Nutrient and Water Management of Lapins Sweet Cherry on Gisela 5

G.H. Neilsen, D. Neilsen and F. Kappel

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Center, Summerland, British Columbia, Canada

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Field trials to investigate the nutrient requirements of sweet cherry are limited compared with apple or peach, although it is generally believed that sweet cherry is less exacting in its mineral requirements than other fruits (Westwood and Wann, 1966). Considerable recent research has been undertaken on managing apple orchard nutrition via fertigation because of the potential for more closely synchronizing nutrient application with plant demand (Neilsen et al., 1999). Fertigation of N through trickle emitters resulted in more efficient uptake of N by sour cherry relative to broadcast N application but research on fertigation of other nutrients for cherry has been limited. Similarly, water requirements for cherry have been based on general principles developed for other temperate-zone fruit trees. It has however been recognized that there may be unidentified consequences to cherry production of irrigating by trickle systems, which wet only a portion of the potential root volume (Hanson and Proebsting, 1996).

Rootstocks are known to affect nutrient requirements of sweet cherry (Ystaas and Frynes, 1995; Neilsen and Kappel, 1996) but few nutrition and irrigation experiments have been reported for the newer dwarfing rootstocks.

Drip irrigation resulted in a narrow wetted strip which reduced cherry tree vigor but not yield over the first four growing seasons.

Gisela 5 (G.148/2) is one such promising dwarfing rootstock for which, however, reduced fruit size relative to fruit on standard rootstock F12/1 has been reported (Franken-Bembeck, 1998). It is not known whether appropriate irrigation and N-fertigation would overcome reductions in fruit size reported for this rootstock.

For these reasons an experimental planting of Lapins/Gisela 5 was established with the objectives of determining the effects of fertigation and irrigation management on the nutrition, vigor, yield and fruit quality of sweet cherry on a dwarfing rootstock. This report summarizes preliminary results from the first 4 years of this planting.

METHODS

An experimental orchard of Lapins sweet cherry on Gisela 5 (*Prunus cerasus* x *Prunus canescens*) rootstock was planted in April 1998 at a spacing of 4 m (within row) x 4.5 m (between row) (13.1 x 14.8 ft). Commencing the year of planting, eight annual irrigation/nutrition treatments were established with six replicates in a randomized complete block design (Table 1). Each experimental plot contained two border and two measurement trees. Treatments included (1-3) three concentrations of fertigated N (42, 84 and 168 ppm), generally applied 8 weeks past full bloom as calcium nitrate; the medium fertigated N rate was also applied with (4) P as ammonium polyphosphate in early spring or (5) with K as potassium chloride fertigated usually in June; (6) N, uniformly broadcast at 75 kg N per ha ammonium nitrate in a 1 m wide strip centered on the tree row; also (7) with broadcast N followed by the medium rate of fertigated N applied 4 weeks postharvest, usually in August; and (8) the medium N rate but drip-irrigated for 8 weeks, post full bloom. A 2 m wide herbicide strip centered on the tree row was maintained in all treatments throughout the study.

Irrigation for treatments 1-7 was applied via Dan 2001 pressure compensating microsprinklers (PSI Irrigation, Fresno, CA) located between trees in the tree row. These sprinklers were capable of applying approximately 35 liters/hour uniformly within an area extending halfway to the next tree row. Irrigation was applied in treatment 8 via 4 x 4 liters/hour pressure compensating trees emitters located at 0.7 and 1.3 m on both sides of the trees within the tree row. Throughout the experiment, irrigation was scheduled according to evaporation as measured by an atmometer (ET Gage Co., Loveland, CO) with irrigation rates manually adjusted to account for the previous days' estimated water use. Details of annual fertilizer applications are indicated in Table 1.

The experimental orchard was located on a gravelly sandy loam, a common fruit-growing soil series located throughout the southern part of the Okanagan Valley. These soils generally drain rapidly, have low water-holding capacity, low organic matter, low N and P content, neutral

TABLE 1

Annual fertilizer applications for 8 treatments for Lapins on Gisela 5 rootstock, 1998-2001.

Treatments	N applied (g/tree)[Z]			
	1998	1999	2000	2001
Sprinkler Irrigation				
1. Low N	26	123	99	177
2. Medium N	56	278	219	324
3. High N	86	346	564	545
4. Medium N + annual P[Y]	49	264	186	328
5. Medium N + annual K[X]	55	226	242	322
6. Broadcast N	60	60	60	60
7. Broadcast + postharvest N	60	60 + 151	60 + 63	60 + 147
8. Drip Irrigation				
Medium N	48	88	56	94

[Z]Fertigated N applied Jul 7-Aug 12, 1998; Apr 30-June 24, 1999; Apr 29-June 23, 2000; and May 30-Jul 9, 2001. Broadcast N applied early May 1998; Apr 29, 1999; Apr 26, 2000; and May 1, 2001. Postharvest N fertigated Jul 27-Aug 24, 1999; Jul 25-Aug 23, 2000; and Aug 2-Aug 30, 2001.

[Y]Fertigated P at 20 g/tree also applied June 29, 1998; Apr 29, 1999; Apr 28, 2000; and May 29, 2001.

[X]Fertigated K also applied at 14 g/tree Jul 17-Aug 12, 1998; 24 g K per tree May 28-June 24, 1999; 31 g K per tree May 24-June 23, 2000; and 22 g K per tree May 30-Jul 9, 2001.

pH and overlay coarse-textured subsoils ranging from gravelly loamy sands to loamy sands.

Annual measurements were made of yield at commercial harvest (July 26, 1999; July 20, 2000; July 25, 2001), pruning weights and trunk diameter at 0.3 m above the graft union from which trunk cross-sectional area (TCA) was calculated. Composite leaf samples were collected from the mid-third portion of new year's growth in midsummer each year. Leaf N, P, K, Ca, Mg, Fe, Cu, Mn and Zn concentrations were determined using standard methods. Commencing with the 2000 harvest, soluble solids, titratable acidity, firmness (Firm Tech), average fruit size and percent natural cracking were determined on the fruit.

In 2001 soil moisture measurements to a 45 cm depth were made in the medium N treatments under both sprinkler and drip irrigation using time-domain reflectrometry (TDR) (Topp et al., 1980). Pertinent to this report was a series of measurements made for 4 replicate transects for each of the drip and sprinkler treatments, perpendicular to the tree row extending into the grass alleyway from the tree row. These measurements were made May 15-16, 2001, during a cool, wet period in early spring and again July 10-11, 2001, at a warm, dry period.

RESULTS AND DISCUSSION

Nutrient and Water Applications

Quantities of nutrients applied per tree for each treatment, 1998-2001, are summarized in Table 1. Much less water per tree was applied via the drip system relative to the sprinklers (approx. 20%). Irrigation via the drip system applied only 20% of the water applied by sprinklers as illustrated for the 2001 growing season (Fig. 1). It is apparent from soil moisture measurements made perpendicular to the tree row in both May and July that a major difference between drip and sprinkler-irrigation treatments was a marked decrease in soil moisture content toward the tree alley in drip-irrigated plots (Figs. 2 and 3). Reduced soil moisture content was apparent at 0.5 m from the tree row and pronounced within the grassed alleyway (beyond 1 m).

Tree Vigor

Drip-fertigated cherry trees were smaller than trees in other treatments by November of the fourth growing season (2001, Fig. 4). For the drip-irrigated trees, the trend to smaller trees began in second year (1999) as indicated by annual trunk cross-sectional area (TCA) increment. Reduction in pruning weights, a further indication of reduced tree vigor, was measured for drip-irrigated trees in both 1999 and 2000 (Fig. 5). In 2001, annual TCA increment of drip-irrigated trees was less than the year previous and much less than sprinkler irrigated trees of the same nitrogen status. Pruning has not yet been completed for the 2001 season. Also apparent by November 2001 was decreased TCA for high N trees (Fig. 4). These growth differences were apparent only this year (2001) although pruning weights were also less for high N starting in 2000 (Fig. 6).

Over the first four growing seasons, the predominant growth effect has been reduction in vigor and size of drip-fertigated trees. This size reduction appears to be a consequence of the restriction in the wetted soil volume measured for these trees.

Tree Yield

A few fruit were harvested in the second growing season for all treatments but yield did not exceed 0.13 kg/tree (Fig. 7). Second year yield averaged 2.58 kg/tree. This year's yield was by far the largest yet, averaging 13.6 kg/tree (approx. 7500 kg/ha). Over all treatments, fruit size averaged 7.5 g, 12.3 g and 9.2 g, 1999-2001, respectively. There were no effects of treatments on fruit yield in 2001 (Fig. 8). Since drip-irrigated trees were much smaller (Fig. 7), these trees had significantly higher yield efficiency (412 g/cm^2 TCA) compared to any other treatments (where yield efficiency ranged from 220 g/cm^2 to 305 g/cm^2 TCA). Average fruit size

FIGURE 1

Irrigation quantities applied via drip or microsprinkler and daily atmometer-measured evaporation (ET), 2001 growing season.

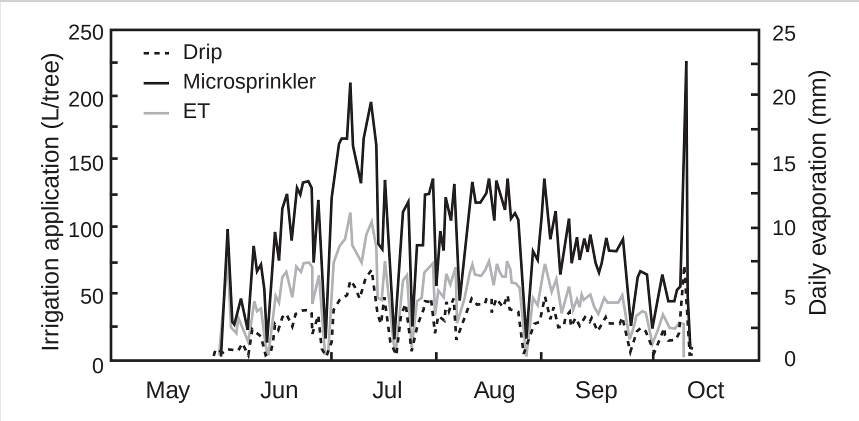


FIGURE 2

Average soil moisture content at varying distances from the water source, perpendicular to the tree row for microsprinkler and drip irrigation (averages of 4 reps on May 15/16, 2001, ±- standard deviation indicated).

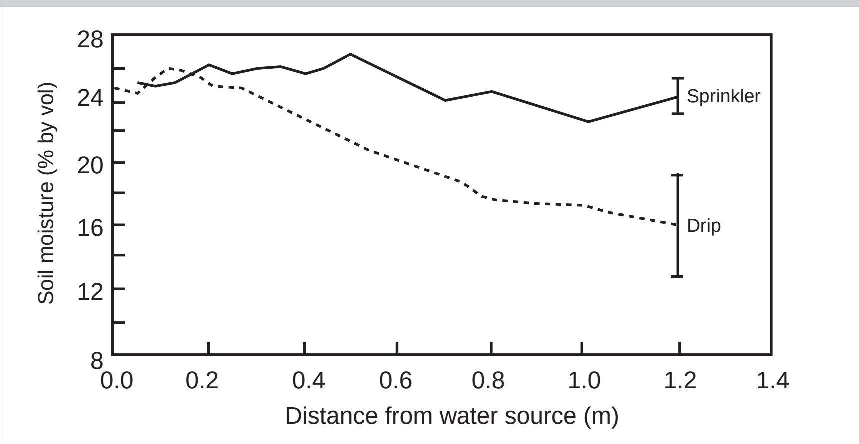


TABLE 2

Fruit quality of Lapins sweet cherry on Gisela 5 rootstock influenced by irrigation and nitrogen treatments, 2001 harvest.

Treatment	Fruit size (g)	Firmness (g/mm)	Titratable acidity (ml NaOH/10 ml juice)	Soluble solids (%)	Splits (%)
Sprinkler Irrigation					
Low N	10.1	240	10.9	18.9	9.1
Medium N	9.5	240	10.6	18.8	8.7
High N	9.2	275	10.1	18.8	11.1
Significance	L(*)	Q(*)	L(*)	NS	NS
Drip					
Medium N	7.3	267	9.7	17.4	5.6
Significance	****	**	**	**	NS

*, **, *** For N rate significant Linear (L) or Quadratic (Q) response of fruit parameter to N rate. For drip irrigation significant difference between medium N rate sprinkler fertigated. Both at p=.05, p=0.01 or p=0.0001 level of probability, respectively. NS=not significantly different.

in 2001 was however significantly affected by two factors including rate of sprinkler-fertigated N and drip irrigation (Fig. 8). Increasing the rate of N from low to high was associated with a reduction in fruit size from 10.1 g to 9.2 g. This also was the first season that reduced fruit size (7.3 g) was associated with the drip-irrigation treatment.

Fruit Quality

The 2001 crop was the first where quality parameters were significantly affected by treatment (Table 2). Increasing rate of fertigated N to high rates reduced cherry size but increased firmness and decreased acidity of the fruit. The smaller cherries on the drip-irrigated trees were firmer, less sweet (lower soluble solids), more acid and lighter colored than sprinkler irrigated trees with the same N regime, implying their maturity was delayed.

Tree Nutrition

Fertilizer/irrigation treatments significantly affected cherry tree nutrition, as illustrated by leaf N, P and K concentrations over the last 3 growing seasons. Leaf N concentrations, 1999-2001, indicated a linear response to rate of sprinkler-fertigated N. The leaf N concentration of drip-irrigated trees has varied over time. In contrast, annual fertigation of P has not affected leaf P concentration. The only significant effect observed has been a linear decrease in leaf P concentration with increased rate of fertigated N in 2000-2001. Similarly, K fertigation has not affected leaf K concentration and a linear decrease in leaf K concentration has been observed with increased rate of fertigated N in all years since 1999. Also noteworthy has been consistently lower leaf K concentrations in drip-fertigated trees compared with all other treatments from 1999.

Leaf N, P and K concentrations, regardless of treatment, were apparently adequate for cherry tree growth, according to local standards (British Columbia Ministry of Agriculture and Food, 1998). The minimum leaf N concentration of 2.38% was measured in third year for the drip-fertigated trees but was still within the adequate range. In contrast, the lack of leaf response to P and K application respectively implies that sprinkler-fertigation of 44 kg P per ha and 51 kg K per ha over 4 years at this site has been ineffective. For apple, fertigated P has to be applied at high rates, early in the first growing season for maximum effectiveness (Neilsen et al., 1999). Reductions on leaf K concentration observed for drip-fertigated cherry trees have also been observed for drip-fertigated apples and attributed to restricted root development (Neilsen et al., 2000). Potassium deficiency was apparent after 3 years for apple but has not yet been observed for drip-irrigated cherry in the current study although average annual leaf K concentrations have continued to decline.

Few effects of treatments on tree micronutrient status have been measured. Leaf Zn concentrations were however lower for all treatments in 2001 averaging 9.7 ppm. It may be that Zn deficiency is the reason for poor performance (vigor and fruit size) of the high N trees.

CONCLUSIONS

Considerable reductions in water application occurred by atmometer scheduling of drip irrigation. Scheduling irrigation allows water application to vary according to daily evapotranspiration (ET) demand rather than to exceed maximum daily ET. Drip irrigation resulted in a narrow wetted strip which reduced cherry tree vigor but not yield over the first four

FIGURE 3

Average soil moisture content at varying distances from the water source, perpendicular to the tree row for microsprinkler and drip irrigation (averages of 4 reps on July 10/11, 2001, ± standard deviation indicated).

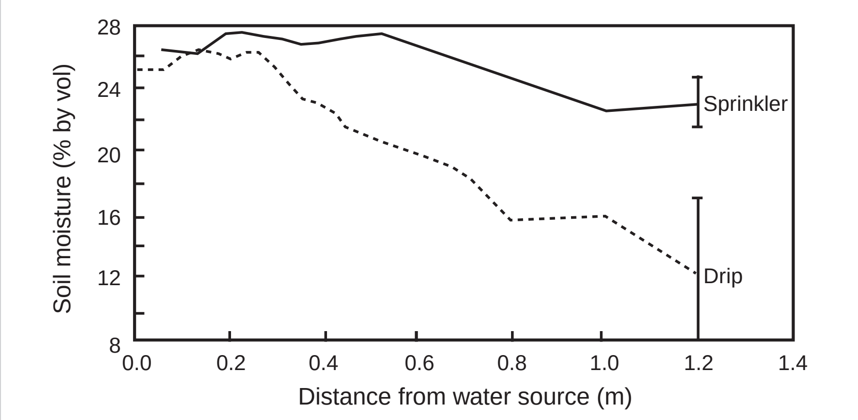


FIGURE 4

Average trunk cross-sectional area (TCA) for Lapins on Gisela 5 as affected by 8 irrigation/fertigation treatments (Trt) after 4 growing seasons (Nov. 2001).

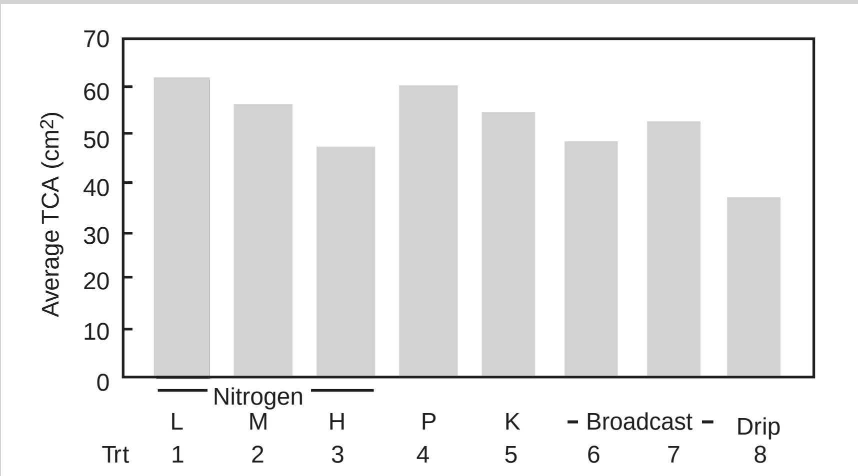
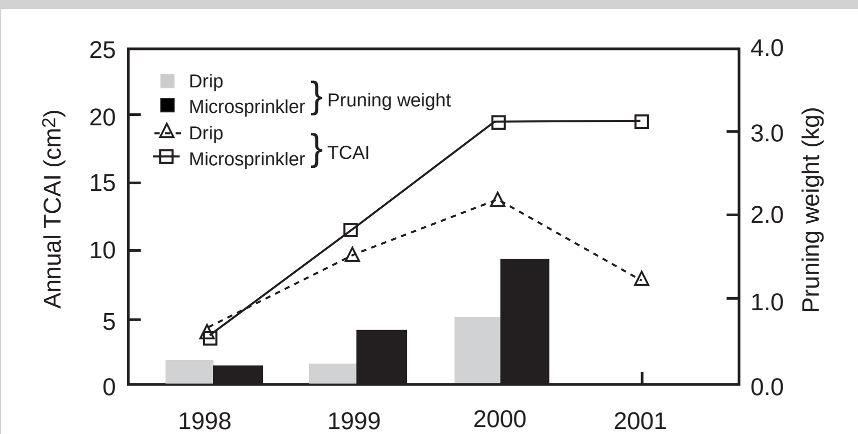


FIGURE 5

Annual trunk cross-sectional area increment(TCAI) and pruning weights for drip- and microsprinkler-irrigated trees fertigated at medium N rate during the first 4 growing seasons.



growing seasons. However, fruit size was reduced and fruit maturity delayed under drip irrigation in 2001. It has been possible to achieve a range of N nutrition via sprinkler fertigation but not significantly alter P and K nutritional status by P and K fertigation. However, it will be necessary to continue monitoring the effects of nutrition/irrigation treatments on tree performance and fruit quality, especially fruit size as crop load continues to increase. The performance of drip-fertigated trees will be of particular interest to determine if cherry yield and fruit size can be sustained on trees that may be under some degree of water stress but have a high yield efficiency.

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FIGURE 6

Annual trunk cross-sectional area increment(TCAI) and pruning weights for drip- and microsprinkler-irrigated trees fertigated at low and high N rates during the first 4 growing seasons.

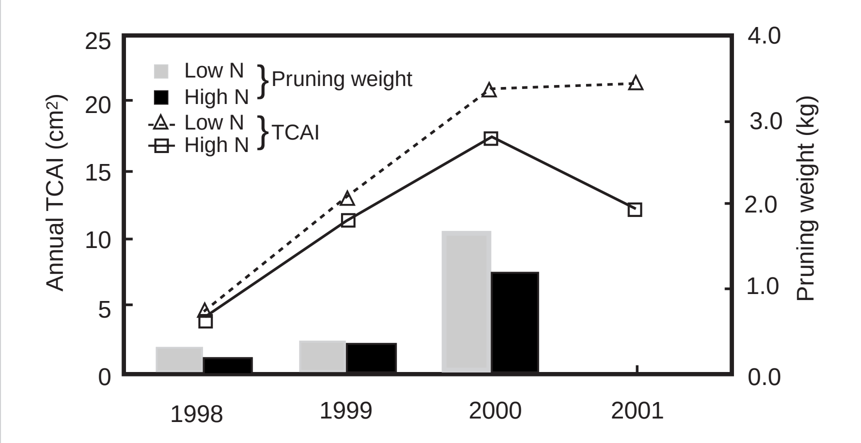

FIGURE 7

Average yield and fruit size for all treatments during the first 3 fruit crops for Lapins on Gisela 5.

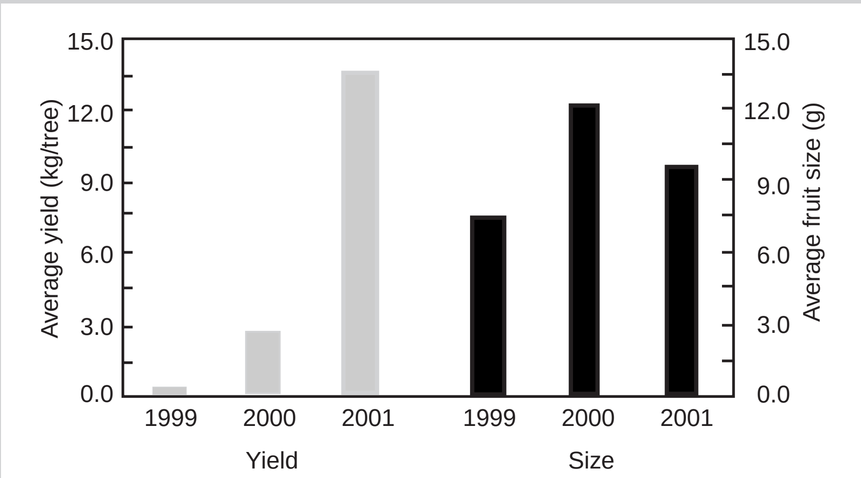

FIGURE 8

Average yield and fruit size as affected by fertigated N and drip irrigation treatments (Trt), 2001 harvest.