when weeds are small and consequently more vulnerable to soil coverage whilst the efficacy of inter-row hoeing is less dependent on weed developmental stage. Spring-tine weeding, therefore, will need to be conducted prior to the onset of the critical weed free period before the weeds become too large. Inter-row hoeing, however, will be able to effectively control weeds either prior to or during this period.

The development of a mechanical weed control strategy, therefore, must take account of both the timing and duration of weed competition as well as weed development in relation to effective mechanical control.

References:

- Welsh J P. (Submitted March 1998). Developing strategies for weed control in organic arable systems. Ph.D. Thesis, Departments of Agricultural Botany and Agriculture, University of Reading.

- Welsh J P, Bulson H A J, Stopes C E, Froud-Williams R J and Murdoch A J. 1997. Mechanical weed control in organic winter wheat. Aspects of Applied Biology 50: Optimising Cereal Inputs - Its Scientific Basis. 375-384.

- Welsh J P, Bulson H A J, Stopes C E, Murdoch A J and Froud-Williams R J. 1997. The critical period of weed competition and its application in organic winter wheat. Proceedings of the 1997 Brighton Crop Protection Conference - Weeds. 105-110.

Thoughts about weed harrowing research and its benefits to farmers

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Abstract

Do research into weed harrowing improve farmers ability to control weeds? Is it possible to assess links between progress of research and progress of weed control at the farm level? Is it possible to assess the success of weed harrowing at the farm level? These questions are linked and it is not possible to answer the first question without being able to answer to last. A method is put forward to assess the success of weed harrowing at the farm level.

To express the success of a weed harrowing one has to think about meaningful success criteria. In my opinion weed harrowing is successful when a high degree of the potential weed free crop yield is achieved. If weed competition is insignificant due to low weed densities or low competitive weeds, weed harrowing is successful when no crop damages is associated with harrowing. In some cases the most successful action might be not to harrow. If weed competition is significant weed harrowing is successful when high degrees of weed control is achieved without associated crop damages.

At the farm level it is only possible to assess the potential weed free crop yield by removing weeds before competition starts. Weed free plots can be obtained by hand weeding or by use of selective herbicides. Currently it is not possible to estimate crop yield losses from weed records in unweeded plots.

A series of data including crop yield in unweeded plots, weed free plots and weed harrowed plots is used to test the success of harrowing expressed as the obtainable degree of the potential weed free crop yield. Regression analysis is applied. Percentage crop yield gain by selective weed control (hand weeding or selective herbicide) is used as the independent variable and percentage crop yield gain by weed harrowing is used as the dependent variable. To make proper regression analysis data from at least 10 fields should be included in one data set.

A series of German experiments has been used in preliminary tests. The experiments were carried out in spring and winter cereals. High densities of annual grass weeds were present in several fields. Regression analyses showed that weed harrowing as practised gave approximately 50% of the yield gain compared to effective and selective herbicide use. In the analyses “year” came out as a significant class variable showing that the success of harrowing was varying among years.

At the time being validation of the method requires a joint action between a number of countries due to lack of appropriate data. It is believed that the proposed method can improve our knowledge about factors affecting the success of weed harrowing at the farm level. Therefore, I hereby invite all researchers who already have or intend to get the data in question, to contact me.

Selective working mechanisms of spring tine harrows

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Abstract

In order to predict and improve the weed control selectivity of tined implements like spring tine harrows, a better understanding of the working mechanism is necessary. During the pass of the implement, plants are uprooted and /or covered by soil. Subsequently, the plants react to this mechanical damage by re-rooting, breaking trough the soil cover, or by being killed. It is important to distinguish this damaging and recovery process, because plants can have different sensitivity to both processes. Furthermore, soil properties and weather play a different role in each process.

Laboratory harrowing experiments with model weeds on sandy soil were performed to examine the effect of working depth, speed and soil moisture content. The position of individual plants was digitised before and after harrowing. After placing the soil bins in a climate chamber for 6 days, surviving plants digitised and weighed individually, so the growth reduction could be related to the damage of each particular plant. The path of the harrow tines was digitised as well, so the uprooting and covering process could be studied in detail.

Seedlings that meet a tine path are uprooted for about 65%, independent on their size. Selective uprooting occurs only in failing soil beside the tine. When garden cress (*Lepidium sativum*) seedlings were 15 mm tall, they were nearly not uprooted (< 5%) by a tine passing at 6-12 mm distance. At the same tine-plant distance, seedlings that were about to emerge were uprooted for 35%. In moist, coherent sand (17% w/w moisture content, density 0.95 kg/l), uprooting was much more selective than in dry, fragile soil (<12.5% moisture content). Working depth and speed had no effect on selectivity.

Covered plants that were not uprooted were not killed, but they had a 16% lower fresh weight compared to plants of the same size that were neither covered nor uprooted. Uprooted plants were only killed if they were not or only partially covered by soil (at 85% air humidity, 18°C). Apparently, the soil cover reduces transpiration. The movement of uprooted plants and the depth of the roots in the tilled layer is also important. Fresh weights of covered uprooted plants that were moved farther than 8 mm from their original position were reduced for 59%. Covered loosened plants (uprooted, < 8 mm moved) showed only 39% fresh weight reduction. A speed increase from 1.2 to 2.4 m/s did not rise the uprooting percentage, but increased the control of visible uprooted plants from 69% to 85%.

Big seedlings (15 mm tall, 2 leaves) experience more resistance from a soil cover than seedlings that have not yet completely unfolded their leaves. This becomes even more pronounced in moist soil. In another series of experiments, quinoa (*Chenopodium quinoa*) was harrowed just before emergence, and put in the climate chamber at a lower (55%) air humidity. In these conditions also covered uprooted plants were partially (25%) controlled. The effect of soil moisture content and speed on mortality of uprooted quinoa white treads (at 55% r.h.) were much higher than the effect on garden cress seedlings (at 85% r.h.). This indicates that white threads are more sensitive to desiccation.

These results show that soil properties have an important effect on harrowing selectivity. However the importance of soil conditions has been widely recognised, it has not been studied systematically. The effectiveness of covering weeds with soil needs to be improved, especially under wet conditions. Seedbed properties can also affect uprooting selectivity, by influencing anchoring strength of crop plants and weeds, force transmission on plants by moving soil and by passive steering of flexible tines.

Except fundamental knowledge of mechanical behaviour of soil and plants, it seems worth while to include a few simple measurements on soil strength, plant anchoring strength and soil disturbance in field experiments with harrows, brushes, finger weeders and torsion weeders. Furthermore, practical methods for assessing the type and degree of mechanical damage should be developed. An accurate damage diagnosis can assist in finding situation-specific optimum implement adjustments, and help predicting the weed control effect.

Guided mechanical weeding in winter wheat - outline of a new project.

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Background.

From 1993-1996 ADAS and IACR Long Ashton have been investigating the combination of low rates of herbicides followed by tined mechanical weeding for weed control in winter wheat.

The general conclusions were;

- A twin row arrangement of 2 closely spaced (10 cm) row separated by 25 cm did not result in significant yield loss. This configuration offers the possibility of more robust weeding within the 25 cm inter-row space.
- An appropriate herbicide applied at 20% of full dose followed by mechanical weeding within 7-10 days gave good control of broad-leaved weeds.
- Grass weed control using this system was NOT adequate.

This project concluded after harvest in 1996 and a new project funded by Ministry of Agriculture commenced in April 1997.

New project

The new project was based around the hypothesis that if a weeder could be guided down the wide row spacing, then more robust weeding could be used between the crop rows. Video camera(s) mounted on the tractor view 3 or more rows of crop and use this image to adjust the weeder as it progresses through the crop.

Weed control within the crop row may be done by localised herbicide applications thus reducing the total amount of herbicide used. This objective may be achieved by using herbicide treated seed, dribble bar / coarse nozzles or by granules.

The approach tested in the previous project (overall spray with subsequent tine weeding) will also be pursued with new active ingredients and the appropriate doses for key species will be selected in controlled conditions at Long Ashton.

References:

Blair, A.M., Jones, P.A., Orson, J.H. and Caseley, J.C. (1997) Integration of row widths, chemical and mechanical weed control and the effect on winter wheat yield. *Aspects of Applied Biology*, 50, 385-392.
Marchant, J.A. (1996) Tracking of row structure in three crops using image analysis. *Computers and Electronics in Agriculture*, 15, 161-179.

EWRS

3rd EWRS Workshop on Physical Weed Control

Wye College,
University of London, UK

23-25 March 1998

Objectives

- Provide platform for research on physical weed control
- Define current state of the art
- Discuss future research priorities
- Have good discussions and fun

Programme

1. Cultural methods and their interactions with direct weed control (5)
2. Mechanical weed control in row crops (12)
3. Thermal weed control (7)
4. Mechanical weed control in broadcast sown crops (8)

1. Cultural methods and their interactions with direct weed control

- Review on preventive cultural methods
- Study of interaction between preventive and direct methods
- Development of multipurpose cultivation systems (e.g. intercropping)

☞ Cultural methods are an important research topic and should be covered by the WG

2. Mechanical weed control in row crops

- Effect and use of tools for mechanical weed control is limited
- Mechanical weed control can be optimized by developing strategies
- Guidance systems helps to control weeds where they need to be controlled
- Wide range of tools provide possibilities for selective in-row control

☞ Selectivity is still a key factor and needs to be improved

3. Thermal weed control

- New technology is on the way and (commercialy) available

- Incorporation in weed control strategy
  - Economical optimization
  - Catch the weed - game for farmers

- Ongoing research on selectivity (laboratory and field experiments)

☞ Organic farming without thermal control is impossible?

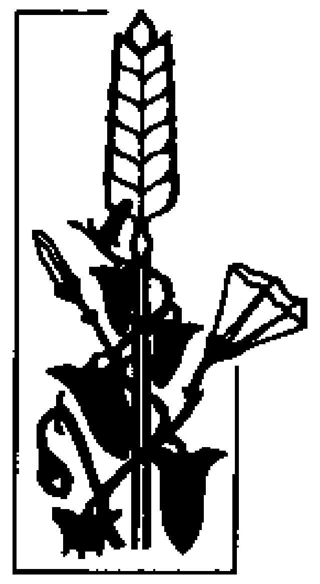
4. Mechanical weed control in broadcast sown crops

- Higher level of understanding of the working principles is reached
- Mechanical control in cereals goes high-tech
- Role of soil conditions for selective control methods are recognized, more research is needed

☞ Working group members have more chance to survive the 21st century

Future activities

- Workshop proceedings (deadline for submission of abstracts to Jesper: 15. April 1998)
- Literature- and publicationlists on the web (DC)
- Discussion group on physical weed control (JM)
- Glossary for implements and tools (DC)
- Demonstration of machinery at EWRS Symposium Basel 1999 (DB)
- Session on physical weed control at Basel 1999
- Contribution to IFOAM meeting Switzerland
- Review of specific topics (RW, RR, DK)



EWRS

4rd EWRS Workshop on Physical Weed Control

The Netherlands

End of March 2000

3rd Workshop on Physical Weed Control, 23-25 March 1998, Wye UK **List of articipants**

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