LUCERNE/VEGETABLE ALLEY CROPPING TO CONTROL LEACHING

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Summary. Most vegetable crops are shallow-rooted and frequently irrigated. It is therefore nearly impossible to reduce the leaching of water and agrochemicals below the root zone by conventional means. We have carried out a three-year field trial in which drip-irrigated silverbeet and processing tomatoes were grown in alleys, 1.3–7.0 m wide, alternating with strips of non-irrigated lucerne, in an attempt to reduce outputs. The lucerne was cut regularly to provide a mulch for the vegetable crops and increased no-till yields by up to 38%, compared to an unmulched control treatment. The lucerne took up much of the water that had leached beyond the rooting depth of the vegetable crops. Competition between lucerne and vegetables was unacceptably high under certain circumstances, but this problem could be easily overcome by small adjustments to irrigation management.

INTRODUCTION

Alley cropping is a method of growing perennial species, usually shrub or tree legumes, together with annual crops. Crops are grown between spaced rows of trees that are pruned regularly to provide mulch and to supply nutrients to the crop. Alley cropping was designed to replace the natural bush fallow, a system which successfully regenerated the soil, but required an unacceptably long rotation interval to do so (1). A major objective of alley cropping is to ensure the long-term fertility, or sustainability, of the soil resource. In the case of vegetable production, a serious obstacle to the attainment of a sustainable system is the loss of water and agrochemicals below the shallow root zone, where they may pollute ground water and contribute to rising water tables. Even if irrigation is scheduled accurately, leaching takes place when rain falls, because the soil profile is maintained near the upper drained limit by irrigation.

In this study, non-irrigated lucerne was alley cropped with irrigated vegetables, in an attempt to minimise leaching. Lucerne takes the role of a tree in a conventional alley crop system, by virtue of its deep-rooting habit. A major advantage of lucerne over trees is that it does not shade the adjacent rows; therefore widths of lucerne and vegetable alleys can be narrow and the lucerne can easily be cut and deposited on adjacent vegetable beds. The success of the system depends on how effectively the lucerne can retrieve water and nutrients which have leached below the root zone of the vegetable crops, and the value of cut lucerne to the vegetables as a source of nutrients and mulch. Set against this is the competition between the two species, specifically the amount of water *stolen* by lucerne from the vegetable root zone.

MATERIALS AND METHODS

The experiment was carried out near Camden, NSW, on a deep alluvial silty clay loam soil on the banks of the Nepean River. Lucerne (L) and vegetables (V) were planted on raised beds, 1.32 m centre to centre, in alternating strips. The treatments consisted of three configurations: alternating single beds, alternating groups of three beds and alternating groups of five beds as illustrated below.

Treatment 1: L V L V L V L V L V L V L V L

Treatment 2: L L L V V V L L L V V V L L L

Treatment 3: L L L L L V V V V V L L L L L

Each treatment was 11 m long and 19.8 m wide (15 rows x 1.32 m), and replicated three times. The vegetable beds in each treatment were divided into two 5.5 m long subplots, one receiving about 10 t/ha mulch from the lucerne and the other remaining bare. The design was a split plot, with bed spacing as the main treatment and mulching as the subtreatment.

Lucerne *Medicago sativa* L. cv. WL605 was sown in two rows per bed on 20 April 1991. Silverbeet *Beta vulgaris* cv. Fordhook Master was transplanted on 26 October 1992, 18 months after the lucerne was sown and when lucerne roots had exceeded a depth of 2 m. The vegetable beds were drip irrigated and the lucerne grown on natural rainfall. For the first eight weeks the silverbeet was irrigated daily, after which every plant was harvested by removing all but the youngest two leaves. Irrigation was then withheld for four weeks, and the silverbeet was harvested as before. For the final four-week period the silverbeet was irrigated once per week.

Processing tomato *Lycopersicon esculentum* cv. UC82B was sown on 26 November 1993. The crop was intentionally under-irrigated to accentuate the competition for water between the lucerne and tomatoes. Root length, water content, nitrate and ammonia were measured to a depth of 3.6 m and soil water monitored continuously by neutron probe and Time Domain Reflectometry. This paper reports only some of the crop yield and water use data.

RESULTS

The benefits of lucerne, and its competition with the vegetable crops, has been summarised in Table 1 by comparing yields in beds bordered by lucerne with yields of a sole crop (2). A sole crop (S) is defined as one where there is no competition from lucerne; this was taken as the middle three beds of the five-bed treatment, where neutron probe readings and soil cores revealed that no lucerne roots had infiltrated. In treatment 1, vegetable beds were bordered by lucerne on both sides (termed V2 beds), and the outer vegetable beds of treatments 2 and 3 were bordered by lucerne on one side only (V1 beds). The benefit of a lucerne mulch was calculated as the vegetable yield from the mulched sole crop divided by the yield of the unmulched sole crop. The competition from lucerne was calculated as the vegetable yield in the unmulched V2 or V1 beds divided by the yield of an unmulched sole crop. The net effect of alley cropping is the yield from mulched V2 or V1 beds divided by the unmulched sole crop (Table 1).

Table 1. The benefits and competition of lucerne/vegetable alley cropping

		Silverbeet			Tomatoes	
		[b]I1	I2	I3	Fruit	Vegetative
Benefit of mulch	[a]S_m/S_o	1.32	1.33	1.32	1.38	0.99
Competition V2	$V2_o/S_o$	0.84	0.97	0.98	0.40	0.83
Competition V1	$V1_o/S_o$	0.94	1.00	1.12	0.64	0.93
Net benefit V2	$V2_m/S_o$	1.19	1.27	1.20	0.70	0.89
Net benefit V1	$V1_m/S_o$	1.34	1.24	1.35	1.00	0.96

[a] S_o sole crop no mulch S_m sole crop mulched

[b] I1 daily irrigation I2 no irrigation I3 weekly irrigation

$V2_o$ alley crop no mulch, lucerne on two sides

$V2_m$ alley crop mulched, lucerne on two sides

$V1_o$ alley crop no mulch, lucerne on one side

$V2_m$ alley crop mulched, lucerne on one side

The lucerne mulch increased silverbeet yields by over 30%, regardless of the irrigation regime. There was some competition from the lucerne over the first eight weeks of the crop, when irrigation was scheduled daily, but competition was negligible for the rest of the season, even when irrigation was withheld. The net benefit of alley cropping ranged from 19 to 27% where the silverbeet was bordered by lucerne on both sides, and from 24 to 35% in the case where the silverbeet was bordered by lucerne on one side only. There was a 38% increase in tomato fruit yield when a sole crop was mulched, but no effect on vegetative growth. Competition by the lucerne was severe when the tomatoes were given suboptimal irrigation; fruit yield was decreased to 40% of the sole crop, and the net benefit of alley cropping was nil or negative when the tomatoes were bordered by one or two beds of lucerne respectively.

Fig. 1 shows the percentage of available water stored in the soil during the tomato crop (planted on day 15 and harvested on day 115) and for the following 400 days, during which no vegetable crops were grown. The 0–0.6 m zone of soil was full of water when the tomatoes were planted, but decreased to 55% of available stored water in the sole crop treatment and 40% in V2 beds at the critical yield-determining stages of flowering and fruit set around day 58 (Fig. 1a). The available water in the profile between 0.6 and 1.8 m ranged between 40 and 60% in V2 beds, and was > 80% in the sole crop treatment (Fig. 1b). The lucerne profile was always dry, apart from two periods of heavy rain around days 135 and 360; lighter falls of rain made little impact, as the water was extracted or lost to evaporation before the next probe readings. The rate of water extraction by lucerne from V2 beds can be seen during the long dry period between days 160 and 350. The unmulched sole crop treatment lost 50% of its available water (44 mm) in the top 0.6 m through evaporation, while the subsoil remained wet and susceptible to large leaching events such as occurred on day 378. The unmulched V2 beds lost 66 mm of water from the top 0.6 m through a combination of lucerne extraction and soil evaporation and 57 mm from the subsoil through lucerne extraction. On day 408, a mulch was placed on the V2 beds and the ideal water content profile developed, i.e. the top soil was wetter and subsoil drier in the V2 beds compared to the sole crop.

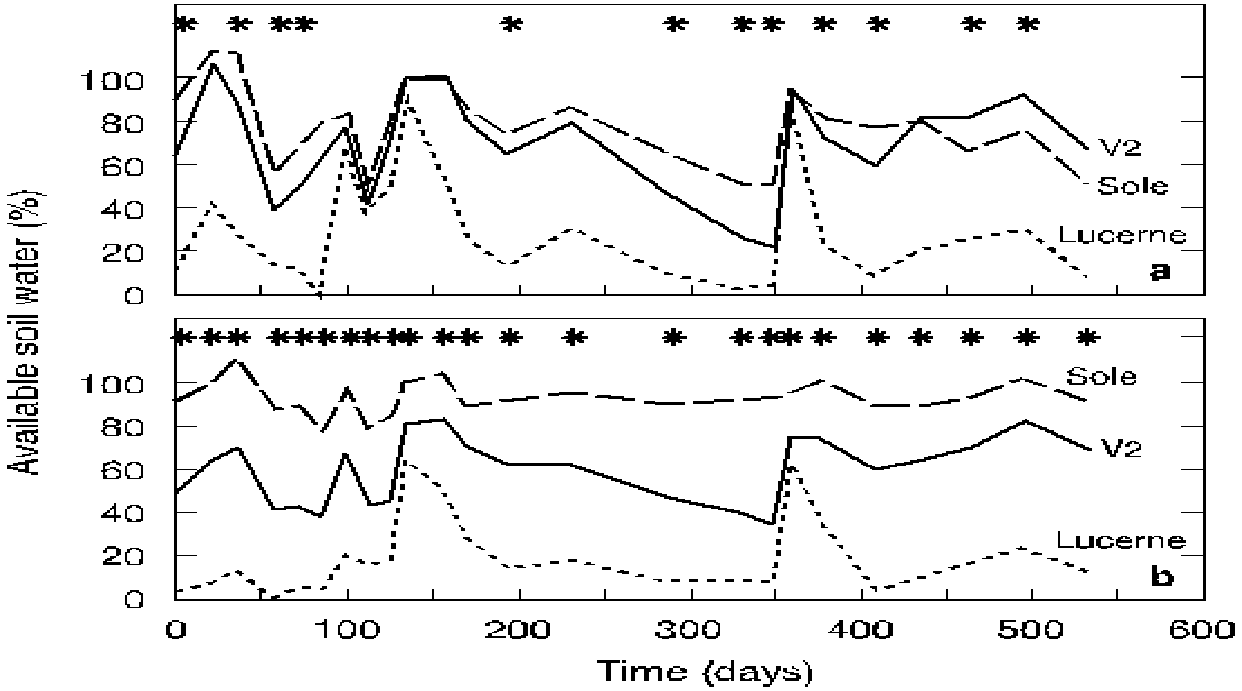

Figure 1. The available water in the soil profile (a) 0–0.6 m depth (b) 0.6–1.8 m depth, ? indicates significant ($P < 0.05$) difference in available water between V2 and sole treatments.

DISCUSSION

A lucerne mulch increased silverbeet and tomato yields by between 32 and 38%. Mulching of no-till vegetable crops, grown under favourable water and nutrient conditions, can increase yields by the modification of soil temperatures, reduction in soil evaporation and soil strength, stimulation of soil fauna and the formation of biopores (3). The magnitude of the benefit due to mulching depends on soil type and management; mulching assumes greater importance as management of soil structure, water and nutrients deviate from the optimum. Competition between vegetables and lucerne was negligible when silverbeet was under-irrigated, but severe when tomatoes were under-irrigated. This apparent contradiction was due to the amount of water in the soil profile beneath the lucerne when each crop was grown. The silverbeet was planted 18 months after the lucerne was sown, and at this stage the lucerne had not yet used all the water beneath it. By the time the tomato crop was planted, 12 month later, the lucerne had used all this water, and the lucerne was extracting water from the adjacent beds.

The low yield in V2 beds was not so much a consequence of lucerne stealing water from the tomato crop while it was growing, but due mainly to the slow removal of water from V2 beds during the much longer 10-month period between the end of the silverbeet crop and the start of the tomato crop. A single irrigation of around 50 mm to the V2 beds at the start of the season would have largely removed the problem of lucerne competition. The rate that water is withdrawn from the tomato alley by lucerne is critical for the success of alley cropping. Withdrawal must be sufficiently slow from the vegetable root zone so that only minor additions of irrigation are needed to remove the competition effect. However, withdrawal of water from the saturated zone beneath the vegetable beds must be rapid enough and over a sufficient soil depth that there is a buffer to store water leaching after heavy rainfall. Competition can also be minimised by reducing the number of lucerne relative to vegetable beds (V1 vs V2), but this comes at the expense of losing valuable mulch material. Un-irrigated lucerne, bordered by irrigated vegetables on both sides, produced 13.5 t dry matter/ha/year, containing approximately 400 kg N/ha, 30 kg P/ha, 200 kg K/ha and 250 kg S/ha.

Alley-cropping inevitably means that land is taken out of vegetable production. However, the lucerne alleys should be viewed as part of a rotation necessary in any well-managed production system. A conventional rotation may involve cropping one hectare of land for five years followed by five years of pasture, and shifting production to new ground. Alley cropping would involve cropping half of a two hectare field, and swapping lucerne rows and vegetable rows after a period of five years. Such a system represents diversification in time and space. It would be more biologically efficient than a conventional rotation, but presents some problems for practical field management.

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