THE EFFECT OF SOLARISATION ON VEGETABLE CROP PRODUCTION

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SUMMARY

The effect of solarisation was investigated at Lincoln in Canterbury. Solarisation increased plant and head weight of broccoli. This was mainly due to increased nitrogen availability, with a lesser effect from reduced weed competition. Plant yield on solarised plots was further increased by adding nitrogen fertiliser. During solarisation, peak soil temperatures reached 55, 51, 47 and 43 °C at 13, 38, 63 and 88 mm depths. In solarised plots the soil temperatures at the 13 mm depth exceeded 35 °C on 48 days of the 58 day solarisation period. At the same depth this temperature was exceeded on only 6 days in the untreated plots.

INTRODUCTION

Solar heating of soil was developed as a method of soil sterilisation for controlling soil-borne pathogens, pests and weeds. Development occurred in Israel, Northern Italy, Texas and California and the process has been further tested in at least 20 other countries (Katan 1981).

To prepare a site for solarisation the soil is cultivated, levelled, irrigated to field capacity and covered with transparent polythene sheeting which is buried at the edges. This simple technique captures radiant heat energy from the sun and induces physical, chemical and biological changes in the soil. A wide range of soil-borne diseases, nematodes and weeds have been reported to be controlled by solarisation (Katan 1981). The beneficial effects of 2 to 4 weeks solarisation during summer can remain apparent 1 year later (Katan *et al* 1983).

The success of solarisation depends on the maximum ambient temperatures achieved (Katan 1981). At Lincoln the average summer daily maximum temperature rarely exceeds 24 °C in any month. Periods of 1-4 days above 30 °C and exceptional temperatures above 35 °C are occasionally recorded. In climates similar to that of Canterbury, soil temperatures of 42-60 °C have been recorded during solarisation (Hesketh 1981; Myers *et al* 1983).

This research was aimed at determining if summer temperatures in Canterbury are high enough for the beneficial effects of solarisation to occur. The effects of solarisation and nitrogen on weed infestation and broccoli yields were investigated.

METHODS

The trial was established in December 1989 on a Wakanui silt loam at Lincoln Canterbury, which had been fallowed during the spring of 1989 after 1 year in pasture. Plots were arranged in a randomised block design with six replicates. All plots (4 m x 4 m) were cultivated and levelled. On December 8 polythene (150 µm Agphane 101) was laid over the solarisation plots. It was removed 58 days later on February 5. Herbicide (diquat) was applied to non-solarised plots for weed control during the solarisation period. Soil temperatures at 13, 38, 63, and 88 mm depths (1 site/treatment) were recorded at 30 minute intervals using a SIDD field data logger.

At polythene removal nitrogen content of the soil (0-10 and 10-20 cm depth) was measured on bulked 30 core samples (2.5 cm diameter) per plot. Quick Test analysis (0-10 cm) were performed on 10 core samples for pH, Ca, P, K, S, Mg, and Na. Four days later two rows of seedlings broccoli were transplanted into each plot spaced at 50 cm between rows and 30 cm within the row.

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Fourteen days after transplanting each plot was split into two, with nitrogen applied to one of the subplots. The nitrogen plots were topdressed with fertiliser (Nitrophoska) (N 12 P 5 K 14) at 600 kg/ha (recommended standard rate) 14 days after transplanting, followed by calcium ammonium nitrate at 180 kg/ha, 30 days later. Nitrogen applied from these two dressings amounted to (72 + 50) 122 kgN/ha.

Weed species were counted (5 x 0.1 m² quadrats) 42 days after polythene removal and weed dry matter yields (2 x 0.2 m² quadrats) were determined at harvest. Six plants per treatment were harvested and dry matter yields of plants and heads measured on 8 May, 1990, 88 days after planting.

RESULTS

Daily soil temperatures under solarisation are shown in Table 1. Soil temperatures due to solarisation were typically 16-24 °C higher than the non-solarised soils. Peak maximum temperatures were 55, 51, 47 and 43 °C at 13, 38, 63 and 88 mm depths.

The weed population in solarised plots was 90% less than in untreated ($P < 0.01$) at 42 days after polythene removal (Table 2), and the weed dry matter weight 78% lower ($P < 0.01$) at harvest (92 days after polythene removal) (Table 3). The predominant weeds controlled were annual poa (*Poa annua*), lesser canary grass (*Phalaris minor*), white clover (*Trifolium repens*), chickweed (*Stellaria media*), fathen (*Chenopodium album*) and mouse-ear chickweed (*Cerastium fontanum*).

TABLE 1: Daily record (no. of days) of maximum soil temperatures (°C) under solarisation (58 days).

Temperature (°C)	Depth (mm)			
	13*	38*	63	88
<35	11	10	15	20
35-39.9	2	7	10	22
40-44.9	5	12	26	16
45-49.9	25	28	7	0
>50	15	1	0	0

*Non-solarised plots reached temperatures greater than 35 °C on 6 days at 13 mm and 2 days at 38 mm depths.

TABLE 2: Weed populations six weeks after polythene removal.

	Weeds/m ²						total
	annual poa	canary grass	white clover	mouse-ear chickweed	other weeds	weed seedlings	
Square root transformed means							
Untreated	6.4	2.3	4.6	5.3	3.8	4.4	16.5
Solarisation*	0.6	0.2	2.6	0.5	1.1	0.9	5.2
LSD (5%)	1.0	1.7	1.8	2.3	2.8	2.9	1.9
Back transformed values							
Untreated	41	5	21	28	14	19	273
Solarisation	0	0	7	0	1	1	27

*Bulked data, N applied and non-applied plots.

Solarisation alone increased the broccoli plant and head weight compared with untreated ($P < 0.05$). Broccoli plant and head weight were also significantly increased ($P < 0.05$) by the addition of nitrogen under both solarisation and no-solarisation compared to the no-nitrogen plots (Table 3).

Available nitrogen more than doubled under solarisation which was a gain equivalent to 76 kgN/ha (Table 4). Sulphate levels were increased under solarisation to 17 v 10 µg/g ($P < 0.01$). Solarisation had no effect on pH, Ca, P, K, Mg or Na levels as determined by the Quick Tests.

TABLE 3: Broccoli and weed dry matter yields at harvest (tonnes/ha).

Treatments	Broccoli plant	Broccoli heads	Weeds
Untreated	4.50	0.48	0.32
Untreated plus N	6.10	0.73	0.37
Solarisation	6.80	0.93	0.07
Solarisation plus N	8.15	1.25	0.04
LSD (5%) ¹	1.18	0.12	0.16
LSD (5%) ²	1.52	0.26	0.16
Contrasts			
Solarisation main effect	**	**	**
No nitrogen main effect	**	**	ns
Solarisation/nitrogen interaction	ns	ns	ns

¹ For comparisons of no nitrogen with nitrogen within either solarisation or control treatments.

² For all other comparisons.

TABLE 4: The effect of solarisation on soil mineral nitrogen levels at polythene removal.

	Soil depth (cm)		
	0-10	10-20	Total
	NO ₃ - N (kg N/ha)		
Non-solarised	41	15	56
Solarised	76	41	117
LSD (5%)	24	10	26
	NH ₄ - N (kg N/ha)		
Non-solarised	1	1	2
Solarised	15	1	16
LSD (5%)	8	1	4
	Total N (kg N/ha)		
Non-solarised	42	16	58
Solarised	91	43	134
LSD (5%)	15	12	20

DISCUSSION

The increased yields and improved weed control obtained following solarisation suggest that soil temperatures were sufficiently raised during the 58 day solarisation period for this technique to be effective in Canterbury. An initial experiment (data not shown) showed no benefit from increasing the solarisation period to 81 days. Solarisation for control of autumn weeds was well demonstrated in these trials showing similar results to those reported by Katan (1981) and Rubin and Abraham (1983).

Solarisation increased yield probably through increased N mineralisation rates particularly NO₃ (Table 4), with the difference in yield between treatments approximately correlated with the initial amount of fertiliser N (72 kg) applied. Similar results have been reported by other workers (Chen and Katan 1980). However, the application of N did not fully explain the increased yields due to solarisation, with a trend towards higher yields in the unfertilised solarised treatment than in the fertilised non-solarised treatment. This difference may be due to reduced weed populations and also to reduced nematode and fungi populations as demonstrated by Alexander (unpublished) and Stapleton and DeVay (1984). The increased yield following application of fertiliser N to solarised plots indicates that nitrogen released from solarisation alone was inadequate for maximum broccoli yield.

Solarisation could be a viable option in organic systems where non-chemical weed control is mandatory and manufactured forms of nitrogen are forbidden. It is a form of soil disinfestation distinct from chemical fumigants and steam, and there are many situations for its implementation in horticulture.

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