J. Trop. Agric. and Fd. Sc. 32(2)(2004): 257–269

Wood decomposition by the 'cord-forming' fungus *Resinicium bicolor:* interactive effect of home base size and quality with its surrounding soil composition

(Pereputan kayu oleh kulat 'bebenang' *Resinicium bicolor*: kesan saling tindak kualiti dan saiz 'home base' dengan komposisi tanah persekitarannya)

Z. Abd Jamil* and L. Boddy**

Key words: wood decomposition, *Resinicium bicolor,* home base size, home base quality, soil composition, cord-formers, soil carbon

Abstract

Wood decomposition by the wood rotting basidiomycete fungus *Resinicium bicolor* as affected by the wood block size itself (home base), its quality and surrounding soil composition, and their interactive effects were investigated in 24 cm x 24 cm soil tray microcosms. Home base relative decay rate (mg/g/d), final percentage of weight loss and mycelial days to regression were not affected by home base size. Exception was when the home base was very small, ranging from 0.5–2.0 cm^3 (as compared to 4–16 cm^3) where the relative decay rate and percentage of weight loss decreased with increase in home base size.

The absolute decay rate (mg/d) of home base was linearly increased with increasing home base size. Home base quality did not affect its relative decay rate, percentage of weight loss and days to mycelial regression. Soil composition greatly influenced wood decomposition. Increased in soil carbon markedly increased the home base relative decay rate and final percentage of weight loss, and reduced mycelial days to regression. There was no significant interactive effect between home base quality and soil composition. Relationship between home base wood decomposition with mycelial biomass and foraging morphology was discussed.

Introduction

Dead wood litter, which represents 30–40% of the total forest ecosystem (Boddy and Watkinson 1995) must be decomposed before the nutrients contained within are gradually released and made available to plants.

The time required to decompose wood can be very long. Wood decay rate depends on many factors including microclimate, wood type and size, decay organisms and species involved (Yoneda 1985; Rayner and Boddy 1988). Wood types containing simple carbon compounds are easy to decompose; cellulose and hemicellulose are moderately difficult, while those containing lignin are difficult to decompose (Rayner and Boddy 1988).

When inhabiting food resources, certain fungi may be classified as 'resource

*Strategic Resources Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
**Cardiff School of Biosciences, Cardiff University, P.O. Box 915, Cardiff CF10 3TL, UK
Authors' full names: Abd Jamil Zakaria and Lynne Boddy
E-mail: zajamil@mardi.my

unit restricted' or 'non-resource unit restricted', reflecting whether or not they can grow out of the food resource in search of new ones (Rayner et al. 1985). *Resinicium bicolor,* a basidiomycete white rot wood decomposer belongs to the 'non-resource unit restricted category'; as they consume the resource they inhabit and then exit the resource to explore the surroundings with their mycelia, to search, locate and colonise suitable new food resources. The outward mycelium growth is supported by food reserves from the original source (also commonly referred as home base).

The morphology of the foraging mycelium and its exploratory pattern varies greatly with species and its adaptability to utilise available resource. In species such as *Phanerochaete* spp., *Phallus* spp., *Mutinus* spp. and *R. bicolor,* the mycelia aggregate into structures termed 'cords'. Although some authors argued that these mycelia aggregate should be called 'rhizormorphs' (Cairney et al. 1992), but many preferred the term 'mycelial cord' or just 'cord' (Thompson and Rayner 1982; Boddy 1984). The ability of many of these fungi to form mycelial cord provides them with an effective mechanism to explore the surroundings even through unfavourable environments, and with greater invasive capability to capture new resources (Thompson 1984; Boddy 1993; Holmer and Stenlid 1993). These fungi have been observed connecting discrete resources many centimetres or even metres away depending on species (Thompson and Rayner 1982, 1983). Additionally, during decomposition processes these cord formers are also able to spatially relocate nutrients from one resource to another (Wells et al. 1990; Hughes and Boddy 1994).

In temperate climate, cord-forming basiodiomycetes are particularly abundant on the floor of deciduous woodlands and less common in coniferous forest plantations. However, in central Sweden, *R. bicolor* is one of the most frequent cord forming fungi colonisers of spruce stumps besides *Armillaria borealis, Coniophora arida* and *Hypholoma capnoides* (Kirby et al. 1990). In Malaysia, the author has observed mycelial cords of unidentified fungi inhabiting dead wood in orchards and forest floors.

It was generally recognised in the many previous studies (Dowson et al. 1986; Bolton 1993; Wells and Boddy 1995) that cord formers regulate their foraging morphology depending on the availability and characteristics of resources available both inside and outside the home base. The foraging strategy adopted was to efficiently utilise available energy in home base to locate and colonise encountered resources.

The effect of these foraging strategies and the resultant decomposition of the home base wood resources were unclear, and previous findings were not consistent and often contradictory. For example, earlier studies (Dowson et al. 1989) reported that when foraging system encountered new resources, it caused decrease in decay rate of home base. However, in later studies it was reported to increase decay rate of home base (Abdalla and Boddy 1996) or there was no significant difference (Donnelly and Boddy 1997).

When foraging mycelial systems extending from a single home base encounter new resources, the mycelial systems respond by relocation of biomass. There were thickening of cords interconnecting resources and recession of the non-connective cords. The intensity of the polarity being increased with increasing size of the newly encountered resources (Dowson et al. 1986; Bolton 1993; Wells et al. 1998).

Attempts made to establish correlations between home base decay rate with the mycelial foraging morphology only revealed slight indication of positive correlation between mycelial extension rate and decay rate (Dowson et al. 1989). No correlation of other parameters was found suggesting that the metabolic pathways between mycelial growth and decay rate were not similar. The

inconsistency and lack of correlation in the earlier findings on decay rates suggest the necessity for re-evaluation.

It has been shown that the percentage weight losses of home base after being decomposed in the previous studies have been mostly less than 40% (Dowson et al. 1989; Abdalla and Boddy 1996). These weight losses were low considering the fact that basidiomycete cord formers are efficient decomposers. This suggests that the foraging duration in the previous studies might have been too short or the foraging space allocated was too small. Microcosms used in the previous studies often consisted of small and narrow compartments of sizes 1.5 cm x 54 cm (Wells and Boddy 1995), 20 cm x 3 cm cylindrical tubes (Dowson et al. 1989) and circular 14 cm diameter dishes (Donnelly and Boddy 1997) and the systems were allowed to grow for not more than 70 days. Yet, it has been shown that the cord formers extended radially from the home base (Dowson et al. 1986) and the amount of carbon in the soil influences foraging pattern and home base weight loss (Abdalla and Boddy 1996).

The present study was conducted to appraise the decomposition attributes of home base wood block in relation to its internal and external resource factors. The experiments were designed in bigger laboratory soil microcosms incorporating two factors at a time, such that evaluation of the main and interaction factors effects could be simultaneously studied. Systems were allowed to forage until the mycelia finally regressed thus allowing the evaluation of the mycelial sustainability, decay rates and maximum weight loss of wood blocks.

Materials and methods

Fungal species

The basidiomycete fungus, *R. bicolor* used in these studies was from the laboratory cultured stock of the University of Aberdeen, United Kingdom. The fungus was originally isolated from Scots pine (*Pinus sylvestris*) wood. The isolate was maintained by routinely sub-culturing every 3–4 months on 2% malt agar (MA) (20 g/litre spray malt and 15 g/litre Lab M agar No 2) in 9 cm diameter non-vented plastic petri dishes and incubating at 15 ± 1 °C. Upon usage 10 pieces of malt agar of size 5 x 5 mm containing the mycelia were aseptically cut and placed into a 2-litre conical flask initially filled with 500 mL WA (experiment 1) or MA (experiment 2).

Preparation of wood block home base

Wood blocks were prepared from a freshly felled tree, sawn into small blocks and stored at –18 °C. Before use the blocks were soaked overnight in deionised water, autoclaved at 121 °C for 20 min and reautoclaved after 24 h. These blocks were then inoculated with *R. bicolor* in 2-litre conical flask pre-inoculated earlier with the fungus. The inoculation was achieved by adding the wood blocks aseptically into the 2-litre flask and incubated for 3 or 9 months on MA or WA respectively. Blocks were scraped free of adhering mycelium before adding onto soil trays. Samples of 10 wood blocks were randomly selected, dimensions measured, dried, weighed and used to determine density (g/cm^3) (Rayner and Boddy 1998) as a measure of decay status at the beginning of the experiment *(Table 1)*.

Soil tray microcosms

Microcosms comprising 24 x 24 cm lidded Perspex trays containing a mixture of soil, sand and water were employed. Sandy loam topsoil collected from mixed deciduous woodland in Tintern, United Kingdom was air dried and sieved through 3 mm mesh to remove stones and debris. The fine river sand was washed with tap water to eliminate any clay or loam particles, oven dried overnight at 200 °C and sieved through 2 mm mesh. The soil and sand were temporarily stored in a covered bin at room temperature prior to usage. Upon usage, the soil was frozen overnight at –18 °C to kill *Collembola* spp. (Hughes 1993). The sand,

Table 1. Relative density of home base wood blocks

Expt.	Home base blocks	Density (g/cm$^{3)}$
1	0.5, 2, 8 cm^3	0.45a
1	4, 16 cm^3	0.42b
2	WA 3 months	0.58a
2	WA 12 months	0.52b
2	MA 3 months	0.59a
2	MA 12 months	0.52b

WA = water agar; MA = malt agar
Values with the same letters in the same column, within an experiment, were not significantly different (Tukey p >0.05)

soil and sawdust (when added) were thoroughly mixed manually before adding pre-determined amounts of deionised water to set the water potential at –0.006 MPa, determined by the filter paper method (Fawcett and Collis-George 1967; Hamblin 1981). About 400 g (oven dry weight equivalent) of the mixture was added to each tray and the surface compacted to about 5 mm thickness.

Experiment 1: Effect of home base size and soil composition on mycelial sustainability and home base decomposition

Five rectangular Scots pine blocks of sizes 0.5, 2.0, 4.0, 8.0 and 16.0 cm^3 were used as home base resources *(Table 1)*. The blocks were pre-inoculated with *R. bicolor* by adding to the fungus cultures growing on water agar (WA) media (7.5 g Beta Laboratory agar dissolved in 500 mL water). Soils of six different compositions were used *(Table 2):* (1) ashed soil (furnaced at 450 °C for 5 h) plus 50% sand (oven dry weight); (2) soil plus 75% sand; (3) soil plus 50% sand; (4) soil plus 25% sand; (5) soil + 0% sand and (6) soil plus 50% sand and 2 g sawdust.

The six soil compositions and five sizes of blocks were factorially combined giving 30 treatment combinations and the experiment replicated six times. A well-colonised wood block was placed centrally in each tray, covered with the lid and the individual tray weight was recorded. The trays were randomly stacked to prevent evaporative water losses and incubated at 15 ± 1 °C in darkness.

Experiment 2: Effect of home base quality and soil composition on mycelial sustainability and home base decomposition

Four wood block home base qualities were prepared by inoculating beech (*Fagus sylvatica*) wood blocks (2 x 2 x 1 cm) on water agar (WA) or malt agar (MA) for 3 or 12 months *(Table 1)*. Soils with five carbon statuses were used *(Table 2):* (1) ashed soil; (2) unamended soil; (3) soil plus 2 g sawdust; (4) soil plus 4 g sawdust; (5) soil plus 6 g sawdust. To all soils, 50% fine river sand (oven dry weight) was added as the first experiment indicated that *R. bicolor* grew optimally on this mixture.

The four home base wood blocks and five soils of different compositions were factorially combined giving 20 treatments and the experiment replicated 5 times. Similar to experiment 1, a well-colonised wood block (block well covered with mycelia) was placed centrally in each tray, covered with the lid and the individual tray weight was recorded. The trays were randomly stacked to prevent evaporative losses and incubated at 15 ± 1 °C in darkness.

Microcosms maintenance and decomposition data collection

Systems were inspected every 2 weeks until the mycelia had fully regressed. Water lost from the systems were replaced every 4–6 weeks based on weight difference and was approximately 2–5 mL/4–6 weeks. When the mycelia had completely regressed, the days to mycelial regress were recorded, the wood blocks were harvested, oven dried at 80 °C for 48 h and dry weight obtained. From these basic data, estimates of the absolute decay rate, relative decay rate and percentage of weight loss were made. The routine maintenance and data recorded for both experiments were similar.

Table 2. Soil pH and combustible carbon composition (%) of soils used

Expt.		Treatment	pH	Carbon (%)
1	Scots pine	Ashed soil	6.2a	0.0a
1	Scots pine	75% sand	4.7b	2.0b
1	Scots pine	50% sand	4.6c	3.7c
1	Scots pine	25% sand	4.4c	5.7d
1	Scots pine	0% sand	4.3d	7.4e
1	Scots pine	50% sand + 2 g sawdust	4.4c	4.1c
2	Beech	Ashed soil	6.0a	0.0a
2	Beech	50% sand	4.8b	3.4b
2	Beech	50% sand + 2 g sawdust	4.8b	3.9b
2	Beech	50% sand + 4 g sawdust	4.8b	4.7d
2	Beech	50% sand + 6 g sawdust	4.8b	5.1e

Values with the same letters in the same column, within an experiment, were not significantly different (Tukey $p > 0.05$)

Absolute decay rate (mg/d) was estimated from the difference in oven dry weight at the beginning and end of experiment per unit time until regression was completed, while relative decay rate (mg/g/d) was obtained from the absolute decay rate per unit home base initial weight. The weight at the beginning was estimated from the relative density sample blocks, (as mentioned in previous section - oven dry weight per fresh volume) while the weight at the end of experiment was the actual oven dry weight. Percentage of weight loss was calculated from absolute decay rate per unit original home base weight.

Statistical analysis

Data were checked for homogeneity of variance and normality of residuals using Bartlett's test and Anderson-Darling test respectively and non-homogenous data were transformed before analysis. Due to missing values, most of the test employs General Linear Model ANOVA (Fry 1993). Significant ANOVA tests were followed with multiple comparisons of means using Tukey test. Both main and interaction data were determined; the latter was plotted to better interpret the effect.

Results

Mycelial regression started with lysis of growing apices and smaller branches. The bigger cords were more persistent and were the last to regress. Advanced regression was recognised by fading of the white cord colour and lyses at intervals along the cord. The mycelia adjacent to the home base were normally the last to lyse. Well-decomposed home base blocks appeared shrunken and soft to touch while those less decomposed were harder with the original size less altered.

Experiment 1: Effect of home base size and soil composition on mycelial sustainability and home base decomposition

Main effect of wood block size The main effects of block sizes were highly significant on home base relative decay rate ($p < 0.001$), percentage of weight loss *(*$p < 0.001$) and absolute decay rate ($p < 0.001$, $\log_{10}$ transformation) *(Figures 1a,d* and *2a).* The effect on days to mycelial regression was not significant ($p > 0.05$) *(Figure 2d).*

There was a decrease in relative decay rate with increase in block size from 0.5– 4.0 cm^3. The relative decay rate of the smallest block 0.5 cm^3 (1.12 mg/g/d) was 90% faster (Tukey $p < 0.001$) than that of 4.0 cm^3 (0.59 mg/g/d) but the latter was not significantly different from the 16 cm^3 *(Figure 1a).* The block percentage of weight loss showed a similar trend to that of relative decay rate *(Figure 1b).* Highest percentage of weight loss ($p < 0.001$) was

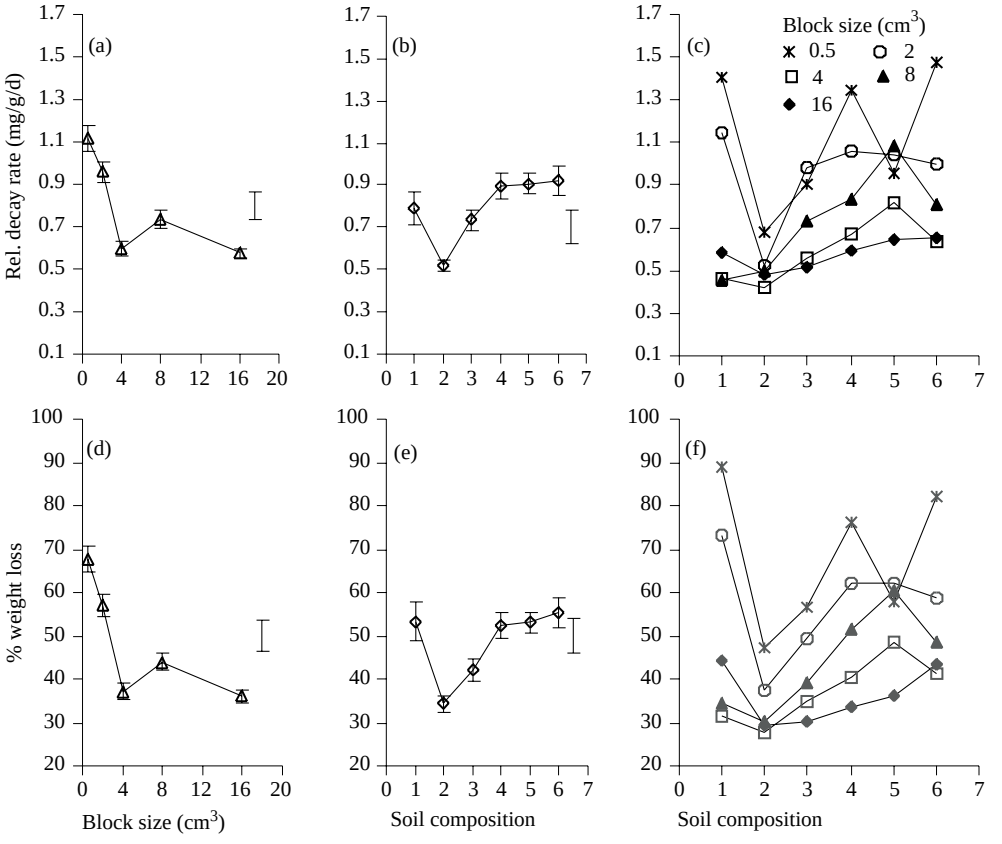

Figure 1. Main effect of home base block size on relative decay rate (a) and % weight loss (d); main effect of soil composition on relative decay rate (b) and % weight loss (e). Bars on points indicate ± SEM and bar off-point MSD values at ***p*** *<0.01. Home base size x soil composition interaction effect on relative decay rate (c) and % weight loss (f). Soil composition labels on X-axis represent (1) ashed soil, (2) soil + 75% sand, (3) soil + 50% sand, (4) soil + 25% sand (5) soil + 0% sand and (6) soil + 50% sand + 2 g sawdust*

obtained with the smallest block 0.5 cm^3 (67.6 %) and drastically decreased with increase in block size until 4.0 cm^3 (37.2%).

The increase in each block size from 0.5–16 cm^3 significantly (Tukey p <0.001) increased absolute decay rate *(Figure 2a).* The increment trend was linear (p <0.001) with the estimated absolute decay rate increase of 0.225 mg/d per cm^3 increase in block size.

Main effect of soil composition The main effects of soil compositions on all the variables studied were highly significant: block relative decay rate (p <0.001), percentage of weight loss (p <0.001), absolute decay rate (p <0.001, $\log_{10}$ transformation), and days to regression (p <0.001) *(Figures 1be* and *2b,e)*

The relative decay rate was slowest in the system with the most added sand (75%) (0.52 mg/g/d) and significantly (Tukey p <0.001) increased with 50% sand (0.74 mg/g/d) and 25% sand (0.90 mg/g/d). The latter was not significantly different from 0% sand (0.91 mg/g/d) or sawdust added (0.93 mg/g/d) or ashed soil *(Figure 1b).*

Similar trend was obtained with percentage of weight loss. The least percentage of weight loss (Tukey p < 0.01) was in the systems developing on soil with 75% sand (34.3%) followed by 50% sand

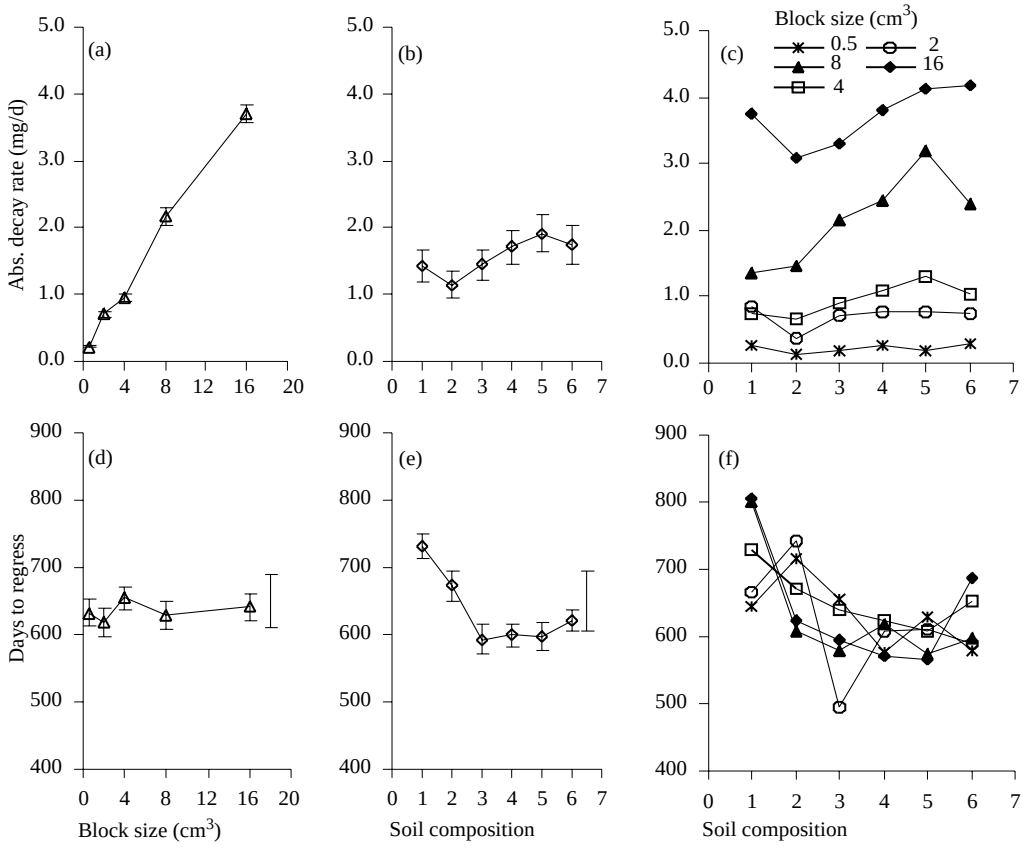

Figure 2. Main effect of home base block size on absolute decay rate (a) and days to regression (d); main effect of soil composition on absolute decay rate (b) and days to regression (e). Bars on points indicate ± SEM and bar off-point MSD values at ***p*** *<0.01. Home base size x soil composition interaction effect on absolute decay rate (c) and days to regression (f). Soil composition labels on X-axis represent (1) ashed soil, (2) soil + 75% sand, (3) soil + 50% sand, (4) soil + 25% sand (5) soil + 0% sand and (6) soil + 50% sand + 2 g sawdust*

(42.0%). The percentages of weight loss among the systems [developing on soils which were ashed (53.3%), 25% added sand (52.4%), 0% added sand (52.9%) and soil with added saw dust (55.3%)] were not significantly different *(Figure 1e)*.

Significantly slower absolute decay rate (Tukey p <0.001) occurred in systems developing on soil containing 75% sand (1.15 mg/d), ashed soil (1.43 mg/d) and 50% sand (1.45 mg/d) as compared to those systems developing on 25% added sand (1.71 mg/d), 0% sand (1.91 mg/d) and soil with sawdust (1.75 mg/d) *(Figure 2b)*.

System developing on ashed soil were sustained significantly longer (732 d) (Tukey p <0.001) than those containing 50% sand (592 d), 25% sand (599 d), unamended soil (597 d) or sawdust (622 d), but was not significantly different from the system containing 75% sand (673 d) *(Figure 2e)*.

Interaction effect of block size and soil composition The block size x soil composition interaction effects were highly significant on relative decay rate (p <0.001) *(Figure 1c)*, percentage of weight loss (p <0.001) *(Figure 1f)* absolute decay rate (p <0.001, $\log_{10}$ transformation) (*Figure 2c*), but not significant on days to regression (p <0.05) *(Figure 2f)*.

The trend of the increase in relative decay rate with decreasing percentages of added sand or with the addition of saw dust (thus increasing soil carbon) were more dramatic with smaller block sizes, especially 0.5 cm^3, but less remarkable with the bigger inocula especially 16 cm^3 *(Figure 1c).* Blocks in 75% sand all showed low relative decay rate. However, when the soil was ashed there was marked increased in relative decay rate in small blocks (0.5, 2.0 cm^3), but only slight increase with bigger blocks *(Figure 1c).*

Similar trend was observed with percentage of weight loss. The weight losses of small inocula (0.5 and 2.0 cm^3) were very high when systems developed in ashed soil, but were drastically reduced when developed in soil with 75% sand. In contrast, the percentage of weight loss of bigger inocula in ashed soil was relatively low and only slightly decreased when developed in the soil with 75% sand *(Figure 1f).*

Big block sizes (8,16 cm^3) exhibited increase in absolute decay rates with decrease in added sand, but contrastingly with small block sizes the absolute decay rates were not altered by decrease in added sand *(Figure 2c).*

Experiment 2: Effect of home base quality and soil composition on mycelial sustainability and home base decomposition

Main effect of block quality The main effects of block quality on relative decay rate, percentage of weight loss and days to regression were all not significant ($p > 0.05$) *(Figures 3a,d,g).*

Main effect of soil composition The main effects of soil composition on relative decay rate, percentage of weight loss and days to regression (1/x transformation) were all highly significant ($p < 0.001$) *(Figures 3b,e,h).*

There was a trend of increase in relative decay rate with increased in added sawdust *(Figure 3b).* The fastest decay rate was produced by the block in the system developing on soil with 6 g sawdust (2.91 mg/g/d), which was about three fold faster (Tukey $p < 0.001$) than those on ashed soil (0.90 mg/g/d) or unamended soil (1.04 mg/g/d). On soil with 2 g sawdust, the decay rate (2.54 mg/g/d) was significantly faster (Tukey $p < 0.001$) than that on ashed soil or unamended soil, but significantly slower (Tukey $p < 0.001$) than that on soil with 6 g sawdust.

The weight loss on ashed soil (59.2%) and on unamended soil (56.5%) was not significantly different from each other, but both were significantly lower than those on soils with added sawdust (83.3%, 89.4% and 90.8% for 2, 4, 6 g sawdust respectively) *(Figure 3e).*

The mycelial system developing on ashed soil was sustained (692.5 d) significantly longer (Tukey $p < 0.001$) than that on unamended soil (565.0 d) and more than two fold longer than that on soil containing 2, 4 or 6 g sawdust. The days to regression among the soils with 2, 4, 6 g sawdust (328.4, 333.0, and 313.2 d respectively) were not significantly different, but were significantly shorter than those on unamended soil *(Figure 3h).*

Interaction effect of block quality and soil composition The block quality x soil composition interaction effects on relative decay rate, percentage of weight loss and days to regression were not significant ($p > 0.05$*) (Figures 3c,f,i).*

Discussion

This is the first study to determine mycelial sustainability of wood blocks in laboratory microcosms and to relate it to decomposition. *Resinicium bicolor* has been categorised as a long range forager since it produces mycelial cords which are fast extending, long and infrequently branching (Boddy 1993, 1999; Abd Jamil and Boddy 2002).

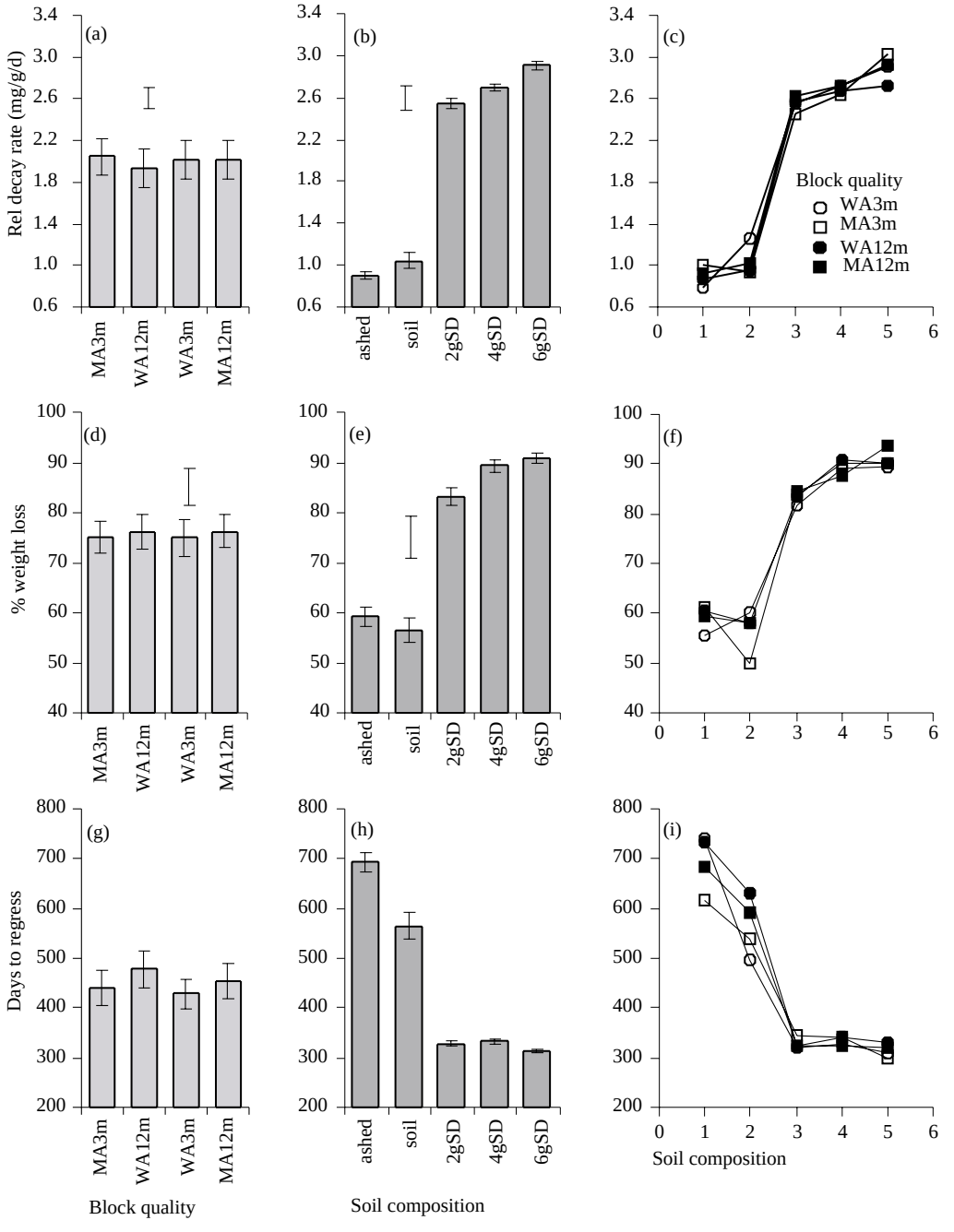

Figure 3. Main effect of home base quality on relative decay rate (a), % weight loss (d) and days to regression (g); main effect of soil composition on relative decay rate (b), % weight loss (e) and days to regression (h). Bars on point indicate ± SEM and bar off-point indicate minimum significant difference (MSD) values at p <0.01. Home base quality-soil composition interaction plots on relative decay rate (c), % weight loss (f) and days to regression (i). Soil composition labels on X-axis represent (1) ashed soil, (2) soil, (3) soil + 2 g sawdust, (4) soil + 4 g sawdust and (5) soil + 6 g sawdust

The decomposition of the wood home base from which the mycelial cord system developed, was presently found to be affected by both the intra- and extra-resource attributes. This was expected since carbon and nutrients can be translocated from the home base to the growing apices (Wells and Boddy 1995; Wells et al. 1999). It is interesting to note that there was no significant interaction between both the home base quality and home base size with the soil composition on the variables studied, indicating that home base of different quality and sizes behave similarly in response to differences in the soil composition. Exception was when the home base was very small (0.5–2 cm^3).

The present study also investigated the percentage of weight loss as an additional indicator of decomposition because a slow decay rate can result in high percentage of weight loss if the system is sustained longer. Many previous studies did not include percentage of weight loss as an indicator of wood decomposition.

The size and quality of home base have been previously found to markedly affect foraging morphology and biomass (Wells and Boddy 1995; Donelly and Boddy 1997; Abd. Jamil and Boddy 2002), but presently found to be not directly affecting mycelial sustainability of *R. bicolor*. The fungus was probably very efficient in regulating their foraging morphology and utilising available energy within home base to maximise survivality. Thus, systems developing from small home base resource probably achieved this by (1) production of relatively lesser biomass, which was achieved by the sparse mycelial distribution, thin cords or reduced extension rate and (2) maximum utilisation of carbon resource available in the home base as evidenced from the high percentage of weight loss found in the present study.

Similarly low quality home base obtained here by incubating wood blocks in water agar were able to conserve the home base energy by producing 50% less biomass than those incubated in malt agar. Details of foraging morphology in relation to home base size and quality have been previously described (Abd. Jamil and Boddy 2002). Thus, whatever the internal quality of the home bases, the fungus would strategise to increase longevity and increase its chance in space and time to encounter new food resources.

The presence of external food resources when encountered by the foraging apices of many cord formers were previously found to markedly alter the foraging morphology (Dowson et al. 1989; Abdalla and Boddy 1996; Abd. Jamil and Boddy 2002) and was shown in the present study to greatly affect days to mycelial regression and relative decay rate of home base. It was found in experiment 1 and especially in experiment 2 that increasing the amount of small homogeneously distributed carbon resources (added sawdust) in the soil increased the relative decay rate of home base and probably led to decrease in days to mycelial regression.

This study substantiates those earlier findings by Abdalla and Boddy (1996) that encountering new resource increases block decay rate. Colonisation of newly encountered resources probably requires more energy, which must be drawn from the home base, thus speeding its relative decay rate. The present study indicated that the effect of increased soil carbon also simultaneously increased the home base percentage of weight loss, thus indicating fast exhaustion of resources from the home base.

As was similarly found in a previous study (Wells and Boddy 1995), the absolute decay rate of the home base increased with increasing home base size. However, in the present study the relationship was linear, but in the previous study the biggest block (8 or 16 cm^3) tend to be decayed relatively slower than smaller home base. This difference might be due to the relatively short duration (about 65 d) and small area (circular 14 cm Petri plates) the systems were allowed to forage in the previous studies.

Foraging mycelial biomass have been shown to increase with increasing home base size (Bolton 1993; Wells and Boddy 1995; Donnelly and Boddy 1997; Abd. Jamil and Boddy 2002). Big home base probably requires more energy to maintain the extensive foraging biomass produced. This energy must be extracted from the home base (Wells and Boddy 1995), thus leading to the observed rapid absolute decay rate of the bigger home base resources as compared to smaller home base resources. Under this condition, when there was no influence from the surrounding soil carbon, the absolute decay rate was proportional to mycelial biomass produced. This also explains why the relative decay rate, which is the absolute decay rate per unit home base weight was constant with the increase in home base size (except small size) obtained in the present study.

Small home base sizes (example 0.5–2.0 cm^3) probably adopted different foraging strategy from big home base resources as indicated by the significant interaction results produced. Although the foraging system is sparse, the biomass of system developing from small inocula per unit size is relatively greater than the big inocula (4–16 cm^3) (Wells and Boddy 1995; Abd. Jamil and Boddy 2002). This is probably a strategy to find new food resources within the fastest time. This creates relatively more energy demand in the smaller (0.5–2.0 cm^3) than bigger home base (4–16 cm^3), thus leading to faster relative decay rate of the former as presently found. The critical size of home base seemed to be smaller than 4 cm^3 as the relative decay rates and percentages of weight loss of those between 4–16 cm^3 were found to be not significantly different.

The ratio of carbon in soil:home base is probably another important factor influencing wood decomposition where high soil carbon resulted in faster decay rate. It was obvious in experiment 1 that with increasing soil carbon, the relative decay rate of small home bases 0.5–2 cm^3 was higher than those in big home bases (4–16 cm^3). Similarly in experiment 2 excessively high carbon in the surrounding soil (example addition of 4–6 g sawdust) have led to increased relative decay rate although the mycelial biomass was found to be low (Abd. Jamil and Boddy 2002). In these cases the relationships between relative decay rate with mycelial biomass were negative.

Conclusion

The home food-base decay rates, mycelial sustainability and final percentage of weight loss by *R. bicolor,* as determined when the mycelial system fully regressed, were greatly influenced by soil composition, but not by the home base quantity and quality.

Increase in home base size did not affect the relative decay rate (mg/g/d), final percentage of weight loss of home base and mycelial days to regression. However, was when the home base were very small, ranging from 0.5–2.0 cm^3, significant interaction indicated that small and big home bases respond differently to soil composition. The relative decay rate and percentage of weight loss of small home base decreased with the increase in home base size. The absolute decay rate of home base (mg/d) was linearly increased with increasing block size and this correlated positively with mycelial biomass.

The rate of wood decomposition was also not affected by home base quality, but was greatly influenced by soil composition. There were increased in relative decay rate, increased in final percentage of weight loss and reduced mycelial days to regression with the increase in soil carbon. The absence of significant interaction effect between home base quality and soil composition indicated that home base of different quality responded similarly to soils of different compositions. The results also suggested that the ratio of intra-resource carbon of home base:extra resource carbon is important in determining the rate of home base decomposition.

Acknowledgement

The authors would like to thank MARDI for the PhD studentship.

References

Abdalla, S.H.M. and Boddy, L. (1996). Effect of soil and litter type on outgrowth patterns of mycelial system of *Phanerochaete velutina*. *FEMS Microbiology Ecology* ***20:*** 195–204

Abd. Jamil, Z and Boddy, L. (2002) Mycelial Foraging by Resinicium bicolor: interactive effect of resource quantity, quality and soil carbon status. *FEMS Microbiology Ecology* ***40:*** 135–42

Boddy, L. (1984). The microenvironment of basidiomycete mycelia in temperate deciduous woodlands. In: *The ecology and physiology of the fungal mycelium*. (Jennings, D.H. and Rayner, A.D.M, ed.) p. 261–89. London: Cambridge University press

—— (1993). Saprotrophic cord-forming fungi: warfare strategies and other ecological aspects. *Mycological Research* ***97(6):*** 641–55

—— (1999). Saprotrophic cord-forming fungi: meeting the challenge of heterogeneous environment. *Mycologia* ***91:*** 13–32

Boddy, L, and Watkinson, S.C. (1995). Wood decomposition, higher fungi and their role in nutrient distribution. *Canadian Journal of Botany.* ***73 (Suppl 1):*** 1377–83

Bolton, R.G. (1993). Resource acquisition by migratory mycelial cord system of *Phanerochaete velutina* and *Hypholoma fasciculare* (Ph.D Thesis) 207 p. Cardiff: University of Wales

Cairney, J.W.G., Jennings, D.H. and Veltkamp, C.J. (1992). A scanning electron microscopestudy of the internal structure of mature linear organs of four basidiomycete species. *Canadian Journal of Botany* ***67:*** 2266–71

Donnelly, D.P. and Boddy, L. (1997). Resource acquisition by the mycelial cord-former *Stropharia caerulea:* effect of resource quantity and quality. *FEMS Microbiology Ecology* ***23:*** 195–205

Dowson, C.G., Boddy, L. and Rayner, A.D.M. (1989). Development and extension of mycelial cords in soil at different temperatures and moisture contents. *Mycological Research* ***92:*** 383–91

Dowson, C.G., Rayner A.D.M. and Boddy, L. (1986). Outgrowth pattern of mycelial cord-forming basidiomycetes from and between woody resource units in soil. *Journal of General Microbiology* ***132:*** 203–11

Fawcett, R.G. and Collis-George, N. (1967). A filter-paper method for determining the moisture characteristics of soil. *Australian Journal of Experimental Agriculture and Animal Husbandry* ***7:*** 162–7

Fry, J.C., ed. (1993). *Biological data analysis: A practical Approach.* Oxford: Oxford University Press

Hamblin, A.P. (1981). Filter-paper method for routine measurement of field water potential. *Journal of Hydrology* ***53:*** 355–60

Holmer, L. and Stenlid, J. (1993). The importance of block size for the competitive ability of wood decomposing fungi. *FEMS Microbiology Ecology* ***12:*** 169–76

Hughes, C.L. (1993). The uptake and allocation of phosphorus by model mycelial cord system of *Phanerochaete velutina*. Ph.D thesis. Cardiff: University of Wales

Hughes, C.L. and Boddy, L. (1994). Translocation of 32 P between wood resources recently colonised by mycelial cord system of Phanerochaete velutina. *FEMS Microbiology Ecology* ***14:*** 201–12

Kirby, J.J.H., Stenlid, J. and Holdenrieder, O. (1990). Population structure and response to disturbance of the basidiomycete *Resinicium bicolor*. *Oecologia* ***85:*** 175–84

Rayner, A.D.M., Powell, D.A., Thompson, W. and Jennings, D.H. (1985). Morphogeneis of vegetative organs. In: *Developmental Biology of Higher Fungi* (Moore, D., Casselton, L.A., Wood, D.A. and Frankland, J.C., ed.), p. 249–79. London: Cambridge University Press

Rayner A.D.M. and Boddy, L. (1988). In: *Fungal decomposition of wood: its biology and ecology*. Chichester: John Wiley International

—— (1998). *Techniques in microbial ecology* (Burlage, S.R., Atlas, R., Stahl, Geesey, D. and Sayler, G, ed.) p. 163–202. London: Oxford University Press

Thompson, W. and Rayner, A.D.M. (1982). Structure and development of mycelial cord systems of *Phanerochaete laevis* in soil. *Transactions of the British Mycological Society* ***78:*** 193–200

—— (1983). Extent, development and function of mycelial cord systems in soil. *Transactions of the British Mycological Society* ***81:*** 335–45

Thompson, W. (1984). Distribution, development and functioning of mycelial cord systems of decomposer Basidiomycetes of the deciduous woodland floor. In: *The Ecology and Physiology of the Fungal Mycelium* (Jennings, D.H. and Rayner, A.D.M., ed.) p.

185–214. London: Cambridge University Press

Wells, J.M. and Boddy, L. (1995). Translocation of soil-derived phosphorus in mycelial cord systems in relation to block resource size. *FEMS Microbiology Ecology* ***17:*** 67–75

Wells, J.M., Harris, M.J. and Boddy, L. (1998). Encounter with new resources causes polarized growth of the cord-forming basidiomycete *Phanerochaete velutina* on soil. *Microbial Ecology* ***36:*** 372–82

—— (1999). Dynamics of mycelial growth and phosphorus partitioning in developing *of Ecology* ***35:*** 57–66

mycelial cord systems of *Phanerochaete velutina*: dependence on carbon availability. *New Phytologist* ***142:*** 325–34

Wells, J.M., Hughes, C.L. and Boddy, L. (1990). The fate of soil-derived Phosphorous in mycelial cord systems of *Phanerocheate velutina* and *Phallus impudicus*. *New Phytologist* ***114:*** 595–606

Yoneda, T. (1985). Relation of wood diameter to the rate of dry weight loss and carbon dioxide evolution of wood litter in evergreen Oak Forest. Studies on the rate of decay of wood litter on the forest floor V. *Japanese Journal*

Abstrak

Pereputan kayu oleh sejenis kulat pereput kayu basidiomycete *Resinicium bicolor* yang diakibatkan oleh saiz ukuran kayu (home base), kualiti kayu dan komposisi tanah serta kesan saling tindak kedua-keduanya telah diselidiki dengan menggunakan dulang 'microcosm' berisi tanah berukuran 24 cm x 24 cm. Kadar pereputan relatif 'home base' (mg/g/d), peratus susut berat, dan bilangan hari sehingga regresi miselium tidak dipengaruhi oleh saiz 'home base'. Pengecualian adalah apabila 'home base' itu berukuran kecil, antara 0.5–2.0 cm^3 (berbanding dengan 4–16 cm^3) dengan pereputan relatif 'home base' dan peratus susut berat menurun dengan pertambahan saiz 'home base'.

Kadar pereputan 'absolute' (mg/d) 'home base' bertambah secara 'linear' dengan pertambahan saiz 'home base'. Kualiti 'home base' tidak mempengaruhi kadar pereputan relatif (mg/g/d), peratus susut berat, dan bilangan hari sehingga regresi miselium. Komposisi tanah banyak mempengaruhi pereputan kayu. Pertambahan karbon di dalam tanah mempercepat kadar pereputan relatif, peratus susut berat dan mengurangkan bilangan hari untuk regresi. Tiada kesan saling tindak yang bererti antara kualiti 'home base' dengan komposisi tanah. Pertalian antara kadar pereputan 'home base' dengan biomass dan morfologi menjalar miselium dibincangkan.

Accepted for publication on 16 June 2004