Irrigation and Fertilization Management effects on Water- and Nutrient-Use Efficiency and Vegetable Yield and Quality

B. Ball-Coelho, R.Beyaert, R.C. Roy

Executive Summary January 2002

Three experiments (tomatoes, peppers and cucumbers) were conducted in 2001 to compare water-use efficiency of overhead irrigation to that of surface- or buried drip irrigation. Drip lines (Streamline 630) with 0.91 L/hr flow (0.24 gph @ 10 psi), 12" emitter spacing, and of 10 mil weight were buried 20 cm deep in late May. Surface lines, which were the same except that weight was 8 mil, were laid after planting. Irrigation was usually triggered when volumetric soil water content fell to 10% for overhead and 14% for drip treatments, as indicated using automated reflectometers with rods placed 10 cm from the emitter, and 10 to 25 cm deep (for overhead and surface drip) or 15 to 30 cm deep (for buried drip treatments). Water was applied to bring the topsoil (for overhead) or wetted zone (for drip treatments) to field capacity (18% v/v), which was 2.5 cm of water for overhead, and 0.6 to 0.8 cm (total area basis) for drip. Overhead irrigation was applied early morning or late evening to minimize wind distortion and evaporation.

Tomatoes (Cv H9478) were planted on 31 May in twin rows (45 cm apart) on 1.5 m centres in a latin square design. Row pairs straddled lines in the drip treatments. Tomatoes were irrigated from 29 June until 18 August, and harvested on 12 September. Drip irrigation triggered every day from 9 July to 16 August, and typically ran for 2 to 3 hr each day. There were 44 irrigation events for buried drip totalling 21.7 cm of water, and 46 irrigation events for surface drip (2 more than the buried treatment because surface drip plots were watered twice on 1 and 7 August), totalling 22.3 cm. There were 8 overhead irrigation events with a total of 18.1 cm of water applied. Red fruit yields were greater in surface drip (121458 kg/ha) and overhead (128796 kg/ha) than in buried drip (103591 kg/ha) treatments. Although green weights were greater in buried (2120 kg/ha) than surface drip (778 kg/ha) or overhead (453 kg/ha), amounts were small, so total weights (red plus green) were greatest with overhead and surface drip. Water-use efficiency (WUE) was greatest with overhead (7104 kg red fruit/cm water applied), intermediate with surface drip (5459 kg/cm), and least with buried drip (4785 kg/cm). Colour (26), soluble solids (4.6), and weights of defects were not affected by irrigation treatments.

Peppers (Redstart and Ironside) were planted in a latin square design in 75 cm-wide rows with 45 cm in-row spacing on 31 May. Each row was located above or a adjacent to a drip line in drip treatments. Peppers were irrigated from 29 June to 18 September. There were 24 events for buried drip (totalling 19.2 cm) and 25 events for surface drip (19.6 cm) with application times of usually 2 hr. There were 6 overhead irrigation events totalling 11.7 cm. Peppers were picked 6 times between 7 August and 3 October. Marketable yield (unblemished, > 2.5" diam. red or 2.75" diam. green) was not significantly different between surface (46925 and 35040 kg/ha), buried drip (42051 and 30249 kg/ha) or overhead (36686 and 37161 kg/ha) irrigation treatments (red and green, respectively). Water-use efficiency was greater with overhead (2760 and 2795 kg/cm) than surface (2398 and 1791 kg/cm) or buried drip (2194 and 1578 kg/cm) (red and green, respectively). Number of marketable red fruit was greater with surface drip (374 /ha) than overhead (271 /ha), although marketable green fruit number (188 /ha) was not affected by irrigation method.

Cucumbers were planted on 12 June in 0.75 m rows in a split-plot design with 7 main-

plot treatments: Overhead watering with dry fertilizer at OMAFRA recommended rate; Subsurface drip with fertigation < recommended rate for dry fertilizer; Subsurface drip with fertigation @ recommended rate for dry fertilizer; Subsurface drip with fertigation > recommended rate for dry fertilizer; Surface drip with fertigation < recommended rate for dry fertilizer; Surface drip with fertigation @ recommended rate for dry fertilizer; and Surface drip with fertigation > recommended rate for dry fertilizer. Within each main plot, Fancipak (a multi-pick variety) was planted at 93000 seeds/ha; and Vlaspik was planted at 177,000 /ha. Fancipak was harvested 11 times from 25 July to 31 August, and Vlaspik was harvested on 30 July. Fruit > 2 cm diameter were picked and graded (1 to 4, nubs and crooks, oversize). Drip irrigation plots were fertigated every 2 to 3 days from the end of June until 29 July (Vlaspik) or 27 August (Fancipak). In early growth stages, drip treatments were watered for about 1 hr with the scheduled fertigation, which maintained water content at field capacity. Later, drip treatments were watered for 1.5 to 2 hr every other day from 20 to 27 July, and every day from July 29 to August 13. There were 11 drip events for Vlaspik totalling 7.8 cm of water, and 27 drip events for Fancipak totalling 19 cm of water. There were 3 overhead events for Vlaspik totalling 6.4 cm of water, and 6 irrigation events for Fancipak totalling 14 cm. With surface drip, marketable yields were greater for both Fancipak (53853 kg/ha) and Vlaspik (21827 kg/ha) than with overhead (38920 and 15907 kg/ha). With buried drip, marketable yields were greater than with overhead irrigation for Fancipak (49347 kg/ha), but not Vlaspik (18867 kg/ha). Resulting WUE for Fancipak was similar with overhead (2780 kg/cm) and surface drip (2814 kg/cm), but lower with buried drip (2578 kg/cm). With Vlaspik, however, WUE was greater with surface drip (2806 kg/cm) than overhead (2493 kg/cm) or buried drip (2425 kg/cm). With Fancipak, marketable yields and returns increased with fertigation rate from 48516 kg/ha and $13874 /ha at the low rate, to 52441 kg/ha and $14197/ha at the medium rate, and 54830 kg/ha and $16293 /ha at the high rate (average of surface and buried drip). Fancipak returns were greater with surface ($15690 /ha) and buried drip ($14577 /ha) than with overhead ($12121) irrigation.

In each experiment less water was applied in overhead than drip treatments. It is noteworthy that overhead water applications were made under low evaporation conditions. On farms where it is not always possible to irrigate very early morning, evaporation losses with overhead irrigation would be greater than observed in these experiments. Subsoil water content measured to 1.3 m deep using a neutron scattering device (in the cucumber experiment) provided no evidence of deep percolation of water into the subsoil with any of the irrigation treatments. Correlations between water content measured using reflectometers (which are more economical than TDR) with the less expensive Watermark sensors were poor in the water content range where drip irrigation is triggered. Increased yields with drip irrigation in cucumber, but not tomato or pepper experiments may be related to supplying nutrients through drip lines in cucumbers (placement in the zone of maximum root density), as opposed to dry broadcast fertilization in tomatoes and peppers (nutrients mixed over the total soil volume and less efficiently utilized). Results with cucumber suggest that, similarly to the Australia example, a switch from overhead to drip irrigation would not reduce amount of water used, but would increase yields. These preliminary results also indicate little advantage of buried lines in terms of water-use efficiency for drip irrigation of vegetables on coarse-textured soils.