APRC Project Report

Project SP77:	Orchard soil management (including requirements for Integrated Fruit Production [IFP])
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Date:	Report to 30 September 1998

Background

The project contains two field trials that have continued from the previous funding period (1994-97). The first compares suitable alternatives to residual herbicides for controlling competition by weeds in an apple orchard (named Trial 4 in previous reports). A second trial (named Trial 6 in previous reports) investigates the effects of previous soil herbicide management on the growth of apple trees.

Alternatives to residual herbicides for controlling weed competition in an apple orchard

This trial investigates the use of plastic (polypropylene woven) mulch, organic (straw) mulch and a non-residual herbicide (glufosinate ammonium) as alternatives to a residual herbicide (simazine) in a Bramley/M.9 orchard (3 m x 5 m spacing) planted in 1992. All treatments were applied with or without irrigation. A mixture of simazine (4.5 l/ha) and diuron (2l/ha) was applied to the residual herbicide plots on 10 March 1998. Glyphosate (4.5 l/ha) was applied to the non-residual herbicide plots between 13-16 March 1998 and glufosinate ammonium was applied between 26 June - 1 July 1998.

<u>1997 fruit quality ex store</u>

Apples were put into controlled atmosphere storage (4^{o}C, 9% $C0_2$, 12% 0_2) after harvest in 1997. The fruit was removed on 25.6.98 and assessed for storage disorders and rots by D.S. Johnson (Table 1). All the apples had scald but differences in severity were not significant between soil management treatments. Damage due to bitter pit was greatest on the trees growing in the straw mulch and this is probably linked to the higher potassium uptake of these trees (see previous report) antagonising calcium uptake. The effects of different soil management treatments on flesh browning, corky core and core flush were generally small and not statistically significant.

Results 1998

Trees grown in the straw mulch treatment had the greatest harvest yields (Table 2). The total harvest weight of apples from these trees was 24% greater than those growing in soil maintained bare by residual herbicide. This effect was due primarily to an increase in mean fruit size as the differences in the numbers of apples per tree caused by soil management treatments were small (Table 2). The grade out of Class 1 fruit 80-110 mm was 10 kg/tree greater from trees grown in straw mulch and almost double that produced by trees grown in soil treated with non-residual herbicide (Table 2).

Differences between the non-straw mulch treatments in total harvest yield and grade out were negligible. The lower yield in the plots containing *Sedum acre* was due to poor weed control before and after the herb was planted. Initially, these plots had weed control with non-residual herbicides. The prevalent weeds inhibited the establishment of the sedum, and subsequent attempts to control the weeds with non-residual herbicide have also reduced the spread of the sedum. The total area of the 'sedum' plots covered by sedum remains small (<20%).

An assessment of weed populations was carried out on 24.6.98 (Table 3). This indicated that very good weed control had been achieved with the plastic mulch and straw mulch treatments. The predominant weeds that were found on the non-residual herbicide and sedum plots were annual meadow grass, groundsel, hairy bitter cress and common chickweed. The main weeds that were found on the residual herbicide plots were groundsel and field bindweed. Moss covered a high proportion of the plots where non-residual herbicides had been used.

Soil water potential is a measure of the force required by plants to extract water from the soil and is related closely to soil moisture content. As the soil becomes drier, the water potential decreases (i.e. becomes more negative) and the plant is less able to withdraw water from the soil. Tensiometers are used to measure soil water potential. During 1998, measurements were taken at 30 cm depth from five tensiometers for each of following treatments: non-residual herbicide, residual herbicide, plastic mulch, straw mulch and residual herbicide + trickle irrigation (Figure 1). These measurements indicated that the straw and plastic mulch treatments successfully conserved moisture until mid-July to a similar extent as that found in the irrigated treatments; afterwards the soil of these treatments became substantially dryer.

The large drop in soil water potential in the trickle-irrigated soil at the end of July was due to an irrigation failure during a period of dry weather that allowed the soil to dry out. In the following weeks the soil in this treatment regained moisture from the irrigation and remained at a higher water potential (i.e. it was wetter) than all the other treatments.

The poorer degree of weed control achieved on the non-residual herbicide treatment is apparent from the early and persistent reduction in soil water potential (drier soil). Soil under non-residual herbicide consistently had the lowest water potential until late July. The soil under residual herbicide remained wetter than the soil under non-residual herbicide due to better control of weeds, but it remained drier dryer than the soil under plastic mulch. This may be explained partly by the better weed control of the latter treatment. The plastic mulch is porous and therefore should not restrict water loss from the soil surface. The moisture conservation that occurred under plastic mulch is surprising and requires further investigation.

Effects of previous herbicide management on the growth of a newly planted apple orchard

This trial investigates the effects of previous herbicide management on the growth, fruit yield and eating quality of Royal Gala/M.9 apple trees (2 m x 3.25 m spacing). The trees were planted in February 1996 on a site that had been previously either under grass or herbicide-treated for 20 years. In 1996 remedial treatments included different rates of nitrogen fertiliser (calcium nitrate) at 0, 20, 40, 60 g N/tree, trickle irrigation and the use of potting compost. In 1997 the application of nitrogen fertiliser was doubled for all treatments so that the application rates were 0, 40, 80, 120 g N/tree respectively (equivalent to 57, 114, 171 kg N/ha). The latter nitrogen treatments and the trickle irrigation were repeated in spring 1998.

The trees were cropped for the first time this year and therefore yields were low (Table 4). Trees grown in soil previously under herbicide had approximately 20% greater harvest yields and number of apples per tree than those that were grown in soil that had previously been under grass. However, in the absence of irrigation, the differences in yield caused by previous soil management were negligible. Supplementary nitrogen fertiliser applied at any of the rates tested had no effect on harvest yield and the numbers of fruit per tree (data not presented). Irrigation alone increased harvest yield per tree by approximately 50% and the numbers of fruit per tree by 41%. This indicates the overriding importance of availability water over all other soil factors in determining yield of young trees. The lower yield of trees grown in soil previously under grass was unexpected because this treatment contains soils with a higher level of organic matter (See Report for Project SP77, September 1996). Normally higher concentrations of organic matter are associated with higher levels of soil fertility and the measurement of soil nitrate contents in soil from this experiment indicated greater concentrations for soil previously under grass (See Report for Project SP77, September 1997). Clearly other factors must also be important in determining harvest yield in relation to previous soil management and these require identification.

Fruit were graded manually after harvest into Class 1 and Class 2 and sizes 55-65, 65-75 mm diameter. The weight of Class 1 fruit 65-75 mm diameter was increased by 260% by trickle irrigation compared to the non-irrigated fruit (Table 5). The effects of the other treatments were negligible by comparison to the effect of irrigation.

Leaf samples were taken in late August and fruit samples were taken at harvest for mineral analysis. In addition, soil samples were taken regularly for extraction of nitrate nitrogen. Results from these analyses will be presented in later reports.

Table 1 Storage disorders (% of all fruit) in Bramley/M9 apple trees fruit harvested on 15/9/97 and removed from cold storage (4ºC, 9% CO_2, 12% O_2) on 25/6/98

	Rots %	Severity Index for Scald 1-100 (100 = severe)	Flesh Browning %	Bitter Pit %	Corky Core %	Core Flush %	Severity Index for Core Flush 1-60 (60 = severe)
Non-residual herbicide	4	80	6	13	4	10	30
Residual herbicide	7	68	9	20	4	6	25
Plastic mulch	3	77	5	19	1	7	26
Straw mulch	3	68	14	29	5	6	23
Significance level	ns	ns	ns	ns	ns	ns	ns

ns = non-significant

Table 2 The effects of different methods of weed control on total yield and grade-out of Bramley/M9 trees at harvest, 1998

	Total yield (kg)	Total numbers apples/tree	Wt. Class I 80-110 mm	% Class I 80-110 mm	Wt. Class II 90-110 mm	% Class II 90-120 mm
Non-residual herbicide	31	175	13.4	43	0.3	1.0
Residual herbicide	33	183	14.7	42	0.2	0.7
Plastic mulch	32	188	15.1	47	0.2	0.9
Straw mulch	41	186	24.8	60	0.5	1.2
Sadum	31	175	11.1	35	0.2	0.6
Significance level	ns	ns	**	***	ns	ns

ns non-significant
** highly statistically significant
*** very highly statistically significant

Table 3 Weed populations within the tree row found in different soil management treatments on 24/6/98

Numbers of weeds /m^2

Latin name	Cirsium arvense	Senico vulgaris	Veronica persica	Lamium purpureum	Bellis perennis	Cardamine hirsuta	Stellaria media	Chenopodium album	Crepis capillaris	Epilobium tetragonum	Malva sylvestris	Kickxia elatine	Sonchus asper	**Total numbers of weeds**
Common name	Creeping Thistle	Groundsel	Bauxbaums speedwell	Red Dead-Nettle	Daisy	Hairy Bitter Cress	Common Chickweed	Fat Hen	Smooth Hawks Beard	Square Stalked Willow Herb	Common Mallow	Sharp leavead Fluellen	Prickly Sow Thistle	
Plastic mulch	0	1.2	0	0	0	0	0	0	0.4	0	0	0	0	**2**
Non-residual herbicide	0	42.8	3.6	0.4	1.2	14.8	0	0	1.2	1.6	0.4	0	3.2	**69**
Residual herbicide	0	18	0	0	0	0	0	0	0	0	0.4	0	0	**18**
Straw mulch	0	0	0.8	0	0	0	0	0	0	0	0	0	0	**1**
Sedum acre	0.4	51.6	4.4	0	0.4	0.4	22.8	0.8	0.8	1.2	0	0.4	2.8	**86**

% creeping cover

Latin name	Elymus repens	Poa parentis	Lolium multiflorum	Convolvulus arvensis	Trifolium repens	**Total**	**Moss**
Common name	Couch	Annual Meadow Grass	Italian Rye Grass	Field Bindweed	White Clover		
Plastic mulch	0	1.5	0.5	0	0	**2**	**0**
Non-residual herbicide	0	16.5	0	7.5	0.5	**25**	**68**
Residual herbicide	0	0.5	0	10	0	**11**	**1**
Straw mulch	1	0	0	0	0	**1**	**0**
Sedum acre	0	9.5	0	0	0	**10**	**68**

Table 4 The effects of previous soil management (grass, herbicide) and irrigation on harvest yield and the numbers of fruit per tree of Royal Gala/M9 apple trees September 1998

Previous soil management	- Irrigation		+ Trickle		Mean (Yield kg/tree)	Mean (no's/tree)
	Yield (kg/tree)	No's/tree	Yield (kg/tree)	No's/tree		
Grass	3.88	47	5.74	63	4.82	55
Herbicide	4.15	50	7.43	74	5.79	63
Mean	4.02	49	6.59	69		
Significance (Irrigation)	Yield ***				Fruit No's ***	
Significance (Previous soil management)	Yield *				Fruit No's *	

* statistically significant
** highly statistically significant
*** very highly statistically significant

Table 5 The effects of previous soil management (grass, herbicide) and irrigation on grade-out of Class I fruit, 65-75 mm, Royal Gala/M9 apple trees, September 1998

Previous soil management	Weight/tree (kg)	%	Weight/tree (kg)	%	Mean Weight/tree (kg)	Mean %
Grass	0.50	12	1.59	24	1.05	18
Herbicide	0.62	13	2.40	30	1.51	22
Mean	0.56	13	2.00	27		
Significance (Irrigation) ***						
Significance (Previous soil management) ns						

ns non-significant
*** very highly statistically significant

Figure 1 The effects of different methods of soil management on soil water potential