EFFECT OF IRRIGATION SCHEDULING ON WATER USE EFFICIENCY AND YIELD

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There is mounting interest in the use of automatic weather stations (AWSs) and the CANEGRO crop model as a means of scheduling irrigation. Two pilot investigations into this technology suggested that a significant saving in water was possible when irrigation was scheduled using the Penman-Monteith equation (PM) to estimate crop water use (CWU) as against the class A pan. Further savings were anticipated using stress indices calculated by the model to schedule irrigation. Concepts of deficit (some yield loss, improved water use efficiency) and near-deficit irrigation scheduling (no yield loss, reduced water application) were included in a trial to investigate these technologies. A replicated trial was laid out on the SASA Experiment Station farm at La Mercy. The aim of the trial was to compare the conventional 'pegboard' or water balance method of irrigation scheduling, using class A pan evaporation and canopy factors (treatment 1), with three other treatments based on evaporation calculated using PM as part of the CANEGRO crop model, and an AWS (McGlinchey *et al.*, 1995).

The following scheduling systems were investigated: (1) conventional irrigation scheduling using monthly mean class A pan evaporation and crop canopy factors determined for the southern areas of the industry (Anon. 1977); (2) PM method using the CANEGRO crop model to calculate evaporation from meteorological variables recorded by an AWS; (3) near deficit irrigation using CANEGRO's estimate of incipient water stress (SWDF2 < 1); (4) deficit irrigation using CANEGRO's estimate of green leaf number per plant (eight green leaves was chosen as the signal to irrigate); (5) rainfed. Treatments were replicated five times. For treatments 1 and 2, 48 mm net was applied when an allowable irrigation deficit (AID) of 48 mm was present in the soil. For treatments 3 and 4, 48 mm was applied when model criteria were met.

Variety NCo376 was planted in September 1994 on a heavy Swartland soil (50-60% clay in the subsoil, estimated total available moisture (TAM) of 100 mm/m) and harvested in November 1995 at an age of 14 months. Water was applied using a drip system for convenience. A single application of 48 mm was applied over 14 hours to simulate a sprinkler system capable of delivering 60 mm gross over a 12 hour stand time (efficiency of 80%). Three potentiometer type growth transducers per treatment were installed in one replication of the trial. These devices were used to monitor daily leaf growth rates as a means of comparing levels of stress. Single leaf conductance, gross photosynthesis and green leaf counts per stalk were measured regularly as further indicators of stress. Only green leaf counts are reported in this short communication.

During February 1995, all five treatments developed signs of moisture stress in the form of reduced leaf extension rates compared with potential rates calculated using mean daily temperature, low leaf conductance, reduced photosynthesis rates and low green leaf numbers (Figure 1). This suggests that, although the TAM of the soil was relatively high, most of this water was held at high tensions and was unavailable to the crop. It became necessary to reduce the AID from 48 mm to 25 mm, and this relieved stress in treatments 1 and 3. Reducing the AID from 48 to 25 mm reduced the cycle time and less water (25 mm) was applied more often, approximating a system capable of delivering 30 mm gross over a six hour stand time.

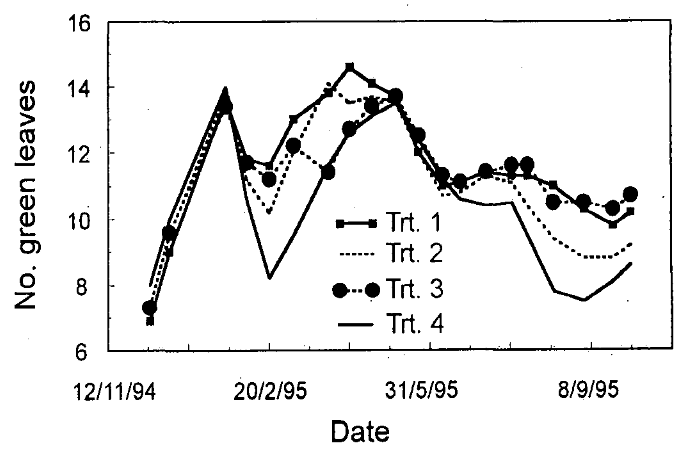

FIGURE 1: Green leaf counts as an indication of stress recorded for the irrigated treatments

There was no significant difference in cane yield, pol % cane or sucrose yield between treatments 1, 2 and 3 (Table 1). However, 909 mm of irrigation water was applied to treatment 1 as compared with 782 mm applied to treatment 2 and 800 mm to treatment 3. This represents savings in water of 14 and 12% respectively. These savings can be attributed to the more accurate estimate of CWU calculated using PM as against monthly mean class A pan evaporation.

Table 1

Effect on yield and water use efficiency of the 5 different irrigation scheduling systems

Treatment	Pol % cane	Cane yield (t/ha)	Sucrose yield (t/ha)	Irrigation (mm)	Water use efficiency (t suc/100 mm)
(1. Pegboard	13,43	112,6	15,2	909	0,80
2. CANEGRO	13,26	118,2	15,6	782	0,90
3. SWDF2 < 1	13,11	115,6	15,1	800	0,87
4. Eight green leaves	13,34	95,6	12,8	348	0,99
5. Rainfed	12,88	57,5	7,4	0	0,78
LSD=0,05	0,70	11,3	1,5	-	0,097

Contrary to expectations more water was applied to treatment 3 (near deficit treatment) than treatment 2 (conventional CANEGRO treatment). Even after the AID was reduced to 25 mm, the model indicated that stress was imminent (treatment 3 criteria) before 25 mm of water had been used by the crop (treatment 2 criteria). Consequently treatment 3 was irrigated more frequently than treatment 2 and more water was applied as a result. Green leaf number per stalk was lower in treatment 2 than treatment 3 during the period July to November 1995 (Figure 1), an indication that treatment 2 was under moisture stress.

Treatment 4 yielded significantly less cane and sucrose than the other irrigated treatments. Although a loss in cane yield was anticipated, it was hoped that the degree of stress would not adversely affect sucrose accumulation and would perhaps improve pol % cane relative to the well irrigated treatments. However, pol % cane was no higher in this treatment than in treatments 1, 2 and 3. As had been expected, the water use efficiency of treatment 4 was higher than that of the other irrigated treatments (Table 1).

In conclusion, it appears that a significant saving of irrigation water can be achieved using the CANEGRO crop model to estimate CWU as against the class A pan and crop canopy factors. A saving in the order of 15% appears possible. This is similar to estimates made on theoretical grounds and is of the same order of magnitude as savings reported by McGlinchey *et al.* (1995). Deficit irrigation as a means of saving further water does show some promise and warrants further investigation in the light of possible increases in the cost of agricultural water.

Attention is drawn to the degree of moisture stress still evident in treatment 2 even after the AID was reduced from 48 to 25 mm. This would not be expected in conventionally designed systems based on TAM alone. On heavy clay soils, application rates and cycle times should be reduced to ensure maximum yields.

REFERENCES

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McGlinchey, MG, Inman-Bamber, NG, Culverwell, TL and Els, M (1995). An irrigation scheduling method based on a crop model and an automatic weather station. *Proc S Afr Sug Technol Ass* 69: 69-73.