Farm Level Optimal Water Management Assistant for Irrigation under Deficit

More yield, more quality and less emission of nitrate

Soil grown Iceberg lettuce under rain-fed conditions

Factsheet: Case study result from the Netherlands

Nutrient emissions in field grown vegetable crops in the Netherlands need to be reduced to meet the demands of the EU nitrate directive. Legislation enforces lower fertilizer use with risks of yield loss. Within the FLOW-AID project new automated irrigation systems were demonstrated that have the potential to raise crop yield with 10%, giving good quality products, and as well save the environment by reducing the fertilizer leaching to ground waters. Farmers are hesitating to use the automated irrigation system because of the costs, but are very interested to use the monitoring part of the system and to get familiar with the decision support system to support their activities.

The Problem

Both the new environmental legislation like the Water Framework Directive and the Nitrate Directive as well as the demand for a constant high quality and production volume will lead to new horticultural cropping systems. Growers need to control their crop more precisely, and need to control the water and nutrient flows. If not, some crops cannot be grown in soil anymore in the near future.

In the Netherlands research focuses on two directions: horticultural crops grown in soil but with intensive control regarding water and nutrient management and horticultural crops grown out of the soil in a water or substrate culture. Regarding the first alternative, during the summer season 2009 and within the scope of the FLOW-AID project, a case study was performed on growing Iceberg Lettuce at the experimental research station PPO-Vredepeel on a slight loamy sandy soil in which water and nutrients drain very rapidly under rain-fed conditions. Under these conditions crops can suffer rapidly from drought, and as well during heavy rain-fall valuable nutrients might leach into the ground water and damage the environment.

Iceberg lettuce grown under rain-fed wet climatic conditions

Objectives

The main objective of this experiment as to evaluate whether the use of drip-irrigation together with fertigation (a combined application of water and nutrients) could reduce the emission of nitrate to the environment, and at the same time enlarge the crop yield, while remaining standard crop quality. Within the case study, the developed FLOW-AID techniques, systems and tools will be used. The automatic sensor activated irrigation control in combination with set-point support by a DSS was evaluated on aspects like simplicity, easy use, and durability.

Methodology

The used standard cropping system in which lettuce was grown on beds with 4 rows (spaced 34 x 37 cm^2), was adapted according to the following:

- The soil was covered with a black plastic foil to ensure a more homogeneous and less dynamical soil climate. Further the foil prevents rain to infiltrate directly into the soil and, as such, to leach large amounts of nutrients during heavy rainfall.
- For irrigation and fertilization sub-soil drip irrigation tape was used (1 line per 2 crop rows) buried about 5 cm in the soil.
- The strategy for water management was to keep the water content as much as possible at a constant level in and underneath the root zone. Irrigation was activated (START-condition) automatically based upon a volumetric water content sensor placed in the root zone at a depth of 15 cm. The water dose (STOP condition; run time of irrigation pump) was determined by a Decision Support System making use of a sensor under the root zone (at 30 cm) giving information about possible leaching of water. When the water content gets higher, the dose is lowered, and the other way around. The effect of this was that compared to manual irrigation practice the irrigations were performed more frequent but with a smaller dosage, preventing leaching of water and nutrients.
- Rather than giving a bulk fertilizer at, or just before, planting, fertigation was done manually on a weekly basis, and the dose was calculated according to crop nutrient needs matching its growth. The amount of mineralized N in the soil top layer (0-30 cm) at the start was 68 kg/ha. Prior to planting the soil was given 660 kg/ha patent kali (200 Kg K/ha.)
- A computer, situated at the farmers house, controlled and monitored all data remotely via two wireless systems, covering a distance of about 500 meters. The

The irrigation controller located in the field to host soil water content sensors and to control valves and pumps for the automation of the irrigation process. The controller can work autonomously but can be programmed from remote by the computer.

overall system was supervised from the Wageningen University remotely via internet.

Within the experiment three watering and fertilizing regimes with foil-coverage and sensor activated control were evaluated: A. Bulk fertilization; B. Fertilization (full); and C. Fertilization at a 70% dosage; which were compared with standard farmer practice, with no foil and bulk fertilization (D.). For the ease of use all 4 regimes were irrigated with drip tape. The crop was planted on May 13th, harvested on June 30th, giving a cropping period of 48 days.

Results

All results for the experiments are summarized in the table below. Crop expression, uniformity, class 1 and crop filling were scored by visual inspection by a crop expert. The water use is a combination of irrigation water and rainfall. For the foil grown crop, the leakage of rain to the root zone was estimated to about 30% of the rainfall. The advised 100% level of fertilizer was 100 kg N/ha. For C and D the fertilizer was not fully given since the last gift was cancelled due to an earlier harvest because of quick growth.

Object	*Crop Expression (0-10)*	*Uniformity (0-10)*	*Mean Crop Weight (g)*	*Class 1 (%)*	*Dry Matter (%)*	*Filling of Crop (%)*	*Water Use[1] (mm)*	*WUE (kg/m³)*	*Fertilizer[2] (Kg N/ha)*	*Available fertilizer (Kg N/ha)*	*Rest Fertilizer (Kg N/ha)*	*Nutrient Use Efficiency (Kg/Kg N)*
A.	8.0	7.4	528	98.8	4.5	80	70	60.3	100	168	20[3]	285
B.	8.3	7.2	592	97.2	4.3	84	70	67.6	83	151	5	324
C.	8.3	7.1	595	98.4	4.5	84	70	68.0	58	126	4.5	391
D. Farmer	7.1	6.9	516	98.6	4.5	84	186	22.3	100	168	3[4]	250

[1]) This water includes the irrigation water as well as the rain water. For the crop grown under foil the leakage through the foil was estimated to be 30% of the rainfall.

[2]) Referring to the soil layer 0- 30 cm after harvest.

[3]) Due to a much dryer soil regime, more N was left unused in the top-layer

[4]) For the farmer treatment, after harvest, nearly no Nitrogen was left in the soil, so a fairly large portion of it must have been leached to deeper layers.

Just prior to harvest the crop and the new cropping system were shown to growers, companies and advisors.

Conclusions

In the fertigated and sensor activated objects a slightly (10%) higher crop yield was obtained, this while remaining crop quality compared to farmer controlled irrigation management. Under the foil the automated system assured a less wet environment keeping the soil moisture more constant and homogeneous, this prevented leaching of water and valuable fertilizers. The technical systems almost worked perfect, including the wireless links. The application of soil moisture sensors is useful for automated irrigation but under practical application it demands extra skills for using it, especially due to large soil variability. Therefore it is advised to adapt the Decision Support System in such away that it relieves the farmer from checking and fine-tuning these systems. There is still a demand for more accurate and cheaper sensors. Farmers are interested to start using sensors and a DSS, even for just monitoring soil water dynamics. Due to the costs and labour intensive handling of the foil and drip irrigation, farmers are not keen on using it, especially due to the short time a lettuce crop is grown. Nevertheless, growers are advised to give more frequently water and nutrients with smaller dosages, to match more closely the crop demand over time preferably by using an automated system, which can save a lot of work.

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