THE EFFECT OF A LIMITED SUPPLY OF IRRIGATION WATER ON THREE VARIETIES OF COTTON

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INTRODUCTION

Greg Constable and I have previously shown that in the Namoi Valley an irrigation water supply of 8 Ml per ha is needed to obtain maximum yields in the driest years. In most years however, because there is more rain, less water is needed. The question therefore arises: with a fixed volumetric allocation of irrigation water is the best strategy to allow 8 Ml per ha or is it better to use less water per ha and to grow more hectares with the water saved? Only in the driest years would yields be reduced and even then the larger area could compensate for the reduced returns per ha.

An analysis of experimental results and long term weather data showed that there is limited scope for increasing net returns with such a strategy. Averaged over a run of years, returns increase from $98 per Ml with 8 Ml per ha to $102 per Ml with 7 Ml per ha but fell to $86 per Ml at 6 Ml per ha. Prices then current ($315 per bale) were used in the analysis. Reducing the price by 25% does not alter the conclusions. The same analysis also showed that if the supply was less than 7 Ml per ha there was no advantage in delaying the start to irrigation or in increasing the interval between irrigations in an attempt to stretch the limited supply further.

The previous study was done with the variety Deltapine 16, which has been replaced first by Deltpine 61 and then more recently by Deltapine 90 and SIOKRA. Claims have been made that these varieties respond differently to water stress and require different irrigation management. An experiment was done in 1985/86 to study the effect of water stress on the new varieties.

METHODS

Irrigation Treatments	Days from sowing start	finish	Deficit
Full irrigation	70	145	90mm
Late start	90	145	90mm
Early finish	70	125	90mm
Long interval	70	145	110mm
Rain grown		no irrigation	

Neutron probe measurements in combination with the SIRATAC irrigation scheduling program were used to determine when the relevant deficits would be reached. These treatments were replicated four times on plots 16 rows wide and 213m long divided lengthwise for the three varieties. The previous crop was wheat. Nitrogen was applied before sowing at 100 kg per ha and treflan applied at 2 l per ha. The field was pre-irrigated on 1st October and the crop was sown on 12th October 1986. Pests were controlled when required. SIRATAC fruit counts and neutron probe readings were done weekly. The plots were machine picked and the seed cotton ginned at the research station.

RESULTS

The treatments were irrigated as follows:

FULL	23 Dec	10 Jan	24 Jan	8 Feb	24 Feb
LATE START		10 Jan	24 Jan	8 Feb	24 Feb
EARLY FINISH	23 Dec	10 Jan	24 Jan	8 Feb	
LONG INTERVAL	30 Dec	16 Jan	3 Feb		24 Feb

Figure 1 shows the profiles at the start and finish of the drying cycle between 1st and 2nd irrigations of the fully irrigated treatment. Figure 2 shows the drying cycle for the whole season for the rain grown treatment. The data suggest that SIOKRA may have extracted more water from the profile than other varieties. Figure 3 shows the intermediate stages in the drying cycle for the 1st irrigation of the late start treatment for SIOKRA and DP90. No differences can be discerned in the dates at which the varieties started to extract water from various levels down the profile. Although SIOKRA might be expected to intercept less radiation and use less water early in the season because of a smaller leaf area, there was no evidence of this.

Soil water deficits in table 1 show the amounts of water used. The amount of irrigation water applied in crop irrigations depends on the deficits immediately prior to irrigation. No pattern is apparent to suggest that one variety consistently used more or less water than another; the differences only reflect the natural variation between plots. The early finish treatment had the smallest sum of deficits prior to irrigation and therefore saved most water. In the late start and long interval treatments

FIGURE 1. Soil water profiles for the 2nd drying cycle of the full irrigation treatment.

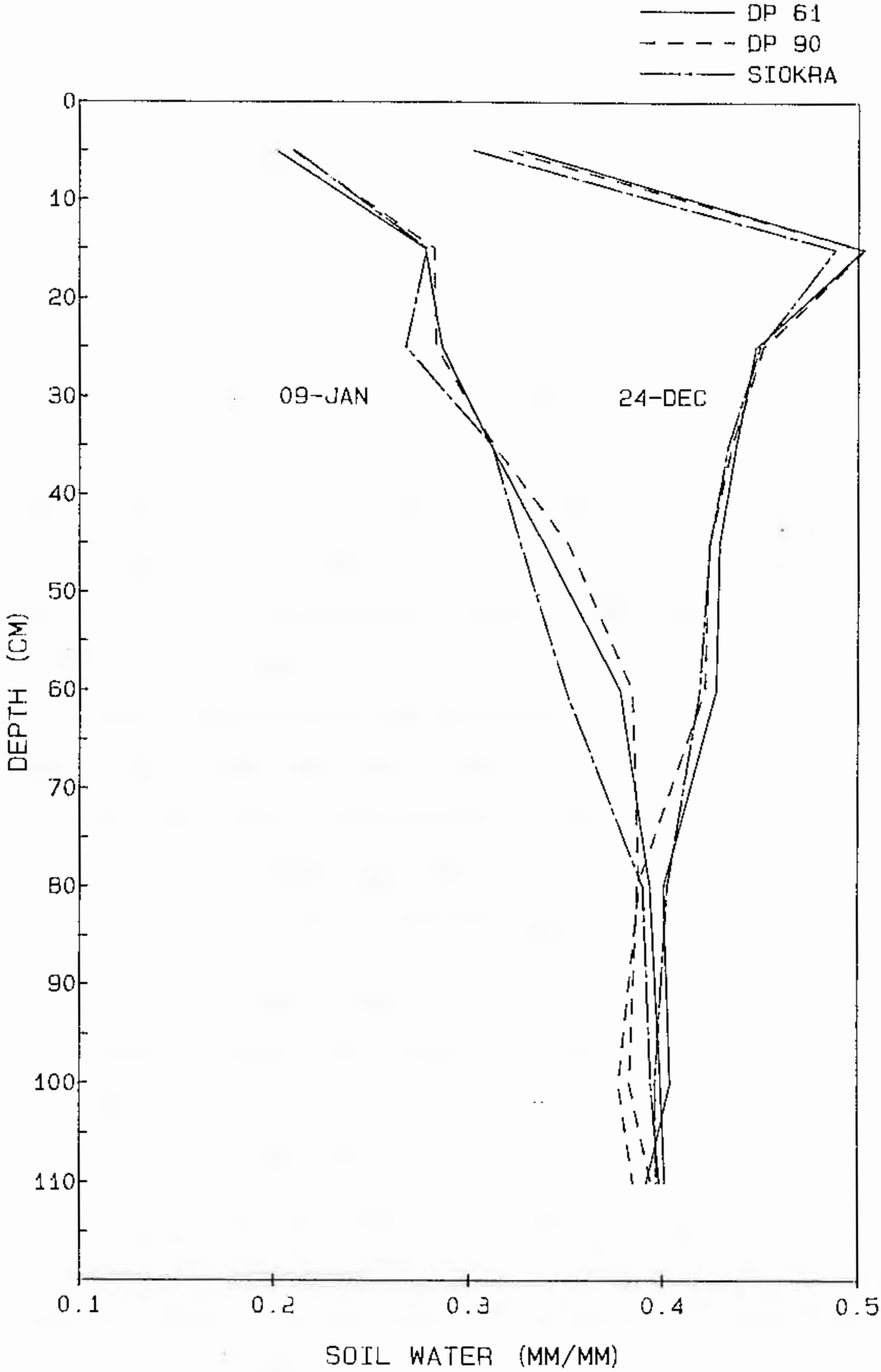
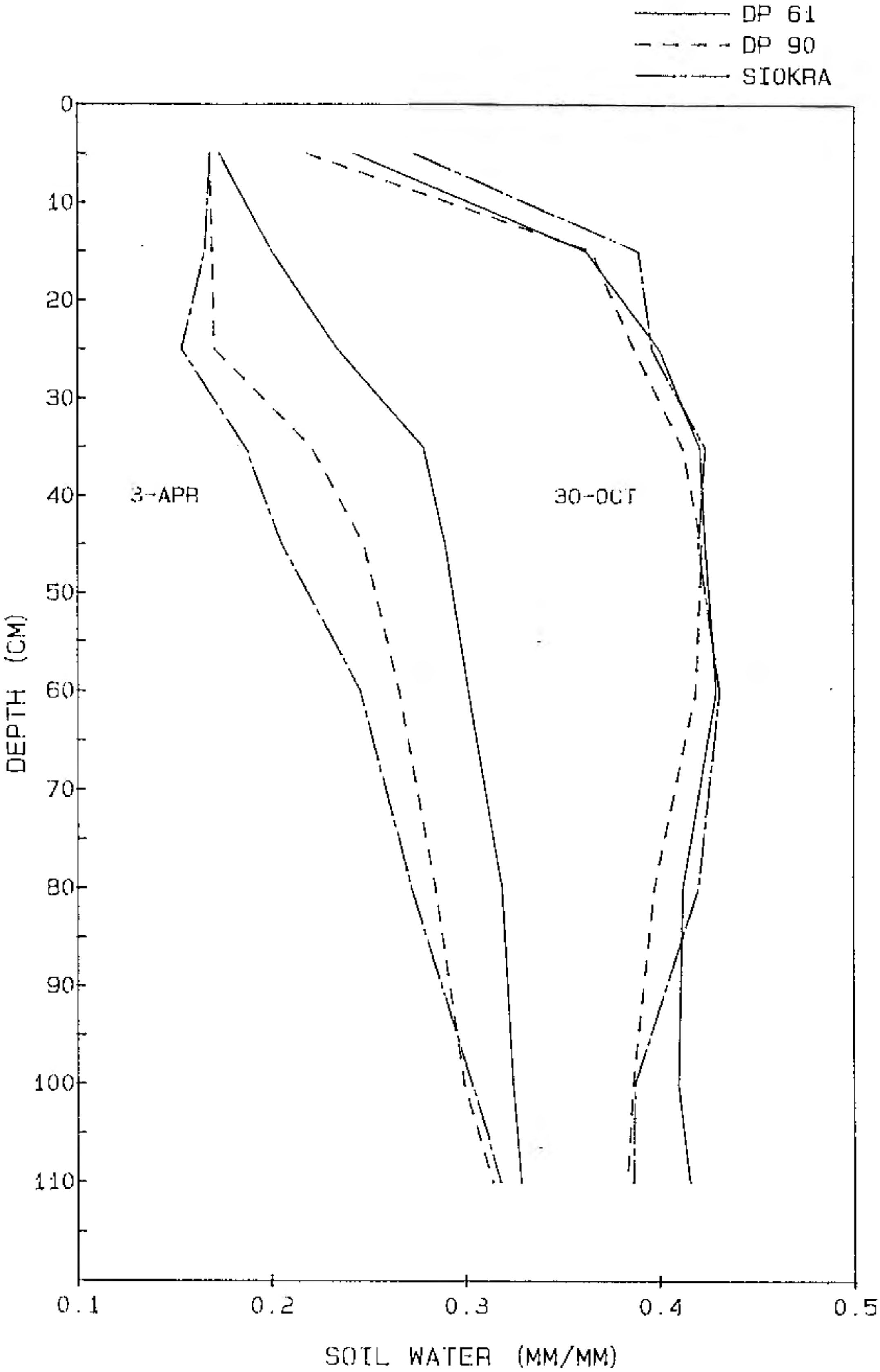


FIGURE 2. Soil water profiles for the rain grown treatment.



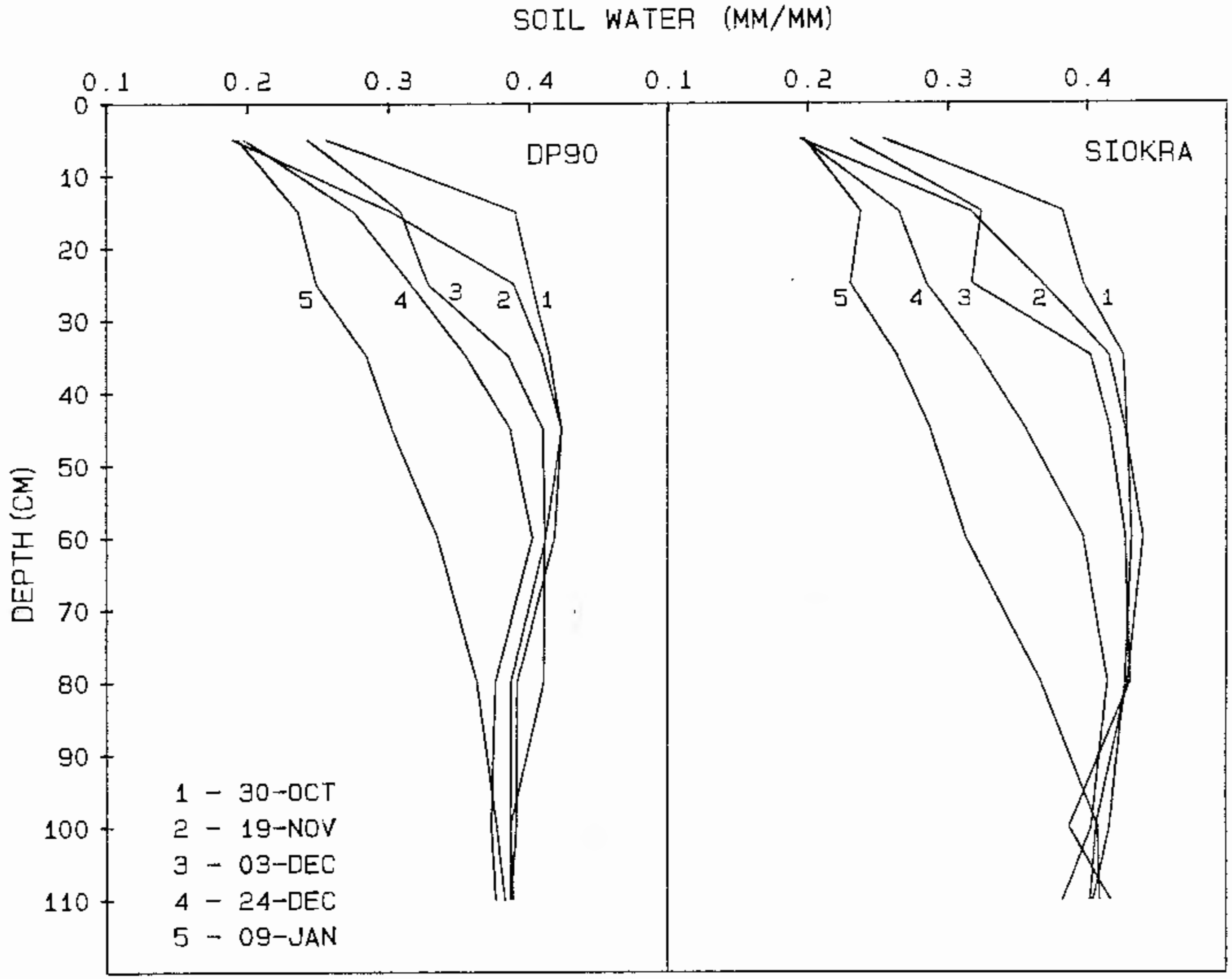


FIGURE 3. Soil water profiles for stages in 1st drying cycle of the late start treatment.

opportunities to save water were limited because delaying irrigation could only save water if rain fell to substitute for irrigation or if water stress reduced the rate of transpiration after the refill point of the full treatment.

TABLE 1. Soil water deficits (mm).

	sum of the deficits prior to irrigation			deficit at the end of the season		
	DP61	DP90	SIOKRA	DP61	DP90	SIOKRA
FULL	472	457	484	173	175	140
LATE START	415	371	400	165	173	143
EARLY FINISH	381	364	384	181	190	179
LONG INTERVAL	456	461	461	154	156	155
RAIN GROWN				190	204	218

The amounts of water applied in crop irrigations, which depend on the deficits prior to irrigation (Table 1), do not represent all the water used by the crop nor the crop water requirements. When considering crop water requirements, physiological requirement must be distinguished from agronomic (or irrigation) requirement. Physiological requirement is the water used by the crop for evapotranspiration. Agronomic requirement is the part of the physiological requirement that has to be supplied by irrigation. Both are shown in Table 2. The physiological requirement was estimated from the sum of the deficits at each irrigation and the final deficit from table 1, and the rainfall of 224mm. In order to estimate irrigation requirement it was assumed that all the deficits at irrigation and half of the final deficit (table 1) were supplied by irrigation and that irrigation efficiency was 0.75.

TABLE 2. Water requirements.

	physiological requirement (mm)			irrigation requirements (Ml)		
	DP61	DP90	SIOKRA	DP61	DP90	SIOKRA
FULL	869	856	848	7.45	7.26	7.39
LATE START	804	768	767	6.63	6.10	6.29
EARLY FINISH	786	778	763	6.29	6.12	6.31
LONG INTERVAL	834	841	840	7.11	7.19	7.18
RAIN GROWN	414	428	442			

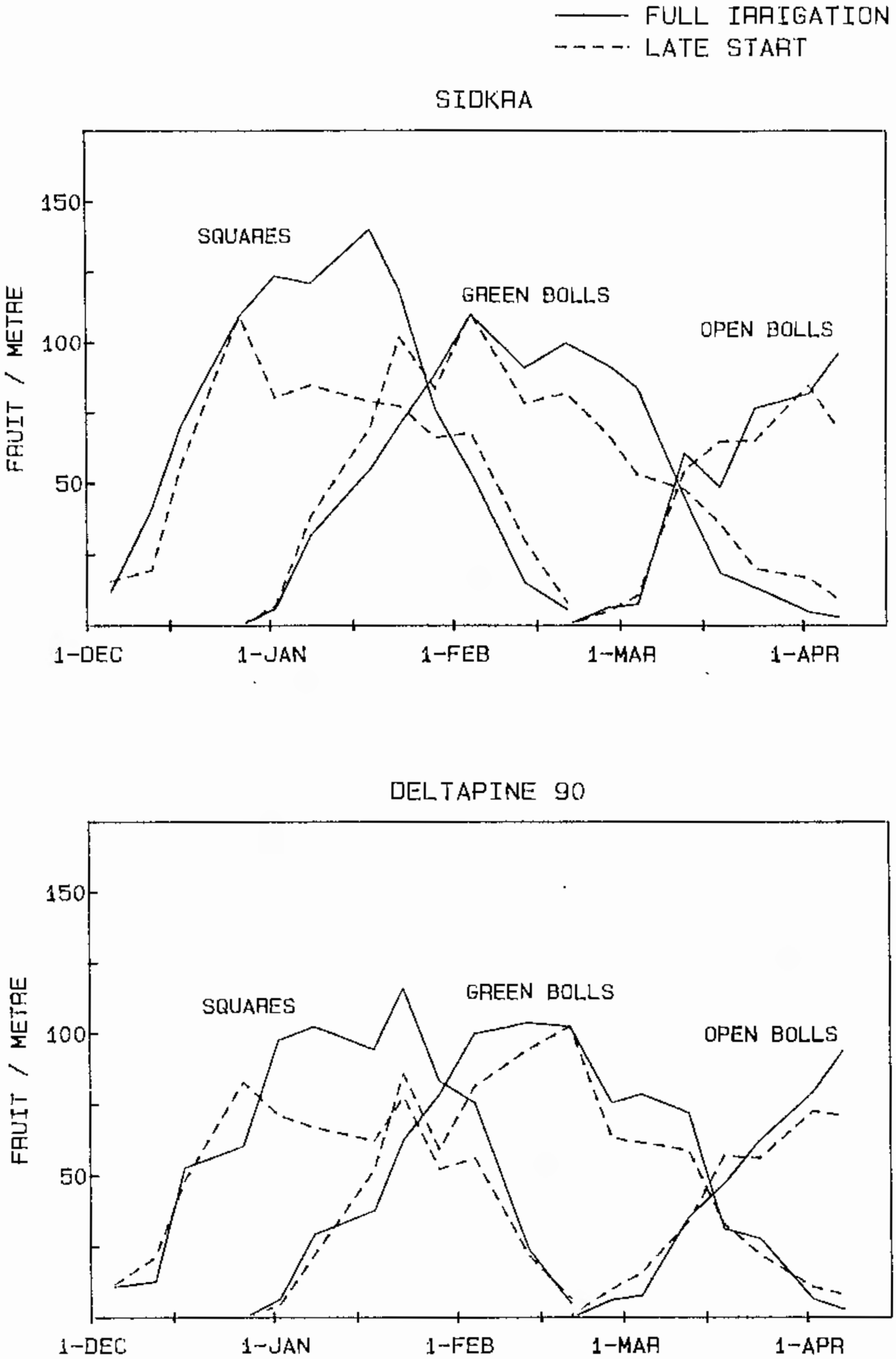
Although pre-irrigation is water used by the crop, the amount depends on the previous crop and should be debited to that crop and not the subsequent crop. The deficit at the end of the season shown in table 1 represents water used by the crop and which may have to be replaced by preirrigation for a subsequent crop, depending on rainfall before the next crop.

Figure 4 compares fully irrigated fruiting curves with late start for SIOKRA and DP90. Table 3 shows the accumulative numbers of squares and the numbers as a percentage of full irrigation for each variety.

TABLE 3. The accumulative number of squares.

	squares per m^2			percentage of the full treatment for each variety		
	DP61	DP90	SIOKRA	DP61	DP90	SIOKRA
FULL	239	235	288	100	100	100
LATE START	199	183	219	83	78	76
EARLY FINISH	235	225	282	99	96	98
LONG INTERVAL	234	214	271	98	91	94
RAIN GROWN	127	126	145	53	54	50

FIGURE 4. Fruiting curves for SIOKRA and DP90 under full irrigation and with late start



SIOKRA produced more squares and restricted watering, particularly the late start to irrigation reduced square production. The data suggest that both SIOKRA and and to a lesser extent DP90 were slightly more affected by water stress than DP61. Counts of bolls set and open bolls show no consistent differences among the varieties or the irrigation teatments, apart from the rain grown treatment in which numbers were greatly reduced and in which SIOKRA showed the greatest reduction.

Table 4 gives the yields as bales per ha and for each variety as a percentage of full irrigation. SIOKRA outyielded the other varieties in all irrigation treatments but not in the rain grown treatment. The restricted irrigation caused a similar percentage reduction in yield in all varieties but when rain grown the percentage reduction of SIOKRA was greater than in other varieties.

TABLE 4. Yield.

	bales per ha			percentage of the full treatment for each variety		
	DP61	DP90	SIOKRA	DP61	DP90	SIOKRA
FULL	8.20	8.45	10.03	100	100	100
LATE START	7.06	7.28	8.32	86	86	83
EARLY FINISH	7.31	7.00	7.94	89	83	79
LONG INTERVAL	7.00	7.03	8.37	85	83	84
RAIN GROWN	1.82	2.02	1.57	22	24	16

DISCUSSION

The results indicate that all three varieties reacted similarly to varied irrigation management. SIOKRA had a superior yield in all treatments except raingrown. Although SIOKRA may be slighly more sensitive to water stress, it is only of commercial significance in rain grown crops for which irrigation management is irrelevant anyway. These results do not support some of the claims made in respect of the behavior (soil water extraction pattern and response to water stress) of SIOKRA and DPL90 and the implications of these for irrigation management. This does not mean those claims are incorrect; it is just that they were not seen in this experiment which is only one observation at one site in one season.

However caution is needed when differences in water extraction between varieties are reported from different paddocks or in the same paddock without replication. It is possible that the differences reflect something else, such as soil compaction. One advantage rightly claimed for the neutron probe is that it can reveal differences caused by such factors. Regarding sensitivity to stress, just as SIOKRA is very distinctive in appearance so also is it distinctive in its visual response to stress and it may appear to be more stressed than it actually is. SIOKRA was selected and tested under agronomic conditions that were optimum for its predecessors such as DP61. It will therefore be well adapted to such conditions and is unlikely to have agronomic requirements that differ greatly from DP61. Its success depends on its making more efficient use of those requirements than DP61.

The irrigation efficiency referred to is the fraction of the water pumped that is transpired by the crop. It is the engineering efficiency and should be distinguished from the physiological efficiency and the agronomic efficiency, corresponding to the physiological and agronomic water requirements already discussed.

In this experiment the physiological efficiency on the fully irrigated treatment was 2.12, 2.22 and 2.66 kg lint per mm water used for DPL61, DPL90 and SIOKRA respectively. This index fell to 1.88 for DPL90 irrigated at a long interval and 0.8 for raingrown SIOKRA. These figures are comparable with those published in the literature and those given by Greg Constable at this conference. Calculations based on measured rates of photosynthesis and evapotranspiration under controlled conditions set an upper limit or potential of 6 kg lint per mm transpired.

Table 5 shows the agronomic efficiency in bales per Ml pumped. SIOKRA is clearly most efficient in all irrigation treatments. The long interval irrigation is less efficient than the other treatments, reflecting failure of the treatment to save as much water as the other restricted irrigation treatment while suffering similar yield reductions. Agronomic efficiencies as high as 2 bales per Ml have been reported elsewhere, mainly with drip and sprinkler irigation but some with furrow. However comparisons because results are not only affected by irrigation method but also soil type and climate.

TABLE 5. Agronomic irrigation efficiency (bales/Ml pumped).

	DPL 61	DPL 90	SIOKRA
FULL	1.10	1.16	1.36
LATE START	1.06	1.19	1.32
EARLY FINISH	1.16	1.14	1.26
LONG INTERVAL	0.98	0.98	1.17

The final efficiency to consider is economic. Is it worth saving irrigations in the way tried in the restricted watering treatments? The marginal benefit of applying each of the irrigations saved in the restricted treatments (or the loss incurred in not applying them) has been estimated from the difference between the treatment yield and full irrigation assuming $200 per bale with results in table 6.

TABLE 6. Marginal benefit of irrigation ($ per ha).

	DPL 61	DPL 90	SIOKRA
FULL - LATE START	228	234	342
FULL - EARLY FINISH	178	290	418
FULL - LONG INTERVAL	240	284	332

In order to estimate the marginal cost of a single additional irrigation the cost of irrigation land development can be ignored. The cost of water and fuel is simple but labour is problematical. If permanent labour is available the opportunity cost may be nil. However assuming a cost of $20 per ha per irrigation provides an upper limit to cover labour charged at full rates for a small paddock. Even at this cost and if an insecticide spray could be saved as well on the early finish strategy, making a total potential saving of $40 per ha per irrigation, the losses involved with restricted watering far outweigh any saving in cost. However this is not a complete economic analysis. The opportunity cost of the saved irrigation must be taken into account. What else could be done with the water? Would it be more better to save the water and use it to grow more cotton? Further analysis of the data shows that it is not economically more rational to do that. Thus these results are consistent with our earlier finding that it is economically optimum to allow 7 to 8 Ml per ha. Restricting water by one irrigation in any of the three ways described reduces the irrigation water below 7 Ml per ha into the range 6.1 to 6.6 Ml per ha (table 2).

ACKNOWLEDGMENTS

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