Effects of Irrigation on Cropping of 'Elstar', 'Golden Delicious', 'Idared' and 'Jonagold' Apple Trees

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SUMMARY

Four apple cultivars grafted on M9 rootstock were grown at high density ('Elstar' and 'Jonagold' 2500 trees/ha, 'Idared' and 'Golden Delicious' 3000 trees/ha). The trial was designed as split-block comprising two treatments (irrigation without fertilisers, and control - without irrigation and without fertilisers) and two timing variants of irrigation (from 1 May - 20 June – variant A, and from 1 May to 1 August – variant B). The treatments were imposed beginning in the second year after planting and lasted eight years (1992-1999). Cumulative yield of 'Elstar' was increased with irrigation, and index of alternate bearing was decreased. 'Golden Delicious' achieved the best results when was irrigated from 1 May to 20 June. Cumulative yield and percentage of bienniality of 'Idared' was not affected by irrigation. Irrigation had no consistent influence on cumulative yield of 'Jonagold', but increased degree of alternate bearing.

KEY WORDS

Malus x domestica, dynamic of yield, cumulative yield, alternate bearing

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INTRODUCTION

In commercial apple orchards, it is important to establish an appropriate balance between vegetative growth and cropping. Excessively vigorous growth is unwelcome because this may cause difficulties in applying appropriate management systems and may influence fruit quality and regularity of bearing. On the contrary, heavy fruit load during tree establishment may delay achieving full orchard productivity. The root systems of dwarf apple trees and newly planted apple trees are small and do not occupy a large volume of soil. This often leads to water stress especially with newly planted trees. Much of the problem of poor tree growth of dwarf apple trees during the first few years can be traced to inadequate water supply (Robinson and Stiles, 2004). Drip irrigation can be used to control the wetted root volume which may influence shoot and fruit growth (Bravdo and Proebsting, 1993). The water distribution under each dripper forms a bulb-shaped zone where formation of a large number of small roots is induced. Consequently, the surface area for water and mineral absorption is increased several-fold, providing high water availability (Bravdo et al., 1992), aeration (Richards, 1986) and appropriate nutrient concentration (Bravdo et al., 1992; Richards, 1986). In addition, drip irrigation effectively overcame the added competition, particularly for water, imposed by permanent sod strips in the row middles (Layne et al., 1994).

Our objectives were to determine the effects of irrigation in comparison with unirrigated control on yield and regularity of bearing of four apple cultivars ('Elstar', 'Golden Delicious', 'Idared' and 'Jonagold') during eight years after planting.

MATERIALS AND METHODS

The orchard site was located at Maribor-Gacnik Fruit-growing Centre in Slovenia. The experiment was conducted on the soil that contained 12% sand, 14% silt, 39% loam and 35% clay from 0- to 30- cm depth. This soil contained 3.2% organic matter, 5.6 mg P_2O_5/100 g soil, 45.0 mg K_2O/100 g soil, and pH (in KCl) was 5.4.

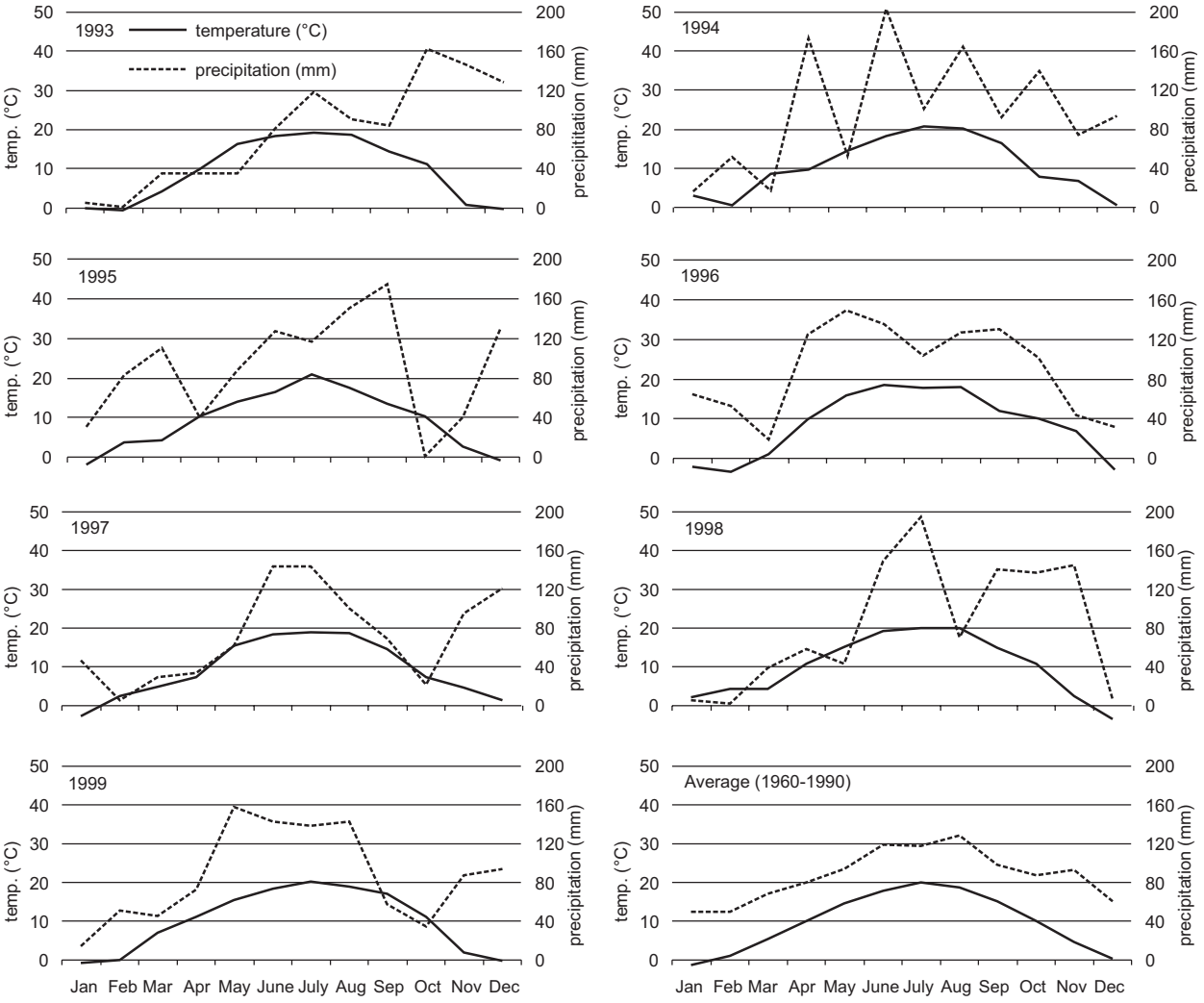

Figure 1. Climatic diagrams – Maribor region

Climatic conditions in the orchard site were favourable for apple growing (Figure 1). Long-term average temperature in Maribor is 9.7°C. Annual precipitation is about 1045 mm, and during growing season is about 638 mm.

Experiment was conducted on four apple (Malus x domestica Borkh) cultivars grafted on M9 rootstock and grown at high density ('Jonagold' and 'Elstar' 2500 trees/ha, 'Golden Delicious' and 'Idared' 3000 trees/ha) and trained as slender spindle supported by posts. Vegetation in the tree row was controlled over a 1 m width with herbicide. Protection against diseases and pests was carried out according to the integrated production rules.

The experimental design was a split-block comprising control (without irrigation and fertilisation), and two timing variants of drip irrigation (irrigation – 1: from 1 May to 20 June, and irrigation – 2: from 1 May to 1 August; in both variants 2 l water/tree/day – irrigation schedule was based on the empirical knowledge), three replications, where each replication comprised five trees.

The treatments lasted eight years and were started in the second year after planting (1992-1999). Yield (kilograms per tree at picking) was recorded annually beginning in the third year (1993). Regularity of cropping was calculated using the equation given by Monselise and Goldschmidt (1982). Analysis of variance was performed using SPSS for Windows 10.0 procedures. The differences were compared using LSD test at P=0.05.

RESULTS AND DISCUSSION

Results obtained over a seven-year period in our experimental apple orchard showed that the intensity of effects of irrigation on cumulative yield and regularity of cropping between cultivars varied (Table 1, Figure 2-5). In an average growing season in the experimental site rainfall was satisfactory for apple growing. However, in several years in the beginning of growing season precipitation was less than that required for optimal tree performance during critical periods of tree establishment and growth (Figure 1). The results in terms of yield and alternate tree bearing as result of water deficit is not easily explainable. Probably the natural tendency of some apple cultivars to alternate bearing could not be broken sufficiently by irrigation.

Robinson and Stiles (2004) indicate that even in humid climate irrigation can improve apple tree performance in the first few years after planting. The effect of irrigation was greater in years 1-3 when trees were developing a root system. However, in years 4-6, there continues to be a significant improvement in tree growth with irrigation.

Table 1.
Cumulative yield (t/ha) and index of alternate bearing (%)

Cultivar	Treatment	Cumulative yield (t/ha)	Index of alternate bearing (%)
Elstar	Control	166.2 b	47.1 a
	Irrigation - 1	180.9 a	23.6 b
	Irrigation - 2	181.3 a	14.7 b
	Significance	*	*
Golden Delicious	Control	189.8 c	42.2 a
	Irrigation - 1	244.4 a	14.5 b
	Irrigation - 2	222.0 b	42.3 a
	Significance	*	*
Idared	Control	228.3 a	20.3 a
	Irrigation - 1	223.2 a	15.4 a
	Irrigation - 2	235.2 a	15.8 a
	Significance	n.s.	n.s.
Jonagold	Control	199.9 b	15.1 b
	Irrigation - 1	196.1 b	38.3 a
	Irrigation - 2	219.9 a	29.4 a
	Significance	*	*

Means followed by the same letters are not statistically different at P=0.

Taken together, the results of our studies indicate that irrigation in humid climate can improve performance of 'Elstar' and cumulative yield of 'Golden Delicious' in the first few years after planting. The effect of irrigation on the performance of other cultivars was not consistent.

'Elstar'

'Elstar' in our trial displayed typical indications of tendency to alternate bearing. The lowest cumulative yield achieved 'Elstar' without irrigation in control. Control trees showed the highest index of alternate bearing. Irrigation increased cumulative yield and decreased alternate bearing. There was no significant difference between timing variants of irrigation. On the basis of obtained cumulative yield and calculated index of cropping alternation it can be concluded that 'Elstar' responded well to irrigation in the ecological conditions such were in the Maribor region.

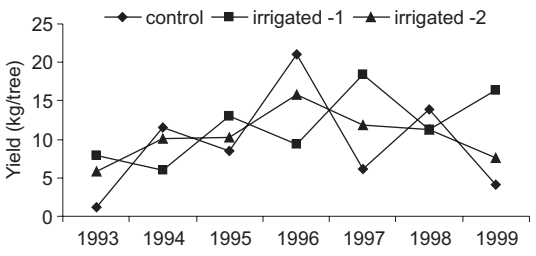

Figure 2. Yield of 'Elstar' apple (kg/tree) during first seven years of cropping

'Golden Delicious'

'Golden Delicious' achieved the highest cumulative yield and showed a low degree of cropping bienniality when trees were irrigated from 1 May to 20 June. In control and in variant with irrigation from 1 May to 1 August cumulative yields were lower, and percentages of alternate bearing were higher.

'Idared'

During the years of cropping (1993-1998) there were no consistent treatment effects for cumulative yield, and regularity of bearing of 'Idared' apple. This results, and generally known vegetative and fruiting characteristics of 'Idared' apple indicated that this cultivar is not very demandingly to application of water and fertilizer

'Jonagold'

Cumulative yield of 'Jonagold' was the highest when trees were irrigated from 1 May to 1 August, but year-to-year differences in yields were higher than in control. Probably the reason for this is that irrigation promotes alternate bearing by stimulating of growth. On the basis of calculated index of cropping alternation it can be concluded that 'Jonagold' achieved very good yield without irrigation under the ecological conditions of the Maribor region.

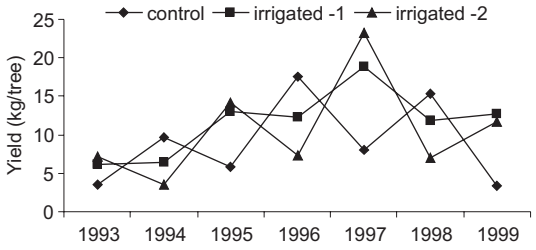

Figure 3. Yield of 'Golden Delicious' (kg/tree) during first seven years of cropping

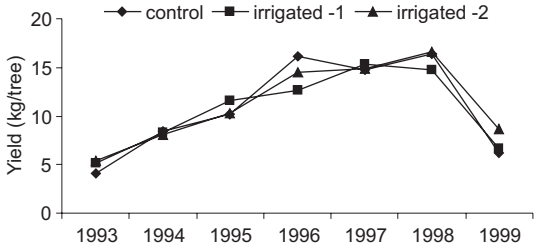

Figure 4. Yield of 'Idared' apple (kg/tree) during first seven years of cropping

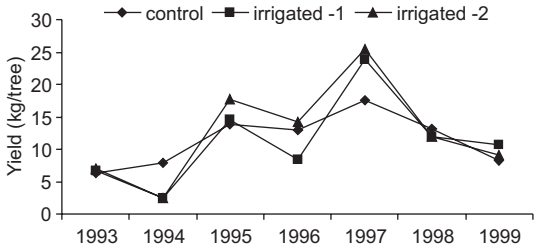

Figure 5. Yield of 'Jonagold' apple (kg/tree) during first seven years of cropping

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