7.3 The Use of Mounds and Organic and Plastic Mulches for the Management of Phytophthora Root Rot of Papaya in Northern Queensland

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Abstract

Options for the control of root rot of papaya caused by *Phytophthora palmivora* were evaluated in a field experiment in northerly parts of Queensland, Australia. In the experiment, growing papaya on 0.75 m mounds reduced the incidence of root rot by 38.4% and significantly increased fruit yield. Soil covers of 2 m wide plastic mulch and organic mulch, in combination with 0.75 m mounds, further reduced plant losses by 20 and 10%, respectively. Plastic mulch on flat ground was as effective as the mounded treatments in reducing the incidence of root rot and increasing yield.

Introduction

The northern Queensland papaya industry (latitudes 16°48'–17°26'S), which includes 90% of all papaya (*Carica papaya*) grown in Australia, consists mainly of farms of no more than 2 ha. However, the soil-borne pathogen *Phytophthora palmivora* Butler, which causes a decay of the taproot and eventual death of plants, is widespread in the growing area (Vawdrey 2001). Recommendations for the control of the disease involve papaya being planted on land not previously planted to papaya (Chay-Prove 2000). This situation has been a major constraint to the expansion of the papaya industry in the region.

The conventional method of growing papaya in all growing areas has involved planting seedlings into flat ground (Dunn 2001). Duniway (1979) concluded that the most important environmental factor influencing phytophthora-related root disease was the duration of saturation or near-saturation of soil. Soil conditions such as these are known to favour the rapid formation of sporangia and infectious zoospores and a high level of disease. Although the most suitable papaya-growing soils in northern Queensland are well-drained loams, these soils are likely to remain saturated for prolonged periods during severe wet seasons. Improving soil drainage through mounding and mulch application has been used successfully in avocado to manage root rot caused by *Phytophthora cinnamomi* (Broadley 1992; Pegg and Whiley 1987).

This study reports on a field experiment that examined the effectiveness of mounds and organic and plastic mulches, with and without the chemical metalaxyl, in reducing root rot of papaya. The experiment was located at a site on a grower's property where *P. palmivora* had been recovered from papaya plants severely affected with root rot.

Methods

Site description and experimental design

The experiment was established on 13 January 1997 in a kraznozem soil on a commercial papaya property at Innisfail, Queensland, Australia. The experiment was set up as a split/split plot in a randomised complete block design. There were

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Edited by André Drenth and David I. Guest
ACIAR Monograph 114
(printed version published in 2004)

three replicates each with two whole plots to which the mounding/flat ground treatments were applied. Each whole plot was divided into 3 subplots to which the cover treatments (1) plastic mulch, (2) organic mulch or (3) nil cover were applied. Each subplot was then divided into 2 sub-subplots where (a) metalaxyl or (b) a nil treatment was applied. There were 10 datum plants and 2 guard plants per sub-subplot.

Treatment application

On the 8 January 1997 the experimental site was deep-ripped and rotary-hoed, and mounds (0.75 m high), each 1.5 m wide and 18 m long, were formed in the appropriate plots. Metalaxyl (Ridomil, 50 g/kg) treatments were broadcast evenly on the surface of the beds and lightly raked into the soil just before the application of the soil-surface mulches. Plots treated with organic mulch were covered to a depth of 7.5 cm with composted shredded tree bark obtained from the local council waste depot. The plastic mulch treatments (Table 7.3.1), consisting of 2 m wide black plastic sheets, were laid and then painted white to prevent sunscald damage to the newly planted seedlings.

Plant establishment

Eight-week-old papaya seedlings (Hybrid 29) were transplanted from pasteurised potting mix into flat beds in the experimental area on 13 January 1997. Plants were thinned to 1 per position at flowering when the sex of the plant could be determined. Plants were irrigated as required using dripper lines positioned either side of the planting line. All plots received a basal fertiliser application of Crop King 55® (13.2% N, 14.7% P, 12.3% K, 1.5% S), and superphosphate (8.8% P, 20% Ca, 11% S), at rates of 55 and 110 kg/ha, respectively, and dolomite (16.5% $CaCO_3$ and 10% $MgCO_3$) at 1100 kg/ha, and two applications of urea (39 kg/ha) through the irrigation system during the growing of the crop.

Data collection

Plant heights (cm) were recorded at 8, 13 and 17 weeks after transplanting. Plant infection counts were recorded as plants showed symptoms of wilting resulting from the decay of the taproot. Diseased plants were cut at ground level and moved to the inter-row. Samples of diseased roots and stems were obtained from each root-rot-affected plant to identify the causal organism. Sections of diseased roots and stems were surface sterilised in 70% ethanol for 1 minute, blotted dry with sterile paper then transferred to PDA plus 50 mg/L streptomycin sulfate, and the *Phytophthora* selective medium P_{10}ARP+H (Jeffers and Martin 1986). On 6 November, fruit with a diameter greater than 7.0 cm was harvested and the total fruit number and total fruit weight per plot assessed.

Results

Some seedlings died within 1–2 weeks of transplanting. *Rhizoctonia solani* was recovered from basal stem lesions on a few plants using PDA plus streptomycin sulfate culture medium, but the cause of most plant deaths was most likely due to physical damage to the taproot at transplanting. Planting sites where all plants had died were replanted within 4 weeks of the initial transplanting.

By 11 March, there were quantitative differences in plant growth between treatments (Table 7.3.1). Assessments conducted on 11 March and 22 April showed a significant mound × soil cover interaction, with the height of plants grown on flat ground with organic mulch significantly reduced ($P < 0.05$) compared with all other treatments. The pre-plant application of metalaxyl had no effect on plant growth ($P > 0.05$) except in the assessment conducted

Table 7.3.1 Plant heights of papaya grown on mounds or flat ground, with organic and plastic mulches.

Treatment	Plant height (cm)[a]		
	11 March	22 April	20 May
Mound/plastic mulch	78.0 a	119.0 ab	176.0 a
Mound/organic mulch	67.0 a	95.0 c	142.0 abcd
Mound/bare soil	88.0 a	107.0 abc	137.0 bcd
Flat/plastic mulch	68.0 a	109.0 abc	161.0 ab
Flat/organic mulch	46.0 b	65.0 d	101.0 e
Flat/bare soil	73.0 a	88.0 c	108.0 de

[a] Means in the same column followed by the same letter are not significantly different ($P > 0.05$).

on 22 April, where the chemical improved plant growth ($P < 0.05$) when applied to mounded soil with organic mulch. In this assessment, plant heights were 123 cm in mounded plots treated with organic mulch and metalaxyl, compared with 95 cm in mounded plots with organic mulch alone. The final assessment, conducted on 20 May, showed a significant mound × soil cover interaction, with a significant increase in plant height ($P < 0.05$) in mounded plots with both organic and plastic mulch compared with mounded plots with bare soil. Plants grown on mounds with and without mulches, and on flat ground with plastic mulch, were taller ($P < 0.05$) than plants grown on flat ground with organic mulch or bare soil.

At the conclusion of the experiment, the use of mounds was shown to be very effective at reducing the incidence of root rot (Figure 7.3.1). The percentage of plants with root rot was significantly greater ($P < 0.05$) in plots where plants were grown on flat ground with either organic mulch or bare soil compared with plants grown on mounds. There was no difference in survival ($P > 0.05$) between plants grown on flat ground with plastic mulch and plants grown on mounds. The pre-plant application of metalaxyl granules had no effect ($P > 0.05$) on reducing the incidence of root rot. *Phytophthora palmivora* was recovered from all root rot affected plants.

Larger, more mature fruit was obtained from larger, more vigorous plants, and fruit weight varied across the various treatments (Figure 7.3.2). Significantly heavier ($P < 0.05$) fruits were harvested from plants grown on mounds, and on flat ground with plastic mulch, than from plants grown on flat ground with organic mulch or bare soil. The highest yield was obtained from plants grown on mounds with plastic mulch.

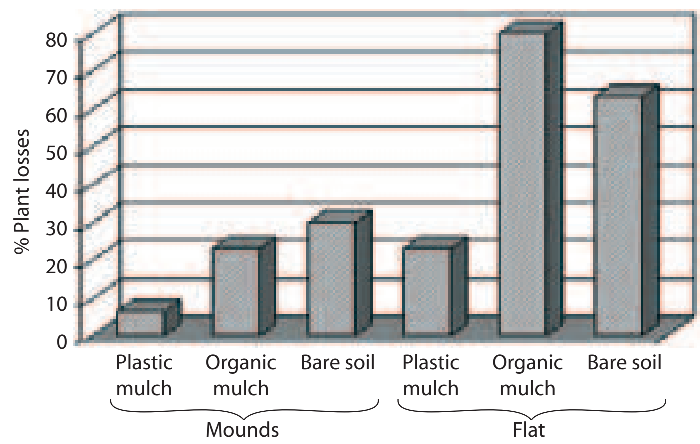

Figure 7.3.1 Effect of growing papaya on mounds or flat ground with or without organic or plastic mulches, on the incidence of phytophthora root rot and plant losses.

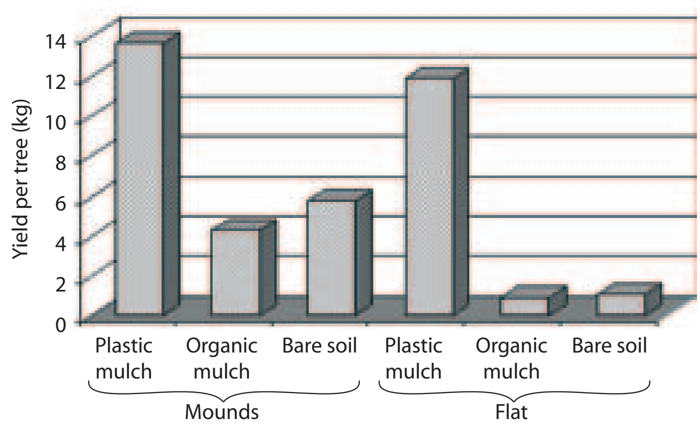

Figure 7.3.2 Effect on yield of growing papaya on mounds or flat ground with or without organic or plastic mulches.

Discussion

In field situations where a soil-borne disease is well established, growers are generally encouraged to create a growing environment that is favourable for the host and less favourable for the pathogen. The persistence of free water in the soil has a major influence on the development of phytophthora-related disease as it favours the increase in *Phytophthora* populations (Duniway 1979). Therefore, optimising vertical drainage should effectively reduce the period of soil saturation and subsequent damage due to disease (Duniway 1983). The use of mounds in our field experiment achieved this result by reducing plant losses due to root rot and substantially increasing fruit yield.

Wide plastic mulch also reduced plant losses and increased fruit yield in both mounded and non-mounded plantings. This result was most likely due to reduced water infiltration into the soil rather than solarisation, as the plastic was painted white before transplanting, and the predominantly overcast conditions at that time of year would have reduced the heating effect. However, the cost of purchasing and laying plastic mulch, and environmental concerns about its disposal, are likely to prohibit its use. The use of shredded tree bark as organic mulch caused severe plant losses due to root rot, and substantially reduced fruit yield in all but mounded plots. This result was most likely due to increased soil moisture retention and the positive influence this has on increasing disease development (Vawdrey et al. 2002). Other types of organic mulch may be more effective, for example some types of bark suppress *Phytophthora,* while leaf litter, straws and manures may improve drainage as well as suppress the pathogen (Konam and Guest 2002; Ribeiro and Linderman 1991). Future research will evaluate the integration of single row mounds and foliar applications of potassium phosphonate for the management of phytophthora root rot of papaya.

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ACIAR Monograph 114
(printed version published in 2004)