Site specific weed management working group

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List of titles:

Leaf area estimation of crop and weeds using computer vision and image processing

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Several studies have estimated the crop yield-loss due to weeds. These studies have used different measures in the estimation, i.e. weed density (Cousens, 1985) or the leaf area (LA) of the weeds in relation to the total LA (Kropff & Spitters, 1991) (Lotz *et al.*, 1996). The relative LA model gave better estimates of the crop yield loss by competition from weeds emerging in flushes than the density models. Due to a very time-consuming data acquisition for the necessary parameters in the relative LA model, this model is unrealistic to use for yield-loss estimation in practical site-specific weed management, unless the relative LA is found automatically.

Lotz *et al.* (1992) proposed a method to estimate the relative weed LA by measuring the proportion of the ground occupied by the vertical projection of the weed LA (coverage). At the early growth stages, where weed-control decisions are taken, a good correlation between LA and coverage was found. Furthermore, recent research has shown that it is possible to use digital image processing of outputs from video cameras to detect weed species and their density, as well as their relative coverage (Ngouajio *et al.*, 1999; Sökefeld *et al.*, 2000).

It could be a major breakthrough for site-specific weed management if automatically measured relative weed coverage could be used to estimate relative the LA of weeds. If the correlation between the relative coverage and the relative LA is known, the automatic measurements could supply decision support systems with necessary parameters for more precise predictions of the optimal herbicide dosage in an "in-season" perspective.

The correlation between relative coverage and the relative LA is mainly dependent on the individual plant size and leaf distribution. Knowledge of the stability (i.e. variation in time and space) in plant size and leaf distribution is therefore needed between different

- crop varieties and weed species
- plants of the same variety/species in
- the same growth stage or
- different growth stages
- under different weather conditions

In a future Ph.D.-study, these aspects will be central points. The aims of the project are to

- Extract knowledge about the variation in time and space of crop density, cover and relative LA
- Explore and describe competition between crop and weed by use of computer vision and image processing techniques
- Uncover the possibilities of using spatial variation in crop and weed density in methods for weed control in cereals or other competitive crops.

The Ph.D.-study will analyse the relationship between coverage and LA of different weed species and cereals under controlled weather conditions. Furthermore, field trials will be conducted, and different computer vision systems and image processing techniques will be tested.

A list of literature cited is available on request.

Norwegian activities in SSWM

Haldor Fykse, Norge

Norwegian activities

We have concentrated on weeds in spring cereals. In these crops the normal procedure is that herbicides are applied to the whole field every year. The main reasons are: 1)Fear of new weed emergence later in the season, and 2)fear of increased weed infestation in future years.

Long lasting field studies have shown that the weed density after a maximum at the 3-5 leaves stage of the crop decreases, and that the weed emergence may differ considerably from one year to the next, even within the same area of a field. The need for weed control varies similarly.

In order to practice SSWM we need a decision tool which can tell how ‘much weed’ is tolerated at the time of spraying. To take the great variability of the damaging potential of a changing weed population of a field into consideration, our approach has been to assign a relative competitive value to the most important weed species. The ‘weediness’ of a species is calculated as the product of its relative competitive value and its density.

The biomass of the weed population and that of the crop, expressed as per cent coverage of the ground, is also evaluated. The values of the three variables 1)’weediness’, 2)weed coverage and 3)crop coverage are then compared with elaborated threshold values.

This approach has given promising preliminary results with figures recorded manually. The great challenge, however, is to automate the field recordings and link them to reliable threshold values in a workable manner.

Practical experiences in developing techniques for site specific herbicide treatment

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Investigations in farms running plant production on large fields (50 to 200 ha) show a broad spectrum of weed distribution. Soil and climatic conditions, as well as the long-term farm-specific production process generally determine the occurrence of varieties, their abundance, and the scale of weed patches. Short-term changes from one year to another are manly caused by weather and the cultivated crop.

Practical experiences from the last 10 years regarding the mapping approach show that 30 to 50 % of herbicides (7 to 15 Euro / ha) can be saved in dependence of the regional climatic and production conditions. If sampling costs (0,5 to 4,5 man hours / ha), costs of data management, and information technology would have been included for example, the costs would exceed the savings. A more economical, site-specific herbicide application should be done in real-time with low-cost technical solutions.

Because it is hard to discriminate between cultivated plants and weeds, especially in cereals, oilseed rape and legumes, we operate an opto-electronic weed sensor within culture-free tram-lines. The sensor does not distinguish different weed species.

The following results from field experiments with regard to the opto-electronic detection of weeds and problems of real-time site-specific application of herbicides are presented:

Based on data from intensively sampled cereal fields from the last 10 years we found an intrinsically non-linear correlation between the total number of weed plants and the total expected yield loss due to the weed species found. According to this function, the decision about the variability of the application rate is made.

In autumn, at early growth-stages of the weed plants, the sensor values were correlated with the weed counts obtained from sampling by hand.

In spring, during the tillering phase of monocotyledons or the ramification phase of dicotyledons, it was found that a single weed plant caused more than one sensor value. The sensor values were correlated with the coverage level estimated from sampling by hand.

The weed sensor was placed in front of a tractor and operates together with a commercial sprayer. In spring 2000 site-specific real-time applications of herbicides were made on 21 ha winter rye, 44 ha winter wheat, 36 ha triticale, 8 ha spring barley and on 8 ha common beans, while 29 ha winter rye were treated in autumn 2000.

Acknowledgement

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Site specific weed control in agricultural practice

Nordmeyer, H., Häusler, A.

Site specific weed control was carried out on agricultural fields within the same farm, all in conventional agricultural use. A heterogeneous weed distribution could be observed for all fields. So a patchy herbicide application was possible. The field portions to be treated with herbicide for single weed species e.g. *Galium aparine* or grouped species varied between 0 and 100 %. For weed monitoring the weed mapping procedure using the Global Positioning System (GPS) was chosen. Based on weed maps application maps were generated and an automatic GPS based herbicide application was carried out. First of all site specific weed control offers the possibility of saving herbicides. As a consequence of limited field travelling it may also contribute to a reduction of man hours and machine work.

Spatial and Population Dynamics of Patches of Wild-oats

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It is likely that for the foreseeable future, patch treatment of weeds will depend on visually created weed maps, so it is important to minimise the frequency of re-mapping to reduce labour costs. The need to re-map will depend on the stability of the patches.

We have been investigating the spatial dynamics of wild-oat patches. 3 x 3 m square patches of wild-oats were established in October 1997 at two sowing densities, 10 and 50 plants/m2. All cultivations and combining directions have been kept constant. Seed production and seed movement has been monitored, together with the shape of the patches, and location of outlying plants. The majority of seeds have remained within 1-2 m of the original patches, though some have moved up to 30 m away from the source, in the direction of cultivations. In March 2000, some of the plots were treated with a wild-oat herbicide, and the impact of this treatment on the patches is currently been monitored. We have found that herbicide treatment has reduced the seed return relative to unsprayed plots. Patch size in sprayed plots has remained similar to the previous year, but has increased in unsprayed plots.

A similar experiment has been established to investigate the stability of patches of cleavers.

Limitations of manually mapping weed patches

As automated weed detection is not yet commercially viable, and discrete quadrat sampling is not a practical option for whole-field scale weed mapping, we have investigated using visual detection from agricultural vehicles as a method of producing weed maps.

Weed patches have been mapped in whole fields and part fields at various times of the year using an ATV, tractor or combine fitted with DGPS and a laptop computer. A voice-activated weed mapping system has been used, enabling a single person to map weeds.

Weed maps produced by visual mapping from a vehicle will be compared with maps of the same area produced by discreet quadrat counts, to explore the accuracy of the visual maps. Comparisons will also be made between maps produced by visual detection at different times of the year.

Continuous visual detection from a vehicle was found to be less accurate than detailed quadrat sampling, and may be limited to tramlines (depending on vehicle type). Consequently, surveying may be restricted to visual strips up to 6m wide every 12 ,18 or 24m, depending on the width of the sprayer. It is also difficult to map differing levels of infestation. It is, however, much quicker, and practical for whole-field scale mapping. More work is needed to make progress with optimising visual detection, in the absence of automated detection.

Spatial distribution of weeds in a maize crop

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Our programme is a collaboration between different teams (INRA [Dijon]; ENESAD [Dijon]; CEMAGREF [Montpellier] and ENSEA [Cergy-Pontoise]. The base of the study is the description of the spatial distribution of weeds in a maize crop, at early stage after emergence, in order to estimate the expected weed competition strength and to devise a local and optimal weed control strategy, under environmental constraints. The first step of the programme starting this year, is the link of 2 levels of weed-crop recognition by image processing: one at 20-30 m from small airplanes (detection of crop rows and weed patches), the other at ground level (weed species caracterisation). Moreover, we study the early growth of seedlings of several weed species usually found in maize.

Spatial scales in site-specific weed management - Weed distribution on Belgian fields

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Weed distribution of broadleaved and grass weed was examined on 5 Belgian fields to assess the possible herbicide savings in site-specific weed treatments and to discover typical weed patch sizes. In 1995, weed populations were sampled along crop rows in maize, sugarbeet and chicory fields. In 1996, the weed populations were sampled in a grid of 5 by 5 m on a sugarbeet field, 2 maize fields and in a grid of 5 by 2 m on a chicory field. A multiscale ordination technique was tested to discover 'typical' weed patch sizes, but no typical size was found. Weed free areas were much higher for grass weeds than for broadleaved weeds. Broadleaved weeds were usually widespread, depending on the success of past weed treatments. Grasses and perennial weeds show a patchy distribution that can lead to considerable herbicide savings in site-specific weed treatments, depending on the spatial resolution of weed sampling and treatment.

Spray systems - Volume regulation

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Background and purpose

Precision pesticide application requires technology for adjustment of the flowrate without changing the spray quality. In practice the spray quality -droplet size and -distribution- will have influences on the biological efficacy and the loss in terms of drift and evaporation.

The most common used nozzles for pesticide application is the hydraulic flatfan nozzles. The hydraulic nozzles produce droplets by liquid pressure and adjust the flow rate by adjusting the pressure. As the droplet size is depending on the pressure there is a clear interaction between droplet size and the flow rate, which means that the spray quality is changing by the flowrate. Furthermore the pressure also influences on the liquid volume distribution patterns. This means that flowregulating by chancing the liquid pressure only can be recommended in a limited flowrange, approximately +/- 25 %.

When the variability in the application rate in a certain field is bigger than +/- 25 %, a flowrate control system for hydraulic nozzles or nozzles with an other droplet generation principle is needed.

By mounting 2 or 3 rows of hydraulic nozzles with different sizes on the same spray boom, it is possible to vary the flowrate in a bigger flowrange. The same can be obtained by pulse width modulated hydraulic nozzles.

Another nozzle design by using air and liquid seems to be suitable for obtaining a higher degree of variation in the flowrate without changing the spray quality. With this system the droplet generation and the flowrate can be adjusted separately. The droplet size distribution can be adjusted by regulation of an airstream.

This abstract deals with the design and performance of air and liquid nozzle systems and its potential uses in connection with variable pesticide application.

Methods

A measurement method for flowrate and droplet sizing has been used for evaluation of the nozzles. All measurements were done in a laboratory.

For continuously measurement of the flowrate a magnetic inductive flowmeter (Danfoss MagFlo) was used. The dropletsize was measured by use of laserbased equipment (Dantec PDA-analyser).

Results and conclusions

Measurement of the dropletsize distribution from a standard flatfan nozzle increasing the flowrate 2,5 times gave a reduction in the dropletsize by 40 percent.

When measuring on an air and liquid nozzle it seems to be possible to increase the flowrate 4,5 times without chancing the dropletsize distribution.

Depending on the design of the air and liquid nozzle it seems to be possible to obtain a good spray distribution pattern when changing the flowrate.

It should be possible to regulate the airflow according to the actual liquid flow to obtain a constant droplet size by using electronic controllers. In that way it will be easy for the farmer to control the spray quality, taking into account the variability in the field and the weather conditions.

Weed mapping spray technology – Q&A

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Background & Discussion

We have made several experiments with site-specific weed management for the last 5 years. We have generally used a regular grid mapping approach followed by a point by point solution for a certain herbicide dose (or mixture), using a decision algorithm for patch spraying (DAPS) developed at our institute. Mapping has usually been done using kriging or inverse distance. We have used three different spray types in our experiments: 1) a conventional sprayer with a field run for every dose level, 2) a conventional sprayer with a pressure/amount regulation (+/- 30%) and 3) an injection sprayer with up to 2 herbicides. We have primarily used the software packages Surfer (from Golden Software), AgroSat (from Datalogisk) and PatchworkPro (from Raven Industries).

Based on this experience we would like to discuss whether the farmer, the researcher and the agricultural IT companies aim at the same target. Provided that we want to continue making some kind of weed mapping:

- Do we want to make point or area calculations?
- How do we come from a certain dose result in one point/area to the final dose map (interpolation procedure)?
- Can we find weed zones to be treated uniformly?
- In that case: How does an area qualify to be uniformly enough to become a weed zone?
- Does the farmer want the same functionality as the researcher? – Probably not!

Demands or wishes to better weed mapping technology

- Delay in tractor computer and sprayer must be well defined or better - must be taken care of!
- Map visualisation in tractor (spray map) should be equal to the originally calculated treatment map (dose map).
- Must be easy to manage large farms with many fields in many years in the GIS-like software.
- Interface standard between equipment!
- An autonomous robot device to monitor weed seedlings prior to spraying (e.g. vision/sensor) would be a major help.

Is weed mapping old-fashioned and soon replaced by real-time equipment
or will there be an interest for planning pre-spray?