Grower Summary

CP 13

Promoting the efficient use of water, and reducing environmental impacts, in horticultural field vegetable irrigation.

Dr. Tim Lacey

Grower summary

Headlines

- Achieving uniform irrigation is essential to maximise the yield and quality of high value vegetable crops.
- The uniformity of individual irrigation events is important – it is not enough to assume that subsequent irrigations will average out any non-uniformity from a single event.
- In carrot crops, it is particularly important to focus on achieving high uniformity irrigation during early-mid season (particularly around the start of root enlargement) for root quality, and during mid-late season (root bulking) for yield.
- Although the application uniformity from hose-reel rainguns is inevitably affected by wind conditions during irrigation, growers can minimise the risks of non-uniform irrigation by following simple checks and procedures.

Background and expected deliverables

Helping growers achieve more efficient use of water has been identified as a target priority within the HDC Field Vegetable Research Strategy. This reflects the increased focus on sustainable farming with efficient use of inputs, particularly water, as identified by regulatory bodies (such as the Environment Agency) and by the marketplace (through grower protocols). Within the field vegetable sector, one of the best ways to achieve more efficient water use has been identified as reducing the non-uniformity typical of the dominant irrigation system; hose-reels fitted with rainguns.

This research aimed to investigate the implications of non-uniform raingun irrigation on field vegetable crop production (focusing on carrots as a representative crop) and to examine the potential benefits of a range of practical measures for improving application uniformity. These aims were achieved through computer modelling by integrating existing raingun and carrot crop growth models. These models were validated against extensive field data gathered from two commercial vegetable farms in East Anglia in 2003 and 2004.

The project expected to provide growers with information and practical guidance to assist them in optimising the operation and management of their raingun irrigation systems. The findings are also expected to help growers to better understand the potential economic impacts that improved water management may have on crop production (yield and quality).

Summary of the project and main conclusions

In England and Wales, rising demands on water resources and competition between sectors are leading to increased pressure on field vegetable growers to irrigate more efficiently. Approximately 40,000ha of field scale vegetables are irrigated in England and Wales in a dry year. Between 60% and 90% of this area is estimated to be irrigated using hose-reels fitted with rainguns. However, despite their popularity, these systems are inherently non-uniform in water distribution, particularly in windy conditions. Improving their application uniformity has therefore been identified as one of the most practical solutions to increasing irrigation efficiency for field vegetable growers.

This research developed an integrated approach to model the impacts of non-uniform irrigation on the yield and quality of a vegetable crop grown in the UK. Carrots were used as a representative crop because of their sensitivity to irrigation and relatively high importance within the field vegetable sector. The impacts of a range of raingun equipment and management strategies (e.g. changing field orientation, lane spacing, and/or sector angle, and night-time versus day-time irrigation) were evaluated.

Raingun irrigation was simulated using two linked models. The first, “TRAVGUN”, was used to generate a database of wind affected wetted patterns for a typical raingun system. The second model, “TRAVELLER”, then simulated raingun movement down and across a field, applying these patterns according to ambient wind conditions and a pre-defined range of equipment and management strategies. Carrot yield response to spatially variable irrigation was simulated using a crop growth model called the “Carrot Calculator”. A spreadsheet model was also developed to quantify the impacts of irrigation non-uniformity on carrot quality. The models were calibrated and validated using data collected during 2003 and 2004 from field sites on commercial farms in East Anglia.

The outputs from the research include new information, datasets and detailed maps showing the spatial and temporal patterns of irrigation application and their consequent impacts on crop yield and quality (Figure 1).

The research found that irrigation uniformity had a considerable impact on carrot crop yield and, in particular, quality. For example, in a typical dry year, simulated non-uniform irrigation throughout the season resulted in a total yield loss of 4%, a marketable yield loss of 8% and a premium root yield loss of 11% when compared to high uniformity irrigation. This would have resulted in an income loss of approximately £288-585 ha^{-1} (4-8%). Importantly, and contrary to grower perceptions, this research demonstrated that a small but appreciable marketable yield loss (up to 1%) may occur due to just a single non-uniform irrigation during

critical crop growth periods. However, preliminary investigations suggested that there might be yield and quality advantages to irrigating during a windy period (despite causing low uniformity) rather than delaying irrigation until calmer conditions.

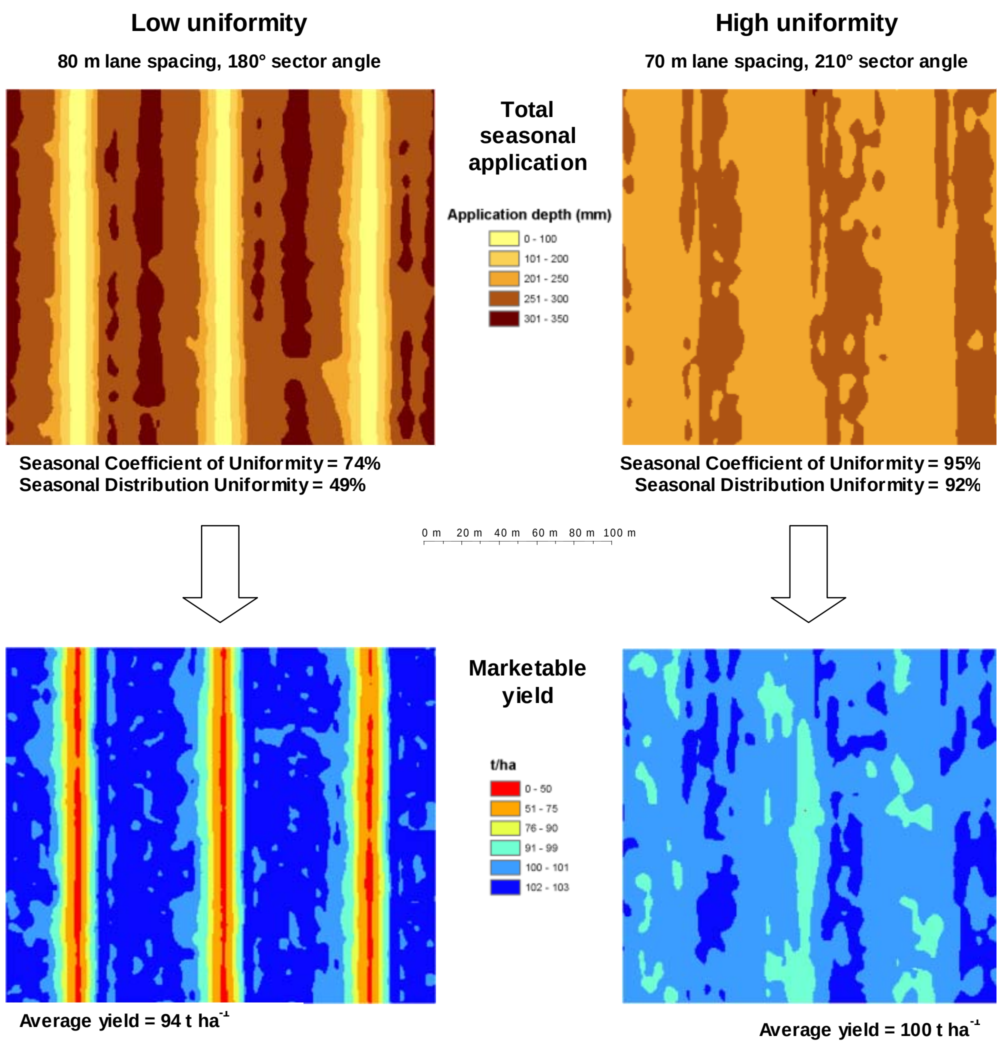

Figure 1 *Example maps showing the impacts of irrigation uniformity on marketable carrot root yields.*

It is therefore important for growers to aim to achieve irrigations with high uniformity (a co-efficient of uniformity (CU) of >80% and a distribution uniformity (DU) of >70%) at all times. This will not only help to improve crop yield and quality, but will also assist growers to demonstrate efficient water use for abstraction licence renewal and grower protocols.

The performance of an irrigation system can be relatively easily assessed using suitable cans laid out across the raingun path at a spacing of 2 m to 5 m to calculate CU and/or DU. However, care needs to be taken when interpreting the results, particularly since variations in wind conditions during a pull and from day to day will affect the measurements. Ideally a number of measurements under different wind conditions should be made both across and down the field.

Growers can achieve high irrigation uniformity from hose-reel raingun systems under most wind conditions by paying close attention to the following equipment settings and management strategies:

Field orientation

Where possible, orientate raingun travel lanes perpendicularly to the prevailing wind direction, particularly in areas with relatively high wind speeds and a strong prevailing wind direction, such as in coastal areas.

Lane spacing and sector angle

The closely linked variables of lane spacing and sector angle have a significant effect on application uniformity, particularly at moderate wind speeds. For the typical raingun configuration used in this study (a Nelson Big Gun SR150® raingun with a 25.4 mm taper nozzle and a fixed trajectory angle of 24°, operating at 4.5 bar), the best uniformity was achieved with a lane spacing of 60-70 m and a sector angle of 180-240° (Table 1).

Table 1 *Optimal sector angle and lane spacing to achieve maximum application uniformity under different wind speeds for the typical raingun evaluated.*

		Wind speed			
		<4 mph	4-7 mph	7-10 mph	>10 mph
Lane spacing	60 m	180°	180°	210°	Avoid if possible
	70 m	210°	210°	240°	Avoid if possible

Green indicates maximum uniformity. Yellow indicates acceptable uniformity.

It is therefore important that close attention is paid to lane spacing and sector angle in order to achieve high uniformity irrigations. In particular, consideration should be given to changing settings to suit forecast weather conditions. However, it should be noted that raingun pull speed should be adjusted if lane spacing is changed, since the effective wetted area will differ.

Night time irrigation

Night-time wind speeds are typically as little as half those measured during the day (but can be more variable) and evaporative losses are generally lower. Consequently, irrigating at night will reduce application non-uniformity. It should be noted, however, that there is anecdotal evidence to suggest that disease pressure may be increased through night-time irrigation as a result of longer periods when the canopy is wet. Therefore, some caution is required if growers wish to move to predominantly night-time irrigation. There may also be health and safety issues and pump noise issues to consider when switching to night-time irrigation.

Water pressure

Previous research indicated that water pressure at the raingun is sub-optimal in over three quarters of the systems investigated in the UK, with serious impacts on application uniformity. Particular attention should be paid to aged pumping systems and water distribution networks and those which have been extended beyond their original design. These extended systems are often constrained by the original pump and pipe sizes, but which are subsequently too small for the larger flows, longer pipe lengths and/or greater lifts required of them. This can lead to significant reductions in water pressure and consequently low application uniformity. Irrigators therefore need to ensure that all pumping and distribution systems are adequately sized to match the peak demands placed on them during the periods of highest use, so that the required pressure for raingun operation (typically 4-5 bar at the raingun) is always attained.

Trajectory angle

Previous research indicated that decreasing the trajectory angle under windy conditions may help to maintain high application uniformity. Most raingun systems currently in use have fixed trajectories, so do not allow such adjustment. However, in areas with consistently strong winds, a fixed trajectory raingun with a lower angle than the industry standard 24° may be considered to reduce wind effects on uniformity. Alternatively, new technology such as the Komet Vari-Angle® or the Nelson SRA150 Big Gun® raingun provides the opportunity to alter trajectory angle according to forecast wind conditions.

Financial benefits

By taking some of the simple and practical steps to reduce irrigation non-uniformity highlighted by this research (e.g. changing raingun equipment set-up and management), growers could significantly increase their returns from high value vegetable crops. For example, if such steps avoided a single poor uniformity irrigation during early-mid season on a carrot crop, growers could assure additional returns of £25-£68 per hectare (1%) through increased marketable yield. For the proportion of the entire UK carrot industry that is irrigated using hose-reel rainguns (approximately 7,500 ha), this equates to about £200,000-£500,000. Improving uniformity on more than one irrigation event would obviously increase these figures. Similar gains in marketable yield (and therefore income) on other high value field-scale horticultural vegetable crops could likewise be achieved through improvements in in-field irrigation management.

Action points for growers

- Be aware that irrigation uniformity has an important impact on crop yield and quality.
- Be pro-active with in-field irrigation management, particularly the following:
    - Ensure irrigation pumping and conveyance systems are able to provide sufficient pressure at the raingun (4-5 bar) during peak times.
    - Ensure equipment is properly serviced and maintained – poorly operating equipment will compromise performance.
    - Where possible, align raingun travel at right angles to the prevailing wind.
    - Irrigate at night where possible, but beware of the potential risks of increased disease pressure.
    - Pay close attention to lane spacing and sector angle – consider modifying these to account for forecast wind conditions.
    - Consider investing in rainguns with variable trajectory angle that can be altered to suit changing wind conditions.