

DECOMPOSITION OF WEED TISSUES IN A PASTURE AND A MAIZE CROP : IMPLICATIONS FOR NUTRIENT CYCLING

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SUMMARY

A field study was conducted to investigate the decomposition rate and microbial activity of various crop and pasture weed tissues in order to determine their potential contribution to the nutrient cycle. Leaf tissue of four cropping and four pasture weed species was collected, air dried and placed in nylon mesh litterbags for assessment of litter decomposition in a sheep grazed pasture and a maize crop. All weed tissues decomposed rapidly, in part due to their high nitrogen content, and decomposition differences between species were not regulated by the microbial biomass on the tissues but rather by site factors. Because of their high nitrogen status and speed of decomposition, weed tissues may have potential in sustaining available soil nutrient levels under certain management systems.

Keywords: decomposition, weeds, microbial biomass, nutrient cycling.

INTRODUCTION

In agricultural systems there is the potential for high numbers of weeds to occur depending on the weed management strategies employed. In cropping systems weed populations that are too low to be economically controlled may in fact be beneficial to the soil system through improving the quality of soil organic matter (Wardle 1994). In some pasture systems a high proportion of litter returned to the soil also derives from weed species. Weedy tissues can decompose extremely rapidly (Wardle *et al.* 1994) and therefore they represent an important form of readily available organic matter.

The purpose of this study was to investigate the decomposition rate and microbial activity of various crop and pasture weed tissues in order to determine their potential contribution to the nutrient cycle in both a pasture and cropping situation.

METHODS

Green leaf tissue was collected from four cropping weed species [willow weed (*Polygonum persicaria*), twin cress (*Coronopus didymus*), black nightshade (*Solanum nigrum*) and fathen (*Chenopodium album*)] at the Rukuhia Horticultural Experimental Area (5 km from Hamilton) and four pasture weed species [nodding thistle (*Carduus nutans*), ragwort (*Senecio jacobaea*), oxeye daisy (*Leucanthemum vulgare*) and hairy buttercup (*Ranunculus sardous*)] from a dairy farm near Ohaupo (7 km from Hamilton). All tissues were collected during November 1993, air-dried at room temperature, and stored until required.

Litterbags (10 x 10 cm) were prepared from fibreglass-nylon material (1.0 mm mesh) and filled with 3 g (d.w.) of weed leaf tissue. Forty litterbags were prepared for each species to give five replicates for four sampling dates at two sites. The litterbags were placed at the field sites on 22 December 1993. The first site was a rotationally grazed sheep pasture at the Ruakura Agricultural Research Centre at Hamilton; litterbags were placed in small gaps between plants. The other site was in a maize crop established in mid October 1993 at the Rukuhia Horticultural Experimental area; here litterbags were placed within the crop rows. All litterbags were in direct contact with the soil surface and were held in position by small lengths of wire. The soil type present at both sites was a Horotiu silt loam.

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Subsequently, five replicate litterbags for each species were retrieved from each site on 6 January 1994 (15 days following litterbag placement), 20 January 1994 (30 days), 17 February 1994 (57 days) and 17 March 1994 (85 days). Any adhering soil or debris was carefully removed from the weed tissue in each harvested litterbag. Approximately one third of the tissue in each bag was oven dried (80°C; 24 h) to enable determination of the dry weight of the tissue remaining; however when the wet weight of the sample was less than 0.20 g the entire sample was used. When sufficient weed tissue was available the remaining two thirds of the litter was used for determining the microbial basal respiration and substrate-induced respiration [SIR; proportionally related to the glucose responsive microbial biomass (Wardle and Parkinson 1990)] of the tissue. The method used was exactly as described by Wardle *et al.* 1994. Day 0 values were made on five moisture adjusted replicate subsamples (0.40 g dry weight) of each weed tissue type immediately prior to litter-bag preparation.

RESULTS AND DISCUSSION

Plant litter decomposition

Decomposition of the leaf tissues proceeded rapidly with most species having lost close to 50% of their initial dry weight after the first 15 days (Table 1). There was no difference in the rate of decomposition between weeds initially collected from pasture or cropping sites. Overall in both habitats twincrest decomposed the most rapidly while willow weed was the slowest of the weed species to decompose. Nitrogen levels in the weed tissues were relatively high - on average 3.9% N for the four pasture weeds and 5.1% N for the four cropping weeds. This is comparable to the levels of nitrogen in leguminous root nodules which are actively fixing nitrogen (Wardle and Greenfield 1991). Correlation analysis demonstrated that there was no detectable relationship between tissue nitrogen content and decomposition rate and therefore it would appear that nitrogen was not a limiting factor for decomposition in our study. This is in contrast to most other studies (eg. Swift *et al.* 1979; Taylor *et al.* 1989) and is probably attributable to the high nitrogen content of tissues in our study.

TABLE 1: Percentage of initial litter of eight weed species remaining in litterbags at two sites after different periods of decomposition.

Species or site	Days of decomposition			
	15	30	57	85
Species effects:				
black nightshade	43	35	29	17
twincrest	35	24	24	15
fathen	51	41	30	17
willow weed	62	52	46	30
hairy buttercup	46	34	30	18
nodding thistle	50	43	33	24
oxeye daisy	48	38	34	20
ragwort	49	34	26	15
LSD (P=0.05)	5	4	5	5
Site effects:				
cropping	52	41	40	26
pasture	44	34	23	14
LSD (P=0.05)	2	2	3	2

Considering the nitrogen status and speed of decomposition of these weed tissues, it is reasonable to assume that they can release significant levels of mineral nitrogen to the soil. A winter weed level of about 2000 kg DM/ha does not cause an economically significant yield loss (Wardle *et al.* 1993). This represents about 100 kg/ha of nitrogen present in weed biomass and even if only a proportion of this is released, it represents a considerable source of nutrients. If the weeds are growing at a time when

the crop N requirements are minimal or non-existent (eg. winter) then the return of weed organic matter to the soil in the spring is likely to result in a pulse of plant available nitrogen coincident with the time of cultivation and replanting. In pasture, weeds are less likely to be important as determinants of soil fertility, mainly because their overall density per unit area is usually low. It is appreciated that the turnover and decomposition of soil microbial biomass is important in maintaining soil fertility (Jenkinson and Ladd 1981). In warm temperate arable systems microbial biomass nitrogen is usually about 200 kg N/ha (Wardle 1992), and our study suggests that the amount of labile N present in weed biomass may be of a similar order of magnitude. Therefore weeds have a similar potential to sustain available soil nutrient levels.

The habitat in which the litterbags were placed affected decomposition rate with all weed tissues decomposing faster under pasture than under cropping. Pasture generally contains higher resident microbial and faunal populations (Wardle 1994) and is also exposed to more microclimatic variation [eg. wetting/drying cycles which increase microbial turnover and hence increase decomposition (Taylor and Parkinson 1988)] than would be found under the shelter of a maize crop.

Microbial biomass

At all sampling dates, the substrate-induced respiration (reflecting the microbial biomass was significantly higher in the litter-bags placed in the pasture site than those in the cropping site (Table 2). The rate of decomposition would be initially, expected to be high at both sites because of the availability of substrate but limited later by site factors such as the amount of microbial biomass present in the soil and effects of microclimate.

TABLE 2: Substrate-induced respiration ($\mu\text{g CO}_2\text{-C/h/g litter}$) of litter of eight different weed species in litterbags at two sites.

Species or site	0	Days of decomposition			
		15	30	57	85
Species effects:					
black nightshade	2	301	226	220	164
twincross	20	349	226	211	145
fathen	20	318	231	195	153
willow weed	15	388	202	208	170
hairy buttercup	46	454	196	221	128
nodding thistle	18	297	177	203	163
oxeye daisy	31	386	223	186	128
ragwort	24	404	265	220	161
LSD (P=0.05)	5	49	41	31	20
Site effects:					
cropping	25	347	184	181	142
pasture	25	377	251	235	170
LSD (P=0.05)	NA ¹	25	20	16	10

¹ NA = not applicable

The habitat that promoted the highest microbial biomass also promoted the most rapid decomposition, but correlation analysis showed that the species with the highest microbial biomass did not necessarily have the fastest decomposition. This suggests that site factors, rather than microbial biomass of the weed tissues are critical in regulating decomposition.

The basal respiration : substrate-induced respiration ratio, a measure of microbial efficiency (Odum 1969; Anderson and Domsch 1985), declined in a predictable way consistent with the study of Wardle *et al.* (1994) (Table 3). The ratio did not appear to be consistently different between any particular weed species indicating that no weed species induced a more or less efficient microbial community.

TABLE 3: Ratio of microbial basal respiration to substrate induced respiration in litterbags containing different weed species and placed at two sites.

Species or site	Days of decomposition				
	0	15	30	57	85
Species effects:					
black nightshade	0.52	0.77	0.44	0.27	0.20
twincress	0.58	0.63	0.51	0.24	0.22
fathen	0.68	0.81	0.41	0.38	0.21
willow weed	0.58	0.74	0.55	0.33	0.24
hairy buttercup	0.64	0.56	0.48	0.25	0.21
nodding thistle	0.63	0.67	0.46	0.31	0.27
oxeye daisy	0.67	0.60	0.39	0.23	0.26
ragwort	0.68	0.66	0.55	0.24	0.22
LSD (P=0.05)	0.10	0.11	0.14	0.07	0.05
Site effects:					
cropping	0.62	0.68	0.39	0.27	0.22
pasture	0.62	0.68	0.56	0.29	0.24
LSD (P=0.05)	NA ¹	0.06	0.07	0.03	0.03

¹ NA = not applicable

In conclusion, it appears that weed tissue decomposition is more influenced by site than by weed species type. Because all the weed species assessed, particularly those from cropping sites, contained high nitrogen levels, they were able to be decomposed rapidly. Management systems that allow low levels of weeds may be potentially highly important in sustaining available soil nutrient levels.

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