European Weed Research Society

Summer school on Integrated Weed Management:

Principles and implementation

Working Groups

Optimization of Herbicide Use in an IWM context

Herbicide Resistance

American Farm School/Perrotis College,

Thessaloniki, Greece

22-25 June 2017

[Per Kudsk, Demosthenis Chachalis]

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GENERAL INFORMATION

The EWRS working groups on Optimizing herbicide use in an IWM context and Weed resistance in collaboration with the Greek Weed Science Society and the American Farm School (AFS)/Perottis College in Thessaloniki, Greece are organizing a summer school for MSC and PhD students with a main focus on weed science as well as young career weed science researchers. Participants from the Greater Balkan area (Slovenia, Croatia, Serbia, Bosnia-Hercegovina, Montenegro, Macedonia, Albania, Greece, Rumania, Bulgaria and Turkey) will be given preference.

Venue: American Farm School/Perrotis College, Thessaloniki, Greece

Chairman:

Prof. Per Kudsk, Department of Agroecology, Aarhus University, Denmark,
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EWRS, Working Group: Optimization of Herbicide Use in an IWM context

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Lecturers:

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BACKGROUND

Since the early 1960'ies weed management in most parts of the world has relied heavily on the use of herbicides. Herbicides are relatively cheap, they are a very effective and reliable tool for controlling weeds and they are easy to apply. With the steadily increasing number of cases of evolved herbicide resistance and the complete lack of new herbicidal modes of action to manage the resistant genotypes the situation has changed and herbicides are no longer the reliable tool they used to be. In the EU the situation is further aggravated by the fact that many older herbicides are not re-authorized due to the new and stricter criteria in Regulation 1107/2009. Finally, new weed species are emerging in many countries posing new challenges to weed management.

This has led to a renewed interest in developing and adopting integrated weed management strategies and this was acknowledged in Directive 2009/128/EC that developed a set of eight principles of IPM that all Member States are obliged to implement. Integrated weed management implies that all available weed control methods are considered (not excluding the use of herbicides) and integrated into strategies that prevent the build-up of large populations of weeds and reduced the reliance on herbicides. A truly integrated approach should focus on preventing the establishment of weeds, minimize the interference of weeds on crop yields and quality and limit the return of seeds or other vegetative organs to the soil seedbank or in the case of perennial weeds the vegetative organ bank.

The course provides a state-of-the-art update on mechanical and chemical control methods including weed resistance and examines the integration of preventive/cultural, non-chemical and chemical control techniques into a weed management strategy in annual and perennial crops with a clear focus on the Balkan region and the weed management issues this region is facing.

The course will run over 3 days (+ 1 day for a field excursion) and consist of a mixture of lectures, journal clubs and group work. The participants will be given 3-5 scientific papers that they are supposed to have read prior to the course. Some of these papers will be discussed in the journal clubs.

PROGRAMME

Day	Topic	Content
22 June		
9:00-9:30	Introduction	Introduction Presentation of the lecturers and participants (round the table) IPM/IWM: Origin and definitions
9:30-11:00	Optimizing herbicide efficacy and dose *Lecturer: Per Kudsk*	Herbicide grouping: important for understanding the interaction with biotic and abiotic parameters How to study the effect of biotic and abiotic parameters on herbicide efficacy The role of biotic factors (weed flora, weed growth stage, crop competiveness) The role of abiotic parameters (soil texture, soil moisture, light, temperature, air humidity, precipitation, dew, wind, application technique, adjuvants/formulation, mixture with other pesticides)
11:00-11:30	Coffee break	
9:00-10:30	Herbicides and risk of water pollution *Lecturer: Spiros Vizantinopoulos*	Factors influencing the movement of herbicides to surface and ground water, European scenarios and models of prediction of the movement of herbicides to surface and ground water, Best Management practices to reduce spray drift, Guidelines for reduction of the pollution of surface and ground water from point sources of herbicides, Monitoring studies for herbicides
13:00-14:00	Recent developments in physical weed control/tillage operations	Newest developments in physical weed control. Sensor-guided tools What will the future bring?

	Lecturer: Ileana Bogdan	How to integrate physical weed control into IWM strategies
14:00-15:00	Lunch	
15:00-16:00	Allelopathy and cover crops *Lecturer: Christos Vasilikiotis*	Theory or reality? Which chemical compounds are involved? Competition or allelopathy? Cover crops as part of an IWM strategy
16:00-17:30	Herbicide resistance *Lecturer: Roland Beffa*	Status Herbicide resistance mechanisms The dose debate Crops and types of herbicides
17:30-18:30	IWM and herbicide resistance management *Lecturer: Demosthenis Chachalis*	Specific focus to glyphosate resistance Current situation, crops, and weed species Detection tools, future problems Strategies for herbicide resistance management
18.30-19:00	End of day 1 and introduction to day 2	

Day	Topic	Content
23 June		
9:00-10:30	An update on cultural weed control methods *Lecturer: Ilias Travlos*	Preventing introduction and spread of weed seeds Soil tillage/false seedbed Sowing time and crop density Spatial arrangement

		Destruction of weed seeds Biodiversity/Seed predation
10:30-11:00	Coffee break	
11.00-12.30	Site specific farming *Lecturer: Athanasios Gertsis*	Prospects of site specific farming Applications for weed management
12:30-13:30	Journal club	Students are supposed to have read two scientific papers. Two of the students will be asked to present the main conclusions of the papers and to initiate the discussion with questions prepared beforehand
13:30-14:30	Lunch	
14:30-15:30	Integrated weed management: A case of maize *Lecturer: Milena Simic*	Examples of successful IWM implementation in maize
15:30-16.00	Coffee break	
16:00-17:00	Integrated weed management: A case of rice *Lecturer: Husrev Mennan*	Cultivar selection and agronomic practices to control weeds, Weedy rice control by using IMI tolerant rice cultivars (advantages and disadvantages), Problem and herbicide resistant weed species
17.00-18:30	Visiting field experiments at the American Farm School/Perottis College field station	
18:30-19:00	End of day 2 and introduction to day 3	

Day	Topic	Content
24 June		
9:00-10:00	Integrated weed management *Lecturer: Per Kudsk*	What does IWM imply? What does research tell us about IWM and IWM implementation? Examples of successful IWM implementation How does herbicides fit into IWM
10:00-10:30	Introduction to group work	
10:30-11:30	Coffee break	
11:30-13:30	Group work: Round 1	
13:30-14:30	Lunch	
14:30-16:00	Group work: Round 2	
16:00-16:30	Coffee break	
16:30-18:00	Presentation of group work	
18:00-18:30	Closing	Last minute questions and feedback from participants
25 June		
Full day	Excursion (not compulsory)	

Integrated Weed Management: Optimization of using environmentally friendly herbicides and strategy for risk reduction of surface and ground water pollution

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Directive 2009/128/EU enforces EU Member States to secure a sustainable use of pesticides. On the other hand all the professional users of pesticides e.g farmers are obliged to follow the general principles of Integrated Weed Management (IWM). So far the main criteria for the selection of herbicides in an IWM are mainly their biological efficacy, the risk for causing weed resistance and secondarily their impact on the biodiversity. Their option on the basis of their potential to contaminate surface and ground water is not a priority. The aim of this study and the new challenge is to be covered this knowledge gap. Moreover the Best Management Practices (BMP) are reported to reduce water pollution due to herbicides from leaching, run-off, erosion and spray-drift.

The Koc, that is the distribution of an active substance (a.s.) between organic carbon and water and the DT50, that is the required time for the dissipation of an a.s. in soil at 50%, are the key factors determining the potential of a herbicide to leach down and contaminate the ground water. The less the value of the Koc and the bigger the DT50 for an a.s., the more the probability to contaminate the surface and ground water, through the main diffuse routes leaching, run-off, erosion and drainage. The values of Koc and DT50 for any a.s. are easy to be found in EFSA archives of the registered herbicides.

The BMP to reduce ground water contamination due to herbicides application include: a) adjustment of the dose or change the herbicide with other having less DT50 or larger Koc values, b) creation of a granular soil surface at a depth 10-20 cm, c) change, if it is feasible, the time of application, if heavy rain is expected, d) avoid spraying on light soils e.g sandy, sandy loam with organic matter less than 1%, e) restrict the application of herbicides during summer time on soils with clay content more than 50%.

The BMP to reduce surface water contamination of herbicides application due to run-off and erosion, include: a) Incorporation of the herbicide at a depth of 5-10 mm or apply simulation rainfall 10mm (reduction of the run-off mass up to 50% for herbicides with Koc <500 and up to 70% for Koc >1000), b) minimum cultivation of the soil, avoid ploughing (reduction of run-off/erosion mass up to 20%), c) contour farming, d) creation of buffer zones (BZ)-The effectiveness of capturing the herbicides of BZ with vegetation is 50%, 90% and 97.5 % for BZ of width 5, 10 and 20m respectively, e) the combination of BZ and the use of low-drift nozzles can minimize the contamination of surface water due to spray drift.

It is should be noted that the selection of the most suitable herbicide and the BMP, as mentioned above, under normal weather conditions are sufficient from protecting surface and underground water from their contamination from herbicides. However extreme weather conditions in combination with specific local soil and landscape conditions (e.g. low soil permeability, relief of soil, steepness of slope) can cause, in some cases, entry risks beyond our mitigation capabilities. It is should be established that in any IWM, the selection of the herbicide should include, besides all other, its environmental risk.

Key words : IWM, herbicide, surface-underground water, BMP

Recent Developments in Physical Weed Control/Tillage Operations

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The aim of this lecture was to present the newest developments in physical weed control methods like an important part of Integrated Weed Management (IWM), in order to achieve the replaceing the herbicide-based weed control systems with integrated weed management systems, based on innovative strategies. The innovative strategies are the combination among preventive methods, cultural methods and direct control methods (flaming, precision hoeing, etc). All tillage operations will help to control weeds: primary tillage (initial breaking of the soil beetween 10-90 cm deep) with high impact on species density; secondary tillage (additional levelling, breaking, and firming to prepare seedbed up to the deep of 10 cm or less) with a major impact in getting a low-weed degree on the onset of crop and, the selective cultivations (weeds control after crop emergence) with a major impact on the weed's competition decrease against the crop and the possibility for maintaining the agricultural land below the economic threshold of weed damage. Advanced physical weed control includes modern mechanical means used in soil tillage systems (especially weeding machineries for precision hoeing) or the use of thermal radiation for weed control. The both of precision hoeing methods supose the use of sensor-guide tools or the use of independent robots. The challange for physical-mechanical weed control machineries is to achieve the selective removal of weeds within the crop rows (intrarow weeding). The efficiently weed control in the crop rows is important because weeds close to the crop cause the highest yield losses. The intra row weeding is made by torsion, weeders with fingers and brush as well as weeders using compressed air to blow away the weeds or weeders with flame. All of this type of weeders function through high technology developed that distinguishes between crop and weeds, that means sensor-guides tools for weedier devices. Nowadays the science and technology give us advanced weed control systems like: mechanical cultivators with automatic weeders guide, as trailed or tractor-driven equipment with a driver for precision inter-row weeding; autonomous tractors carrying herbicide sprayers coordinating with drones equipped with weed-detection systems which have proven to save up to 75% of the herbicide doses; autonomous tractors equipped with on-board weed detection systems which are able to kill 90% of weeds on a field (inter and in-row weeding) and aerial or terrestrial robots (without tractors). The possibilities for using of one of these weeding machines vary according to crop type, crop growth stage and field and weather conditions and depend on their selectivity. This selectivity is based on differences between weed and crop plants, for example in root anchorage forces, leaf type and their surface and plant height and, on their own capacities for weed detecting depending on type of sensors. Nowadays at least three brands of sensor-

tools weeders are produced and commercially available in Europe: The *Garford Robocrop* – United Kingdom (Robocrop Guided Hoes and Robocrop InRow Weeder), the *Steketee IC* – Netherlands (IC Cultivator) and the *Robovator* – Denmark (Robovator with mechanical tools and Robovator with thermal tools). The recently finished project RHEA (*Robot Fleets for Highly Effective Agriculture and Forestry Management*) developed a fleet of tractors and aerial robots with sensor systems to discriminate weeds from crops and apply herbicides where needed or flaming and row crop cultivator implement on RHEA Robot. Bosch startup *Deepfield Robotics* develops technologies for weed control, like BONIROB. In the world, there are many functional and very interesting robots for weed control so we can hope in precision agriculture developing and efficient tactics and strategies for herbicide use reduction

Key words: physical weed control, sensor guides

Allelopathy and Cover Crops

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A presentation on the role of allelopathy and cover crops on Integrated Weed Management. Allelopathy is the production of chemicals or exudates by living and decaying plant species or microorganisms which interfere with the germination, growth or development of another plant species or microorganism sharing the same habitat.

Allellopathy can be affected through the release into the environment of compounds that are either toxic in the form they are produced, or that become toxic as a result of transformation by microorganisms. Even though the allelopathic effect of a large number of allelochemicals has been shown in laboratory based experiments, there is a lack of adequate field studies and appropriate bioassay models. There is also difficulty in establishing the role of microbes in the release of allelochemicals and their subsequent transformation and in determining the mechanism of action, particularly when the chemical nature of allelochemicals is unknown.

Allelopathic weed control can be accomplished through the use of allelopathic crops as cover crops, mulches or green manure, use of allelopathic plants in crop rotations, crop mixtures and intercropping, and crop varieties with strong allelopathic potential.

Cover crops are crops whose main purpose is to benefit the soil or other crops in one or more ways, but is not intended to be harvested for feed or sale. Cover crops are an important fertility and integrated weed management tool. Weed control is accomplished through outcompeting weeds by rapid canopy development, vigorous growth, production of allelopathic compounds and provision of dense mulch.

Allelopathy in combination with cover crops can be one of the most important cultural methods in Integrated Weed Management.

Key words: allelopathy, cover crops, weed management

IWM and herbicide resistance management: the case of glyphosate resistance

Demosthenis Chachalis

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In Greece, due to a number of reasons have resulted in the development of glyphosate resistant *Conyza spp*. biotypes in perennial crops. Specific reasons are as follows: long history (more than 30 years) of glyphosate use and an increasing overreliance on this herbicide, with limited application of herbicides with a different mechanism of action, use of suboptimal glyphosate application rates, and little alternative integrated weed management approaches (such as crop rotation and use of mechanical weed control). All three horseweed species have developed resistance but the problems are especially focused on *Conyza canadensis* and tall fleabane (*C. bonariensis*). This presentation will provide a full account of the glyphosate resistance in Greece focusing on data regarding: 1) characterization of contrasting biotypes; 2) the level of resistance on a large number of field collected biotypes from regions and different perennial crops in Greece; 3) the mechanism of glyphosate resistance. The scope of this presentation is to highlight, the ecophysiology of resistant biotypes, the mechanisms of glyphosate resistance and propose control strategies to manage and prevent glyphosate resistant *Conyza spp.* in perennial crops in South East Europe.

Integrated Weed Management: Cultivar selection and agronomic practices to control rice weeds

Husrev Mennan

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Rice is among the crops that possess a significant role in global food security. Currently, rice is grown and consumed throughout the world. Other than grain consumption, rice straw, husk and bran are utilized to synthesize several important products. Weeds are among the most important biotic factors that cause a major decline in rice productivity. If proper management practices are not performed, the weeds may cause a 35% or more decrease in rice grain production on a global scale. Nearly 90 weeds could infest rice crop causing a yield losses ranging from >20% to total failure of crop. Recent literature from across the world indicate that rice is infested by a complex weed flora. Important weeds are *Echinochloa* spp., *Oryza sativa var sylvatica, Cyperus* spp., *Leptochloa* spp. and *Scirpus* spp. in Europe. Different rice production systems may have a different choice of agronomic integrated weed control strategies. Those are using competitive cultivar, sowing date, seeding rates, row spacing, water management and rotations. In this case study the fallowing question has been tested; growing highly competitive rice cultivars and increasing the crop seeding rate may improve red rice control in an integrated weed management system?

The experimental design was a randomized block design with four replications. Three rice cultivars; Koral, Osmancik and Gonen were used at 160, 180 and 200 kg ha^{-1} seeding. To determine the competitive ability of cultivars in different seeding rate against to weedy rice, cultivars biomass, weed density, total weed dry biomass, plant height, tillering capacity and yield were assessed.

Tiller production was affected by rice cultivar. Koral had more tillers than the others cultivar at different densities of weedy rice. All cultivars showed a general downward trend in plant height with increasing red rice density. Weedy rice density had significant effects on rice heights. Osmancık was naturally shorter than Koral and Gonen but suffered a smaller reduction in height in presence of weedy rice. Rice yield was increased almost 20% when seeding rates were increased from 160 to 220 kg ha^{-1}. Seeding rate studies with the big-grain, early maturing cultivars Osmancık, Koral and Gonen found seeding rates of 180 and 220 kg ha^{-1} provided a competitive advantage for rice growing with weedy rice. Weedy rice reduced rice grain yield for all cultivars. Averaged over growing season, rice grain yield reduction due to presence of 37 red rice plants m^{-2} was 28.84%, 39.45% and 45.68% for Osmancık, Koral and Gonen. Results of this study indicate that differences exist in competitive ability among rice cultivars, against weedy rice, underwater-seeding production protocol. Our findings, confirm that both tiller number and rapid early growth are important determinants of potential yields and those characters can be useful selection criteria in anaerobic rice in breeding programs.

Key words: cultivar competition, weedy rice, seeding rate
The authors thank The Scientific and Technological Research Council of Turkey (TUBITAK) for supporting the project (TOVAG 2140446).

Weedy rice control by using IMI tolerant rice cultivars

(advantages and disadvantages)

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Weedy rice (*Oryza sativa*), a conspecific weed of cultivated rice, is a global threat to rice production. It can be found heavily infesting paddy fields, competing with cultivated rice. This weed has a vigorous growth that makes it a significant competitor for space and nutrients, and when present in cultivated rice fields, rice yields will unavoidably be reduced. Yield losses due to weedy rice could range from as low as <5% to as high as 100% in severely infested areas. Eradication of weedy rice is difficult because it is of the same species as cultivated rice, with similar physiological characteristics. Thus, herbicides that kill weedy rice would also injure cultivated rice. The introduction of Clearfield® technology allowed producers to selectively control red rice in irrigated rice areas with little effect on crop safety. The adoption of this technology was rapid in many countries. On the other hand, because the continued use of this technology and minimal alternative cultural practices being adopted concomitantly, several weedy rice biotypes have evolved resistance to imidazolinone herbicides. Clearfield technology has been very successful developed by a group of researcher in Trakya Agriculture Research Institute 4 years ago. The variety was commercialized since 2 years. The popularity of Clearfield! rice among farmers does not always produce positive consequences. Implementation of this technology without long-term planning, appropriate stewardship, institutional collaboration and oversight could have adverse ecological impact in terms of gene escape to weedy or wild relatives

The challenge is to sustain this yield advantage by minimizing the evolution of HR weedy rice populations. This is very difficult because rice monoculture is widely practiced in rice growing area. Some preventive approach can be prolonging the utility of Clearfield rice technology;

1) implementation of herbicide programs that incorporate all possible modes of action
available for rice production
2) adoption of best management practices that ensure maximum efficacy of the herbicide
3) minimizing the synchronization of flowering between HR rice and weedy rice (by knowing the phenology of the weedy rice relative and adjusting planting dates accordingly)
4) preventing escaped weedy rice in a Clearfield rice field, and remnant weedy rice after crop harvest, from producing seed
5) preventing the seed production of volunteer rice or weedy rice in the next crop cycle by controlling it in a rotational crop such as IMI-tolerant legumes, pasture, or other compatible commodity
6) Stale seedbed e reducing the potential population density of weedy rice in a season by allowing a big batch of weedy rice germinate prior to rice planting and killing these seedlings either by a second tillage or with a non-selective or grass herbicides

Integrated Weed Management: A case of maize

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Agricultural production today is influenced by the global climate changes, soil degradation and biodiversity losses. In order to develop maximum yield strategies, innovative research have to serve for better understanding of soil-plant relations within the agro-ecosystem, maximal utilization of genetic potential of new genotypes and optimization of cropping technologies. Yield losses and stress effects should be minimalized and, in case of maize, weed interference have to be eliminated. Herbicide application has been the most often used option for weed control in maize. This effective and not expensive method beside the contribution, also have shown some negative effects such as soil and ground water pollution, weed communities changes, occurrence of weed resistance, etc. In Serbia, the potential resistance to triazine and sulfonylurea herbicides were detected and many changes in maize weed associations such as prevalence of some invasive and troublesome species - *Chenopodium* sp., *Amaranthus* sp., *Solanum nigrum*, *Datura stramonium*, *Ambrosia atremisiifolia*, *Sorghum halepense*, *Xathium strumarium*, *Abuthilon theophrasti* etc.

The more effective and environmentally safe method for successful weed control in maize is application of IWM. This system is based on the combined application of preventive, direct, mechanical, biological and alternative measures and good knowledge from field history; it is aimed and settled to give long-term results in the certain maize growing area. This system does not mean excluding of herbicides, but less reliance on chemical control.

In the research program conducted in the Maize Research Institute Zemun Polje in central Serbia, the effects of different IWM measures in maize have been studied during several years. Effects of crop rotation, soil tillage and fertilizers have been studied in standard and maize varieties with specific traits (red, white, flint and other), under rainfed and irrigated conditions. As alternative measures, cover crops and intercrops were studied and their effects on weed distribution in sweet maize and popcorn, grown without herbicide application. Crop-weed interactions i.e. competition was studied in the experiments with combined application of changed spatial arrangement of maize, fertilizers form and herbicide rates.

After six years of long-term experiment aimed to investigate different crop rotation and level of herbicide application on maize weedness, it seems that maize-soybean-winter wheat and maize-w. wheat together with recommended dose of herbicides have shown the best effect in weed biomass reduction, 92.1% and 92.2%. Results show that winter wheat is a better preceding crop for maize than soybean, especially in combination with herbicide application in recommended, as well as, in a half of recommended dose. Application of herbicides affected weed seed bank richness and the highest number of seeds was identified in untreated control. The significantly highest average number of weed seeds was identified in maize monoculture, 6425.0 seeds/m^2.

According to two years observation from long-term experiment with tillage systems in maize, soil tillage have significantly influenced weed presence and grain yield of maize. The best results in weed control and grain yield of maize were achieved with conventional tillage. Discussing three years results, it could be concluded that herbicide application was the only one factor influencing weed biomass while row space and urea form did not cause differences in weed biomass decreasing. Between the five cover crops, common vetch have shown the best effect in number of species, number of plants and fresh and dry weed biomass reduction. Growing maize in intercropping with soybean has resulted in some positive effects on weed abundance. The best effects were observed with alternate rows model and without application of fertilizers.

Key words: maize, weed control, system of measures

An update on cultural weed control methods

Ilias Travlos

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Several cultural practices like tillage, planting, crop rotation, proper fertilization and irrigation are employed for creating favorable condition for the crops. These practices if used properly can have a great impact on weed control. Preventing introduction and spread of weed seeds, false and stale seedbed, altering sowing time and crop density and promoting destruction of weed seeds and seed predation are only some of the agronomic practices which can be implemented in terms of an integrated weed and crop management system. Special attention should be paid on the most noxious and invasive species and moreover into planting certified seed, control of volunteer weeds along field edges and cleaning equipment before moving from field to field. While all cultural practices cannot be expected to eliminate weed problems, they can make a significant contribution to seed bank management when integrated with other practices and consequently to enhance crop vigor and competitiveness and increase yield

MATERIAL PROVIDED

I) Herbicides and risk of water pollution

Dr S. VIZANTINOPOULOS [Selected Relative literature]

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<u>Dr I. Bogdan</u>

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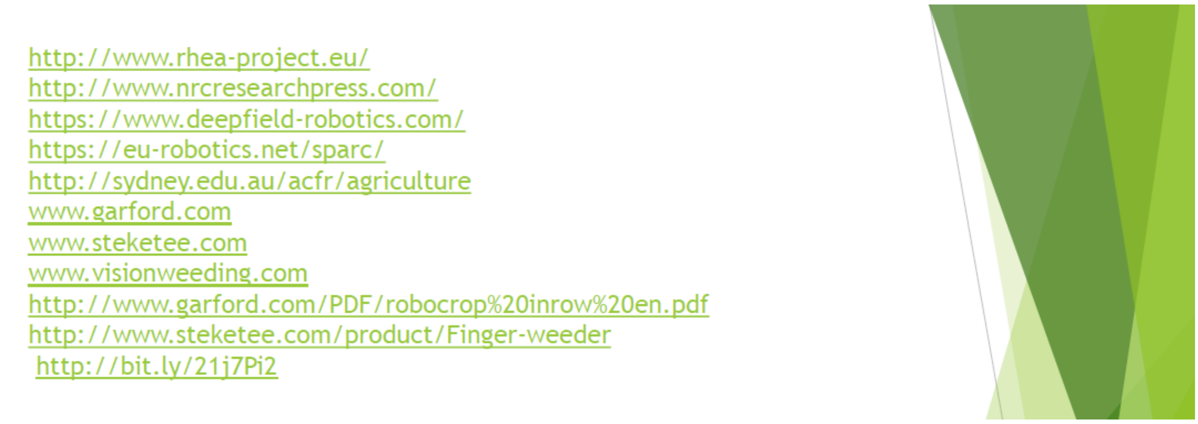

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III) Allelopathy and cover crops

Dr C. Vasiliokiotis [Selected Relative literature]

1) **Proving Allelopathy in Crop–Weed Interactions**

Stephen O. Duke

Weed Science 2015 Special Issue:121–132

http://www.bioone.org/doi/pdf/10.1614/WS-D-13-00130.1

2) **Controlling weeds with fungi, bacteria and viruses: a review**

Dylan P. Harding and Manish N. Raizada

Additional article information

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4551831/

IV) IWM and herbicide resistance management

Dr D. Chachalis [Selected Relative literature]

1) **Control of Conyza spp. with Glyphosate – A Review of the Situation in Europe**

Manda SANSOM, Antonio A. SABORIDO and Marielle DUBOIS

Plant Protect. Sci, Vol. 49, 2013, No. 1: 44–53

https://www.agriculturejournals.cz/publicFiles/84990.pdf

2) **Handbook on Herbicides: Biological Activity, Classification and Health & Environmental Implications**

Editors: Daiki Kobayashi and Eito Watanabe

vi Contents

https://www.novapublishers.com/catalog/product_info.php?products_id=40672

V) An update on cultural weed control methods

Dr I. Travlos [Selected Relative literature]

1) **False and Stale Seedbeds: The most effective nonchemical weed management tools for cropping and pasture establishment**

Nov 2015. Report number 2-2015

Dr Charles N Merfield

https://www.bhu.org.nz/future-farming-centre/ffc/information/weed-management/false-and-stale-seedbeds--the-most-effective-non-chemical-weed-management-tools-for-cropping-and-pasture-establishment-2015-ffc-merfield.pdf

The BHU Future Farming Centre Permanent Agriculture and Horticulture Science and Extension www.bhu.org.nz/future-farming-centre

2) **Weed seed predation increases with vegetation cover in perennial forage crops**

   Helmut Meiss et al.

   Agriculture Ecosystems & Environment 138(1):10-16
http://agris.fao.org/agris-search/search.do?recordID=US201301850148

3) **Spatial patterns of weeds along a gradient of landscape complexity**
   Audrey Aligniera,∗, Vincent Bretagnolleb, Sandrine Petita

   Basic and Applied Ecology 13 (2012) 328–337

   http://www.cebc.cnrs.fr/publipdf/2012/ABAE13_2012.pdf

4) **The spatio-temporal distribution of weed seed predation differs between conservation agriculture and conventional tillage**

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   http://agris.fao.org/agris-search/search.do?recordID=US201600240963

VI) Integrated weed management: A case of maize

Dr M. Simic [Selected Relative literature]

Please, find some addresses for a papers have been published already and associated with my lesson in the summer school.

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Maize Cropping With Less Herbicide

Bo Melander, Aarhus University, Denmark Paolo Bàrberi, Sant'Anna School of Advanced Studies Pisa, Italy Nicolas Monier-Jolain, National Institute for Agricultural Research, France Rommie van der Weide, Applied Plant Research, Wageningen UR, The Netherlands Arnd Verschwele, Julius Kühn Institute, Germany Maurizio Sattin, National Research Council, Italy

https://pure.au.dk/ws/files/1495316/Integrated_Weed_Management_Case_Study_Guide_1.pdf

Influence of growing measures to weed control and water use in maize

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SUMMARY

Weeds make a strong competition influence to the growing plants, especially when herbicides are not properly applied. In order to support crop growth, the optimal level of resources and nutrients is also needed. The aim of the investigation was to evaluate the effect of nitrogen form, maize row spacing and herbicide treatment on 1. Weed biomass, 2. Herbicide efficacy and 3. Maize biomass production.

The investigations were conducted in Maize Research Institute Zemun Polje, Belgrade, during 2014-2016. Field experiment was settled as a split-split-plot block design with four replications. Maize was planted with application of standard and slow-realize form of urea. Within each N source, maize was grown into two inter-row spacing (50 cm and 70 cm) and with following weed control treatments: without herbicide application, application of pre-emergence (s-metolachlor + mesotrione) and post-emergence (nicosulfuron + mesotrione) herbicides mix. Maize hybrid ZPSC 388 was sown in the second decade of April, 2014, 2015 and 2016. Six weeks after herbicide application, the fresh biomass of uprooted weeds from 1 m^2 was measured and coefficient of efficacy was calculated. At the same time, aboveground biomass of whole crop plants was evaluated.

Results show that weed biomass was slightly higher in 70 cm than in 50 cm row distance but it was significantly lower on treatments than on untreated control. Pre-emergence mixture of s-metolachlor + mesotrione provided good control and at the higher extent when it was applied after slow-realising urea. The best efficacy was observed in post-emergence treatment with mesotrione + nicosulfuron in 50 cm row distance and standard urea application (96.65%). Chemical control of weeds significantly increased biomass of maize plants, while row spacing and nitrogen form, didn't show greater influence. Maize biomass at the developmental stage of 22-24 leaves was the highest in the herbicide treatments, application of standard urea and 50 cm inter-row distance which indicates that space between maize rows could be decreased from standard 70 cm.

Keywords: Weeds, Maize, Herbicides, Row space, Water

VII) Integrated weed management: A case of rice

Dr H. Mennan [Selected Relative literature]

Competitiveness of rice (Oryza sativa L.) cultivars against Echinochloa crus-galli (L.) Beauv. in water-seeded production systems

H Mennan et al. 2012.

Crop Protection 41:1–9; DOI. 10.1016/j.cropro.2012.04.027