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General presentations

General information about organic agriculture and physical and cultural weed control in Turkey

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Turkey is a major producer and exporter of various agricultural products. Organic agriculture was commenced with the international demand from major export partners. Production has been realized according to the standards and certification systems of the importing countries, which were mainly EU countries. Currently 103.190 hectares of agricultural land are cultivated organically, which corresponds to 0.4% of the total agricultural area. Initially, dried grape and dried fig was (were) the main organic products exported from Aegean Region. By the time new products such as dried apricot and nuts, were added to the export products and organic agricultural export spread to all regions in Turkey. In order to be harmonious with the organic farming improvements in EU, with the collaboration of some organizations, institutions and Ministry of Agriculture and Rural Affairs, regulation on 'Methods of Organic Production of Vegetal and Livestock Products' came into force after it was published in Official Gazette. The new regulation contains rules, techniques and requirements for the production and processing of vegetal and animal products, harvesting of the crops, labeling, packing, storage, transportation, inspection, certification and marketing. There are two levels of organic farming in Turkey, namely, certified organic production and non-certified or agro-ecological farming. Certified production is mostly geared to products destined for export to EU. Non-certified products are being tried to be introduced in small province to Turkish consumers

Organic producers have limited tools for managing weeds. Numerous surveys of organic producers reveal that weed control remains a major concern for practicing farmers and is a barrier to converting to organic management by transitioning farmers. Mechanical cultivation and hand hoeing are the most common methods used to control weeds in organic production in Turkey. But, the details of other weed management approaches used will obviously vary from crop to crop. We have drawn some of information that obtained in organic weed management for specific crops based on the results of research work and practical experience in Turkey.

Crop management

This methods including choosing varieties, seeding rate, crop spacing and crop establishment. The most effective way to control weed growth is to have highly competitive crops. (i.e. rice).

Mulching

This method provides a physical barrier to weed development and it is often used in horticultural crops to control weeds (i.e. vegetables, citrus, and wineyard)

Allelopathy

Some plant species compete with each other by releasing chemical substances that inhibit the growth of other plants.

Use of cover crops for different vegetable and horticulture crops (i.e.grain sorghum (*S. bicolor*), sudangrass [*Sorghum vulgare* Pers. var. sudanense (Piper) Hitchc.], hairy vetch (*Vicia villosa*), grain amaranth (*Amaranthus cruentus*), pea (*Pisum sativum*) ryegrass (*Lolium multiflorum* L.), oat (*Avena sativa* L.), rye (*Secale cereale* L.), wheat (*Triticum aestivum* L.), gelemen clover (*Trifolium meneghinianum* Clem.), Egyptian clover (*Trifolium alexsandrinum* L.), common vetch (*Vicia sativa* L.).

Selecting allelopathic crops can be useful in particularly weedy fields with reducing overall weed pressure (i.e. rice)

Using sun-dried olive processing waste (OPW) in growing different vegetable crops

Mechanical weed control

This method provides an overview of the range of options and implements available for direct mechanical weed control in the field (i.e maize)

Manual weed control

This method is still an important component of many weed management program and this section provides an overview of techniques available for use on farm (i.e. chickpea)

Thermal weed control is becoming more popular and is described in this section (i.e. wiyneyard)

Grazing

Depending on the weeds and their growth, it could be able to use grazing animals to such as heep, goats,

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Highlights from recent research in physical and cultural weed control at Aarhus University

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The perennial species, *Tussilago farfara* and *Cirsium arvense*, are problematic weed problems in organic farming. Especially, *T. farfara* is poorly studied and there is an urgent need for better management strategies. However, several perennial species often occur in the same field simultaneously and weed control strategies need to address a mixed occurrence of perennials. A field study on a sandy soil showed that p.t.o.-driven rotary cultivators used twice, with a 3 week interval between treatments, in the stubble period after harvest of spring barley markedly reduced a mixed stand of *T. farafara*, *C. arvense* and *Elytrigia repens*. If the treatments were followed by cultivation in spring - and the whole strategy was repeated again following the subsequent crop - an accumulated reduction of more than 95% was achieved for the mixed stand.

For the control of *E. repens*, we are also investigating an innovative approach: effective uprooting, exposure and destruction of rhizomes in one go using new machinery. We are looking for new tool configurations that ensure an effective uprooting of rhizomes including methods that instantly can destruct the sprouting ability of exposed rhizome buds. This will allow the return of nutrients imbedded in the rhizomes but with now risk of re-infesting the soil with *E. repens*. Thermal destruction using hot water is effective, but energy demanding, and removal of rhizomes from the field for composting and then returning the compost is too laborious and costly. However, crushing rhizome buds using pressure appeared promising.

Band-steaming is now used commercially for organic carrot production in Denmark and the performance of two band-steamers has been investigated. It was concluded that a maximum soil temperature of 80ºC should ensure satisfactory weed control under moist soil conditions, especially if the soil is cultivated prior to steaming. Surprisingly, the rapidity of cooling from the maximum temperature did not affect the efficacy of the treatment on weed seed mortality. Temperature measurements clearly revealed that successful performance of the two band-steamers strongly depended on their ability to disperse the heat evenly in the soil volume in order to reach target maximum temperature homogenously.

Two new robotic weeders, *Robocrop* (www.garford.com) and *Robovator* (www.visionweeding.com), for intra-row weed control in row crops are now operating on a commercial basis. At this stage, the technology is only useful in transplants, such as cabbage and lettuce. Experiences from practise are promising and growers claim that 70-100% of the labour normally needed for hand weeding can be saved with robotic weeders. We compared *Robovator* with non-selective mechanical methods in transplanted onion in 2010 and found no clear differences in weeding effectiveness provided that the non-selective tools were steered accurately. However, the two robotic weeders have more operational advantages than current low-technology solutions.

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Mechanical weed control

New innovations for intra-row weed control

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At present there are three different plant-recognising systems available for intra-row weeding.

The Radis from France is intended for larger crops and is a intelligent weeder with a simple crop detector system based on a light interceptor, which guides a hoe in and out of the crop row around the crop plants. The changed intelligent intra-row weeder for lettuce has been improved by fitting the weeder with a cutting blade at either side of the crop row. This reduces the uncultivated area around the crop plant by half, leaving fewer weeds. Because the blade only needs to bridge half the distance in the row, it is also possible to drive almost twice as fast (4 km/hr) without damaging the crop. However, a working speed of 4 km/hr is still rather slow and the aim is to get a speed of 6-7 km/hr. In 2010 the pneumatic steering system for the hoes was changed so that the valving system is now mounted very close to the cylinders that control the hoes. In addition, the normal cylinder has been replaced with a faster muscle cylinder. In tests, it has been possible to get the system working at 7 km/hr.

The Robocrob from Garford in England works with a camera system that can locate the crop plants from three or four rows and a disc weeder that is steered around the crop plants by an hydraulic system. The speed is about 2 plants per second, which a plant spacing of approx. 35 cm equates to 3 km/hr. Minor adjustments in the future will allow it to go faster.

The Robovator from Poulsen in Denmark also locates the crop plants with a camera, one for each crop row. Like the Radis system, the Robovator works with two hoes per row for intra-row weed control, but they are hydraulic-powered

A fourth system, Steketee from the Netherlands, was exhibited at the Biovak (Zwolle, the Netherlands) in January this year. This system also works with a camera for plant detection and weeds with two hoes per crop row. However, these hoes are powered by a pneumatic system. In 2011 this system will be tested in the field.

The major challenge for the future is to build an intra-row weeder that can locate weed plants in a full field-sown crop such as spinach or carrots. Some organic farmers in the Netherlands believe that this is possible. The challenge in coming years will be to locate the research expertise and entrepreneurs within and outside the agricultural industry to develop new types of weeders into a working system within 10 years or so.

Design, construction and evaluation of two novel cultivation tools

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Cultivation is a critical component of organic weed management and has relevance in conventional farming. Limitations with current cultivation tools include: high purchase and maintenance costs; limited efficacy; excessive soil disturbance; and, marginal applicability across a range of crops, soil types, soil moisture conditions, and weed growth stages. The objectives of this research were: to design and construct two cultivators that would be cost effective and simple to operate; to compare the weed control potential of both novel tools directly to that of a conventional S-tine cultivator; and, to evaluate crop response when these tools were used in transplanted pepper and broccoli.

Two new tractor-mounted cultivators were designed and constructed as loose extractions of antique hand-held tools. The first tool, a block cultivator, has a flat surface in the front of the tool which rests against the soil and limits the entrance of a rear-mounted blade. The second tool resembles a stirrup hoe, where a horizontal steel blade with a beveled front edge slices through the upper layer of the soil. Block and stirrup cultivators were mounted on a toolbar with a traditional S-tine sweep, so that the novel cultivators could be compared directly with a common standard.

In 2008, the tri-part cultivator was tested in 20 non-crop field events. In each event, four replicated cultivations were made at speeds of 2, 6, or 10 km hr-1. Weed survival and reemergence data were collected from the cultivated area of each of the three tools, at each cultivation speed. Environmental data were also collected at each event. A multivariable model was created to assess the importance of cultivator design, and environmental and operational variables, on post-cultivation weed survival. Additional trials in 2009 evaluated the yield response of bell pepper and broccoli to narrow and wide cultivations with each of the three tools.

The influence of cultivator design on post-cultivation weed survival was highly significant ($P<0.0001$). Averaged across the three tested speeds, the block design provided significantly greater weed control than the sweeps in 17 of the 20 cultivation events, and equivalent control in the other three cultivation events ($P\leq0.10$). The stirrup design significantly improved weed control in 6 of the 20 cultivation events; provided control equivalent to the sweeps in 13 events; and, lowered control in one event. Of the 11 individually assessed environmental and operational parameters, seven had significant implications for weed control with the sweep; five impacted control with the stirrup cultivator, and only one (surface weed cover at the time of cultivation) influenced control with the block cultivator. When each cultivator was used for inter-row weed control of bell pepper and broccoli, crop response was identical. The block cultivator, because of its increased effectiveness and operational flexibility, has the potential to improve inter-row mechanical weed management.

Control of perennial weeds by mechanical methods and anaerobic soil disinfection

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Perennial weeds are difficult to control and ask for a specific approach. During the most recent years it has even become a great challenge to control these weeds in conventional farming systems, although in comparison effective perennial weed control in organic farming systems remains more difficult. Without the option of herbicides, perennial weed control asks for a combination of proper timing and adequate mechanical weed control. Other options such as anaerobic soil disinfection may be useful as well. A field trial on marine loam soil in Lelystad was setup testing three mechanical weed control strategies and two anaerobic soil disinfection strategies to control *Cirsium arvense*, *Rorippa sylvestris*, *Sonchus arvensis*, *Calystegia sepium*, *Equestium arvense*, *Tussilago farfara*, *Elymus repens*, *Rumex obtusifolius*, and *Polygonum amphibium*. A rod weeder mounted behind a rigid-tine cultivator was compared with a broadcast root knife operating at 5 cm depth and at 15 cm. The machines were brought into action whenever weather conditions were suitable. Anaerobic soil disinfection treatments comprised the incorporation into the plough layer (c. 25 cm) of the weed biomass with 40 tons/ha fresh grass biomass or incorporation of the weed biomass alone. The grass was added to improve soil oxygen use thus lengthening the period with anaerobic conditions. Both treatments were covered with plastic sheets immediately after incorporation. The soil remained covered between 28 July and 15 October 2010.

In the untreated control plots, soil coverage reached 100% in the course of the season, regardless of weed species. Of the mechanical weed control methods the rod weeder showed the greatest reduction in soil coverage. Seven passes with the rod weeder between April 15 and August 12 reduced soil coverage from at least 90% for *Rorippa sylvestris* to 99% or more for *Cirsium arvensis*, *Sonchus arvensis*, *Calystegia sepium*, *Equestium arvense*, *Tussilago farfara*, and *Polygonum amphihibium*. Soil coverage was reduced less by treatments with the broadcast knife. Furthermore, soil coverage was reduced stronger by seven passes with the knife at 5 cm depth than after five passes with the knife at 15 cm, although cultivations at 15 cm were supposed to be more effective, needing fewer passes, than the root knife at 5 cm depth. The broadcast knife was most effective in controlling *Cirsium arvensis*, *Sonchus arvensis*, *Equestium arvense*, and *Polygonum amphibium*, resulting in at least 90% reduction of soil coverage at both treatment depths. At *Tussilago farfara* this level of control was only reached after seven passes at 5 cm depth, the deeper cultivation only reaching 50% reduction of soil coverage. Treatment of *Calystegia sepium*, *Elymus repens* and *Rumex obtusifolius* with the root knife showed a soil coverage reduction of between 45 and 75% at 5 cm depth and between 15 and 40% at a 15 cm working depth.

Anaerobic soil disinfection without fresh grass addition reduced soil coverage with at least 96%, whereas addition of grass material increased this to at least 98.5%. Addition of fresh grass increased soil coverage reduction at all weed species compared with plastic sheets alone.

This experiment was performed in Wageningen on a sandy soil with the same species (except for *Tussilago farfara*, which was replaced with *Mentha arvensis* and *Stachys palustris*) First year results indicate that the rod weeder performed best on a sandy soil as well (72 to 97% control, depending on the species), compared to the root knife treatments at 15 cm (3 to 96% control, depending on species) and 5 cm (69 to 99% control, depending on species), respectively. In the upcoming season analyses and the trials will continue, monitoring long term effects of the treatments in 2010.

Determination of the optimal timing and number of ridgings to control ragweed (*Ambrosia artemisiifolia*) in organically produced soyabean

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Ragweed (*Ambrosia artemisiifolia*) is a problem weed in organically produced soyabean. A few seedlings will escape cultivations with the rotary hoe or the spring tine harrow. It is only well controlled between crop rows when cultivated by an inter-row weeder. Even if only a few ragweed plants persist on the crop row, it is enough to decrease yield and crop grades when the grain is destined for human consumption.

Ridging was identified as a technique that could control ragweed on the crop rows in a previous study. This project was undertaken in order to determine the optimal timing to build the ridge and to determine the effect of ridging once compared with ridging two, three or four times.

The experiment was a randomized complete block design repeated 4 times. There were 18 treatments in total, including 2 controls, a weedy check and a hand weeded treatment. The other treatments were all cultivated twice followed by an inter-row cultivation. Subsequently, ridging was done once a week for a period of 4 weeks. Within that period, the treatments were ridged 1, 2, 3 or 4 times 1, 2, 3 or 4 weeks after the inter-row cultivation, creating a systematic combination of all possible time and number of ridgings.

Overall, in the 2010 experiment, soyabean yield did not differ among most treatments but ragweed biomass was significantly decreased when ridging was done earlier (week 1 or 2 after the inter-row cultivation) rather than later (week 3 or 4 after the inter-row cultivation). Generally, ridging twice was sufficient to control ragweed and to maintain yields. Treatments ridged 3 or 4 times caused a greater ragweed population decrease but soyabean yields were similar to the other treatments that were only ridged once or twice.

State-of-art methods in mechanical weed management

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The aim of this paper is to introduce two strong initiatives as examples how novel technologies can serve the education of weed sciences. New learning methods have reached significant importance in education in the last decade. Application of novel technologies is a great challenge and opportunity as well for universities to follow the direction where education develops.

Green Plant Protection (GPP) will provide an easy access to all key issues of plant protection in organic agriculture using web platform designed for standard (www.greenplantprotection.eu) and mobile version (m.greenplantprotection.eu). Internet is the key media of modules designed for eLearning and mLearning environment and the content can easily be upgraded. Training material is prepared in Slovakian, Hungarian, Italian and English languages. Users will access the on-line learning resources after the registration on the web site.

The project will provide useful information for developing environmentally safe agricultural technologies heading to sustainable development that is one of the top priorities of European Union. GPP is dealing with animal pests, plant pathogens and weeds in cropland. A concise description in table format with hyperlinks to pictures and photos helps the users to identify the problematic weed first, then familiarize with the damage the weeds cause and the possible control methods.

The project and its deliverables will offer additional career development training for users, and the practical implications of the project could significantly contribute to a reduction in the use of pesticides in agriculture.

CerOrganic is a two year Leonardo da Vinci Multilateral Project financed by the European Commission that aims to develop and test a quality assurance procedure for the vocational education/training of agricultural advisors/trainers in Organic Agriculture, based on the European Quality Assurance Reference Framework (EQARF).

In the CerOrganic Training of Trainers Summer School academic lectures (presentations) and practical sessions (hands-on e-learning material, field visits) on principles, methods and practices in Organic Agriculture will be discussed.

As for agro-ecological weed management, which is going to be an integrated component of the 7-day course, the task is to discuss the most important questions: how we can solve weed control by agro-ecological weed management.

Less intra-row weeds - experiences with a punch planter and a cycloid hoe based on GPS

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Experiences with a punch planter and an intelligent rotary tine weeder are summarized. The objectives were to investigate (1) to what extent punch planting and pre-emergence flame weeding can reduce intra-row weed emergence in direct sown crops like onion, carrot and sugar beet, (2) to what extent an intelligent intra-row weeder, a cycloid hoe based on RTK-GPS technology, can control intra-row weeds without damaging the crop in direct sown crops, (3) and to what extent there exists synergy between punch planting with pre-emergence flame weeding and mechanical intra-row weeding.

In punch planting, holes are punched into the ground and seeds are inserted into them, with minimum soil disturbance outside the holes. This is expected to reduce weed emergence due to lack of soil disturbance as compared to normal sowing. Weeds that emerge before crop emergence are controlled by pre-emergence flaming.

The cycloid hoe unit consists of eight sigmoid-shaped tines that are placed in a circle around an axis. When the axis turns around and the implement moves along the rows, the tines describe a cycloidal path. The tines can be released to allow individual tine rotation to avoid collision with the crop plants. The implement works on the basis of RTK-GPS crop maps.

Experiments show that there are potentials in punch planting in slow germinating row crops in terms of reduced weed emergence. Punch planting with pre-emergence flame weeding reduced the average intra-row weed density by about one third in onion and carrot but there was no effect in sugar beet as compared to normal sown plots with flame weeding. However, the experiments also show that the prototype of the punch planter needs innovation in order to make use of the full potential of the punch planting principle. Earlier experiments with punch planting carried out by hand showed significantly better results (Rasmussen, 2003)

The cycloid hoe showed unexpected poor results, which challenges our understanding of crop-weed selectivity of intelligent tine cultivators. There were no positive interactions between punch planting and the success of mechanical intra-row weed control even though weeds were smaller in the punch planted plots. Results will be published soon (Rasmussen *et al*. 2011a; 2011b).

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From key research concepts in post-emergence weed harrowing to an automatic adjustment of the intensity

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It is well known that crop yield and quality are negatively influenced by weeds, therefore weed control is a crucial element in farm management. In Ecological farming, weeds can be suppressed through interactions between preventive and mechanical weed control methods, however, conventional farming may also get advantage of those measures. Mechanical weed control mainly refers to cultivating tillage, meaning that both crop and weeds are cultivated, thus resulting in a trade-off between weed control and crop injury. Post-emergence weed harrowing is a cultivation method frequently used to control annual weeds in growing cereals and legumes. The primary control mechanism is burial of weed seedlings with soil, but larger weeds may require to be uprooted to be killed. A main challenge in weed harrowing is to find the right crop growth stage and the optimal intensity to obtain the highest control effect and the least crop damage. Research in weed harrowing has been focused on key concepts to successful weed control: selectivity, crop tolerance, competitive ability of weeds, and potential to yield gains. We carried out field experiments in winter and summer cereals from 2007 to 2010 to gather information about selectivity, crop tolerance and crop yield gains, with the aim of developing algorithms for site–specific weed harrowing. Different crop growth stages and harrowing intensity levels were tested in previous experiments. Variability of the soil and weeds was measured with different sensors mounted on a field vehicle. Bi–spectral cameras were used to determine the total leaf coverage (crop and weeds); also recognition of the weed composition was achieved. A sensor measuring the power transmission was used to calculate the soil resistance to the forward movement of the harrow. The vehicle was connected to a RTK-DGPS for positioning, which allowed creating weed distribution, crop–weed coverage and soil resistance maps. Our results showed high variability in total leaf coverage and soil resistance within the fields, meaning that permanent intensity adjustment is needed to avoid crop damages. A linguistic fuzzy model was developed to adjust the harrowing intensity; it was based on analog input of continuous percentage (0–100%) values of resistance, leaf coverage, and weed density. Intensity levels which achieved at least 80% weed control and caused no yield loss were used as the best possible settings for automation. Application maps were elaborated and the intensity settings were tested in an experiment for off-line harrowing application to validate and improve the algorithm. The prototype of the automatic harrow will be presented in the workshop through some photos and a video.

Pro's and con's of reduced tillage in maize with respect to weeds

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Herbicides cause problems with respect to the quality of surface and groundwater. European and national regulations demand a reduction of this impact. To achieve this, innovations are required that result into a herbicide and crop protection product emission reduction in general, together with cost reduction.

In recent years both worldwide and in the Netherlands there has been increasing agricultural interest in reduction of the intensity of soil cultivation. The reason for this increase is twofold. First, no or less soil tillage benefits the producer in terms of less energy and labor input as well as lower mechanization costs. Secondly, the increased awareness of society to climate change and soil and water quality demands agriculture to improve current systems.

In the past, exploratory research has shown that weed control was the main bottle neck for the introduction of reduced or no till systems and making those systems not economically feasible. However, recent technological developments and innovations have brought new agricultural systems in with considerably reduced energy use and costs. Some of these systems even suppress weed growth and have reduced the dependence of herbicides. Especially in North and South America and Australia many different cultivation systems and techniques are used, and the development of innovations to tackle specific problems is ongoing. This has led to many different forms of minimum tillage. With increasing reduction of soil cultivation, we discriminate:

- non inversion tillage (no ploughing but cultivation in various ways, often in combination with a powered tool (harrow or cultivator);
- permanent ridge tillage (the ridges are built once; only the top is removed and ridged back);
- strip tillage, where only a strip of soil is cultivated;
- no till, direct sowing in preferably a green manure crop.

In Western Europe and the Netherlands, the development of these production systems are lagging behind, although mainly in England, Germany, France and Switzerland, the areas which are not ploughed are now substantial. The objective of our research is to investigate the usability of ridge till /no till systems as recently developed in the US and Canada for Dutch conditions.

In 2009, a multi-year experiment in maize (after grassland on a marine loam soil) started including:

- 5 tillage systems (no till, ridge till, strip till, non inversion tillage and ploughing);
- 5 green manure crops (organic cultivators and weed suppressors);
- 2 weed control systems (mainly mechanical or chemical weed control).

The results of the first year will be presented and indicate:

- Several reduced tillage systems resulted in good yields, in case cover crop control and weed control were good. No till yields remained slightly behind the first two years;
- The green manure crops rye and rape had a better performance compared to no green manure, grass/clover or hairy vetch cover, improving weed suppression and manageability;

- Mechanical weed control was possible but at higher risk in case of reduced tillage systems due to higher weed pressure. Mechanical equipment had to be adapted to anticipate on green manure remains in superficial soil layers and/or more compacted soil;
- Not killing the green manure with Roundup reduced the possibilities to fight the weeds mechanical and reducing the soil cultivation.

Economic, agronomic and environmental sustainability during development in several years will be followed.

Various weed control techniques and systems (cultural weed control methods, allelopathy, mulches, cover crops, crop varieties, etc)

The effect of some trap crops on *Orobanche aegyptiaca* damage reduction in tomato

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One of the most susceptible hosts of the *Phelipanche aegyptiaca* (pers.) Pomel (Egyptian Broomrape) is tomato. Broomrape causes yield loss in tomato due to severe infestations in many regions of Iran. The main objective of this investigation was to evaluate and compare the effect of some trap crops on reducing the broomrape damage and to increase the yield of tomato in broomrape infested field. Trap crops consisting of Egyptian clover, sesame, mungbean, common flax, brown Indianhemp, cotton, pepper and black-eyed pea were studied during 2008 and 2009. Through the first year, trap crops were cultivated in pots and in the next year, tomato was transplanted into those pots.

Results showed that Sesame, brown Indianhemp, common flax and black-eyed pea decreased broomrape biomass by 86, 85.3, 75.2, and 74.4%, respectively. Reducing broomrape biomass caused increases in the tomato yield. Meanwhile, sesame, brown Indianhemp, Egyptian clover and mungbean increased total biomass of tomato by 71.4, 67.5, 65.5, and 62.5 %, respectively. It was found that these plants have a great potential to reduce broomrape damage and they can be used in rotation in broomrape infested fields.

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Crop yield and weed suppression in three different vegetable management systems in Central Italy

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The aim of this study was to compare a conventional (CS), an integrated (IS) and an organic (OS) management systems within the same vegetable crop rotation (lettuce, spinach, carrot, cauliflower). In this work we focus on the agronomic (yield and weed management), operative (machine performances and labour time) and economic aspects of the first two crops. The trial started in 2009 at the CIRAA "Enrico Avanzi" (University of Pisa, Italy) and is still on-going. The experimental design is a RCB (Randomized Complete Block) with three replications. Plot size is 50 x 1.5 m.

The three management systems are characterized by different initial soil disinfection treatments, different weed control and different fertilization strategies. CS consists in an initial soil steaming treatment, herbicide application and mechanical weed control when necessary. Fertilization is performed using mineral fertilizers. IS consists in an initial activated soil steaming treatment (steam + 4000 kg ha^{-1} of CaO) and physical weed control treatments. Fertilization is carried out using a mineral-organic fertilizer. OS consists in an initial soil biofumigation with 3000 kg ha^{-1} of Biofence® (*Brassica juncea* L. meal) and physical weed control treatments. Only organic fertilizers are applied.

Steaming was performed with the self-propelled machine Celli Ecostar SC 600 and the subsequent physical treatments were carried out with a precision hoe equipped with rigid elements and elastic tines for intra-row and in-row weed control, respectively. Under CS, one herbicide post-emergence application was carried out with 1600 g ha^{-1} of propyzamide for lettuce and with 960 g ha^{-1} phenmedipham + 69 g ha^{-1} fenoxaprop-P-ethyl for spinach. In the case of IS and OS the false seedbed-technique was performed before spinach seeding for IS and OS using a rolling harrow and a flaming machine. One hand weeding treatment was required for spinach in IS and OS.

Operative performances of the different machines and total labour time for each cropping system were registered. Weed biomass at harvest, total and marketable fresh yield were determined by collecting samples from two 3 m^2 areas plot^{-1}.

In case of lettuce, weed management was effective in all systems. Precision hoeing performed before harvest had a large effect on weed biomass, that was approximately equal to zero. Marketable fresh yield was significantly higher in IS (15.9 t ha^{-1}) than CS (9.7 t ha^{-1}), whilst no differences were found with respect to OS (13.4 t ha^{-1}).

In spinach we observed a lower weed biomass at harvest (-87.5% on average) and a higher marketable fresh yield (+30%, on average) under IS and OS than in CS.

From an economic point of view, IS and OS were more expensive than CS only as a consequence of the major labour demand due to hoeing and hand weeding (on average, about +20 h ha^{-1} for the two crops), whilst soil disinfection costs the same (~4000 € ha^{-1}).

After this preliminary analysis, we conclude that in our environmental conditions innovative crop management strategies can be at least as effective as conventional ones in terms of weed reduction and vegetable yield.

Mulch textile, a physical control method for weeds and parasitic plants in Turkey

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Several materials can be used for mulching to control of weeds. Mulch provides many benefits to our agroecosystems other than weed control. But type of the material depends on many factors such as decay duration, cost, availability, adverse effects to soil. Mulch textile (geotextile) have more advantageous because of porous structure, resistant to chemicals, weather conditions and microorganisms than other mulch materials used in the weed control. It eliminates disadvantageous of the other polyethylene mulch materials so it's an important alternative methods than the others.

To determine effect of mulch textile on weed management, the geotextile material was produced to a manufacturer by us. And the first time used as mulch material for controlling weeds in Turkey. The different studies were conducted in tomato (greenhouse and field) and citrus in Adana province of Turkey between 2004-2009. In these studies, 0.38, 0.58 and 0.72 mm thick black mulch textile was used and compared with some physical, mechanical and other alternative methods. Annual and perennial grass weeds (*Cyperus rotundus* L., *Seteria verticillata* (L.) P.B., *Sorghum halepense* (L.) Pers., *Digitaria sanguinalis* (L.) Scop.) and broad-leaved weeds (*Amaranthus hybridus* L., *Chrozophora tinctoria* (L.) Rafin., *Convolvulus arvensis* L., *Portulaca oleracea* L.) and a parasitic weed (*Phelipanche ramosa* L.) were identified dominantly in the trial areas. Mulch textile was found as the most effective method since no weed was in this application. Among all applications, mulch textile was provided sufficent control alone. This material is recommended due to be effective, economical and advantageous compared to other synthetic mulches for controlling weeds especially in organic farming system.

Comparison the effects of chemical fertilizers on *Phelipanche aegyptiaca* in tomato

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Egyptian broomrape (*Phelipanche aegyptiaca*.) is an obligate parasite plant species widespread in Mediterranean areas, Asia and Southern and Eastern Europe. The aim of this study was to compare effect of four fertilizers on Phelipanche damage reduction in tomato. An outdoor pot-experiment was conducted to evaluate the effect of various fertilizers on reduction *Phelipanche aegyptiaca* pers. (Egyptian Broomrape) damage in tomato at Research Farm of University of Tehran, Karaj, during 2008 and 2009. Experimental design was a randomized complete block with four replications. Treatments comprised ammonium nitrate, ammonium phosphate and urea each at rates of 150 and 300 kg/ha and ammonium sulfate at 250 and 500 kg/ha. In this research control pot for the first year was sowing *Phelipanche aegyptiaca* seed and in the second year, control without *Phelipanche aegyptiaca* seed also was included.

Results in the first year showed that Ammonium sulfate applied at 250 and 500 kg/ha and control without broomrape was the most effective treatments in increasing tomato yield and reducing broomrape damage. Ammonium phosphate and urea both at 150 kg/ha and ammonium sulfate at 250 kg/ha had most tomato dry weight while the minimum was belonged to ammonium nitrate used at 150 and 300 kg/ha. Ammonium phosphate applied at rates of 150 and 300 kg/ha decreased aerial and tuber dry weight of broomrape more than other treatments. According to these results applying ammonium sulfate at 250 kg/ha for broomrape control in tomato is the best treatment.

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What is the basis of early vigour, being an important trait of weed competitiveness in rice

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Cultural control is a promising alternative weed management strategy to help reduce the strong dependency on chemical weed control. One of the components of cultural control is the use of cultivars with improved weed suppressive ability. The possibility to breed for an increased weed suppressive ability has been explored for a variety of crops. Repeatedly, early vigour, or the ability to grow relatively fast during early growth stages, has been identified as an important trait associated with the ability of the crop to better suppress weeds. Often times, screening for early vigour is based on a rather subjective visual score. In this study the aim was to find out whether early vigour in rice is based on specific traits or related to a particular growth strategy. In such case, it might be possible to define more objective and easy quantifiable traits for weed suppressive ability that would favour the screening and selection process.

Field experiments with over forty rice cultivars were conducted to identify cultivars with superior weed suppressive ability. Based on these results, four rice cultivars were selected for further study in growth chambers. In these studies, regular plant sampling was used to determine initial growth and leaf area development of the cultivars throughout a four-week-period. These data were used as basis for a classical growth analysis. In addition, a simple plant growth model was used to establish the influence of growth strategy, characterized by assimilate allocation pattern, on early growth.

The field experiments revealed that a visual vigour rating at 4 weeks after sowing was highly significantly correlated with weed suppressive ability (Zhao et al., 2006a,b,c). Further experimentation in growth chambers indicated that differences in total accumulated dry weight after 26 days corresponded to the observed weed suppressive ability in the field. The two fastest growing cultivars had opposite growth strategies, with one cultivar investing in a high amount of leaf area and the other investing in high-quality leaves. Model simulations confirmed that differences in growth strategy not necessarily result in differences in overall growth rate. In the growth chamber experiments, differences in relative growth rate (RGR) between cultivars only became apparent after the first fourteen days. From that moment on the RGR of all cultivars dropped steadily, but this reduction in RGR was less strong in the more competitive cultivars. It was hypothesized that the reductions in RGR are a result of self-shading, and that the more competitive cultivars are better able to avoid self-shading, for instance through tillering. Whether the morphology of rice cultivars is indeed a more significant factor in the realization of early growth than initially assumed, is currently being investigated.

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The phytotoxical properties of aromatic and medicinal plants. A challenge for physical weed control.

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Abstract

Aromatic and medicinal plants consist the typical flora of the countries around the Mediterranean basin. Particularly, the species of the botanical genus *Origanum* are the most common in the phytogeographical territory of Greece. The "origanum" type plants produce volatile essential oils characterized by the high content in carvacrol, a component of particular biological importance with antibacterial, antifungal and biochemical activity.

Several experimental strategies for assessing potential phytotoxical targets of A/M plants are outlined in this study. The main strategies involve the phytotoxicity of "oregano" plant extracts on *Sorghum halepense*, *Cyperus rotundus* and *Solanun eleagnifolium*, in terms of (i) inhibitory effects by *in vitro* and *in vivo* assays, and (ii) effects on weed growth in field experiment using "oregano" as cover crop in maize.

Plant tissues (leaves, inflorescences and shoots) from *Origanum hirtum* collected from Ikaria, an island of east Aegean Sea, were evaluated for their inhibitory action on the studied weeds and on the bioindicators *Avena sativa* and *Vicia faba*. The tissues were physically dried, extracted according to the methodology at room temperature and aqueous dilutions of 5 and 10% v/v were tested on the growth of the aforementioned plants. Pot experiments were curried out in growth champers. The inhibitory action was evaluated by determining the shoot and root dry weight of the studied plants. *In vitro* experiments were conducted in petri dishes, where the weed seeds were subjected to dose response bioassays with "oregano" extract. The seed germination and the radical length were measured to evaluate the phytotoxicity of oregano extract. In the field experiments, oregano residues were incorporated into the soil before the maize sowing and the uniform weed seed dispersal. Weed emergence was recorded, while the plants were harvested six weeks after sowing.

According to the results, the dilution (10 % v/v) of "oregano" extracts showed an important inhibitory activity against *S. halepense* and *C. rotundus* decreasing significantly their shoot and root dry weight, whereas did not presented any activity on *S. eleanifolium*. The dose response bioassays showed great phytotoxic response of the studied weeds and the bioindicators to oregano extract. Among the weeds *S. halepense* showed the greater inhibition to all applied bioassays.. On the other hand, *S. eleanifolium* indicated its tolerant to any phytotoxic agent. The data from field experiment showed that in mulched plots the emergence and the dry weight of the weeds were reduced by 5 to 55 % and by 5 to 35 % respectively, in terms to weed species and compared to control plots.

Taking into account the increasing interest to obtain alternative new herbicidal agents for weed control, the data showed that the "oregano" plants have a great potential as "phytochemical pool", due particularly to their generalized environmentally acceptance as natural biodegradable compounds .

Introduction

Oregano is considered one of the most important temperate culinary herbs (Olivier, 1994). The term "oregano" refers to a large number of species that belong to different botanical families and genera and is very common in countries around Mediterranean basin. The essential oil from "oregano" plants is characterized by the high content in carvacrol, a component of particular biological importance: it is known for its antibacterial and antifungal activities, antispasmodic effects, acetylcholine esterace inhibition, lipid peroxidase inhibition, radical scavenging effect, white blood cell macrophage stimulant and cardiac depressant activity (Kirimer et al., 1995). High carvacrol concentrations are observed in arid and semiarid environments (D'Antuono et al., 2000; Lawrence, 1984).

The sustainability of agriculture relies on the development of strategies that lower the need for costly external inputs and minimize detrimental effects on the environment, which often involve either inappropriate or excessive use of agrochemical inputs. Sustainable agriculture integrated with allelopathy could reduce the heavy dependence on synthetic herbicides and other agrochemicals, and therefore ease problems such as environmental contamination, use of unsafe agricultural products and effects on human health (Khanh et al., 2007). Indeed, in aromatic plants, allelopathy has been investigated as an interactive mechanism to explain competition between species (Muller et al., 1964; Angelini et al., 2003; Economou et al., 2007). Essential oils have been extracted from many aromatic plants (including *Origanum* sp.) and evaluated for allelopathic properties. The germination of several plant species was strongly inhibited by essential oils. Therefore, the possible use of essential oils as herbicides is widely discussed (Katz et al., 1987; Dudai et al., 1999).

Several experimental strategies for assessing potential phytotoxical targets of A/M plants are outlined in this study. The main strategies involve the phytotoxicity of “oregano” plant extracts on *Sorghum halepense*, *Cyperus rotundus* and *Solanun eleagnifolium*, in terms of (i) inhibitory effects by *in vitro* and *in vivo* assays, and (ii) effects on weed growth in field experiment using “oregano” as cover crop in maize.

Materials and methods

Laboratory experiments

Plant tissues (leaves, inflorescences and shoots) from *Origanum hirtum* collected from Ikaria, an island of east Aegean Sea, were evaluated for their inhibitory action on the studied weeds and on the bioindicators *Avena sativa* and *Vicia faba*. *Avena sativa* was included in this study, because (a) it is extensively used in allelopathy research as the receiver plant to test compounds released by donor plant (2), (b) its seeds germinate evenly, resulting in uniform and rapid plant growth to quantify the biological response and (c) oat biotest is considered as sensitive method (Rice, 1984). *In vitro* experiments were conducted in Petri dishes, where the weed seeds were subjected to a dose response bioassays with “oregano” extract. The seed germination and the radical length were measured to evaluate the phytotoxicity of oregano extract. Therefore, 20 oat seeds (or 5 faba bean seeds) were placed onto two layers of filter paper in Petri plates (9 cm in diameter) treated with 3 ml of test solution as per treatment, covered and incubated at 25 ^{o}C in the dark. The tissues were physically dried, extracted according to the methodology at room temperature and aqueous dilutions of 5 and 10% v/v were tested on the growth of the aforementioned plants. Pot experiments were curried out in growth champers. The 10-cm diameter pots were filled with 500 g of soil mixture (soil/peat/perlite, 2:1:1 v/v) and irrigated with 100 mL full-strength Hoagland nutrient solution (Hoagland and Arnon, 1950) twice weekly and with tap water when needed. The pots were sown with 10 seeds of oat (or 5 seeds of faba bean) and aqueous extracts were also added. The inhibitory action was evaluated by determining the shoot and root dry weight of the studied plants. The experiments were conducted in a Complete Randomized Design (CRD), treatments were replicated 4 times and only deionised water was used in control.

Field experiments

Two field experiments were conducted during 2009 and 2010 in the Vonitsa region of western Greece. Site was located at 38^{o} 53′36.44″ N, 20^{o} 53′54.91″ E. The soil was a clay loam, whose physicochemical characteristics (0- to 15-cm depth increment) were clay 283 g kg^{-1}, silt 320 g kg^{-1}, sand 396 g kg^{-1}, organic C content 16.1 g kg^{-1}, pH (1 : 2 H_2O) 8.1, $CaCO_3$ 12 g kg^{-1} and organic matter content of 27 g kg^{-1}. The previous crop was alfalfa (*Medicago sativa* L.). In the field experiments, oregano residues were incorporated into the soil before maize sowing and uniform weed seed dispersal. Weed emergence was recorded, while the plants were harvested six weeks after sowing and dried at 80 ^{o}C until constant weight was achieved.. The experiments were conducted in a Complete Randomized Design (CRD) and the several treatments were replicated 4 times.

Results and discussion

According to the results, the dilution (10 % v/v) of "oregano" extracts showed an important inhibitory activity against *S. halepense* and *C. rotundus* decreasing significantly their shoot and root dry weight, whereas did not presented any activity on *S. eleanifolium*. The dose response bioassays showed high phytotoxic response of the studied weeds and the bioindicators to oregano extract. Among the weeds *S. halepense* showed the greater inhibition to all applied bioassays. On the other hand, *S. eleanifolium* indicated its relative tolerance to any phytotoxic agent. (Tables 1 and 2). The data from field experiment showed that in mulched plots the emergence and the dry weight of the weeds were reduced by 5 to 55 % and by 5 to 35 % respectively, in terms to weed species and compared to control plots (Table 3).

Table 1
Effects of oregano aqueous extracts of several concentrations on radicle elongation of the bioindicators *Avena sativa* and *Vicia faba* and the weeds *Sorghum halepense* and *Solanun eleagnifolium*. Means followed by the same letter in each row are not significantly different at P = 0.05.

Concentration (mg ml^{-1})	*Avena sativa*	*Vicia faba*	*Sorghum halepense*	*Solanun eleagnifolium*
	Radicle length (cm)			
Control	3.96 a	3.3 a	2.66 a	2.32 a
0.0625	0.73 d	1.96 ab	0.93 ab	1.56 ab
0.125	1.63 bc	1.3 bc	1.04 ab	1.23 ab
0.25	0.93 cd	0.73 bc	0.36 b	0.65 b
0.5	0.1 e	0.63 bc	0.07 b	0.32 b
1	0.02 f	0.14 c	0.03 b	0.07 b

Table 2
Effects of oregano aqueous extracts on dry weight of the above and below-ground part of the bioindicators *Avena sativa* and *Vicia faba* and the weeds *Sorghum halepense, Cyperus rotundus* and *Solanun eleagnifolium*. Means followed by the same letter in each row (for each parameter) are not significantly different at $P = 0.05$.

Concentration (mg ml^{-1})	*Avena sativa*	*Vicia faba*	*Sorghum halepense*	*Cyperus rotundus*	*Solanun eleagnifolium*
	Above-ground dry weight (g)				
Control	0.86 a	0.79 a	1.34 a	0.81 a	0.33 a
0.5	0.34 b	0.78 a	0.18 b	0.3 b	0.28 a
1	0.13 b	0.64 a	0.17 b	0.12 c	0.31 a
	Below-ground dry weight (g)				
Control	0.44 a	0.72 a	3.48 a	1.55 a	1.48 a
0.5	0.17 b	0.59 a	0.92 b	1.03 ab	0.68 ab
1	0.17 b	0.5 a	0.66 b	0.54 b	0.41 b

Table 3
Effect of incorporated oregano biomass on the seedling emergence and the dry biomass of the weeds *Sorghum halepense, Cyperus rotundus* and *Solanun eleagnifolium*.

Weed species	Seedling emergence	Dry weight
	(% reduction compared to the untreated control)	
Sorghum halepense	33-55	21-35
Cyperus rotundus	5-26	5-19
Solanun eleagnifolium	21-42	11-28

Conclusively, the present study clearly demonstrated that water-soluble inhibitory substances were clearly present within the oregano tissues. The inhibitory substances have the potential to significantly affect oat, faba bean and several weeds growth. Further research is already being conducted towards the directions of testing other species and varieties in terms of their response to oregano tissue inhibitory compounds and determining the actual constituents of oregano that cause growth inhibition (Economou et al., 2011).

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Effect of burial depth and soil water regime on the fate of *Cirsium arvense* seeds in relation to burial time

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Cirsium arvense (Creeping Thistle) is an increasing annual weed in winter crops such as wheat and barley in the semiarid region of Iran. Recent years this weed distributed under low impact tillage systems and current agricultural practice that has become popular. Seed dispersal in the soil profile under conventional tillage will change when reduced tillage is implemented, thus affecting on the micro environmental condition. A field experiment was carried out to determine the effect of seed burial depth and soil water regime on field's germination, obligate and innate dormancy, and seed decay in relation to burial time. In addition, the effect of burial depth on the seed germination and seedling emergence was studied under laboratory conditions. The experiment was performed using a completely randomized factorial design with three replicates .Treatments consisted of seeds buried at 2 and20 cm under two different fluctuating water regimes ,rain-fed (RAINF) and rain-fed plus irrigation (IRRIG),exhumed at different time intervals. Each treatment (combination of a given burial depth, soil water regime and time of burial) was applied to a mesh bag containing 50 seeds.

Results showed that Field's germination of buried seed ranged from 45-60% for shallow depth (2 cm), and from 5-25% for greater depths (20 cm). Obligate dormancy was significantly higher among deeper burial seeds. The amount of innate dormant seeds was reduced to<10% after a year of burial. *C. arvense* seed banks can be classified as short-term persistent. Germination in the laboratory was unaffected by burial depth, while reducing in the seedling emergence was effectively described by a sigmoidal model. Results indicate that agricultural practices that accumulate *C. arvense* seeds near the soil surface enhance seedling recruitment.

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Effect of row spacing, nitrogen amount and different densities of velvet leaf (*Abutilon theophrasti* L.) on sesame (*Sesamum indicum* L.)

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Abstract
Among oilseed crops, sesame (*Sesamum indicum* L.) has an oil with high quality. Weeds are important factors decreasing yield in sesame. Velvet leaf (*Abutilon theophrasti* L.) is one of the most important weeds in sesame fields, reducing seed yield, considerably. In order to evaluate the effect of sesame row spacing (40 and 60 cm), nitrogen amount (50 and 100 kg N/ha) and velvet leaf densities (0, 4, 8 and 12 plant per square meter) on sesame, an experiment was conducted in Ramian, Golestan province, Iran, in 2009. The experimental treatments were arranged in factorial split plots based on complete randomized block design with four replications. The results showed that, total dry matter of sesame was affected by the weed. Also leaf area index and morphological characters such as plant height and secondary stem numbers of sesame were significantly different, affected by different treatments. Seed yield of sesame was decreased with increase in weed density. The mean seed yield of sesame was 644 and 800 kg/ha in 50 and 100 kg N/ha, 683 and 762 kg/ha in 40 and 60 cm sesame row spacing, and 895, 740, 653 and 601 kg/ha in 0, 4, 8 and 12 velvet leaf plant per square meter, respectively.

Introduction:

Caliskan *et al*., (2004) showed that grain yield and yield components of sesame were significantly affected by planting methods are. They stated that planting a row of about 34 percent increase in yield will be. Plant height, branch number and yield per plant decreased with increasing density. Effect of culture pattern in the study sesame yield increase was 48 percent. However, the nitrogen concentration increased only 6 percent increase in seed yield (Mujaya & Yerokun, 2003). Common patterns are different cultures that can affect crop performance. Whatever theory of the distance between rows than to plant distances on a number of rows to be closer (square planting pattern) less competition for available resources will be together (Banai *et al*. 2004). Ottman and Welch (1979) also were told that the pattern of maize cultivation compared with the pattern of rectangular squares, due to more uniform distribution of the distance between the plant and the efficient use of development resources, particularly light, had a greater yield. Have stated that the above-mentioned differences in the performance of the two planting systems in high density is more evident. Faraji (2004) the effect of row spacing and seed rate and yield and yield components of rapeseed concluded that increased eruption space increases the number of branches at a distance of 35 cm to 25 cm long distances, and ultimately increase the number of plant capsule is.

One of the essential elements of nitrogen in plant nutrition management is the lack or increase in the different reactions by plants creates. Kazemini and Ghadiri (2004) showed that nitrogen fertilizer increased grain yield of rice was, but between levels 80 and 120 kg N ha^{-1} significant difference was observed with the addition of nitrogen fertilizer, fertilizer efficiency decreased. Increasing nitrogen fertilizer, harvest index decreased but this decrease was not significant. paparimoghaddamfard (2000) results showed that quite a significant effect of nitrogen fertilizer on crop characteristics such as sesame numbers per plant, plant height and grain yield was final. Other increases in the concentration of nitrogen only 6 percent increase in performance was sesame seeds (Mujaya & Yerokun, 2003).

Weed management of essential factors for success in agriculture is a production system. Weed Control in Sesame cultivation is important. Weed species that cause interference are the sesame, summer weeds are Velvet leaf one of them. Weeds not only to absorb water, light and food are competitive, but also create problems at harvest and reduce product quality (Ogg & Rogers, 1989). Bennett (1993) reached the conclusion that the early growth period Sesame (4 weeks) because the seedlings grow little competitiveness. Zeinali and Ehteshami (2003) also observed that the densities of three and 12 plants m^{-2} Velvet leaf on 37 and 72 percent respectively soybean losses occur. Therefore, identifying the amount of damages weed management practices and requires less consumption of chemicals and herbicides, which many environmental problems is to follow, becomes less. The purpose of this study the effect of row spacing and density of nitrogen Velvet leaf on vegetative components and performance is sesame.

Materials and methods:

The survey in 2009 on a farm located in the city Motahari Company Golestan was Ramian. Split-plot factorial experiment design based on completely randomized blocks with four replications was performed. Two levels of 50 and 100 kg N ha^{-1} and the distance between two rows of sesame 40 and 60 cm for the factorial plots combined and formed the original test. Four densities 0, 4, 8 and 12 plants per square meter as Velvet leaf factor was considered minor. Velvet leaf plants between rows of sesame were planted simultaneously with it. Before the plant cultivation, preparation of soil samples based on soil test results, including the base rate of 85 kilograms of fertilizer per hectare of P_20_5 sources triple superphosphate were used. Nitrogen levels tested as a third base prior to planting, flowering, and a third in one-third at the start of grain filling was used. After plowing the soil by doing a disk plow and fertilizer spraying operations were based. Intervals in rows 40 and 60 cm sesame seeds, is the number of rows of plants, respectively 15 and 10 cm intervals so that the number of operating plants constant per unit area equivalent to 16.6 plants per square meter is. The first watering plants before planting and watering was done by the next turn with a time of nitrogen fertilizer was done. During the growing season weeds in all plots except the weed is Velvet leaf were hand-weeding. Maturity in 10 ground sesame, were taken by observing the sidelines and vegetative traits, yield components and grain yield were measured. Harvest index of dry matter into grain dry matter of shoots was calculated at physiological maturity. Oil samples using soxhlet apparatus and in the laboratory sector reform and plant seeds of Agriculture and Natural Resources Research Center of Golestan Province was measured. Finally, data obtained by statistical software SAS (1996, SAS) were analyzed and averages data for different traits using LSD test at the 5 percent level were compared.

Results and discussion:

Final Height: The results showed that treatment 100 kg N ha^{-1} Sesame positive effect on final height was increased to 13 percent of Sesame height than 50 kg treatment was ha. Mean final height in the treated sesame 50 and 100 kg of pure nitrogen, respectively 101 and 116 cm respectively (Table). Sesame could possibly Cody maximum efficiency of resources to increase the final height to use. David *et al*. (2000), Noora *et al*. (2009) and paparimoghaddamfard (2000) Effect of nitrogen fertilizer showed quite significant final height sesame.

40 cm row spacing to increase the final height of 6 percent compared to the distance Sesame row was 60 cm. Mean final height in the treated sesame 40 and 60 cm between rows, respectively 112 and 105 cm respectively (Table). 40 cm between rows, between plants on rows higher than row

spacing was 60 cm. It seems that this issue has led to better conditions in the canopy created every plant and plant height and leaf area index Sesame significantly increased. Be reminded that the gap in the line of sesame plants between rows 40 and 60 cm respectively were 15 and 10 cm. Different densities Velvet leaf Sesame negative effect on final height and final height of sesame caused by increasing density to 12 plants m^{-2} Velvet leaf rate of 9 percent compared to the control, was reduced. Mean final height in treatments 0, 4, 8 and 12 plants m^{-2} respectively 112, 111, 108 and 102 cm respectively (Table). Seem to affect final height Sesame competition between species, and been a member of The availability of resources reduced the height of primary products and been impressed dropped. Mousavi and Bararpoor (1998) in the densities of different experimental Velvet leaf have done with cotton showed that there even a weed Velvet leaf m long row at a reduced rate of plant height 22.7 percent over the control was no competition . Abdollahi and Bararpoor (2006) also showed that the density effect on growth of soybean cultivar Williams Velvet leaf density 0.25 m row Velvet leaf plant height, soybean 14.5 percent compared with weed-free treatment reduced. Mousavi (2001) reported that Velvet leaf absorb nutrients from the soil has a greater capacity than is cotton. Velvet leaf height due to the addition of water and food for the cotton they are in competition are competing over the light. Aguyoh and Masiunas (1992) showed a rapid increase in height of an important competitive advantage as compared to other species are.

LAI: 40 cm row spacing increased about 11 percent compared to 60 cm row spacing on leaf area index was sesame. Sesame average LAI in treatments 40 and 60 cm between rows, respectively in 1.01 and 0.90 respectively (Table). Therefore, keeping constant density and decreasing the distance between the rows between the rows consequently increased, increasing LAI was. Vegetative phase appears on Sesame 40 cm row spacing and growth rate is better. Morrison *et al*. (1990) stated that in this case between rows of plants were planted less, the amount of dry matter per unit area and length of their growing larger and thus had greater LAI.

Treatment 50 kg ha^{-1} nitrogen increased 16 percent compared to LAI Sesame treatment 100 N kg ha^{-1} was. Sesame average LAI in treatments 50 and 100 kg of pure nitrogen, respectively in 1.04 and 0.87 respectively (Table). The results showed increasing N increased LAI was sesame. Appears to reduce the effect of sesame leaf nitrogen fertilizer application because, very high impact on increased nitrogen fertilizer use more leaf area is Velvet leaf the next episode will be referred to. Okafor and Datta (1976) also found that increased nitrogen in rice is more in favor *Cyperus rotundus* and reduced leaf area index is rice.

Control treatment without Velvet leaf sesame leaf area index was significantly increased 12 plants m^{-2} Velvet leaf, sesame leaf area index less than 53 percent without Velvet leaf control treatment were recorded. Sesame average LAI in treatments 4, 8 and 12 plants m^{-2} respectively 1.51, 0.88, 0.72 and 0.71 respectively (Table). Probably by increasing competition between species density Velvet leaf stronger and one of the factors in this competition, increasing weed leaf area index compared to sesame has been able maximum efficiency of light sources to increase LAI to create and decreases LAI is sesame. Sadeghi *et al*. (2002 & 2003) also found that leaf area index greater impact on weed dry weight loss products and therefore have more competitive power will be more soybeans. Probably by increasing plant population density of the final leaf area index per unit area increased.

Sesame branch number: 100 kg N treated ha increased 15 percent from the branch number 3.69 numbers in treatment 50 kg N $ha^{-1}$to 36 quarters were branch number (Table). Number of branches, one of the important performance characteristics are increasing nitrogen has shown a positive response. paparimoghaddamfard (2000) reported nitrogen fertilizer quite significant impact on crop characteristics such as number of branches per plant is sesame.

60 cm row distance rate of about 13.5 percent to 40 cm row spacing on number of branches increase in effect. Average number of treatments in the branches 40 and 60 cm between rows, respectively 3.73 and 4.32 was the number (Table). Crop apparently more willing to increase the number of branches in the space between rows was created. Kim and Moody (1980) and Alhani (2006) showed that increasing density reduced the number of secondary branches.

In weed control treatment without Velvet leaf most number of branches and sesame were caused in 12 plant density Velvet leaf Sesame branch number to 27 percent rate with no weed control treatment decreased. Average number of branches in the treated sesame seeds 0, 4, 8 and 12 plants m^{-2} respectively 4.83, 4.17, 3.59 and 3.51 the number (Table). Any increase in space to form a sub-category with the lowest Sesame competitive conditions and vice versa, the number of branches of positive and negative effects of sesame has established itself. Sadeghi *et al*. (2002 and 2003) found that in determining the share of each of the attributes of soy in the ability to compete with weeds, whatever the number of branches is higher, more effective on weight loss, dry weeds have and thus the power of competition more weeds will be more.

Highest Aerial dry matter: final dry weight of sesame in weed control treatment without Velvet leaf observed. Any Velvet leaf weed density increased final dry weight also decreased sesame; If Velvet leaf at 12 plants m^{-2} decreased 20 percent compared to sesame final dry weight with no weed control treatment was. Average dry weight in the final aerial treatment Sesame 0, 4, 8 and 12 plants m respectively in 2969, 2769, 2470 and 2378 kg ha^{-1}respectively (Table). Sadeghi *et al*. (2002 & 2003) found that in determining the share of each of the attributes of soy in the ability to compete with weeds, whatever the total amount of dry matter is higher, more effective on weight loss, dry weeds have and thus the power of competition more weeds will be more. Andy and Larry (1997) also showed the impact of weeds on Increasing crop canopy and Increasing biomass associated products increased with was successfully compete. Hagood *et al*. (1980) in a study reported that the density of 2.4 to 40 plants m^{-2} Velvet leaf decrease in dry weight final. was soy Abdollahi and Bararpoor (2006) also showed that the effect of density on growth and yield Velvet leaf soybean cultivar Williams, density 0.25 Velvet leaf plant dry weight in soybean Row m soybeans, respectively 6.4 percent compared with weed-free treatment to reduce said. Effect of nitrogen and row spacing on dry matter aerial harvest at the time was not statistically significant.

Sesame yield: Distance of 60 cm row spacing increased grain yield of about 10 percent compared to row distance was 40 cm. Average grain yield of sesame in the treatment of 40 and 60 cm row spacing, respectively 683 and 762 kg ha^{-1}respectively (Figure 1). In a constant density of 60 cm row spacing, final dry weight and branch number. AnithaVasline *et al*. (2000), Sakila *et al*. (2000) and Laurentin *et al*. (2004) showed that the reduction side number of branches per plant, sesame yield decreased sharply.

100 N kg treated ha increased 19.5 percent yield to treatment 50 kg N $ha^{-1}$was. Average yield in the treated sesame 50 and 100 kg of pure nitrogen, respectively 644 and 800 kg ha^{-1}respectively (Fig 2). Thus increasing the amount of nitrogen, 100 kg ha^{-1}product height increases, the number of branches and yield of sesame seeds was a result. Hatami (2009) Effect of nitrogen fertilizer on growth and yield of soybean cultivars indicated that grain yield significantly affected by nitrogen fertilizer was used. Mujaya and Yerokun, (2003) have also increased as the concentration of nitrogen can yield 6 percent increase sesame seeds. paparimoghaddamfard (2000) and AnithaVasline *et al*. (2000) showed that quite a significant effect of nitrogen fertilizer on crop characteristics such as number of branches per plant and final height was sesame.

Comparison of the obtained show that the performance of state-free sesame Velvet leaf more and actually had the highest yield in the case of sesame has been affected by competition. Fitting the data showed that 17.3 percent yield loss in the first Sesame density (4 plants m^{-2}) indicates the high sensitivity to competition is Velvet leaf. Meanwhile, cultivars cultivated type (native fork) so the competition has Velvet leaf according to review resources in comparison with other products, has a good competitive strength. In high densities, which includes eight and 12 plants m^{-2} is the amount of yield loss to 27 and 32.8 percent. Comparison of grain yield shows that all treatments are statistically significant. The densities of respectively 0, 4, 8 and 12 plants m^{-2} Velvet leaf, yield rate of 895, 740, 653 and 610 kg ha^{-1} was recorded. So that the maximum decrease in performance density 12 plants m^{-2} Velvet leaf, most damage was estimated Velvet leaf weed (Fig 3). Blakshow (1991) study competition in beans with pigweed Planning observed that increasing the crest of the planned 20 to 100 plants m^{-2} rows, due to competition between species within weed yield loss slightly increased. Also Leger and Schreiber (1989) stated that an increased density of pigweed plants m^{-2} to 8 rows significantly reduced while performance is increasing the density to 16 plants to reduce weed is proven performance. Marwat and Nafziger (1995) in the review found that soy interfere with Velvet leaf one Velvet leaf plants m^{-2}, to be soybean yield reduced 34 percent rate. Competition in 10 and 25 plants m^{-2} Velvet leaf, respectively 58 and 74 percent caused soybean yield loss has been. Miller and Hebert (1991) in review Velvet leaf compete with cabbage expressed by the density 1.2 and 3.6 plant in Velvet leaf m^{-2} respectively in the competition all season 52 and 71 percent were caused reduced performance. Zeinali and Ehteshami (2003) also observed that 37 and 72 percent respectively in soybean losses densities 3 and 12 m^{-2} was recorded in Velvet leaf plant.

Table. Mean vegetative characteristics of sesame

treated	The final height (cm)	Leaf area index	number of branches per plant	final dry weight ($kg\ ha^{-1}$)
Nitrogen ($kg\ ha^{-1}$)				
50	101^{b}	1.04^{a}	3.69^{b}	2649^{a}
100	116^{a}	0.87^{b}	4.32^{a}	2643^{a}
Row distance (cm)				
40	112^{a}	1.01^{a}	3.73^{b}	2631^{a}
60	105^{b}	0.90^{b}	4.32^{a}	2661^{a}
Velvet leaf density (plants m^{-2})				
0	112^{a}	1.51^{a}	4.83^{a}	2969^{a}
4	111^{a}	0.88^{b}	4.17^{b}	2769^{b}
8	108^{b}	0.72^{c}	3.59^{c}	2470^{c}
12	102^{c}	0.71^{c}	3.51^{c}	2378^{c}

Numbers in each column of each group at least one letter in common are not statistically significant difference at 5 percent are based on LSD test.

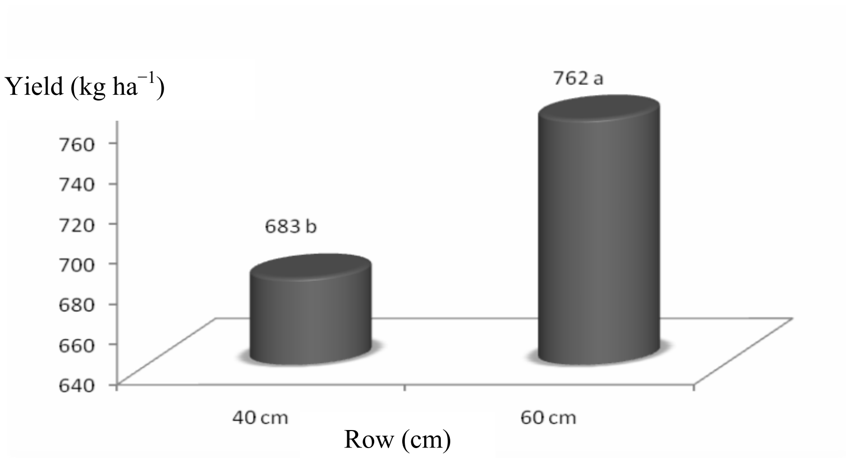

Figure 1. Row spacing on yield of sesame seeds

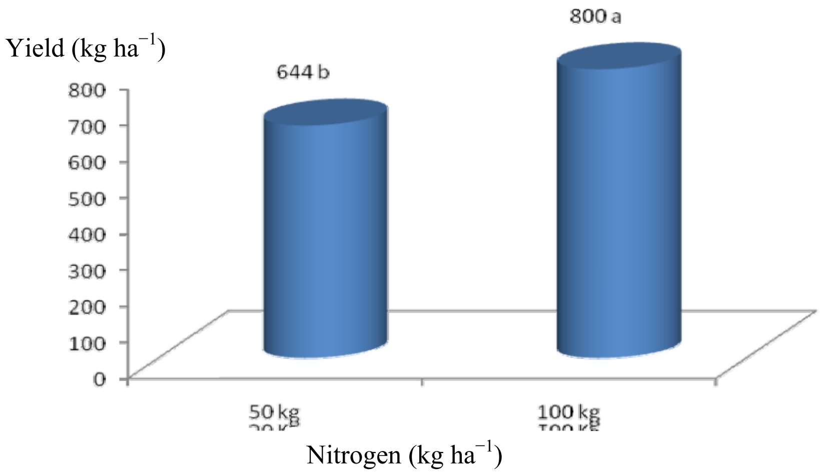

Figure 2. Effect of nitrogen on yield of sesame

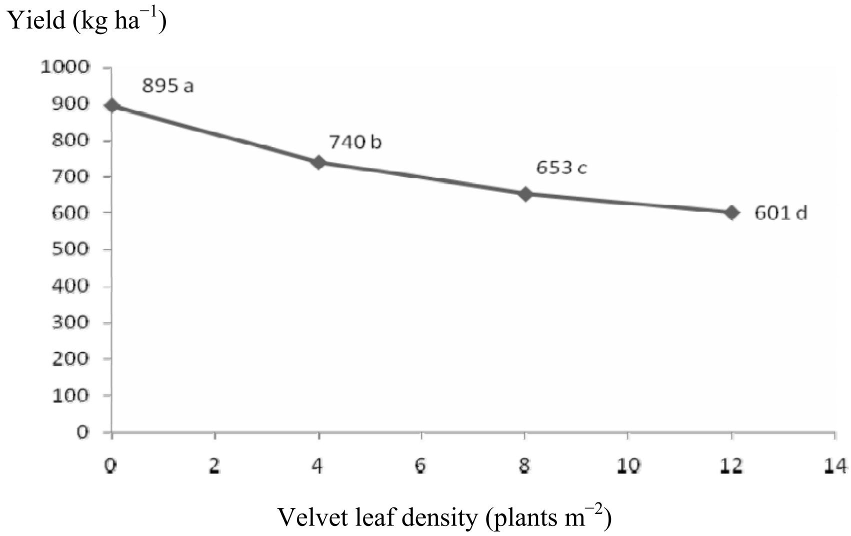

Figure 3. Effect of density on yield of sesame Velvet leaf

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Effect of nitrogen on vegetative growth parameters of sesame (*Sesamum indicum* L.) in competition with velvet leaf (*Abutilon theophrasti* L.)

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Abstract
In order to study the effect of nitrogen regimes on vegetative growth parameters of sesame (*Sesamum indicum* L.), in competing with velvet leaf (*Abutilon theophrasti* L.), an experiment was conducted in Ramian, Golestan province, Iran, in 2009. The experimental treatments were arranged in factorial split plots, based on complete randomized block design, with four replications. Two nitrogen amount (50 and 100 kg N/ha) and two sesame row spacing (40 and 60 cm) were arranged in main plots as a factorial form, and four velvet leaf densities (0, 4, 8 and 12 plants per square meter) were arranged in sub plots. Investigation on main effects of experimental treatments showed significant increase in leaf area index and dry weight of shoot in sesame when nitrogen level increased and velvet leaf density decreased. Increase of nitrogen amount in different weed densities had significant negative effects on sesame leaf area index and shoot dry weight. Also increase of weed density decreased plant height, stem diameter, above-ground dry mater, oil percent, yield and yield components of sesame, in both nitrogen regimes.

Introduction:

Velvet leaf through factors such as competition for nutrients and soil moisture and shade on the crops up, a significant reduction in performance of their cause (Zeinali & Ehteshami, 2003). Velvet leaf when accompanied by green crop is usually late in the growing season than the crop has a greater height (Regnier *et al.* 1988). So most of the interference reduced soybean yield Velvet leaf up leaves through the upper shadow is caused by weeds (Stoller & Woolley, 1985). Weber and Stainforth (1966) expressed the shade weed great savings on soybean plants are weed than the savings are less shadows, causing yield losses are greater.

Among the nutrients, nitrogen is the element with the most competitive weeds and creates concerns about the impact of nitrogen on crop competitiveness with weeds much research (Ditomaso, 1995, Patterson, 1995 & Matthew *et al.,* 2004) was conducted. Vengris *et al*. (1955) in maize and weed review concluded; since it can not overcome the lack of nutrients can therefore compensate for the competition over nutrients by weeds should increase soil fertility levels. But more studies of other results if Applby *et al.* (1976) showed high levels of nitrogen in combination with high density darnel, a wheat yield reduction was greatest. Darnel data showed that nitrogen fertility conditions than wheat answers. Nitrogen in plant nutrition management, or lack of increase in the different reactions by plants creates. Kazemini and ghadiri (2004) showed that nitrogen fertilizer increased grain yield of rice was, but between levels 80 and 120 kg N ha^{-1} significant difference was observed with the addition of nitrogen fertilizer, fertilizer efficiency decreased. Increasing nitrogen fertilizer, harvest index decreased but this decrease was not significant. The purpose of this study the effect of nitrogen and the condensation on the components Velvet leaf eruption is sesame.

Materials and methods:

The survey in 2009 on a farm located in the city participate Motahhari Golestan was Ramian. Split-plot factorial experiment design based on completely randomized blocks with four replications was performed. Two levels of 50 and 100 kg ha and the distance between two rows of sesame 40 and 60 cm for the factorial plots combined and formed the original test. Four densities 0, 4, 8 and 12 plants per square meter as Velvet leaf factor was considered minor. Velvet leaf plants between rows of sesame were planted simultaneously with it. Before the plant cultivation, preparation of soil samples based on soil test results, including the base rate of 85 kg of fertilizer per hectare of P_20_5 sources superphosphate triple were used. Treat nitrogen levels tested as a third base prior to planting, flowering, and a third in one-third at the start of grain filling was used. After plowing the soil by doing a disk plow and fertilizer spraying operations were based. Intervals in rows 40 and 60 cm sesame seeds, is the number of rows of plants, respectively 15 and 10 cm intervals so that the number of operating plants constant per unit area equivalent to 16.6 plants per square meter is. The first watering plants before planting and watering was done by the next turn with a time of nitrogen fertilizer was done. During the growing season weeds in all plots except the weed is Velvet leaf were hand-weeding. Maturity in 10 ground sesame, were taken by observing the sidelines and vegetative traits were calculated. Data obtained by statistical software SAS (1996, SAS) were analyzed and averages data for different traits using LSD test at the 5 percent level were compared.

Results and discussion:

Final Height: The results showed that treatment 100 kg ha^{-1} Sesame positive effect on final height had increased to 13 percent of Sesame height treatment than 50 kg ha^{-1} been. Mean final height in the treated sesame 50 and 100 kg of pure nitrogen, respectively 101 and 116 cm respectively (Table). Sesame could possibly maximum efficiency of resources to increase the final height to use. David *et al*. (2000), Noora *et al*. (2009) and paparimoghaddamfard (2000), Effect of nitrogen fertilizer showed quite significant final height sesame.

Different densities Velvet leaf Sesame negative effect on final height and final height of sesame caused by increasing density to 12 plants m Velvet leaf rate of 9 percent compared to the control, was reduced. Mean final height in treatments 4, 8 and 12 plants m^{-2} respectively 112, 111, 108 and 102 cm respectively (Table). Seem to affect final height Sesame competition between species, and been a member of the availability of resources reduced the height of primary products and been impressed dropped. Mousavi and Bararpoor (1998) in the densities of different experimental Velvet leaf have done with cotton showed that there even a weed Velvet leaf m long row at a reduced rate of plant height 22.7 percent over the control was no competition . Abdollahi and Bararpoor (2007) also showed that the density effect on growth of soybean cultivar Williams Velvet leaf density 0.25 m row Velvet leaf plant m height soybean 14.5 percent compared with weed-free treatment reduced. Mousavi (2001) reported that Velvet leaf absorb nutrients from the soil has a greater capacity than is cotton. Velvet leaf height due to the addition of water and food for the cotton they are in competition are competing over the light. Aguyoh *et al*. (1992) showed a rapid increase in height of an important competitive advantage as compared to other species are.

LAI: treatment 50 kg ha^{-1} nitrogen increased 16 percent compared to LAI Sesame treatment 100 kg ha^{-1} was. Sesame average LAI in treatments 50 and 100 kg of pure nitrogen, respectively in 1.04 and 0.87 respectively (Table). The results showed increasing N increased LAI was sesame. Appears to reduce the effect of sesame leaf nitrogen fertilizer application because, very high impact on increased nitrogen fertilizer use more leaf area is Velvet leaf the next episode will be referred to. Okafor and Datta (1976) also found that increased nitrogen in rice is more in *Cyperus rotundus* and reduced leaf area index is rice.

Control treatment without Velvet leaf sesame leaf area index was significantly increased 12 plants m^{-2} Velvet leaf, sesame leaf area index less than 53 percent without Velvet leaf control treatment were recorded. Sesame average LAI in treatments 0, 4, 8 and 12 plants m^{-2} respectively 1.51, 0.88, 0.72 and 0.71 respectively (Table). Probably by increasing competition between species density Velvet leaf stronger and one of the factors in this competition, increasing weed leaf area index compared to sesame has been able maximum efficiency of light sources to increase LAI to create and decreases LAI is sesame. Sadeghi *et al.* (2002 and 2003) also found that leaf area index greater impact on weed dry weight loss products and therefore have more competitive power will be more soybeans. Probably by increasing plant population density of the final leaf area index per unit area is increased if Morrison *et al.* (1990) stated that in the same plants that grow in less space, the amount of dry matter per unit area and length of their growing larger and thus had greater LAI.

Main stem diameter**:** maximum diameter of the treated sesame shoot without Velvet leaf weeds were recorded. The density of 12 plants per square meter Velvet leaf, 27 percent of Sesame stem diameter less than the control treatment showed no weed. Average stem diameter in treated sesame zero, four, eight and 12 plants m^{-2} respectively 7.11, 5.99, 5.25 and 5.18 mm, respectively (Table). Appears to increase competition and interaction between species, has been able Velvet leaf its negative effects on the main stem diameter Sesame to create and cause weakening in these traits are treatments. Abdollahi and Bararpoor (2007) showed that the densities of the soybean cultivar Williams Velvet leaf density 0.25 Velvet leaf m row soybean plant, stem diameter compared to 11 percent weed-free treatment reduced these results show that the competitive power Velvet leaf much weed. Kim and Moody (1980) as they also increase the density of rice stem thickness is reduced.

Branch number**:** 100 kg treated ha increased 15 percent from the branch number 3.69 in treatment number 50 kg ha^{-1} to 4.36 quarters were branch number (Table). Number of branches, one of the important performance characteristics are increasing nitrogen has shown a positive response. Paparimoghaddamfard (2000) reported nitrogen fertilizer quite significant impact on crop characteristics such as number of branches per plant is sesame. In weed control treatment without Velvet leaf most number of branches and sesame were caused in 12 plant density Velvet leaf Sesame branch number to 27 percent rate with no weed control treatment decreased. Average number of branches in the treated sesame seeds0, 4, 8 and 12 plants m^{-2} respectively 4.83, 4.17, 3.59 and 3.51 the number (Table). Any increase in space to form a sub-category with the lowest Sesame competitive conditions and vice versa, the number of branches of positive and negative effects of sesame has established itself. Sadeghi *et al.* (2002 and 2003) found that in determining the share of each of the attributes of soybean in the ability to compete with weeds, whatever the number of branches is higher, more effective on weight loss, dry weeds have and thus the power of competition more weeds will be more. Kim and Moody (1980) and Alhani (2006) showed that increasing plant population density reduced the number of secondary branches.The final dry aerial: Most final dry weight in sesame without weed control treatment was Velvet leaf. Any Velvet leaf weed density increased final dry weight also decreased sesame; If Velvet leaf at 12 plants m^{-2} decreased 20 percent compared to sesame final dry weight with no weed control treatment was. Average dry weight in the final treatment Sesame 0, 4, 8 and 12 plants m respectively in 2969, 2769, 2470 and 2378 kg ha^{-1} respectively (Table). Sadeghi *et al.* (2002 and 2003) found that in determining the share of each of the attributes of soybean in the ability to compete with weeds, whatever the total amount of dry matter is higher, more effective on weight loss, dry weeds have and thus the power of competition more weeds will be more. Andy and Larry (1997) also showed the impact of weeds on crop canopy and associated products increased with was Increasing canopy biomass and successfully compete. Hagood *et al.* (1980) in a study reported that the density of 2.4 to 40 plants m^{-2} Velvet leaf decrease in dry weight final. Abdollahi and Bararpoor (2007) also showed that the effect of density on growth and yield Velvet leaf soybean cultivar Williams, density 0.25 Velvet leaf plant dry weight in soybean respectively, 6.4 percent compared with weed-free treatment to reduce said.

Table. Comparison of vegetative traits Sesame

Treatment	Height final (cm)	LAI	Main stem diameter (mm)	Number of branches per plant	Final dry weight (kg ha^{-1})
Nitrogen (kg ha^{-1})					
50	101 b	1.04 a	5.75 a	3.69 b	2649 a
100	116 a	0.87 b	6.02 a	4.36 a	2643 a
Velvet leaf density (plants m^{-2})					
0	112 a	1.51 a	7.11 a	4.83 a	2969 a
4	111 a	0.88 b	5.99 b	4.17 b	2769 b
8	108 b	0.72 c	5.25 c	3.59 c	2470 c
12	102 c	0.71 c	5.18 c	3.51 c	2378 c

Numbers in each column of each group at least one letter in common are not statistically significant difference at 5 percent are based on LSD test.

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Stale seedbed techniques for corn production in Samsun - Turkey

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Corn (Zea mays L.) is an important crop for northern Turkey. Turkey corn production has increased during the past 10 years to 550,000 ha areas in 2007. Weed interference is a major constraint to corn production in Turkey, as in many other countries. Worldwide yield losses in maize due to weeds are estimated to be around 37%; therefore, weed control plays an important role in maize production. Weed control in maize is carried out mainly by mechanical and chemical methods, but herbicide use is increasing, along with increases in growing areas and production costs.

Soil tillage and seedbed preparation, as well as the use of soil herbicides are applied for weed control in corn before sowing. In the recent studies, it was reported that weed populations could be reduced by utilizing stale seedbed preparation to provide a less competitive environment during earlier growth stages. The main purpose of this system is to stimulate weed emergence before crop sowing by means of early soil tillage (from several days or weeks prior to sowing) and killing weeds by secondary tillage during seedbed preparation and/or by using broad spectrum herbicides. A variety of techniques may be used to form a stale seedbed. The aim of the research described in this paper was to investigate the effects of different stale seedbed strategies on the weed density in corn, comparing different treatments and controls without stale seedbeds.

Field experiments were conducted in 2010 at the Black Sea Agricultural Research Institute Experiment Station, in the Northern region of Turkey. The plots were established on a clay loam soil with pH 6.9, 0.08% total salt, 0.3% lime, and 2.9% organic matter content. Average monthly precipitation (mm) and temperature (C) during the experiment were collected from Çarşamba airport located about 5 km from the experimental site. Soil preparation was conducted according to local practices for corn production. Main soil tillage at the experimental fields was carried out in early April to allow weed emergence before sowing. Weeds emerging after stale seedbed preparations were either controlled chemically or mechanically. The experimental design was a randomized complete block with four replications. Each plot was 2,8 m wide, 5 m long, and consisted of four corn rows. The middle two rows of each plot were used for data collection.
Data derived from experiment showed that stale seed bed preparation techniques could be used for weed control in corn production in Turkey. As a stale seed bad preparation technique for weed control; the best results were obtained from the glyphosate application after 5 days after sowing. Result also displayed that a combination of stale seedbed technique with mechanical treatment can be considered an effective alternative weed control system to reduce weeds by up to 90% during the critical period. This would reduce the intensity, costs and negative environmental impact of chemical treatments.

The determination of the weed species in organic vineyards of the Aegean region and investigation of the alternative management methods

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Dry grape is one of the most important and widely produced and exported *product* in Turkey. (Anonymous 2009).

This study was carried out in organic vineyards of Alaşehir - Manisa province with the objective of determining the presence of the weeds, and investigate the possibilities of using physical control method in their control.

For the above mentioned purpose survey and field experiments were conducted in organic round seedless (Sultana variety) vineyard. Field experiment, included 12 characters namely, control, black polyethylene mulch, olive waste, hand-hoeing,mechanical-hoeing, flame burning, cereal-straw (covered at least 10 cm), peanut waste, wood waste, cover crop (5kg/da Barley(Akhisar variety) + 6 kg/da wetch (Menemen 79 variety), cover crop (8 kg/da Hairy wetch (Efes79 variety), and 500 kg/da cabage waste. Weed presence was evaluated both inter-row and in-row.

.Survey results,showed that in organic vineyard the most abundant weed spesies were, *Matricaria chamomilla* L. (74%,), *Phragmites communis* L. (71%), *Poa annua* L. (70%*), Cynodon dactylon* (L.) Pers. (67%), Sonchus oleraceus *L.* (63%), *Stellaria media* L.(61%) *Convolvulus arvensis* L. (60%), *Lactuca serriola* L.(58%), *Cynanchum acutum* L. (53%) *Cyperus roduntus* L.(48%), *Setaria verticillata* L. (40%).

Field experiments showed that in inter-row, black polyethylene mulch provided almost total control of *Avena fatua* L.,(%100) *Medicago polymorpha* L., (% 100) *Papaver rhoeas* L., (%100) *Lactuca serriola* L., (100) *Sisymbrium officinale* (L.)., (%100) *Hordeum murinum* L., (%100) *Cynanchum acutum* L., (%100) *Matricaria chamomilla* L., (%98,0) *Sonchus oleraceus* L. Good control was also provided with wood waste, cereal straw, peanut shell,followed by cover crops.

A similar result was taken as the in-row, black polyethylene mulch provided almost total control of *Cynanchum acutum* L. (100%), Dacus carota L. (100%), *Hordeum murinum* L.(100%), *Lactuca serriola* L.(100%), *Matricaria chamomilla* L.(100%), *Medicago polymorpha* L. (100%), Malva neglecta L. (100%), *Poa annua* L.(100%), *Phalaris minor* L. (100%), *Sisymbrium officinale* (L.) (100%), *Sonchus oleraceus* L. (100%), *Stellaria media* (L.) Vill. (100%), *Amaranthus retroflexus* L. (100%), *Cynodon dactylon* L. (100%), *Cyperus rotundus* L. (100%), *Xanthium strumarium* L. (100%). Good control was also provided with cereal straw, wood waste, peanut shell followed by cover crops.

İn conclution, in inter row black polyethylene mulch, wood waste, cereal straw, peanut shell and cover crop are promising for physical weed control. Is in-row of organic vineyard, mulch cover, cereal straw, wood waste, peanut shells and cover crops for weed control are promising.

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Determination of critical period of weeds in potato areas in Van/Turkey

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This study was conducted to determine the critical period of weeds at the potato fields grown in Erciş district of Van province at the ecological conditions of 2006-2007 growing season. The experiments were designed in a randomized block design with four repetitions. To determine the critical period, plots were kept weedy and weed-free at weekly interval for 1 to 8 weeks after emergence (WAE) with periodic hand hoeing. The potato tuber yield per decar was investigated in the conditions of weed competition with potato. When the potato tuber yield is considered, no statistically significant differences were found ($P<0.05$) between weed-free and weed infested parcels in 2006 and 2007. The present findings show that the potato is well competitor in the competition with weeds suggesting that no weed management is needed in the potato growing areas in the Erciş district.

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Weed management in organic and herbicide-free systems under conservation tillage: the ultimate challenge

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The success of conservation tillage in organic farming depends on high standards of management, including diversified crop rotations, and an IWM approach. A study was initiated at La Pocatière, Québec, in 2007 to compare the effects a herbicide-free (HF) system and a system based on agronomic practices typical of organic agriculture (ORG) to that of cropping systems using either regular (CONV) or GM crops on weed communities and crop yield. The cropping systems were applied to three well established (since 1987) tillage treatments (MP: moldboard plow, CP: chisel plow, NT: no-till) in a four-year barley (2007) - red clover forage (2008) - corn (2009) - soybean (2010) rotation.

Barley yields in 2007 were similar across all treatments ($p>0.250$) in spite of greater weed density as tillage was reduced ($p<0.050$) across all systems. In the 2009 corn crop, weed density increased as tillage ($p<0.001$) and synthetic input use ($p<0.001$) were reduced. Tillage effects on weed biomass varied with cropping system ($p=0.008$), the tillage effect (NT>CP & MP) being greater in HF than in other cropping system. Corn yields in CONV and GM were 25% greater than those in HF and ORG ($p=0.009$), regardless of tillage ($p=0.396$). CP yields were similar for all systems except ORG. The HF system with CP produced corn yields comparable to those in CONV and GM systems whereas the HF and ORG systems with NT failed to produce a corn crop. Mechanical weed control operations (one pass Hiniker cultivator / one pass Hatzdenbichler harrow) failed to control weeds in these systems.

In the subsequent soybean crop (2010), tillage effects on weed density varied according to cropping system ($p=0.020$). Weed density in HF and ORG systems with CP was greater than in other treatments. Weed biomass increased as tillage ($p=0.001$) and synthetic input use ($p=0.013$) were reduced. Weed biomass in HF and ORG systems with CP and NT was greater than in other treatments. Tillage had no effect on soybean yield in CONV ($p=0.480$) and GM ($p=0.154$) systems. Yields in HF and ORG with MP were similar to those in CONV and GM ($p=0.108$). The HF and ORG systems with MP produced soybean yields comparable to those in CONV and GM systems. The HF and ORG systems with CP and NT produced a soybean crop but yields were half or less those in other treatments. Mechanical weed control operations (stale seedbed + one pass Hatzdenbichler harrow) failed to control weeds. Including a forage crop prior to corn did not provide expected benefits in ORG-NT, because of poor red clover establishment. Some form of primary tillage (CP, MP) was needed to achieve adequate weed control and yield in both corn and soybean in ORG and HF systems.

Crop rotation as the ultimate cultural practice: 18 years of cereal yield stability in three tillage systems

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Current agricultural systems are often based on crop monocultures or very short rotations, in spite of little if any benefits from agronomic, environmental, and even economic perspectives compared to well planned crop rotations. The benefits of diversified crop rotations have been extensively documented. Our objective is to demonstrate that crop rotation can ensure greater and more stable crop yield over time, even when using conservation tillage practices.

Crop yield is determined by its various components, each of which is being affected by agro-environmental conditions at different times during the growth season. For cereal crops, seed density (number of crop plants x number of flowers per head x number of head per plant) is determined mainly in the period prior to weed management operations whereas grain weight (1000-seed wt) will be affected by conditions in the post weed management period, including the effects of potential competition from residual weed communities during grain filling. Using a grouping methodology based on means and coefficient of variation (c.v.), we examined crop rotation and tillage effects on cereal yield and yield components from a long-term conservation tillage study, conducted at La Pocatière Québec. Two time periods were examined: a first phase (1988-1994) which compared a 2-yr cereal-forage rotation to a cereal monoculture, and a second phase (1998-2005) which compared a 4-yr cereal-oilseed rotation to a cereal monoculture. Tillage treatments included: moldboard plow (MP), chisel plow (CP), and no-till (NT).

On average, seed density and yields were greater and less variable in the second phase (c.v. = 28% than in the first phase (c.v. = 41%). Seed density and yields from rotation treatments were greater and generally less variable than that from the monoculture. According to the groupings defined by the average of means and c.v. over time, first-phase rotation-MP and rotation-NT were optimum treatments, providing high yields with low variability (3732 kg ha-1, 24.4% and 3397 kg ha-1, 33.4%, respectively), whereas the monoculture-CP provided the lowest yield with the highest variability (2450 kg ha-1, 50.6%). In the second phase, rotation yields averaged 3946 kg ha-1, with a c.v. of 19.3%, compared to 3155 kg ha-1, with a c.v. of 35.6% in the monoculture. In both phases, variability of seed density was in the same range as that for yield, and treatment effects followed very similar trends. Conversely, values for 1000-grain wt were much less variable, with an average c.v. of 7% and 14%, in the first and second phase, respectively. Values for 1000-grain wt were consistently greater in the crop rotation than in the monoculture. Overall, cereal yields were influenced more by early (seed density) than late (1000-seed wt) season agro-environmental conditions, which suggested minor effects of residual weed populations during the grain filling period in crop rotation treatments.

Crop rotation ensured greater and more stable yields over time than the monoculture. These benefits were slightly greater in the 4-yr crop rotation (second study phase), in spite of greater environmental variability compared to conditions during the first study phase. Whether the crop rotation effect in the second phase is attributable solely to the cereal-oilseed rotation or to the cumulative effects of both cereal-oilseed and previous cereal-forage rotation could not be determined. Diversified crop rotations proved beneficial, particularly in these aging conservation tillage systems.

Effects of cover crops on weed populations in hazelnut (*Corylus avellana* L.)

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The cultivated hazelnut (*Corylus avellana* L.) is native to the Black Sea coast of northern Europe, and Turkey is one of the few countries in the world with a suitable climate for its production. The relatively high rainfall and fertile soils of hazelnut orchards in the Black Sea region favour establishment of a wide range of annual and perennial weed species. Weed management in hazelnut orchards is necessary to eliminate competition, conserve nutrients for the trees, and improve hand harvesting efficiency. Weed management in hazelnut is a major production challenge, with glyphosate being the main herbicide used. Weed control without the use of herbicides is an expensive and time-consuming task in orchard management. Mechanical weed control methods are thought to be environment friendly and could help to prevent public pressure to reduce herbicide use in hazelnut orchards. Orchard floor management practices such as the use of cover crops either alone or combined with mechanical methods, could have significant effects on weed management in hazelnut production.

Field trials were conducted from 2009 to 2010 to evaluate effects of cover crops on weed populations. The cover crop treatments consisted of *Lolium perenne* L., *Vicia villosa* Roth., *Medicago sativa* L., *Onobrychis sativa* L., *Brassica napus* var. oleifera L., and *Brassica rapa* L. Cover crop seeds were broadcast and incorporated into the soil with a shallow cultivation. All cover crops or weeds growing in the fallow plots were killed mechanically by mowing on April 24, 2010. To determine the suppressive effects of the cover crops during growing season, weed species, weed density, and total weed dry biomass were assessed at 14, 28, and 56 DAI from all plots using a 50 by 50-cm quadrat placed randomly in the plots. Additionally, visual estimates of seedling emergence were conducted at 28 and 56 DAI using a scale of 0 to 100%, where 0% represents no weed control (fallow treatment) and 100% complete weed control. After 56 DAI the entire experiment was hand weeded to eliminate further weed competition.

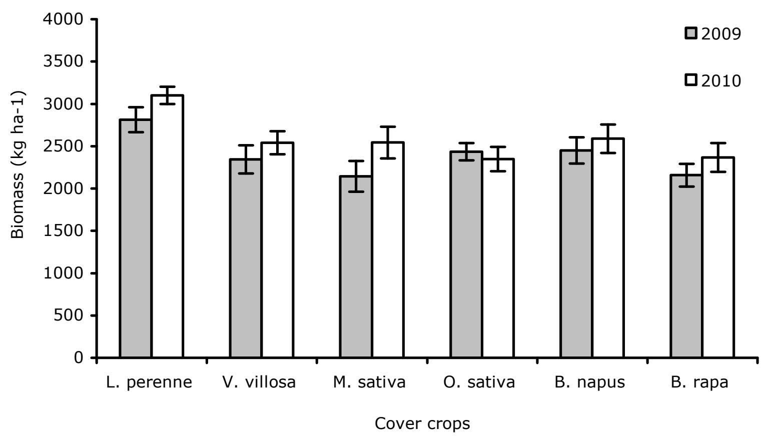

Figure 1. Biomass production (kg ha^{-1}) of cover crops prior to incorporation in 2009 and 2010. Vertical lines represent standard errors of the means.

All cover crops established well and *L. perenne* biomass was the greatest in both years (Fig. 1). In 2009, *L. perenne*, *V. villosa*, *M. sativa*, *O. sativa, B. napus* and *B. rapa* produced 2.812, 2.345, 2.143, 2.435, 2.450 and 2.158 kg ha^{-1} biomass, respectively. Similar results were obtained in 2010 about biomass production. When compared with the bare soil system, the cover crops reduced weed density, number of weed species that emerged, and total weed dry biomass. All cover crop treatments resulted in a decrease in the number of weed species compared to the bareground. The number of weed species was lowest at 14 DAI then increased at 28 and 56 DAI. Residues from the cover crops suppressed *Urtica urens* L., *Convolvulus arvensis* L., *Chenopodium album* L., *Lapsana communis* L., and *Poa annua* L. Weed dry biomass was significantly reduced in the cover crop treatments at 14 days after desiccation. Our findings indicated that cover crops suppressed many weed species in hazelnut orchard during early summer, but should not be used as the only weed control method.

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İnvestigations on the using of cover plants for control of weeds being problem in apple orchards in Yalova province

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İt was aimed to investigate possibilities for using of covered plants for control of the problematic weeds in apple orchards in Southern Marmara Region, in addition, to evaulate chemical and physical changes in soil, Whether it is different with respect to soil humidity or not, and in terms of productivity with this study.

Study was conducted as Red fescue, (*Festuca rubra* L.), White Clover (*Trifolium repens* L.), Subterranean clover (*Trifolium subterraneum* L.), Bentgrass (*Agrostis tenuis* Sibth.), 2 tillage, chemical, and control plots in apple orchards having about 4 years old plants in Atatürk Central Horticultural Research Institute

It was evaluated exchanges in the soil and plant flora, weed and covered plant densities, different in the quantity of irrigation and exchanges in fruit yield and quality components in every covered plant species plots. Additionally, it has been investigated the economical aspect of covered plant using for weed controlling in the different fruit orchards, in a way that was transferred into practice

Effect of different temperatures on seed germination of susceptible and herbicide-resistant populations of *Avena sterilis* L.

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Herbicide resistant weeds are one of the main problems in agriculture worldwide. Several herbicide resistant weed species were documented in Turkey as well. Sterile oat (Avena sterilis L.) is a miserable weed species in cereals and in some other crops such as lentil, onion etc, which are rotated with cereals. Herbicide resistant wild oat populations were determined in several regions of Turkey. Knowledge on weed biology and ecology is one of the factors preparing integrated weed management programs which includes physical and cultural weed control techniques. Difference in fitness between wild and resistant populations of weeds has been already suggested to manage resistant weed populations. Germination rates under different regimes of susceptible and resistant sterile oat were compared.

Populations were collected from Eastern Mediterranean (starting with K) and Southern Marmara (starting with A) Regions. Resistant populations (AKR2, AV14) that are already proved resistant to both APP (Aryloxy-phenoxy-propionate) and CHD (cyclohexanadione) herbicides were compared with four susceptible populations (KTA, KRL3, AV01, AV02) that are from fields or non-crop areas. Experiments were carried out in petri dishes with 25 seeds in incubators under 10, 15, 20, 25, or 30 °C constant temperatures. Experimental design was RCBD with four replications. Germination rate was recorded daily.

The data from two experiments pooled and total number of germinated seeds at the 12th day were presented in table 1. Southern Marmara populations were germinated higher under lower temperatures while Eastern Mediterranean populations germinated higher under higher temperatures regardless their resistance status. There was no difference in germination rate among Southern Marmara populations. Resistant Mediterranean population (AKR2) germinated higher than two susceptible Mediterranean populations of which germination delayed approximately 2 days. There is a need for further investigation at biotype level which has different resistant patterns. However, it can be concluded that there is no fitness penalty for populations investigated. These results suggest that physical weed control method would be one of the most prominent ones to control herbicide resistant weeds, which resulted from solely relying on chemical control methods.

Table 1. Germination rates of sterile oat populations under different temperatures

Temperature (^{0}C)	Sterile oat Populations AV01	AV02	KTA	AKR2	AV14	KRL3
	The Number of Germinated Seed					
10	24.88	23.50	10.25	24.25	24.62	17.38
15	22.50	23.50	17.38	24.12	22.38	21.38
20	20.38	20.88	17.38	24.50	17.50	21.50
25	17.38	19.50	20.25	24.25	21.12	19.88
30	10.12	7.75	11.38	23.38	5.62	18.38

Estimation of cereal varieties for competitiveness against weeds

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Assessing weed suppression ability of crops became more important with the development of organic plant breeding. This report introduces with first results on the project “Development, improvement and implementation of environmentally friendly and sustainable crop breeding technologies” (2009/0218/1DP/1.1.1.2.0/09/APIA/VIAA/099). The investigation is carried out with barley, oat, triticale and winter wheat varieties and breeding lines in organic crop rotations at State Priekuli Plant Breeding Institute and at State Stende Cereals Breeding Institute in Latvia. The aim is to develop the methodology for an estimation of cereal varieties and breeding lines for their competitive capacity against weeds, to establish more effective criteria of the selection by significant crop characteristics in the breeding process. Plant density after emergence, growth habit at tillering and at stem elongation, tillering capacity, crop canopy height at the beginning and at the end of stem elongation and crop plant height before the harvesting, amount of plants with inclined flag leaves at booting, beginning dates of such phenological phases as germination (emergence), tillering, stem elongation, heading and fully ripening, crop and weed ground cover several times from the end of tillering to full flowering, weed dry weights at cereal flowering for winter cereals or at fully ripening for spring cereals, as well as crop yields are taken into account, to evaluate cereal varieties competitiveness. Harrowing was not used in the trials, to exclude the impact of this factor. Multivariate methods were used for statistical data analysis. Detection of the most important crop characteristics, which provide the competitiveness against weeds for cereal breeding aims in organic growing conditions, is stressed as a desired result.

Impacts of different crop management systems on arable weed flora

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Although weed issue arose already along with the dawn of agriculture, there still is not enough knowledge on weed biological and ecological nature, to solve the weed problem. The aim of our study was to establish the role of different crop growing practices in influencing arable weed flora, to provide new knowledge for environmentally friendly crop management systems. The early summer arable weed data were collected from long-term investigation field at State Priekuli Plant Breeding Institute (57˚19´ N, 25˚20´ E). Investigation field consisted of five different crop rotations that were established in six different fertilization systems. Crop rotations were: 1) summer cereals (barley or oat) – potatoes – summer cereals; 2) summer cereals – perennial grasses – winter cereals (rye or wheat) – potatoes; 3) summer cereals – perennial grasses – summer cereals – winter cereals – summer cereals – potatoes; 4) summer cereals – perennial grasses – potatoes; 5) summer cereals – perennial grasses – perennial grasses – winter cereals – summer cereals – potatoes. Fertilization systems were: 1) unfertilized; 2) animal manure (20 t ha^{-1}); 3) $N_{66}P_{90}K_{135}$; 4) animal manure + $N_{66}P_{90}K_{135}$; 5) $N_{132}P_{180}K_{270}$; 6) straw + $N_{66}P_{90}K_{135}$. In total 44 different weed taxa (at species or family level) were found in 22-year period between 1973 and 2009. Data were analyzed using descriptive statistics, general linear model (GLM) and canonical correspondence analysis (CCA). Six GLMs were created - three for both weed density (plant m^{-2}), and weed species diversity, for annual, perennial and total weed accordingly. The CCA model included 31 weed taxa, which incidence was more than five percent. Fertilization system more affected annual weed densities and species composition, while crop rotation had significant impacts on perennial weed densities. Some weed taxa were found that had an indicator value for identifying the impact of particular crop rotation or fertilization system. Results can be applied to other areas, which have similar soils and climate conditions as they are at investigation in Priekuli.

Agrotechnical approaches for maintaining the soil surface in the fruit plantations in a good agrotechnical and ecological condition

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Abstract
The present paper considers the conditions, approaches and problems connected to the systems for maintenance of the soil surface in Bulgarian orchards. Weed control is one of the most important agrotechnical practices, which determines to a great extent the success of contemporary fruit production and its economic viability. Information is presented on different species of weeds, typical weed associations in planted rows and main systems for maintenance of the soil surface in orchards: black fallow and grassing. The main advantages and drawbacks of the applied systems, as well the necessary conditions (irrigation depending on the climatic conditions in production areas and micro-areas and additional fertilization) for cropping of trees with grassed inter-rows are considered. The application of some agrotechnical practices such as shallow tilling during the vegetation period (disking, cutting, etc.) has a negative effect on the spread of tenacious weeds developing rhizomes or root offshoots. The integrated approach for weed control combining good agricultural practices and application of herbicidal products with proven selectivity which are suitable for the conditions in integrated fruit production, as well as the search for alternative approaches to limit the use of herbicides, ensure that the crops are maintained in a good agrotechnical and ecological condition.

The success of modern fruit production is based on the adoption of a complex of good agricultural practices aimed at providing the most favourable conditions for manifestation of the biological and commercial qualities of the rootstock – cultivar combinations while preserving the elements of the environment in good ecological condition. The soil and climatic conditions in Bulgaria are prerequisites for development of fruit growing, represented by a wide variety of fruit tree species, cultivars and cultivar – rootstock combinations. Specialized areas and micro-areas have been established for their economically efficient cultivation, where the production of a particular orchard crop prevails. The area of Silistra in Northeast Bulgaria is specialized in production of apricots; the Tundzha area in the central part of the country is characterized by production of peaches; in central Bulgaria, a number of orchard crops are cultivated - cherries, peaches, apples and plums.

The conditions for cultivation (soil type, irrigation, cultivar – rootstock combination, planting distance, canopy arrangement, etc.) are favourable for development and reproduction of particular weed species.

Under the conditions in Bulgaria, over 300 species of wild and semi-cultivated herbaceous plants are listed in the category of weeds, while the category of economically important weeds contains about 100 species (Kolev, 1963; Fetvadzhieva, 1973; Lyubenov *et al.,* 1988; Tonev, 2000).

The need to maintain soil fertility and limit the use of pesticides accounts for the necessity of research on the influence of different systems for soil surface maintenance and weed control in order to apply ecologically sound approaches in cultivation of fruit plantings under the conditions in the country (Rankova, 2006).

Weed vegetation is one of the main factors limiting the growth and development of fruit trees. Weeds compete with the trees for water, sunlight and nutrients. The depressing influence of weeds is most strongly manifested by young fruit trees, before their first fruiting. During this period their root systems are shallow and the competition for the factors, necessary for vegetative growth, is most pronounced. Two main types of weed associations are differentiated in fruit tree plantings. These are the earthed-up type and meadow type (Tonev *et al.,* 2007). In young plantings and gardens where regular soil cultivation is performed, weed associations of the earthed-up type are common. The main weed species included in it are representatives of the late spring weeds: *Chenopodium album* (L.) (White Goosefoot), *Amaranthus retroflexus* (L.) (Red-root Amaranth), *Xanthium strumarium* (L.) (Rough Cocklebur), *Polygonum aviculare* (L.) (Common Knotgrass), *Portulaca oleracea* (L.) (Common Purslane), *Solanum nigrum* (L.) (European Black Nightshade), *Erigeron canadensis* (L.) (Canadian Horseweed), *Datura stramonium* (L.) (Jimsonweed), etc. Other species belonging to this association are representatives of the early spring and winter-spring weeds, as well as of the group of ephemerals: *Stellaria media* (L.) (Common Chickweed), *Capsella bursa-pastoris* (L.) Medic (Shepherd's Purse)*, Senecio vulgaris* (L.) (Common Groundsel)**,** *Veronica hederifolia* (L.) (Ivy-leaved Speedwell), *Veronica agrestis* (L.) (Green Field Speedwell), *Lamium purpureum* (L.) (Red Deadnettle), *Lamium amplexicaule* (L.) (Henbit Deadnettle), etc. Perennial weeds forming rhizomes and root offshoots are represented as accompanying species.

In fruit tree plantings grown under poor agrotechnics, where no annual cultivation of the soil is being performed and no herbicides are applied, the weed association is of the meadow type. Major representatives of this type of associations are the tenacious perennial weeds forming rhizomes and root offshoots: *Sorghum halepense* (L.) Pers. (Johnsongrass), *Cynodon dactylon* (L.) Pers. (Bermuda Grass), , *Cirsium arvense* (L.) Scop. (Creeping Thistle), *Convolvulus arvensis* (L.) (Field Bindweed), *Sambucus ebulus* (L.) (Danewort), etc. These species are difficult to control and inappropriate measures may lead to an increase in their populations.

The major priorities in weed control in orchards are: control of weed vegetation during preparation of the cultivated area before planting a new orchard; choice of a suitable system for maintenance of the soil surface; choice of a suitable herbicide, rate and period of application; use of herbicides with good efficacy against weeds, high selectivity (safety) towards fruit trees and short persistence (period of residual herbicidal activity) in order to prevent contamination of the soil with residual quantities of herbicide; alternation of herbicides with different chemical composition in order to prevent the development of resistant weed biotypes (Rankova, 2006; Rankova and Kolev, 2009).

Weed control during preparation of the cultivated area before planting a new orchard is an important agrotechnical measure which ensures the establishment of a good agricultural background at the beginning of the cultivation of the orchard (Rankova, 2008; Dzhuvinov *et al.,* 2007). In this respect, it is necessary to clear the area intended for planting of the new orchard from the preceding crop, if possible in early summer. A complex of agrotechnical measures is performed for preliminary elimination of weeds in the area. Under arid conditions, the method of drying is utilized. Deep tillage (plowing) is performed during the hottest summer months July and August. Thus the organs for vegetative reproduction (rhizomes, offshoots) are lifted on the soil surface and are subjected to the drying action of sunlight. The drying of rhizomes leads to rotting of a large number of dormant bulbs. The method of drying is essential for the control of *S. halepense* and *C. dactylon* in lowland areas. The soil is maintained free of weeds until planting of the young trees through shallow cultivation. In regions with more humid, cooler climate, the method of exhaustion is applied. In this case, shallower tilling is performed first in order to cut the rhizomes of the weeds into pieces and provoke collective development of their dormant buds. Deep cultivation is performed two to three weeks after the development of the offshoots but before they have started to root. The soil is maintained free of weeds with shallow cultivation until planting of the fruit trees. This is aimed at preventing the reproduction of weeds which have developed from seeds (Fetvadzhieva, 1973; Tonev, 2000; Tonev *et al.,* 2007)

Best results in control of weed vegetation, including tenacious perennial weeds forming rhizomes and root offshoots, are achieved through a combination of agrotechnical measures (the method of drying or exhaustion) and application of total herbicides. In this respect during the period June – July a treatment with products with active ingredient glyphosate is performed (Roundup, Nasa 360 SL, Glyphogan, Glyphodin, Glyphosate C, etc.). The most suitable phenophase for treatment with these herbicides is the beginning of ear formation of cereal weeds, budding (*C. arvense*) and full blossom (*C. arvensis, Aristolochia clematitis* L.). Basic cultivation is performed one month after the treatment (Tonev, 2000; Tonev *et al.,* 2007).

Currently two major systems for maintenance of the soil surface in fruit tree plantings in Bulgaria are applied – black fallow and grassing (natural grassing, grass – mulch system) (Stamatov *et al.,* 1982; Petrov and Grigorov, 1981; Iliev *et al.,* 1983; Zhivondov *et al.,* 2008; Stoynev *et al.,* 1986). Black fallow is the major system for maintenance of the soil surface in orchards. It is recommended for cultivation of young trees planted under relatively dry conditions for the country when there are not any options for irrigation.

This system requires periodic shallow spring-summer cultivations (at a depth of 7 to 10 cm) and autumn tillage in the inter-rows at a depth of 14 – 16 cm once every three years. The major advantages of black fallow are: efficient mechanical control of weeds; soil cultivations break the soil crust which enhances the water and soil regime of the soil; allows for plowing-in of organic and mineral fertilizers (Stamatov *et al.,* 1982).

However it has been established that along with its positive effects, black fallow also has a number of disadvantages: the frequent passage of agricultural machines leads to soil compaction and formation of grooves which retain water during heavy rains or irrigation; significant expenses for fuel and lubricating materials; the use of disking machines causes fragmentation of the rhizomes of perennial weeds favouring their reproduction; frequent passage of machines leads to dust formation in the top soil layer, which has a negative impact on the soil structure; the soil becomes less rich in organic substances (Stamatov, 1982; Taseva and Ilieva, 1992; Taseva, 1995; Todorov *et al.,* 1982; Simeonov *et al.,* 1979).

While keeping black fallow, it is most appropriate to combine agrotechnical measures (soil cultivation) and herbicide application in the rows of plantings. The first soil cultivation is performed early in spring when soil humidity allows passage of machines. Immediately after this, soil herbicides are applied. During the vegetation period, the number of mechanized soil cultivations is determined by the degree of weed infestation. Cutters with diverter sections can be used for destruction of weed vegetation in the rows (Stamatov, 1982; Taseva and Ilieva, 1992).

In line with the global trend for adoption of ecological approaches and protection of biodiversity, fruit growing needs to conform to the requirements of Integrated Fruit Production (IFP). According to the definition of the International Ogranization for Biological and Integrated Control of Noxious Animals and Plants (IOBC), IFP is the economical production of high quality fruit, giving priority to ecologically safer methods, minimising the undesirable side effects and use of agrochemicals, to enhance the safeguards to the environment and human health (Cross and Dicker, 1994; Rankova, 2006).

IFP is the major method for fruit production in Europe. One of its overarching aims is to ensure high quality fruit which are economically viable, while maintaining biodiversity, preserving soil fertility and protecting the health of farmers and end-consumers.

In the context of the requirements of IFP, grass systems for maintenance of the soil surface are defined as an environmentally friendly approach, which preserves the biodiversity and the structure of the soil (Zhivondov and Rankova, 2009).

Grass systems for cultivation of fruit trees (natural grasslands, cultivated grasslands, grass-mulching system) are suitable for use in humid regions and on irrigated areas. Permanent grass sod is established in the inter-rows and the periodically mowed down grass mass is left at the site for mulching and organic fertilization. The grass sod is most commonly established in the inter-rows, while the rows are maintained free of weeds by mechanical cultivation (cutters with diverter sections) or application of herbicides. Grass mixtures of the following species are recommended for grassing of the inter-rows:

Lolium perenne (L.) (Perennial Ryegrass), *Festuca platensis* Huds., *Poa pratensis* (L.) (Smooth Meadow Grass), *Phleum platens* (L.) (Timothy Grass) – individually or in mixture with *Trifolium repens* (L.) (White Clover) or *Trifolium pratense* (L.) (Red Clover).

The following grass mixtures are recommended for inter-rows: 40 – 50 kg/ha *L. perenne* or 30 – 40 kg/ha *L. perenne* + 2 kg/ha *T. repens*; 20 – 30 kg/ha *F. platens* + 2 kg/ha *T. repens*; 20 – 25 kg/ha *F. platens* + 2 kg/ha *T. repens* (Stamatov, 1982). The seeds of the grass mixtures are sown in spring (April) on the year of planting of the new orchard or in the following years. If there is a system for irrigation, sowing of the grass can be performed in the year of planting of the young trees. If no irrigation is provided, then it is advisable to sow the grass in the second or the third year after planting of the trees when they have developed a deeper root system in order to limit the competition between the grasses and the trees. The grasses are mowed periodically to a height of 10 – 12 cm. The mowed down mass is left at the site as mulch, thus also delivering additional organic substances to the soil.

The main advantages of the grass-mulch system are the enhancement of the soil structure and the regime of the water, air and nutrients. It allows for passage of agricultural machines throughout the year without formation of grooves. Grass mixtures suppress the development of weeds, including tenacious perennial species forming rhizomes and root offshoots: *S. halepense, C. dactylon, C. arvensis, C. arvense* (Stamatov *et al.,* 1982; Mitov *et al.,* 1981)

Research on the influence of the grass-mulching system on the development of apple trees and the quantity and composition of the soil microflora shows that the trees develop well under irrigated conditions (Taseva and Ilieva, 1992; Taseva, 1995).

Grass systems are suitable for maintenance of the soil surface in plantings in mountain and hilly regions in the country, preventing erosion (Domozetov and Doychev, 1999; Petrov *et al.,* 1994).

Under analogous conditions it is recommended that cover crops are grown in the inter-rows to provide green manure. It has been established that winter fodder peas and mixtures of peas and rye are suitable for green fertilization of young plum plantings and contribute to the increase of the organic content in the soil (Petrov *et al.,* 1994; Vitanova, 1995). Green fertilization with repco has a positive effect on the vegetative growth and yield of apricot trees (Nikolova, 1995).

The results of the research on the impact of different systems for maintenance of the soil surface with almond tree plantings show different influence on tree growth, yield and fruit quality (Rankova and Djeneva, 2010; Rankova and Djeneve, in print). Winter peas and vetch can be recommended as crops, suitable for green manure with a positive effect on fruit yield. Winter broad beans are not suitable for green manure as this cover crop has a negative influence on fruit tree growth and yield. The application of a combination of herbicides selective for almond trees in the rows (4 l/ha pendimetalin Stomp 33 EK and 6 l/ha diuron + glyphosate, Trevisimo – 10 l/ha) and planting of crops for green fertilization in the inter-rows – winter peas and vetch – comprise a suitable system for maintenance of the soil surface which provides effective weed control and has a positive effect on the growth and yield of the fruit trees.

Conclusion

The application of a complex of agrotechnical approaches for maintenance of the soil surface in fruit tree plantings based on the choice of a system suitable for the local soil and climatic conditions and for the biological characteristics of the cultivar – rootstock combinations is an important element in Integrated Fruit Production. The creative integration of different approaches ensures maintenance of the plantings in good agrotechnical and ecological condition.

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Investigation of row spacing effect on competitive ability of canola in competition to *Sinapis arvensis* (Wild mustard)

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In order to investigation of canola competitive ability in competition with *Sinapis arvensis*, an experiment in the form of randomized complete block design with three replications was conducted at the research field of gorgan university of agricultural sciences and natural resources in 2009-2010.Treatments were components of 3 row spacings of canola (12،24 and 36 cm) and weed density (0 and 8 plant in m$^{2)}$. The results showed that *Sinapis arvensis* decrease leaf area index, crop growth rate, relative growth rate, dry matter and canola yield in all of row spacings. The most of leaf area index, crop growth rate, relative growth rate was observed in row spacings of 36، 24 and 12 cm and the most of dry matter and yield of canola was observed in row spacings of 12، 24 and 36 cm respectively.The results of this research indicated that increase of crop density via decrease of row spacing, is an effective practice in decrease of *Sinapis arvensis* density.

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Effects of soil tillage systems on seed distribution, seedling emergence and surviving of *Centaurea tchihatcheffii* Fisch. & Mey., an endangered annual plant

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This study investigates the effects of plowing, cultivation and no-till on the distribution of *C. tchihatcheffii* seeds in the soil for 2-year field experiment. Seed distribution was determined by sieving of the soil samples obtained from soil depths of 0-2, 0-5, 5-10, 10-15 and 15-20 cm. Seeds were counted by first sieving dry, then wet. Plowing moved 95 % of the seeds to a soil profile deeper than 5 cm, a level at which most of the seeds lost their ability of germination. Approximately half of the seeds localized the first 5 cm of the soil layer in the cultivated plots, whereas more than 90% of the seeds were localized at this depth in no-till plots. Seed emergence was greater in the no-till plots than in the cultivated plots. Seed emergence in the plowed plots was lower than of plots in which other tillage techniques were used. Mature plant number was greatest in the no-till plots and lowest in the plowed plots at the end of growing seasons. As a result it was concluded that plowing isn't an appropriate tillage method to survive of *C. tchihatcheffii*.

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Chlorsulfuron and trifensulfuron-methyl (herbicides)-resistant *Sinapis arvensis* L. biotypes show vigorous germination potential

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Our studies have identified and confirmed at biochemical and molecular levels the presence of chlorsulfuron-resistant biotypes of the weed S. arvensis in wheat fields of Turkey. Here, we present evidence that freshly harvested and after-ripened wild mustard (Sinapis arvensis) seeds from chlorsulfuron resistant and susceptible biotypes exhibit different patterns of germinability under the tested conditions.

Experiments were carried out under controlled (laboratory, environmental chamber and greenhouse) conditions to compare seed germination patterns and emergence differences of chlorsulfuron resistant (R) and susceptible (S) S. arvensis biotypes. Seed germination was tested at different temperature regimes (5º,.10º,.15º and 22ºC) and after extended periods of dry-storage (after-ripening) (4 months, 2 years and 4 years).

Results of the study showed that S.arvensis seeds from two resistant biotypes had higher germination rates, 74.0-81.9%, compared to two susceptible biotypes, 24.3-27.1%. Except at 5ºC, where no germination occurred, similar germination patterns were obtained at 10º,15º and 22ºC under laboratory, greenhouse and environmental chamber growth-conditions. Total cumulative seed germination percentage of ‘R’ biotypes was significantly higher than that of the ‘S’ biotypes. Moreover, seeds of R biotypes germinated 72 hours sooner than the S biotypes. However, the maximum cumulative germination was found to be a function of dry storage (after-ripening).period. Freshly harvested 4-months dry-stored seeds of ‘S’ biotypes had higher initial germination, which considerably decreased with storage time of 2 and 4 years. The seeds from ‘R’ S. arvensis biotypes showed an opposite trend: low initial germination (12%) in seeds stored for 4 months compared to 68% germination of seeds stored for 4 years.

These data suggest that chlorsulfuron-resistant S.arvensis biotypes, with the ability to germinate fast and at a higher percentage, and the advantage to sustain their germinability even after a long storage time of 4 years, have the capacity to be more competitive than the susceptible counterparts. The impact of these observations on developing new weed management strategies will be discussed.

The critical period for weed control in red pepper (*Capsicum annum* L.)

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Field studies were conducted in Kahramanmaraş, Turkey, in 2008 and 2009. Weeds are a major constraint in red pepper production. Understanding the critical period for weed control (CPWC) can be a tool for effective weed control and reducing the impacts of weeds. The critical period for weed control in red pepper based on a 2.5%, 5% and 10% acceptable yield loss level was calculated by fitting logistic and Gompertz equations to relative yield data. The critical period for weed control in red pepper was determined to be from 0 to 1087 growing degree days (GDD) in 2008 and from 109 to 796 GDD in 2009 for 10% yield loss after emergence in red pepper; for 2.5-5% yield loss, the critical period starts with germination and lasts longer. Preemergence (PRE) or presowing (PPI) herbicides would be preferred to avoid higher yield losses. If a farmer can tolerate 10% yield loss, a postemergence (POST) herbicide can be applied in between beginning of the germination and 1-2 nd week after crop germination, and the field should be kept weed free for corresponds 7 weeks to 7-8 weeks.

Allelopathic studies in Çukurova region, Turkey

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Chemical control is the most common method to manage weeds, but it disturbs the balance of nature, causes environmental pollution and health problems. The increasing consumer awareness and interest for sustainable agriculture and ecological farming systems have necessiated to search alternate methods for weed control. One of these methods is use of allelopathy. Allelopathy is direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that escape into the environment.

Many allelochemicals suspected of causing germination and growth inhibition have been idendified (such as phenolic acids, coumarins, terpenoids, flavonoids, alkaloids, glycosides, glucosinolates, isothiocyanate) from plant tissues. Taking advantage of this feature, we did some researches using allelopathic plants or products made from them for controlling weeds.

The Brassicaceae family is important for allelopathic potential, as its members produce allelopathic substances. The genus *Raphanus* is a member of *Brassicaceae* family. The allelopathic effects of *Raphanus sativus* succesfully controls the *Sorghum halepense* in cotton fields from Çukurova. The influence of aqueous extracts of *R. sativus* were determined on seed germination, seedling and rhizome growth of some weeds and crops.

Some of our additional studies;

-Allelopathic and bioherbicidal effect of the plant parts residues from *Eucalyptus camaldulensis, Melia azedarach, Nerium oleander* etc. on growth of weeds and crops,

-The effect of vinegar and citric acide on weeds,

-Effect of mustard and other oils on germination and development of weed species,

-The effect of industrial production waste on weed density in perennial crops.

When the results were evaluated in general in Cukurova region, the tested plants affect the vegetative and generative development of an important weed species in field conditions and also inhihibited germination of weed seed under laboratory condition. The preparations obtained from allelopathic plants can be used economically against weeds.

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Allelopathic Effects of *Juglans nigra* L. and *Datura stramonium* L. on *Cyperus rotundus* L. and *Cynodon dactylon* L. Pers.

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Abstract

The allelopathic potential of dried leaves of walnut (*Juglans nigra* L.) and jimsonweed (*Datura stramonium* L.) on germination and growth of *Cyperus rotundus* L. (purple nutsedge) and *Cynodon dactylon* L. Pers. (bermuda grass) were studied Walnut leaves were collected from young leaves. The other allelopathic material jimsonweed leaves were collected in the period of blooming in the morning hours. The leaves were dried at 25 ^{0}C after than grounded. These extracts were added into soil with four different doses (5, 10, 20, 40 g/pot). The experiments were evaluated after 25 days. Both walnut and jimsonweed dry extratct had negative effects on growing of the purple nudsedge and bermuda grass. The highest effect was obtained from the rate of 40 g/pot. Bermuda grass and purple nutsedge dry weight was affected from walnut extracts by 76% and 74 respectively. There is a possibility to use walnut and jimsonweed plants as ann natural allelochemicals for the management of these perennial weeds.

Introduction

Allelopathy is a natural phenomenon that refers to direct or indirect positive or negative effect of one plant (including the microbes) on another through the release of chemical compounds into the environment. (Rice,1984; Delabays et. al., 2004). According to Putnam(1988), chemicals with allelopathic potential are present (commonly in conjugated form) in almost all plants and in many diffrent tissues, such as leaves, stems, flowers, fruits, seeds and roots. These chemicals are released into the environment (atmosphere or rhizosphere) by means of volatilization, leaching, decomposition of residues, and root exudation under specific conditions (Chou, 1990). Information on the chemical nature and mode of action of allelochemicals is expanding (Dayan et al., 2000; Inderjit and Duke, 2003; Marcías et al., 2004). An equally promising way to use allelopathy in weed control is using extracts of allelopathic plants as natural herbicides (Dayan, 2002). The most practical and immediate way to use allelopathy in weed control is to use allelopathic cover crops in rotations, or apply residues of allelopathic weeds or crops as mulches (Rice, 1984, Arslan, 2006). For instance; Six *Brassicaceae* crops were investigated under laboratory and field conditions for allelopathic potential of their residues to control johnsongrass. In both conditions all species suppressed johnsongrass and followed similar pattern. It has been shown that *Brassicaceae* crops, which are grown in Turkey, can be used as rotational crops in cropping systems to reduce johnsongrass infestation (Üremiş et. al. 2009).

The aim of this study were to found allelopathic effect of dry leaves of *J. nigra* and *D. stramonium* on germination and growth of *C. rotundus* L. and *C. dactylon* (L.) Pers.

Materials and methods

Walnut young leaves were collected in the morning hours. Jimsonweed leaves were collected in the period of blooming in the morning hours. The collected plants were air-dried for 15 days in dark condition at room temperature (25 ±4°C). Then, dry leaves were grounded by fine cut (FC). Experiments were established as a pot experiment. The pots diameter were 14 cm. Grounded exctracts were separately added into soil at four different doses (5, 10, 20, 40 g/pot). Five cm long rhizomes were used for both purple nutsedge and bermuda grass These rhizomes also had at least two live nodes. In addition, there was a tuber in the purple nutsedge. The rhizomes or tuber+rhizomes of each pot (soil mixed with different doses) were sown separately. In addition to that control pots were arranged. Plants lengths and dry weights of two weeds were evaluated after 25 days.

Experiments were arranged in a completely randomized design with four replications and repeated twice, in Atatürk Central Horticultural Research Institute of Plant Protection Department's greenhouse in 2009. The data were analyzed by using SPSS and means grouped on basis of least significant difference (LSD) at the 0.05 probability level.

Results and discussion

Target plants were sprouting in rhizomes, but walnut and jimsonweed had significantly inhibited the dry weight of purple nutsedge and bermudagrass.

As a result, walnut and jimsonweed plants had negative effects on growing of the purple nudsedge and bermuda grass. These effects were incresed by doses. The highest effect rates for the both plants were determined at the rate of 40 g/pot. Bermuda grass dry weight average was affected % 76, and purple nutsedge dry weight average was affected % 74 by walnut. Similarly, bermuda grass dry weight was affected % 66.5, and purple nutsedge dry weight was affected % 61.4 by jimsonweed.

The responses of weeds to walnut are given in Table 1 and 2. Similarly results showed (Table 3 and Table 4) that the effects and response rates for jimsonweed.

Conclusions

The results of the greenhouse experiments of this study indicate that inhibitory substances are present in extracts of walnut and jimsonweed leaves. Wulnut and jimsonweed had many allelocheicals substances that could potentially influence the growth of purple nutsedge and bermuda grass.

There is a possibility to harness the allelochemicals of walnut and jimsonweed plants as natural herbicides for the management of these perennial weeds. But allelopathy needs to be researched as well as the mechanism.

Walnut

Table 1: The effect of walnut on dry weight of target plants (g)

	Purple nutsedge	Bermuda grass
Doz	Dry weight	Dry weight
0	14,30 a	17,00 a
5	11,00 a	9,80 b
10	6,80 b	7,50 bc
20	3,80 bc	5,50 bc
40	3,00 c	3,30 c
LSD	*3,40*	*4,52*
0	14,30 a	17,00 a
5*	11,50 b	10,30 b
10*	10,00 bc	10,30 b
20*	8,00 c	8,13 bc
40*	4,50 d	4,90 c
**LSD*	*2,30*	*4,50*

P ≤ 0.05: probability level

Table 2: Response rates of walnut on dry weight of target plants (%)

Target plants	Doses (g)			
	5	10	20	40
	Dw -1	Dw -1	Dw -1	Dw-1
Bermuda grass	42,30	55,80	67,60	80,50
Purple nutsedge	23,10	52,40	73,40	79,00
	Dw-2	Dw -2	Dw -2	Dw-2
Bermuda grass	39,40	39,40	52,20	71,20
Purple nutsedge	19,60	30,00	42,50	68,50
	5	10	20	40
Bermuda grass*	40,85	47,60	59,90	76
Purple nutsedge*	21,35	41,20	57,95	74

Dw = Dry weight 1: First experiment 2: Second experiment * *means: Avarages*

Jimsonweed

Table 3: Effect of jimsonweed on dry weight of target plants (g)

	Purple nutsedge	Bermuda grass
Doz	Dry weight	Dry weight
0	10,23 a	9,20 a
5	8,20 a	6,00 ab
10	7,07 ab	5,20 b
20	5,63 b	4,50 b
40	4,20 b	3,33 b
LSD	*3,82*	*3,41*
0	10,23 a	9,20 a
5*	8,80 a	6,30 ab
10*	8,00 a	5,00 bc
20*	4,44 b	3,20 bc
40*	3,80 b	2,83 c
**LSD*	*3,80*	*3,24*

$P \leq 0.05$: probability level

Table 4: Response rates of jimsonweed on dry weight of target plants (%)

Target plants	Doses (g)			
	5	10	20	40
	Dw -1	Dw -1	Dw -1	Dw -1
Bermuda grass	34,80	43,50	51,10	63,80
Purple nutsedge	19,80	31,00	45,00	60,00
	Dw -2	Dw -2	Dw -2	Dw -2
Bermuda grass	31,50	45,60	65,20	69,20
Purple nutsedge	14,00	22,00	55,00	62,80
	5	10	20	40
Bermuda grass*	33,15	44,55	58,15	66,5
Purple nutsedge*	16,90	26,50	50,00	61,4

Dw = Dry weight 1: First experiment 2: Second experiment * *means: Avarages*

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Thermal weed control

Effect of flame weeding at different time intervals before crop emergence

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A research project studying 'Effective weed management in row-grown organic carrots' was carried out at SLU Alnarp. The project used a slightly modified form of the 'participatory research' concept, which meant that it was associated with a reference group consisting of the growers participating in the project, advisors and researchers. The aim of the project was to examine various weed control methods combined into entire weed management strategies. After discussions with the growers in the group, the studies focused on weed control measures to be carried out before crop emergence, since these measures were considered to be the most important in the weed management strategy.

One experiment carried out in Karlskrona, in the county of Blekinge in southern Sweden studied the importance of weed flaming shortly before the emergence of an organic carrot crop. The experiment included four replicates and examined four different times of flaming treatment in relation to the seeding date. The field in which the experiment was carried out was tilled with a rotary power harrow on 16 May and the carrot crop was sown on 27 May. Weed flaming was performed 5, 6, 7 and 9 days after sowing. The first carrot plants began to emerge from the soil 7 days after sowing. The plots were weeded by hand 29 days after sowing.

The results showed that the number of weeds in the carrot crop decreased by 10% and the manual weeding requirement was reduced by 10-15 hours per hectare for every day flaming was delayed in relation to carrot emergence. Weed flaming one day too early increased the cost of manual weeding by SEK 2600 per hectare (approx. € 280 per hectare). The optimal conditions for successful weed flaming were found to be careful seedbed preparation, resulting in an even soil surface, and sowing in a moist seedbed, resulting in simultaneous and uniform emergence of weeds and cultivated plants.

It was concluded that it is important to flame as late as possible before crop emergence. The optimal time is just before crop emergence, or when a few percent of the carrot plants have emerged. Losses in crop plant numbers due to planned late flaming relative to emergence can be compensated for by slightly increasing the seed rate.

Weed control and crop tolerance to propane flaming as influenced by time of day

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Abstract

Variability in flaming efficacy has been observed for early morning versus late afternoon flaming operations. The basis for the differential plant response is not well understood; however, daily variation in leaf relative water content (RWC) is thought to contribute to the response. Leaf RWC is the ratio of the amount of water in the leaf tissue at sampling to that present when fully turgid. To determine the influence of leaf RWC in plant response to propane flaming, greenhouse experiments were conducted during April and September of 2009. Two crops (4-leaf corn and second trifoliate soybean) and two weed species (5-leaf velvetleaf and 6-leaf green foxtail) were flamed with four propane doses (0, 29, 43, and 87 kg ha^{-1}) at various times of day (0, 4, 8, and 12 h after sunrise-HAS). Leaf RWC was measured before treatment application. Flaming treatment was conducted utilizing a hand flamer with one VT 2–23C vapor phase burner positioned 20 cm above soil surface and angled horizontally at 30°. The propane pressure was 120 kPa and the application speeds were 1.6, 3.2, and 4.8 km h^{-1}. The plant responses evaluated were visual injury (1, 3, and 7 d after treatment-DAT) and fresh weight (7 DAT). All plant species were more susceptible to flaming during the afternoon and presented lower leaf RWC at 8 HAS; however, the response of these plants did not differ with the plants flamed at 12 HAS. For example, green foxtail flamed with the highest propane dose of 87 kg ha^{-1} at 0 HAS had 62% injury at 7 DAT compared to significantly higher injury of 76% and 82% with the same propane dose at 8 HAS and 12 HAS, respectively. The same tendency was demonstrated by velvetleaf showing 80% injury when flamed with 87 kg ha^{-1} at 0 HAS and 93% injury when flamed at 12 HAS with the same propane dose at 7 DAT. Similar trends occurred for corn and soybean suggesting that leaf RWC is likely one of the factors affecting plant response to flaming. Practical implication is that flaming operation should be conducted in the afternoon in order to improve efficacy of weed control and reduce propane consumption rate.

Introduction

Weeds are one of the major problems for producers and are responsible for significant crop yield reduction for both conventional and organic production systems (Stopes and Millington 1991). In particular, organic farmers rank weed interference as the number one problem limiting crop production (Walz 1999). Hand weeding and cultivation are the most utilized methods for managing weeds in organic farming systems (Hiltbrunner et al. 2007). However, hand weeding requires the availability of sufficient hand labor and is costly (Kruidhof et al. 2008). Repeated disturbance of the soil caused by cultivation prevents the build-up and/or the maintenance of a stable soil structure, increases the chance for soil erosion, and promotes emergence of new weed flushes (Hiltbrunner et al. 2007; Wszelaki et al. 2007). In addition, recent developments in conventional cropping systems, including an increasing number of herbicide-resistant weeds, higher costs of herbicides, and more concerns about leaching of herbicide into surface and ground water contaminating drinking water and food have sparked public awareness and restrictions on herbicide use (Rifai et al. 2002; Wszelaki et al. 2007). For these reasons weed scientists are considering alternative and integrated weed management practices to reduce herbicide inputs and impacts (Rifai et al. 2000). The use of propane for flame weeding could be used as one of the alternatives to chemical weed control

(Knezevic and Ulloa 2007; Ulloa et al. 2010a, 2010b, 2010c, 2010d; Wszelaki et al. 2007), as it eliminates concerns over direct residual effects on soil, water, and food quality (Ascard 1998) and could lessen the reliance on herbicides, hand weeding, and/or mechanical cultivation (Wszelaki et al. 2007).

Flame weeding is an acceptable weed control option in organic production and has received considerable attention recently for its potential in both organic and conventional production systems (Bond and Grundy 2001; Parish 1990). Propane burners can generate combustion temperatures of up to 1900 C, which raises the temperature of the exposed plant tissues rapidly (Ascard 1998). Flaming kills weeds mainly by boiling the water inside the cell, which ruptures cell membranes and desiccates tissue (Lague et al. 2001; Rifai et al. 1996). Increase of temperatures above 50 C inside the plant cells results in protein coagulation (Parish 1990; Pelletier et al. 1995), and consequently weeds die, or their competitive ability against the crop is severely reduced. Flame weeding does not disrupt the soil surface, thus reducing the risk of soil erosion, and it does not bring buried weed seeds to the surface, thus minimizing the chance of new flushes of weeds (Wszelaki et al. 2007). The susceptibility of plants to flaming largely depends on their heat avoidance, heat tolerance, or both (Ascard 1995).

The efficacy of flame weeding was reported to be influenced by several factors, including the growth stages of the plant (Ascard 1994, 1995; Cisneros and Zandstra 2008; Knezevic and Ulloa 2007; Sivesind et al. 2009; Ulloa et al. 2010a, 2010b, 2010c, 2010d), the physical location of the growing point at the time of flaming (Ascard 1995; Hansson and Ascard 2002; Knezevic and Ulloa 2007), the presence of protective layers of hair or wax and lignification (Ascard 1995; Ascard et al. 2007), the technique of flaming (Parish 1990), and the regrowth potential of plant species (Ascard 1995; Ascard et al. 2007). Knezevic and Ulloa (2007) conducted some preliminary studies to examine the response of several crops and weed species to broadcast flaming and observed that plants were more heat sensitive when flamed in the afternoon than early in the morning. We hypothesize that such difference are associated with leaf relative water content (RWC), which varies during daytime. Leaf RWC is the ratio of the amount of water in the leaf tissue at sampling to that present when fully turgid. However, there is little published research describing the effect of leaf RWC on the response of plant species to propane flaming. Leaf RWC depends on many factors, including air temperature, relative humidity, and light intensity, and these factors also vary during the time of day (Saini and Rathore 1982).

The objectives of this research were to determine the time of day when selected crop and weed species would be more susceptible to propane flaming and determine the relation between flaming efficacy and leaf RWC.

Materials and Methods

Plant Materials and Growth Conditions. This study was conducted in April and repeated in September of 2009 in a greenhouse at the University of Nebraska-Lincoln East Campus in Lincoln, NE. The experiment was set up as a completely randomized design with 16 treatments and three replications. Two crops (corn and soybean) and two weed species (green foxtail and velvetleaf) were treated with four doses of propane (0, 29, 43, and 87 kg ha^{-1}) at four times of day (0, 4, 8, and 12 h after sunrise-HAS). Seeds were germinated in flats with peat–perlite–loam (1:2:1, v/v/v) soil mix media. On emergence, one seedling was transplanted into individual 10 cm by 10 cm by 10 cm pots filled with the same soil mix. Plants were irrigated as needed and grown under natural light supplemented with a 14 h photoperiod with artificial illumination of 600 to 1,000 µmol^{-2} s^{-1} photosynthetic photon flux density. Plant growth stages at the time of flaming were: 4-leaf stage (V4) for corn, V6 for green foxtail, V2 for soybean, and V5 for velvetleaf. The weather data at the time of flaming treatments for the trials are reported in Table 1.

Leaf RWC Determination. For each plant species and timing of flaming, one set of three pots were kept aside only for leaf RWC determination. These plants did not receive any flaming treatments. Leaf RWC was determined according to the standard method of Barrs and Weatherley (1962). A composite sample of leaf discs from each plant was weighted immediately, providing a measure of fresh weight (FW). After weighing, the disks were soaked in deionized water for 24 h and then weighted again to obtain a fully turgid weight (TW). Finally, the leaf discs were oven-dried to a constant weight at about 85 C and weighted to get a dry weight (DW). The leaf RWC is calculated as follows (Barrs and Weatherley 1962):

$$RWC = (FW - DW) / (TW - DW) \qquad [1]$$

Although originally defined as a percentage, leaf RWC is now commonly expressed in decimal form (Smart and Bingham 1974) and this convention is followed in our studies (Table 2).

Flaming Procedure. Flaming was done at four times of day (0, 4, 8, and 12 HAS), which covered four different leaf RWC. To obtain different leaf RWC, the soil in each pot was watered up to field capacity at 6 P.M. of the previous day, thus flaming was done approximately at 12, 16, 20, and 24 h after watering. Flaming treatment was conducted utilizing a handheld flamer with a single VT 2-23C vapor phase burner[1] positioned 20 cm above soil surface and angled horizontally at 30˚. The propane pressure was 120 kPa, which produced a flow rate of 95 g h^{-1}. The application speeds (conducted by walking) were 1.6, 3.2, and 4.8 km h^{-1}, which corresponded to the propane doses of 87, 43, and 29 kg ha^{-1}, respectively.

Visual Plant Injury Estimation and Fresh Weight. Visual plant injury was assessed at 1, 3, and 7 d after treatment (DAT) using a scale from 0 to 100%, where 0 represented no plant injury based on the nonflamed plants, and 100 represented plant death. At 7 DAT, each plant species was clipped at the soil surface and shoot fresh weight was recorded.

Statistical Analyses. Analysis of variance (ANOVA) was performed by the PROC GLIMMIX procedure in SAS (SAS Institute 2005) to test for the significance ($P < 0.05$) of experimental runs, treatments, replications, and their interactions on the basis of the visual ratings of plant injury and fresh weight data. There were no significant interaction effects of treatment and experimental run; therefore, the data were pooled over two experimental runs. Data were subjected to a non-linear regression analysis and were analyzed using the four-parameter log-logistic model (Seefeldt et al. 1995):

$$Y = C + (D - C) / \{1 + \exp[B(\log X - \log E)]\} \qquad [2]$$

where Y is the response (e.g., percent injury), C is the lower limit, D is the upper limit, X is the propane dose, E is the dose resulting in a 50% response between the upper and lower limit (also known as inflection point, I_{50} or ED_{50}), and B is the slope of the line at the inflection point (also known as a rate of change). All statistical analysis and graphs were performed with the open-source statistical software R 2.3.0[2] utilizing the dose–response curves (drc) statistical addition package (Knezevic et al. 2007). For visual plant injury, the hours after sunrise when flaming resulted in a 90% of the maximum injury (HAS_{90}) for crops and weed species were calculated from Figure 1b and presented in Table 4. Time of day that corresponded to each HAS_{90} value in Table 4, was calculated on the basis of an arbitrarily assigned day of June 15, 2009.

Results and Discussion

Plant Injury. Significant interaction ($P = 0.02$) between propane dose and time of day was observed with the visual plant injury data at 7 DAT (Figures 1a–b). All plant species exhibited more injury when flamed during the afternoon, particularly at 12 HAS (Figure 1a). There were no differences in the injury levels among 0, 4, and 8 HAS treatments for most of the plant species evaluated based on the size of their standard errors (see upper limit of the curve, Table 3). The difference was only pronounced at 12 HAS treatments compared to 0 HAS applications. For example, corn flamed with the highest propane dose of 87 kg ha^{-1} at 0 HAS had 60% injury compared to significantly higher injury of 74% at 12 HAS with the same propane dose (Table 3). The same tendency was demonstrated by velvetleaf showing 80% injury when flamed with 87 kg ha^{-1} at 0 HAS and 93% injury when flamed at 12 HAS with the same propane dose. Similar trends occurred for green foxtail and soybean. On the basis of visual ratings, broadleaf species (e.g., soybean and velvetleaf) exhibited more injury compared to grasses (e.g., corn and green foxtail) when flamed with the highest propane dose (87 kg ha^{-1}). For example, significantly higher injuries were for soybean (89%) and velvetleaf (93%) compared to corn (74%) and green foxtail (82%) at 12 HAS. These results suggest that broadleaf species were more susceptible to flaming than grasses.

It is interesting to note that plants flamed with the lowest propane dose (29 kg ha^{-1}) during the afternoon hours exhibited similar level of injuries as the plants flamed with the middle dose (43 kg ha^{-1}), and in some cases with the highest propane dose (87 kg ha^{-1}) flamed during the morning (Figure 1b). For example, velvetleaf plants showed a maximum injury of 75% when flamed with 29 kg ha^{-1} propane during the afternoon while 68% injury was evident with 43 kg ha^{-1} propane during the morning (Table 4). Similar trends occurred with other plant species. The calculated HAS_{90} values for most of the curves occurred around 9 to 12 HAS suggesting that flaming was more effective during afternoon. These results also suggest that flaming would likely be less effective if conducted at night.

Fresh Weight. There was no propane dose by time of day interaction for fresh weight. Therefore, the data were averaged across propane doses (Figure 2). Averaged across doses, fresh weight was greater in the plants flamed immediately after sunrise compared to the plants flamed during the afternoon (e.g., 8 and 12 HAS). Fresh weights of the plants flamed during the morning were 11.9, 5.7, 2.6, and 2.7 g plant^{-1} for corn, green foxtail, soybean, and velvetleaf, respectively (upper limit of the curve, Table 5). However, with the exception of corn, fresh weight of each plant species was reduced significantly when flamed during the afternoon. Fresh weights were 10.9, 3.8, 1.5, and 1.6 g plant^{-1} for corn, green foxtail, soybean, and velvetleaf, respectively (lower limit of the curve, Table 5). These results suggest that the efficacy of flaming can be improved by flaming during the afternoon. For example, there was a 50% improvement in green foxtail control when flamed at 12 HAS compared to 0 HAS. Similar trends occurred with other plant species resulting in 73% and 69% improvement in soybean and velvetleaf, respectively, when flamed at 12 HAS compared to 0 HAS.

In our study, all plant species had the lowest leaf RWC around 8 HAS (Table 2). However, all species exhibited more injury when flamed during the afternoon hours (8 and 12 HAS) regardless of the propane dose (Table 3). It is important to notice that the inflection point for plant injury (Table 4) and the lowest leaf RWC in all the treated species occurred around 8 HAS (Table 2).This suggests that leaf RWC is likely one of the factors affecting plant response to propane flaming. Our results are similar to those of Taylor-Hill et al. (2007) and Taylor (2008), who also measured the effectiveness of flaming at 8 A.M., 12 P.M., 4 P.M., and 8 P.M. and reported improved weed control with the noon and 4 P.M. treatments compared to the other treatment times. They mentioned that the differences in weed control among flaming times could not be explained by differences in temperature, relative humidity, or the presence/absence of dew.

Results from this study also indicate that plant susceptibility to flaming varied among species and broadleaf species were more susceptible to flaming than grasses. Our findings are consistent with the results previously reported in the literature (Ascard 1994; Knezevic et al. 2009a, 2009b; Ulloa et al. 2010a, 2010b, 2010c, 2010d). It is interesting to note that plants from broadleaf and grass families differed in the way they responded to the heat (Wszelaki et al. 2007; Ulloa et al. 2010a). It has been shown that leaves of annual broadleaf species turned brown and died within a few days after flaming, resulting in no regrowth whereas leaves of grass species turned white shortly after flaming, leaving an appearance of a dead plant (Ascard 1995; Knezevic et al. 2009a, 2009b). However, within a week grass species begin to recover with the growth of new leaves. Similar responses were also reported for grass type crops compared to broadleaf crops. Teixeira et al. (2008) demonstrated that soybean flamed at the third trifoliolate stage had higher injury by broadcast flaming than corn at the 5-leaf stage, which re-grew a week later. Such differences are likely a result of the physical position of the growing point at the time of flaming (Ascard 1995; Hansson and Ascard 2002; Knezevic and Ulloa 2007; Ulloa et al. 2010a). The growing point in grass species during early growth stages is typically below the soil surface and, thus, would be protected from the flame. In contrast, the growing point in broadleaf species is usually above the ground and, thus, would be exposed to the flame.

Practical Implications. The practical implications of our findings are that flaming should be more effective if conducted during the afternoon, particularly from 3 P.M. to 6 P.M. (calculated arbitrarily on the basis of a standard day of June 15, 2009, Table 4). Flaming during afternoon might result in better weed control; however, crops would also experience more injury at this time. We believe that adjusting the angles of torches and positioning the flames below the crop canopy would result in lower crop injury and yield reduction under field conditions. An experiment should be conducted to test such a hypothesis. Further experiments are required to determine whether the improved flaming efficacy observed during the afternoon in this early growth study occur to the same degree under field conditions and whether these effects continue through to harvest impacting crop yield. More research also needs to be done with flaming of other important weeds and crops to determine the biologically effective propane dose with respect to various times of day. Information from such research would enhance flaming recommendations in integrated weed management plans for both organic and conventional crop production systems.

Sources of Materials

[1] Vapor phase VT 2-23 C burner, http://www.flameengineering.com/Weed_Dragon.html. Flame Engineering, Inc., LaCrosse, KS 67548.

[2] R statistical software, R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.R-project.org.

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Table 1. Weather data at the time of flaming treatments for greenhouse experiment at Lincoln, NE in April and September of 2009.

Application date	Application time (hours after sunrise)	Sunrise/ sunset[a]	Temperature	Relative humidity
	H		C	%
April 29	0	6:24 A.M./	20	46
	4	8:18 P.M.	34	20
	8		27	24
	12		26	37
September 26	0	7:15 A.M./	10	22
	4	7:15 P.M.	32	19
	8		30	19
	12		24	23

[a] Time from Custom Sunrise Sunset Calendar for Lincoln/Omaha, NE, http://www.sunrisesunset.com/custom_srss_calendar.asp

Table 2. Leaf relative water content of corn, green foxtail, soybean, and velvetleaf as influenced by various times of day. The values are estimated using Equation 1.[a]

Hours after sunrise	Corn	Green foxtail	Soybean	Velvetleaf
0	0.98	0.89	0.82	0.63
4	0.90	0.84	0.85	0.67
8	0.90	0.79	0.63	0.60
12	0.95	0.90	0.80	0.66
SE	0.01	0.03	0.04	0.08

[a] Abbreviation: SE, standard error.

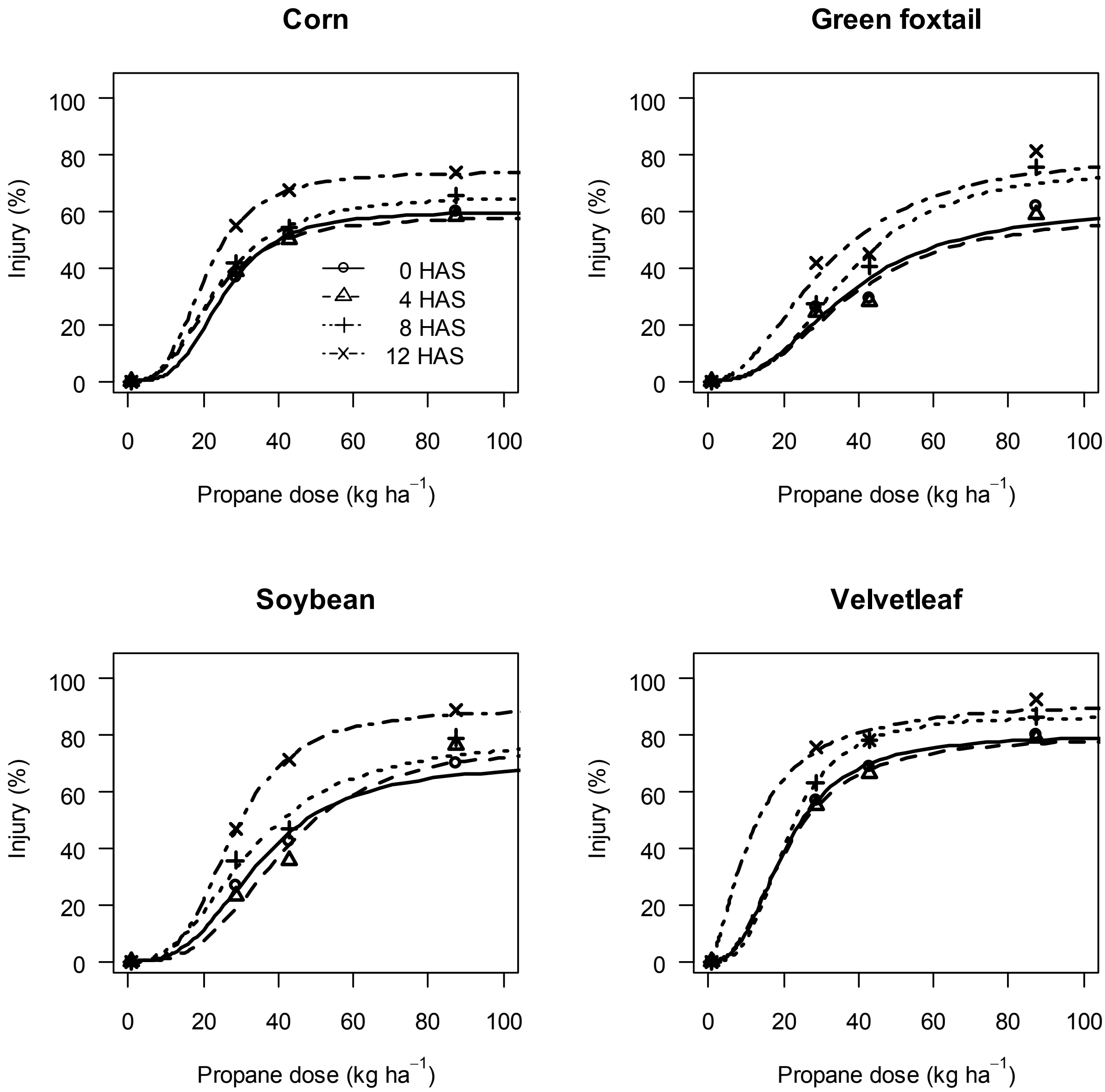

Figure 1a. Plant injury as influenced by propane dose at various times of day (0, 4, 8, and 12 h after sunrise-HAS) at 7 d after treatment. The plant species tested were corn, green foxtail, soybean, and velvetleaf. The regression lines are calculated using Equation 2, and the parameter values are presented in Table 3.

Table 3. Regression parameters (Figure 1a) for plant injury of corn, green foxtail, soybean, and velvetleaf as affected by propane dose at various times of day at 7 d after treatment. Regression parameters are estimated using Equation 2.[a,b]

Species	Hours after sunrise	Regression parameters (± SE)		
		B	*D*	I_{50}
Corn	0	–3.5 (0.2)	60 (7)	25 (1)
	4	–2.9 (0.3)	58 (5)	22 (1)
	8	–2.7 (0.4)	66 (4)	24 (1)
	12	–3.2 (0.2)	74 (4)	21 (1)
Green foxtail	0	–2.5 (1.0)	62 (5)	37 (5)
	4	–2.6 (1.0)	59 (5)	37 (5)
	8	–2.9 (0.7)	76 (7)	37 (3)
	12	–2.2 (0.9)	82 (4)	32 (5)
Soybean	0	–3.0 (0.6)	70 (7)	35 (2)
	4	–3.2 (0.9)	77 (7)	41 (4)
	8	–2.5 (0.7)	79 (6)	33 (3)
	12	–3.4 (0.3)	89 (5)	28 (1)
Velvetleaf	0	–2.7 (0.4)	80 (6)	21 (1)
	4	–2.5 (0.4)	79 (4)	21 (2)
	8	–3.2 (0.2)	87 (2)	21 (1)
	12	–1.6 (0.7)	93 (2)	12 (6)

[a] Abbreviations: *B*, the slope of the line at the inflection point; *D*, the upper limit; I_{50}, the dose of propane resulting in a 50% response between the upper and lower limit.
[b] No treatment-by-experimental run interaction occurred; therefore, the data were pooled over two experimental runs.

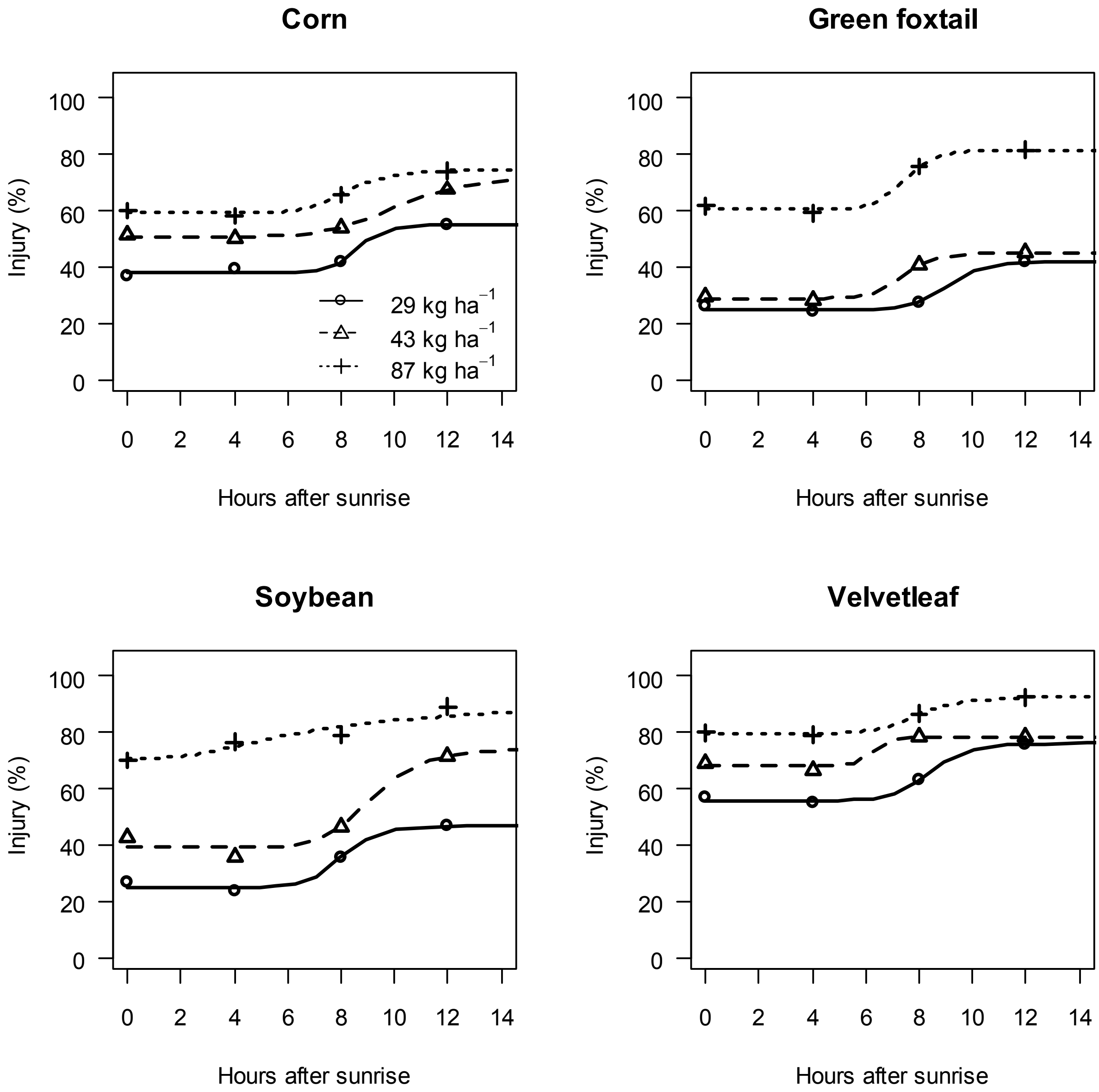

Figure 1b. Plant injury as influenced by various times of day at different propane dose at 7 d after treatment. The plant species tested were corn, green foxtail, soybean, and velvetleaf. The regression lines are calculated using Equation 2, and the parameter values are reported in Table 4.

Table 4. Regression parameters (Figure 1b) for plant injury of corn, green foxtail, soybean, and velvetleaf as affected by various times of day at different propane dose at 7 d after treatment. Regression parameters are estimated using Equation 2.[a,b]

Species	Propane dose	Regression parameters (± SE)				HAS_{90}[c]	Time of day[d]
		B	*C*	*D*	I_{50}		
Corn	29	–19.1 (8.3)	38 (1)	55 (7)	8 (2)	9 (2)	3 P.M.
	43	–12.3 (4.4)	51 (1)	68 (2)	9 (1)	10 (1)	4 P.M.
	87	–15.7 (9.9)	59 (1)	74 (4)	8 (1)	9 (1)	3 P.M.
Green foxtail	29	–13.9 (6.3)	25 (1)	42 (3)	9 (1)	10 (1)	4 P.M.
	43	–7.9 (7.2)	28 (2)	45 (7)	7 (1)	9 (1)	3 P.M.
	87	–5.0 (2.5)	56 (3)	81 (4)	6 (1)	9 (1)	3 P.M.
Soybean	29	–16.9 (9.8)	25 (2)	46 (6)	8 (1)	9 (2)	3 P.M.
	43	–14.4 (8.9)	39 (6)	71 (2)	9 (1)	10 (1)	4 P.M.
	87	–2.3 (1.2)	70 (5)	89 (6)	6 (2)	12 (3)	6 P.M.
Velvetleaf	29	–15.6 (9.9)	55 (4)	75 (4)	8 (1)	9 (1)	3 P.M.
	43	–21.2 (9.6)	68 (1)	78 (2)	6 (3)	7 (4)	1 P.M.
	87	–16.9 (9.9)	79 (5)	92 (5)	8 (1)	9 (1)	3 P.M.

[a] Abbreviations: *B*, the slope of the line at the inflection point; *C*, the lower limit; *D*, the upper limit; I_{50}, the hours after sunrise resulting in a 50% response between the upper and lower limit.
[b] No treatment-by-experimental run interaction occurred; therefore, the data were pooled over two experimental runs.
[c] The hours after sunrise when flaming resulted in a 90% of the maximum injury for weeds and crops.
[d] Time of day is calculated by adding the corresponding HAS_{90} value with the sunrise hour on June 15, 2009. The time for sunrise was 5:50 A.M. on June 15, 2009 (Time from Custom Sunrise Sunset Calendar for Lincoln/Omaha, NE, http://www.sunrisesunset.com/custom_srss_calendar.asp).

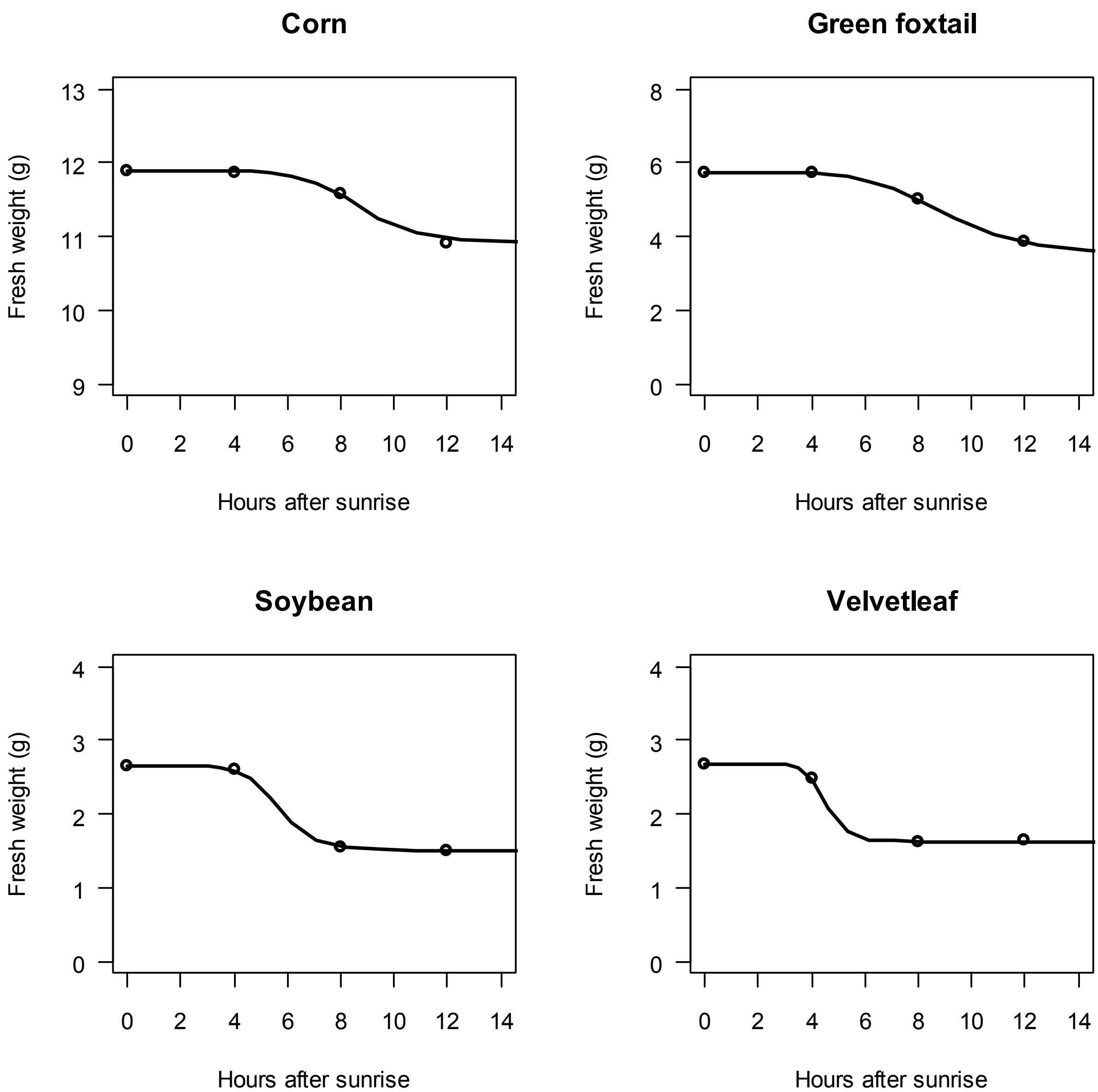

Figure 2. Fresh weight (g) of corn, green foxtail, soybean, and velvetleaf as affected by various times of day at 7 d after treatment. There was no propane dose by time of day interaction; therefore, the data were averaged across propane doses. The regression lines are plotted using Equation 2, and the parameter values are presented in Table 5.

Table 5. Regression parameters for fresh weight production for each plant species at 7 d after treatment as influenced by time of day (Figure 2). Regression parameters are estimated using Equation 2.[a,b]

Species	Regression parameters (± SE)			
	B	*C*	*D*	I_{50}
Corn	8.2 (2.7)	10.9 (1.0)	11.9 (0.5)	8 (1)
Green foxtail	5.6 (1.9)	3.8 (0.8)	5.7 (0.5)	9 (1)
Soybean	8.5 (1.2)	1.5 (0.4)	2.6 (0.4)	6 (1)
Velvetleaf	14.4 (2.6)	1.6 (0.5)	2.7 (0.4)	4 (1)

[a] Abbreviations: *B*, the slope of the line at the inflection point; *C*, the lower limit; *D*, the upper limit; I_{50}, the hour after sunrise resulting in a 50% response between the upper and lower limit.
[b] No treatment-by-experimental run interaction occurred; therefore, the data were pooled over two experimental runs. There was no propane dose by time of day interaction; therefore, the data were averaged across propane doses.

Weed control with flaming and cultivation in maize

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Weed management is a major constraint in organic crop production. Propane flaming and cultivation could be combined into a single operation as an additional tool for weed control in organic maize (*Zea mays* L.) Field experiments were conducted at the Haskell Agricultural Laboratory of the University of Nebraska, Concord, NE in 2010, and will be repeated in 2011 to determine the level of weed control and maize response to propane flaming utilized alone, or in combination with inter-row cultivation. Total of seven treatments were applied at several growth stages of maize (V3 (3-leaf) and V6 (6-leaf) with the propane doses of 20 and 45 kg/ha for the banded and broadcast flaming , respectively. Flaming and cultivation treatments were applied utilizing a custom built research flamer-cultivator mounted on the back of a tractor moving at a constant speed of 6.4 km h^{-1}. The weed control ratings and response of maize was evaluated at 7, 14, 28, and 60DAT (days after treatment-DAT). Overall, weed control and maize response varied among treatments and growth stages. Cultivation at the V3 stage only, provided the poorest weed control (20%) and the lowest yield (9.7 t/ha) due to weed competition from uncontrolled weeds. The best treatment was a combination of cultivation and banded flaming conducted twice, at the V3 and V6 stages of maize. Such treatmentprovided above 95% weed control and yielded about 27% more than cultivation alone conducted at the same time (12.6 t/ha vs. 9.9 t/ha). All other treatments provided significantly lower weed control levels, ranging from 20-80%. Based on data from just the first year of this study, it appears that the most promising season-long weed control was achieved with a combination of flaming and cultivation treatment applied twice in field maize, at V3 and V6 stages.

Broadcast flaming in warm-season turfgrasses

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An innovative solution for vegetative establishment of warm-season turfgrass species seems to be field planting of seedlings (similar to vegetable planting). This technique is an Italian patent (called "Erbavoglio system") and gives some of the advantages of sodding (the use of pallets or rolls of pre-established turf) with lower costs. On the other hand, these species, when planted, can suffer from weed competition during the first period of establishment. A long term experiment, started in July 2009, is being carried out with the aim of assessing the tolerance of three different warm-season transplanted turfgrasses to open flame treatments, *Zoysia tenuifolia* Willd. ex Thiele *Cynodon dactylon* L. Pers. and *Paspalum vaginatum* Sw. during the first 5 weeks of development, in the perspective of application of selective thermal weeding interventions. The plants were grown in a greenhouse and transplanted in 30 cm high 23,5 cm wide and 5 cm deep pots, containing peat based substrate. Four plants were hand transplanted in each pot. The thermal treatments were performed with a test bench equipped with a belt conveyor driven by an electric engine, a 25 cm wide rod burner and a LPG feed group that allowed to operate with different values of pressure. LPG dose per unit surface was obtained by combining the different speeds with the different working pressures. For each species different doses and different frequencies of treatment were tested. The frequency of treatment was also differently distributed along the time. Digital images were analyzed with an automated procedure, originally programmed in MATLAB3, and later developed into a web-based software (www.imaging-crops.dk), with the aim to asses crop canopy one week after treatments. Crop biomass was assessed at the end of the cycle. In order to find a relationship between the doses of LPG and the plant cover percentage, non-linear regression was performed fitting a 3 parameters log-logistic model. Biomass loss was described using a yield loss-Michaelis Menten model ("R" software, "drc" package – Ritz & Streibig, 2005). *Cynodon dactylon* was the most sensitive species showing on average a 50% reduction of the canopy using about 15 kg ha^{-1} of LPG, a maximum biomass loss of 75% with one treatment and 100% with two or more treatments. *Paspalum vaginatum* appeared the most tolerant showing on average a 50% reduction of the canopy at about 30 kg ha^{-1} of LPG, a maximum biomass loss of 65% with one treatment and 100% with two or more treatments. *Zoysia tenuifolia* showed on average a 50% reduction of the canopy using about 25 kg ha^{-1} of LPG, while biomass sampling and data processing are still on-going. However, selective flame treatments seem possible for warm-season turgrasses, if applied with an adjusted dose.

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Can image analysis be a tool to measure changes in vegetation cover after flame treatments?

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In many countries the risk of pollution of the environment has led to restrictions on the use of pesticides in urban areas, and herbicides are often replaced by flame weeding. Flame weeding controls a wide range of annual weed species, but plant species with protected meristems, such as grass weeds, pose a special problem because of their ability to regrow after the treatment. Therefore, repeated treatments are necessary, which increase the costs. In this study, the changes in vegetation cover of the test species *Lolium perenne* (L.) (perennial ryegrass) was measured by image analysis during an entire growing season. Measurements of the effect of non-chemical weed control by flaming can be done in several ways. The most used method is to take biomass samples from the experimental plots and dry and weigh the plants. Dry weight of plants gives a useful estimate of the effect of the treatment. If the aim of the investigation is to measure the effect of repeated treatments, the removal of the biomass makes is impossible to measure how regrowth would occur under normal conditions. Additionally it is very labour demanding. Other methods can be used, such as measuring light reflection, visual assessment, or, as in our case, use of image analysis.

In the present study, a large number of treatment plots were treated with a gas burner with different doses (0-180 kg gas ha^{-1}) and time intervals (2-10 yearly treatments). To measure the treatment effect on regrowth, images were taken every second week (14 days after the last treatment) from May to October 2008. The experiment was repeated in 2010. To avoid camera shaking and to get images of the same size, a camera mounting was used. All images were taken with a Canon EOS 400D (iso speed and shutter speed manually adjusted). Camera position was vertical. To obtain diffuse light on sunny days the camera mounting was covered with nylon material. Inside the “tent” a frame (0.63*0.45 m = 0.27 m^2) was placed with a white balancing reference in order to calibrate the colors to different illumination. Three times a year, biomass samples were taken and the results from these data were compared with the results from the image analysis. The data showed that it was possible to achieve full control of *L. perenne* with flaming, but it highly depended on the number of treatments as well as the dose that was applied. Image analysis can be an easy measurement method of vegetation cover but did not give precisely the same results as biomass measurements, because of overlapping vegetation. However, image analysis was a useful method to get a fairly precise estimate of the effect of the treatments.

Effect of short duration exposure to high temperatures on weed seed germination

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Physical soil management is considered an alternative to chemical disinfestation to lower the pressure of many soil-borne pests ad diseases, particularly on high-value crops. Thermal methods, and steaming in particular, have proved to be effective also in reducing weed seed germination. However, limited information exists on requirements in terms of temperature and time of exposure for seed thermal death in different weed species. Some studies pointed out that in the case of steaming, the degrees of weed seed devitalisation is strongly related to the maximum temperature achieved into the soil, while treatment duration seems to play a secondary role.

At this purpose, we started a series of experiments aimed at defining, for some weed species, the effects on germination of several combinations of temperature and time under controlled conditions. The objective of this work, in particular, was to estimate the effect of temperature only, by exposing the seeds for a very short time to a wide range of temperatures. Seeds of *Echinochloa crus-galli* (barnyardgrass), *Solanum nigrum* (black nightshade), *Galinsoga quadriradiata* (sin. *G.* ciliata, hairy galinsoga), *Setaria viridis* (green bristlegrass), *Portulaca oleracea* (little hogweed) and *Amaranthus retroflexus* (redroot amaranth) were treated at twenty thermal levels, ranging from 48°C to 86°C with a 2°C-interval between temperatures. For each species and temperature three 10ml Pyrex test-tubes were filled with 3g of sandy-loam soil mixed with 60 seeds. Soil moisture was previously adjusted to 80% of field capacity. The tubes were maintained at 4°C during the 24h before the thermal treatment (2h in the case of *P. oleracea*) to prevent seed germination, yet allowing the seeds to imbibe water from the soil. Thirty minutes before thermal treatment, the tubes were dipped in a 23°C water bath. Soil temperatures were monitored using T-type thermocouples inserted into the tubes by-passing the cap and in contact with the soil. Temperatures were acquired by a datalogger every 2s and average of two probes were used to monitor the temperature into the tubes. The tubes were dipped in a water bath in which the temperature was set 3°C higher than treatment temperature, in order to quickly heat the soil. As soon as the temperature in the tubes reached the treatment temperature, the tubes were immediately immersed in a 1°C water bath until the attainment of the initial temperature of 23°C. Immediately after, the seeds of each tube were distributed in three Petri dishes (9cm diameter; 20 seeds/dish), wetted and incubated at 25°C for 19 days. For each species three untreated tubes were maintained at room temperature as control.

The thermal resistance to very short exposure of each species was described using a 3-parameters log-logistic model, plotting the percentage of mortality respect to control (dependent variable) against the temperature (independent variable). Results showed that the species have a different thermal susceptibility. Yet, in the majority of species seed germination was severely affected by short exposure to temperatures falling in the range 54-74°C. The only exception was *E. crus-galli*, which was much more resistant to heat than other species and a temperature higher than 82°C was required to totally avoid seed germination.

Cost comparison between soil steaming and conventional methods for weed control

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Soil disinfestation is a widespread practice used before planting of high-value crops in horticulture, breeding and floriculture, where it is necessary to control soil-borne diseases, in particular pathogenic fungi and weed seeds.

Methyl bromide (MB), has been the main fumigant used for disinfestation for several decades. It was gradually banned since 1994, following the Montreal protocol. Many studies were conducted to find sustainable alternative techniques to MB. Water steam has been employed largely in the past and abandoned for less expensive chemical products. Nowadays it is considered an ecological technique and may represent a valid alternative to MB.

This work is aimed at estimating the gross income in lettuce production by adopting three weed control strategies: use of herbicides, mulching and soil steaming. The study was conducted in parallel to an evaluation of the herbicidal efficacy on weed seeds of a sub-superficial steam application for soil disinfestation.

The lettuce production process was divided in seven phases: pre-transplant, transplant, fertilization, herbicide and fungicides treatments and foliar fertilization, irrigation, harvest and post harvest operations. In each phase the costs of cultural operations were estimated by considering several factors, including the labour, the inputs (e.g. kind, amount, unit and total cost of fertilizers, herbicides, etc.), and fuel and lubricants of the machines used.

The gross incomes of the three weed control strategies were calculated as a difference of gross marketable production and variable production costs. Considering three cycles of lettuce per year and only one soil steaming treatment per year (carried out before the first cycle), no relevant differences were found across the three incomes. In particular, the total variable costs averaged 25657, 26767 and 27023 €/ha/year with the use of herbicides, mulching and soil steaming, respectively. The cost of soil steaming was estimated as 2112 €/ha/year.

Weed control in non-agricultural areas

Weed inhibitory effect of different paving constructions

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The recent phase out of herbicidal use on public pavements by the Flemish government triggers the development of new alternative weed control strategies. Besides the search for effective non-chemical curative methods, there is also a need for weed preventive strategies on pavements. In this study, effects of type of joint filling material, joint width, pollution and type of street layer material were assessed for their impact on weed germination and coverage.

In 2009, a paving experiment with 96 block paving plots was set up under a rain shelter. Block paving plots were 60 cm x 24 cm and were arranged in a randomized complete block with 3 replications. Each block paving plot consisted of a conventional (non permeable) concrete block paving (11cm x 11cm pavers + joint filling, thickness: 8 cm) on top of a street layer (thickness: 4 cm), supported by a base layer (thickness: 13 cm). Paving plots comprised factorial combinations of five joint filling materials, two joint widths, two pollution levels and two street layer materials. Tested joint filling materials were (in brackets grain size fraction): fine white sand (0-2 mm), sea sand (0-2 mm), crushed porphyry (grain size fractions 2-6.3 mm), crushed limestone (0-6.3 mm) and Dansand® (a sodium silicate enriched sand specifically designed for weed prevention). Joint filling materials were evaluated in pure (0% fine compost by volume) and organically polluted state (10% fine compost by volume). This pollution level was designed to mimic *in situ* organic pollution of joints. Street layer materials tested comprised crushed porphyry (2-6.3 mm, a good water permeable aggregate) and crushed limestone (0-6.3mm, a less water permeable aggregate). After establishment of the block paving plots, each paving plot was oversown with a mixture (100 germinable seeds per species) comprising *Taraxacum officinale*, *Poa annua*, *Plantago major* and *Trifolium repens*, all dominant, hard to control weed species on pavements. Weed inhibitory effect of paving plots was determined by examining weed germination and weed coverage. Weed germination was recorded weekly during the first five weeks after sowing. Weed coverage was recorded monthly over a two-year period by using Image J Software. Pavings were watered three times a day by automatic sprinkler irrigation (2.1 mm/day).

Weed germination and weed coverage was highest in pavings with wide joints and polluted joint filling material. In pavings with polluted filling material, the type of street layer material significantly influenced weed germination and weed coverage. Weed preventive ability of joint fillers was highest for sodium silicate enriched sand (Dansand®) followed by crushed porphyry, irrespective of pollution level, joint width or type of base layer. The weed inhibitory effect was higher for the coarser filling materials porphyry and limestone than for the finer filling materials white sand and sea sand, irrespective of pollution level or type of base layer. Within standard filling materials, unpolluted sea sand and porphyry reduced seedling emergence of all species tested. Shifts in weed composition occurred due to observed species-specific inhibitory effects of joint filling materials. Overall, these results show an opportunity for weed prevention by using suitable paving materials in the construction of pavements. Pavings showing long-lasting weed suppressive ability might reduce total adverse environmental impact of curative weed control by reducing its frequency required to keep weed density at an acceptable *level*.

Integrating preventive and curative non-chemical weed control strategies on concrete block pavements

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The recent phase out of herbicidal use on public pavements by the Flemish government triggers the development of new alternative weed control strategies. In this study frequency of weed control required to maintain a minimum picture quality of the pavement was determined for six different non-chemical weed control scenarios and four different block pavings.

In September 2009, a strip plot experiment was established in Sterrebeek comprising four different block pavings (vertical plots) and six different curative weed control scenarios (horizontal plots) in four blocks. Size of intersection plots was 1.6 m by 7.5 m. Block paving types included concrete block paving with drainage holes, concrete block paving with enlarged joints, porous concrete block paving and conventional (not permeable) block paving. Joints were filled with organically polluted (by adding 20% fine compost by volume) sand of Lustin for the porous and conventional pavings and organically polluted crushed porphyry for the pavings with drainage holes and enlarged joints. Before filling the joints, filling materials were contaminated with a seed mixture containing seven dominant, hard to control weed species (*Taraxacum officinale*, *Poa annua*, *Plantago major, Trifolium repens*, *Cerastium fontanum*, *Sagina procumbens* and *Conyza canadensis*). Polluted joint fillers were used to simulate *in situ* organic pollution of joints over time. Curative weed control scenarios comprised four scenarios with repeated use of one single weed control method (brushing, flaming, application of hot air and selective application of hot water) and two scenarios with alternating use of brushes and hot air technique (scenarios differ in time interval between brushing and hot air application). The energy dose applied by the weed control equipment was regulated by the driving speed and corresponded to the dose required to achieve a 80% reduction in weed coverage (ED80 value). Treatments were repeated each time weed coverage exceeded a predefined maximum weed coverage percentage. During the growing season of 2010, weed coverage (%) and weed composition were periodically recorded in 6 fixed quadrats per plot by using Image J software. Treatment frequency obtained in this study was defined as the number of treatments required to guarantee a minimum picture quality of the paving during the growing season.

Treatment frequency was highest for pavings with drainage holes and enlarged joints (between 3-5) and lowest for porous pavings (between 1-2), irrespective of the weed control scenario. Lowest frequency (1-3) was recorded for hot water technique, irrespective of paving type. Frequencies of scenarios with hot air technique and flaming were similar (3-5).Compared to repeated use of a single weed control technique, alternating weed control techniques did not yet result in a reduction of treatment frequency. Due to the observed species-specific sensitivity to thermal weed control techniques, shifts in weed composition occurred in plots treated repeatedly with the same technique. Overall, these results show an opportunity for integrating weed prevention strategies (using suitable paving materials) and curative strategies (using effective weed control techniques) to lower adverse environmental impact of weed control by reducing its frequency required to maintain weed coverage to an acceptable *level*.

Maintenance of railway embankments - how to use the Yara N-sensor for prognosis of weed control measures

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Introduction

Railway embankments in Sweden need to be weeded regularly in order to keep the track in good technical condition. Today, this weeding is carried out mainly by herbicides and is based on local contractors' possibility to find suitable time for this kind of work. There are no general recommendations of acceptable level of weed infestation.

The Swedish Railway Maintenance Authority (SRMA) has experienced difficulties in making prognosis for when and where the weed control should take place in order to optimise staff, machines and suitable measures for the weeding operation.

One major problem is the time consumption to identify a need for weeding, i e. are there too much weeds on the tracks which may impair train performance or is the level of weeds too small to motivate herbicide use.

Material and methods

In the pilot project we have used the Yara N-sensor as a tool for weed infestation assessment. A test rig was constructed for use on railway tracks (fig 1). This rig was equipped with the N-sensor including software and a GPS. By moving the test rig on a railway line in central Sweden, we obtained data on biomass, expressed as S/N-value, which could be connected to a visual assessment of the weed coverage on the track.

We did not measure weed density expressed as weight or percent coverage, only as a visual estimation of the amount of vegetation on the tracks being 'non-existent' (fig 2), 'acceptable', 'increasing' (fig 3) and 'non-acceptable' (fig 4).

Based on the measurements of the N-sensor a "weed map" of the railway line could be constructed (fig 5).

Results and discussion

The N-sensor identifies presence of vegetation which in turn can be connected with a herbicide treatment. However, although all vegetation on railway tracks should be removed, economical restrictions, lack of equipment and unsuitable weather conditions prevents herbicide use or other weed control measures.

By using the N-sensor as a tool to detect unwanted vegetation on tracks in combination with a system for classifying weed coverage, an action plan for maintenance of the railway tracks on a national level can be created.

A first step to introduce this system, is to identify levels of acceptable and non-acceptable weeds (species) and/or weed coverage. These levels will be connecting presence of weeds with the function of the railway, i.e. standard of the track in terms of e g maximum load of wagons and maximum speed. Tolerance of weeds is often lower at high speed lines while seldom used tracks in industrial areas can be allowed to have more vegetation.

A second step is to assess the railway lines with the N-sensor technology and create weed-maps. In turn, these maps are used by the SRMA to address weeding operations (chemical or mechanical) on the lines and schedule equipment and staff to areas that need maintenance.

The N-sensor can also give a measurement of unwanted vegetation along the railway embankment, thus indicating a need of clearing of trees and shrubs.

Further R&D must of course be conducted, but we anticipate that an operating system mounted on a maintenance train will be built in 2011-2012.

Acknowledgements

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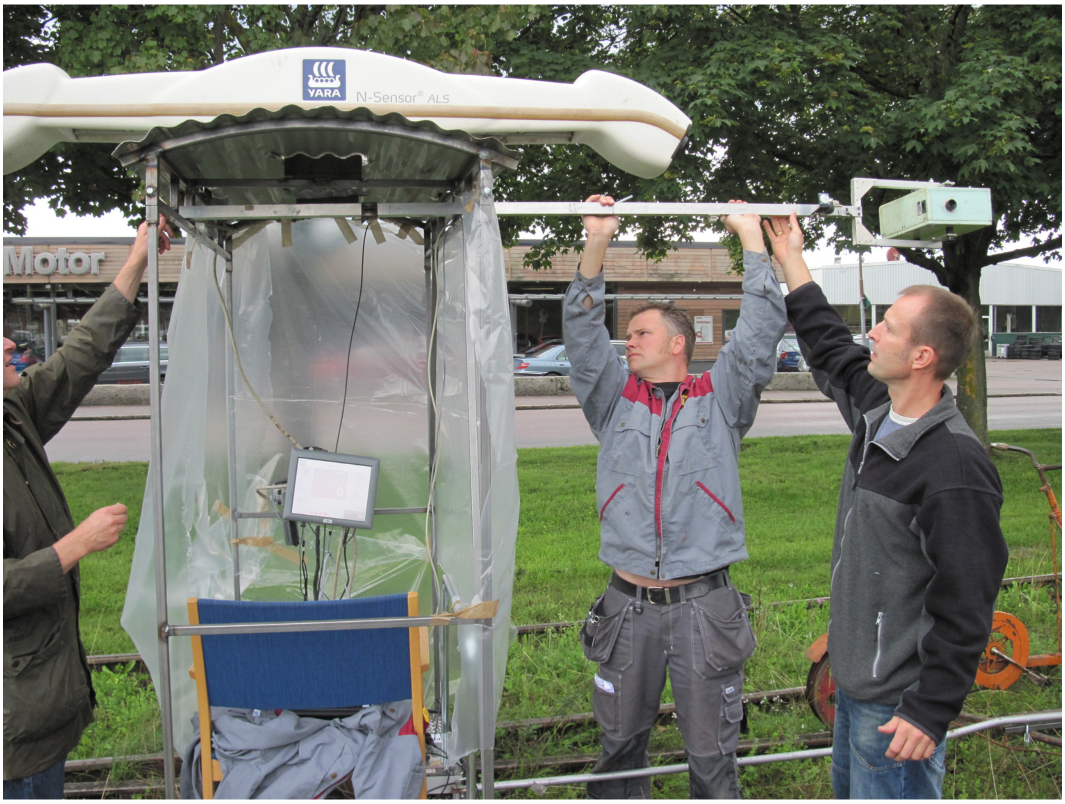

Figure 1. The test rig. A N-sensor is mounted on top of a small wagon pulled by a inspection trolley. The software of the sensor includes information on biomass and position.

Figure 2. Weed level: 'Non-existent' Biomass value 1. An example of a railway line in proper condition.

Figure 3. Weed level: 'Increasing problem' Biomass value 13. Weeding measures should be initiated during the season..

Figure 4. Weed level: 'Non-acceptable' Biomass value 26. Weeding measures using herbicides only is no longer possible. Mechanical weeding measures or cleansing of embankment must be carried out

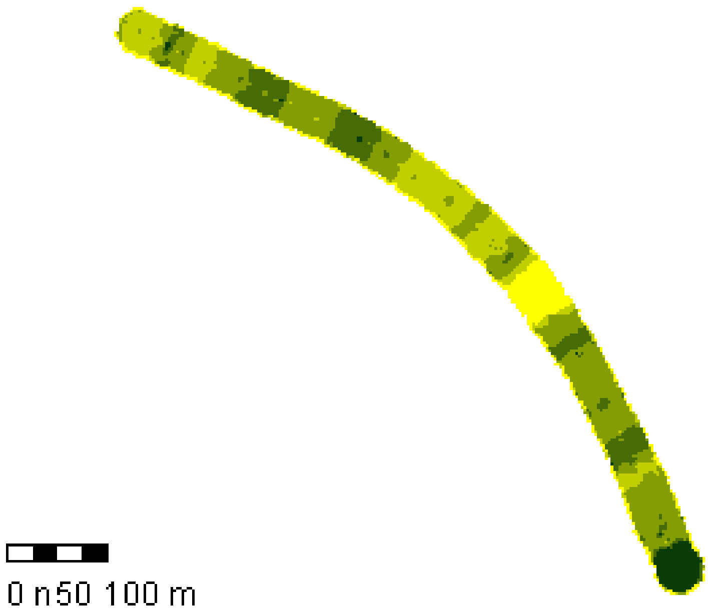

Figure 5. 'Weed map' (vegetation map) of a railway line. Yellow areas are weed free and green areas indicates presence of weeds at different levels of coverage.

Sustainable turf and weed management within a conversion of a cool-season turf to Bermudagrass hybrid (*Cynodon dactylon* (L.) Pers x *transvaalensis* Burtt-Davy)

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Warm-season species are more and more replacing the "common" cool-season turfs for sports and recreational uses, in Italy, thanks to the excellent adaptability to the Mediterranean environment. Turf establishment can be performed in many different ways, like seeding, stolonizing/sprigging or sodding. An innovative technique of planting has been recently patented in Italy ("Erbavoglio system"). It is based on the quickly ground cover capacity of these species by means of stolons and rhizomes. "Erbavoglio system" allows to easily convert from a cool-season turf to a warm season turf. Planting can be performed both in tilled and untilled soil. This second option allows the site to be used immediately after the planting as the better soil carrying capacity is provided by untilled soil.

Two experimental trials were carried out in 2009 and 2010 spring-summer period in order to test different innovative physical weed control techniques used before and/or after warm season grass planting. The aim of the first trial was to evaluate different pre-planting treatments as they affect the establishment of bermudagrass hybrid **(***Cynodon dactylon* (L.) Pers x transvaalensis Burtt-Davy.) in untilled soil covered by cool season turf. The treatments were: activated steaming at different doses, flaming at different LPG (Liquified Petroleum Gas) doses and two different conventional herbicide treatments (Glyphosate and Glufosinate). The second trial, that is still on-going, was to evaluate different pre and post planting treatments on the establishment of bermudagrass in tilled soil. The treatments were: pre planting activated soil steaming *plus* post planting flaming, post planting selective herbicide (Oxadiazon) .

In the first trial weed canopy was asses by digital analysis images technique, with an automated procedure, originally programmed in MATLAB3, and later developed into a web-based software (www.imaging-crops.dk), moreover a visual assessment of ground cover was made until complete bermudagrass establishment was reached.

In the second trial a visual assessment of weed ground cover was made and weed number per unit area was counted after bermudagrass planting. On bermudagrass, visual assessment of ground cover was made until complete establishment was reached.

The innovative physical methods seem a promising alternative to chemical ordinary treatment both for conversion of turf (untilled soil) and for weed control in tilled soil.

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Round table reports

Weed control in vegetables – Report from a round table discussion

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In our round table discussion we were 33 participants from nine countries. This session discussed how to proceed in research and extension service to develop competitive physical and cultural weed control methods in vegetables in order to reduce the need of hand weeding in growing systems with no or limited use of herbicides.

Before the workshop, the participants were invited to initially present some new ideas and innovative methods and techniques for weed control in vegetables and other high value row crops.

Introduction – challenges in cultural and physical weed control in vegetable crops

The major weed problems in organic vegetable production, and in production systems with limited or no use of herbicides, are weeds growing within the crop rows, especially in direct-sown small-seeded vegetables, such as carrots. The removal of in-row weeds in order to maintain crop yield and quality is associated with high labour costs. In organic production of carrots, labour requirements of around 200 man-hours per hectare is common.

Inter-row weeds can usually be controlled rather easily by ordinary row crop cultivation. Various cultural and physical methods and techniques are available to control in-row weeds, but some of them are rather expensive compared with herbicides, and they typically do not control enough weeds.

Cultural techniques include repeated stale seedbeds, delayed sowing, mulching, soil cultivation in darkness, and transplanting systems. There are also mechanical in-row cultivators e.g. finger weeder, torsion weeder and weed harrow, and thermal methods such as flame weeding and band steaming. Combined methods using for example stale seedbed, flame weeding and in-row cultivation offer promising results, as do advanced systems for robotic in-row weed control in certain crops with rather large crop plant distance, above 15 cm.

Typically the methods for in-row weed control are most suitable in transplanted crops and large seeded crops. The big challenge remains to control in-row weeds in early established direct-sown small-seeded vegetables.

Several methods and techniques have been developed and evaluated in research, but relatively few are widely used in practice. Some techniques are expensive and have relatively low capacity, while others have limited use in certain high value crops. Some methods have low selectivity and adjustment and timing of treatment may be difficult. Many farms are relatively small and diversified and cannot invest in expensive and specialised machinery, so they opt for tools that can be used in many different crops. There is a need to develop economical and robust methods that can reduce weed emergence during the first weeks after crop emergence in small seeded direct-sown crops and methods to control in-row weeds with high selectivity.

Round table discussion

After a general introduction we focussed on discussing a few topics.

We concluded that small scale technique for weed control is interesting for small scale farmers regardless of country. There are many examples of farmers having 1-3 hectares, often many crops, who have neither the financial means nor the skill to work and invest in expensive machinery. Nevertheless, they are interested in decreasing the use of hand weeding.

The machines should be adapted to local conditions. These conditions comprise both agronomical conditions such as soil and crop, as well as the skill of the farmer and his ability to repair and maintain the equipment.

In some geographical areas chemical weed control is the method most used. Hence, to replace spraying, the non-chemical technique must be introduced to the farmers and supported by education and sometimes with economic support.

Pieter Bleeker from the Netherlands initiated a discussion on some specialised techniques by highlighting some research on cluster seeding and mulching. Cluster seeding is a novel technique that seems promising for direct seeding of bulb onions. Dutch experiments have shown the possibility to use this method in organic production.

Mulching on top of the seeds is another promising technique. A specialised machine for large scale production is developed and evaluated in the Netherlands in cooperation between a farmer, a machinery company and weed scientist. A 2 cm layer of weed-free compost is applied on top of the seeds instead of ordinary topsoil. The crop seeds are thus emerging through a weed-free compost layer. The Dutch results so far have shown about 80 per cent weed reductions. A similar technique is evaluated in Sweden.

Automation in crop and weed assessments – what does it mean to mechanical weed control?

V Rueda-Ayala & J Rasmussen

After a short introduction to automation in crop and weed assessment (from simple image analysis programmes to advanced sensor systems), experiences within the use of automation are shared among the round-table participants, within the context of mechanical weed control. The following questions are proposed for discussion: What are the current possibilities for real time assessments? What are the utility values? What kind of developments in assessments do we need in order to improve mechanical weed control? How to translate the assessed data into a model to develop algorithms for automation?; and, Are we ready to make use of data from automation in crop and weed assessments? If time allows, ideas about future decision support systems based on real time assessments of crop and weeds will be shared.

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