DECOMPOSITION AND NITROGEN USE EFFICIENCY OF HIGH QUALITY TREE PRUNINGS AND LOW QUALITY CROP RESIDUES IN AGROFORESTRY SYSTEMS

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ABSTRACT

Crop yields are low in agroforestry systems due to assynchrony between nutrient release by the organic materials and nutrient demand by the crop. The decomposition and N release patterns of high quality tree prunings (gliricidia and sesbania) and crop residues (pigeon pea leaves and roots, and maize stover) were studied in agroforestry systems. The experiment was arranged in a 3 x 6 factorial, the high quality levels were: no tree prunings (NTP), gliricidia (Gs) and sesbania (Ss), and the crop residue levels were: no crop residues (NCR), pigeon pea leaves (Pea-L), pigeon pea leaves + roots (Pea-LR), pigeon pea roots (Pea-R), and two rates of maize stover (Stover-1 and Stover-2). Maize grain yield and N uptake of Gs/Pea-L, Gs/Pea-LR, Ss/Pea-L and Ss/Pea-LR treatments were statistically not different from Gs/NCR and Ss/NCR during the two seasons. Mixtures of tree prunings with 2.5 t ha^{-1} maize stover increased maize N uptake and grain yield whereas 5 t ha^{-1} maize stover had reduced during the wetter season. Mixtures of Pea-R, Stover-1 or Stover-2 with tree prunings depressed yields during the drier season. Stover-2 had the highest N fraction immobilized N, 15% and 35% N during the wetter and drier conditions respectively. We conclude that (1) mixing of high quality tree prunings with crop residues may enhance the decomposition of low quality crop residues but there is no special interaction, (2) remineralization of N immobilized early in the season by the low quality organic materials is stimulated by well distributed rainfall.

Key words: high quality, low quality, maize, N uptake, immobilization, remineralization

INTRODUCTION

Use of green manure from tree/shrub prunings has been promoted as an alternative source of nitrogen (N) for Sub-Saharan countries. Although it has been shown that addition of such prunings increase soil N and crop yields (Kang *et al.*, 1999; Kwesiga *et al.*, 1999; Hartemink *et al.*, 2000), the effectiveness of the organic N applied is low compared to that of inorganic fertilizer (Mulongoy and van der Meersch, 1988; Akinnifessi *et al.*, 1997). The low N uptake by crops from the applied organic N is attributed to lack of synchrony between the N released by organic materials and N demand by the crop.

Lack of synchrony can arise from two situations: (i) when mineral N supply comes too late for the demand, in the case of slowly decomposing materials, (ii) the N supply comes too early for the crop demand, in the case of fast decomposing organic materials releasing N in excess of current plant demand (Myers *et al.*, 1994, 1997). Myers *et al.* (1994) suggested that synchrony between N release and demand by the crop may be achieved by combining low and high quality organic materials. Handayanto *et al.* (1995 and 1997) examined the effects of mixing high and low quality organic materials in laboratory and glasshouse experiments, and concluded that N release pattern of high quality organic materials can be manipulated by combining them with low quality material. Becker *et al.* (1994) and Whitbread *et al.* (1999) demonstrated that mixtures of sesbania prunings or pigeon pea leaves with rice straw/rubbles increased the yield of flooded rice more than sesbania prunings alone. These results point at complex relations between N release by crop residue and prunings and N demand by the specific crop.

Information obtained from glasshouse and laboratory experiments may not directly be applied to explain the complex decomposition and N release patterns under field conditions. Most glasshouse experiments do not last long enough as to allow for complete decomposition and also most large soil fauna is usually excluded. In flooded rice (*e.g.* Ladha *et al.*, 1997; Whitbread *et al.*, 1999) mineralization occurs under anaerobic conditions and the processes governing mineralization may not be the same as in the upland where aerobic conditions dominate. There is also a knowledge gap in the decomposition patterns of the mixtures and interaction between high and low quality organic materials.

We had the following hypotheses: (1) decomposition patterns of mixtures of tree prunings and crop residues are not interactive but additive; (2) mixtures of high and low quality organic materials can increase N uptake and yield of the current crop when the immobilized N is released within the course of maize growth. The general objective of this study was to improve the N uptake and crop yield through mixing of low and high quality organic materials. More specifically the objectives were (1) to increase the understanding of decomposition of crop residues and tree legume prunings (2) to increase the understanding of the interactions between low quality crop residues and high quality tree legume prunings with respect to N uptake and yield of maize.

MATERIALS AND METHODS

Site description

The experiment was conducted at Makoka Agricultural Research Station, Zomba, Malawi. The soil had 38% clay, 54% sand and the chemical characteristics were: pH (water) = 5.6; organic carbon 9.3g/kg; P-Olsen = 10.3 mg/kg; Exchangeable K = 3.7 mmol/kg, Ca = 17.3 mmol/kg and Mg = 4.2 mmol/kg. The soil was characterized as Ferric Lixisols (FAO). The rainfall during the two seasons of our study was 1200 mm in 2000/01 and 800 mm in 2001/02.

In situ decomposition and mineralization experiments

Litterbags; decomposition of organic materials

The litterbag experiment was conducted in the 2000-2001 season. The experimental design was a 3 x 6 factorial. The levels of high quality factor were: no tree prunings (NTP), 15 g gliricidia (Gs) pre bag, and 12 g sesbania (Ss) per bag; the levels of the low quality factor, henceforth denoted as crop residues were: no crop residues (NCR), 7.5 g pigeon pea leaves (Pea-L), 2.5 g pigeon pea roots (Pea-R), 10 g pigeon pea leaves + roots (Pea-LR), 7.5 g maize stover (Stover-1), and 15 g maize stover (Stover-2). A control treatment without organic materials, NTP/NCR, was of course not applicable in the litterbag experiment.

The organic materials were chopped to about 2 cm long pieces and were placed in 20 x 20 cm nylon bags with 2 mm mesh. The litterbags were lightly buried in the field on 2nd December 2000. The litterbags were sampled after 14, 21, 42, 63, 70 and 84 days, two from each treatment at each sampling time. Soil particles and roots growing in the litterbags were manually removed and the remaining organic material was washed with distilled water and oven dried at 75 °C for 48 hrs. The dry-matter of the remaining biomass was determined.

Decomposition rate constants were calculated assuming first-order reactions:

$$Y_t = Y_0 e^{-kt} \qquad \text{Eq. 1}$$

Where Y_0 is the original mass and Y_t is the remaining mass at time t, and k is the decomposition constant. To calculate the decomposition rate constant values the formula was reorganized as:

$$\ln Y_t = \ln Y_0 - kt \qquad \text{Eq. 2}$$

$$k = [\ln(Y0/Yt)]/t \qquad \text{Eq. 3}$$

In a plot of $\ln Y_t$ against time t, the slope of the linear regression line is k (the decomposition constant).

Field trial

Treatments and design

The field experiment was a 3 x 6 factorial arranged in a Randomized Complete Block Design with three replicates. The 18 treatments were combinations of high and low quality materials. The levels of the high quality factor were: no tree pruning (NTP), sesbania pruning (1.5 t ha^{-1}) and gliricidia pruning (3 t ha^{-1}). The levels of crop residues were: no crop residues (NCR), pigeon pea leaves (Pea-L) consisting of green leaves (0.64 t ha^{-1}) + litter (0.86 t ha^{-1}), pigeon pea roots (Pea-R) (0.5 t ha^{-1}), Pea-L (1.5 t ha^{-1}) + roots (Pea-LR) (0.5 t ha^{-1}), 1.5 t ha^{-1} maize stover (Stover-1) and 3.0 t ha^{-1} maize stover (Stover-2). The gross plot size was 11.7 x 12.0 m and the net plot size was the interior 6.7 x 8.6 m. Each plot with trees consisted of 8 rows of leguminous trees with 13 trees per row.

Management and chemical properties of organic materials

The field trial was conducted in 2000-01 and repeated in 2001-02 at the same site, maintaining the treatments in same plots. In the first season (2000-01), 3-months old gliricidia coppices and 10-months old sesbania trees were cut and incorporated on 11th November 2000. In the second season (2001-02), trees were cut and incorporated in the soil on 6th November 2001. Tree leaves and small twigs were stripped and incorporated on the ridge while fresh. Due to low biomass yield of sesbania the amount of biomass applied was reduced to 1.5 ton DM/ha in both years.

Pigeon pea biomass was cut and incorporated at the same time as gliricidia and Sesbania biomass. Pigeon pea litter that had accumulated on the ground during the growing period was swept and removed from the plots where roots only were applied. The pigeon pea roots growing within the ridge (30 cm soil depth) were removed from the plots where pigeon pea leaves only were applied. Pigeon pea leaf biomass consisted of leaf litter (leaves that dropped during the season) and the green leaves harvested at the time of cutting.

Gliricidia, sesbania and pigeon pea samples were collected a week before cutting for determination of dry-matter; sampling was repeated at the time of incorporation of tree prunings for chemical analysis.

The nutrient mass fractions are tabulated in Table 1.

Table 1. Mass fractions of N, P, K and C (mg/g), and C:N ratio of the organic materials incorporated in the soil.

Organic material	N	P	K	C	C:N
Sesbania	34.4	1.2	11.7	488	15
Gliricidia	28.9	4.0	12.2	467	16
Pigeon pea fresh leaves	32.4	1.4	11.6	463	14
Pigeon pea litter	16.3	1.1	9.8	472	29
Pigeon pea roots	8.6	0.6	13.7	490	57
Maize stover	4.7	0.6	7.9	405	86

Gliricidia, sesbania and pigeon pea green leaves had high N content and low C:N ratio. Maize stover had low N and a wide C:N ratio. The mass fractions of N, P and K in the crop residues decreased in the order of pigeon pea leaves, pigeon pea roots and maize stover. Since pigeon pea green leaves were combined with litter, the combined pigeon pea leaf material was considered as medium quality material. The amounts of organic N applied via the organic materials are presented in Table 2.

Table 2. Organic N and P (kg ha^{-1}) applied in the field trial with the various treatments, and weighted mean C:N.

	Organic N			**Organic P**			**Weighted mean C:N**		
	NTP	Ss	Gs	NTP	Ss	Gs	NTP	Ss	Gs
NCR	-	52	87	-	2	12	-	15	16
Pea-L	35	87	122	2	4	14	20	17	17
Pea-LR	39	91	126	2.3	4.3	14.3	24	19	19
Pea-R	4	56	91	0.3	2.3	12.3	57	17	18
Stover-1	7	59	94	0.9	2.9	12.9	86	23	21
Stover-2	14	66	101	1.8	3.8	12.8	86	30	26

Maize yield and N uptake

Maize was harvested in the first week of May. Maize yield was measured from the net plot. All maize stover harvested in the net plot was weighed and the weight was recorded. A sample was taken to determine dry matter content and used to correct the weight of the dry-matter yield of stover. After shelling the maize cobs, grain and rachis were weighed separately and their weights were recorded. Samples of grain and rachis were collected and dried in an oven at 72 °C for 48 hrs and their dry-matter contents were determined. The dried plant materials were finely ground and analyzed for total N following the method of Terminghoff et al., (2000). N present in each of the three parts of the maize plant was calculated as the product of its dry-matter yield and N mass fraction. The Total N uptake reported is the sum of the amounts present in the three plant parts.

PRIMARY RESULTS

In situ decomposition and mineralization experiments

Litterbag; decomposition of organic material

The weight of tree pruning dry-matter decreased faster than that of the crop residues and their mixtures. After 14 days 56% of gliricidia and 59% of sesbania dry-matter remained in the litterbags whereas for the crop residue the dry-matter ranged from 71 to 97% (Table 3). At the end of the experiment, after 84 days, most of the dry-matter of the tree prunings had decomposed and only 8% of gliricidia and 9% of sesbania dry-matter was left in the litterbags; from the crop residues alone 12-36% remained and from the mixtures between 10 and 23%.

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was generally higher in Gs/Pea-L, Gs/Pea-LR and Gs/Stover-1 than Gs/NCR in 2000-01 season but this difference was statistically not significant. In 2001-02, maize stover (Stover-1 and Stover-2) reduced maize yield by 30% below NCR/NTP but the difference was not significant. In 2001-02, mixtures of tree prunings with Stover-1 and Stover-2 had significantly lower maize grain and dry-matter yield than tree prunings alone or mixed with Pea-L, while mixtures with Pea-LR and Pea-R took a position in between. Generally, maize yield was lower in 2001-02 than in 2000-01 season.

Table 4. Maize grain yield and total dry-matter yield (t ha^{-1}) as a function of the addition of high quality and low quality organic materials. See text for explanation of the codes.

	2000-01				2001-02			
	NTP	Sesbania	Gliricidia	Mean	NTP	Sesbania	Gliricidia	Mean
Grain yield								
NCR	0.85 c	2.0 a	3.1 a	*2.0*	1.0 b	1.9 a	3.0 a	*2.0*
Pea-L	2.7 a	2.2 a	3.7 a	*2.9*	1.6 a	2.2 a	3.1 a	*2.3*
Pea –LR	2.4 a	2.2 a	3.5 a	*2.7*	1.5 a	2.0 a	2.5 b	*2.0*
Pea-R	1.7 b	1.5 a	3.1 a	*2.1*	1.3 a	1.4 b	2.4 b	*1.7*
Stover-1	1.5 bc	2.2 a	3.4 a	*2.4*	0.7 b	1.2 bc	2.1 bc	*1.3*
Stover-2	1.4 bc	1.9 a	3.1 a	*2.1*	0.7 b	1.0 c	1.7 c	*1.1*
Mean	*1.7*	*2.0*	*3.3*	***2.4***	*1.1*	*1.6*	*2.4*	***1.7***
Total dry-matter yield								
NCR	1.9 c	3.9 a	6.4 a	*4.1*	2.1 bc	3.9 a	6.1 ab	*4.0*
Pea-L	5.9 a	4.5 a	7.8 a	*6.0*	3.5 a	4.6 a	6.4 a	*4.8*
Pea –LR	5.1 a	4.7 a	7.2 a	*5.7*	3.2 a	4.4 a	5.1 bc	*4.4*
Pea-R	3.5 b	3.2 a	6.5 a	*4.4*	2.6 b	2.9 b	4.8 bc	*3.5*
Stover-1	3.0 bc	4.6 a	7.1a	*5.5*	1.6 cd	2.5 b	4.1 cd	*2.7*
Stover-2	2.9 bc	3.9 a	6.3 a	*4.4*	1.5 d	2.2 b	3.4 d	*2.4*
Mean	*3.7*	*4.2*	*7.2*	***5.0***	*2.4*	*3.4*	*5.0*	***3.4***

Analysis of variance (Table 5) showed significant effects of the addition of high quality and low quality organic materials. Also their interaction on maize was significant, but far less important than the main effects.

	NTP	Sesbania	Gliricidia
NCR		2.28	2.93
Pea-L	2.64	2.11	2.83
Pea-LR	2.01	1.69	2.21
Pea-R	1.38	1.63	1.98
Stover-1	2.14	2.19	2.50
Stover-2	1.80	1.73	1.96
***Expected mean decomposition constants**			
Pea-L		2.42	2.82
Pea-LR		2.14	2.45
Pea-R		2.05	2.52
Stover-1		2.22	2.58
Stover-2		1.98	2.21

Fractions of N immobilized

The N fraction immobilized by the Pea-R and Stover were determined graphically (Fig. 2)

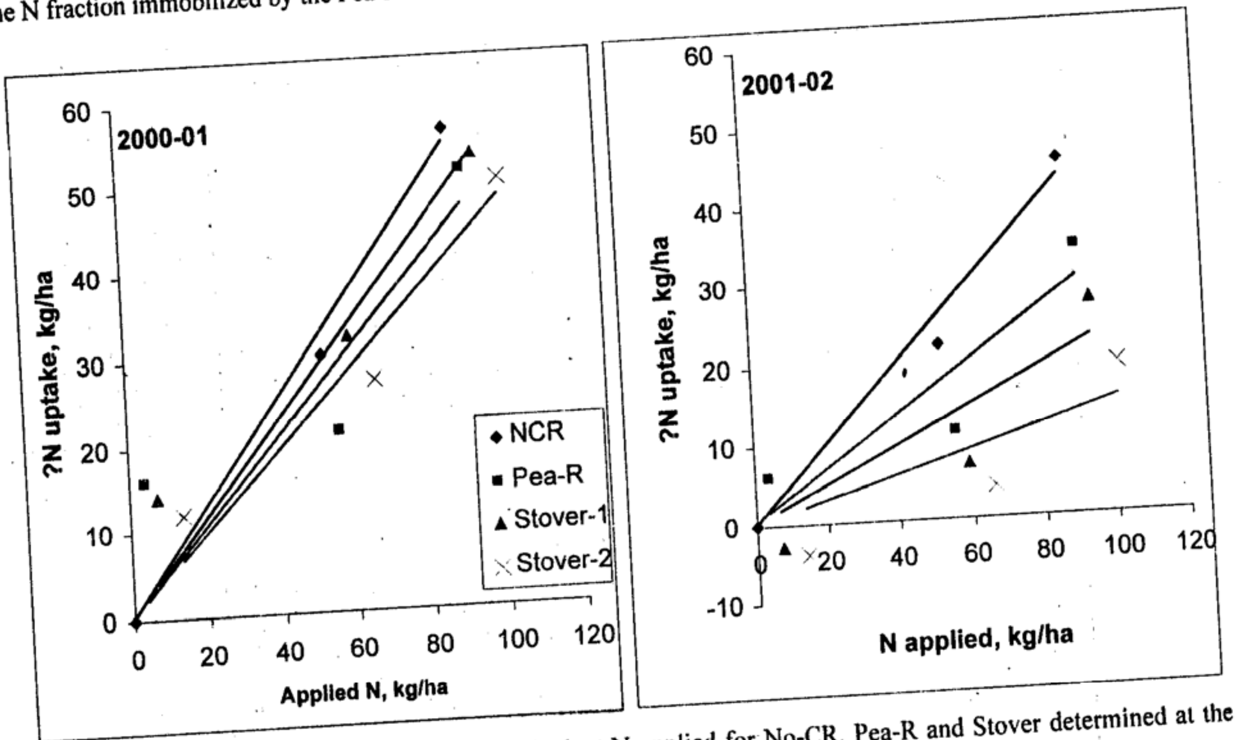

Fig. 2. Relationship between _N uptake and equivalent N applied for No-CR, Pea-R and Stover determined at the time of harvest.

The regression coefficients, R-square and N fraction immobilized had been reported in Table 9. Absolute amounts of N fraction immobilized were also calculated for each mixture with tree prunings (Table 10). The average N fraction immobilized found by the two methods differed only in the first season (2000-01) for the Stover but were same in the second season, 2001-02. From both methods it is clear that more N was still immobilized in 2001-02 by the time of harvest than in 2000-01. Considering the first method of regression, Stover-2 had the highest N fraction immobilized in both seasons, 15% in the wetter season (2000-2001) and increased to 35% in the drier season (2001-2002). During the wetter season the crop residues remineralized more N that was immobilized early in the season resulting in high N uptake by the maize than in the next season where less N was remineralized hence reducing N uptake.

Table 9. Values of regression coefficient a and of R-square of regression coefficient equations (y = ax) relating _N uptake at the time of harvest to the applied equivalent fertilizer N.

	Regression coefficient a	R-square	Fraction of N immobilized
2000-01			
NCR	0.63	0.99	

Table 7. ANOVA table for N uptake by maize

		2000-01				2001-02			
s.v.	d.f.	s.s.	m.s.	f	sign.L	s.s.	m.s.	f	sign. L
Rep (R)	2	945	472	2.74		174	87	4.40	
Tree Pruning (TP)	2	13253	6627	38.43	<0.001	8419	4209	212.50	<0.001
Crop residue (CR)	5	3410	682	3.96	0.006	3348	670	33.80	<0.001
TP x CR	10	2181	218	1.26	0.029	571	57	2.88	0.01
Error	33(1)	5691	172			674	19		
Total	52(1)	25271				13185			

DATA PROCESSING

Decomposition rate constants

Figure 1 shows the graphs of natural log of the fraction of remaining weight of dry matter plotted against time t (days).

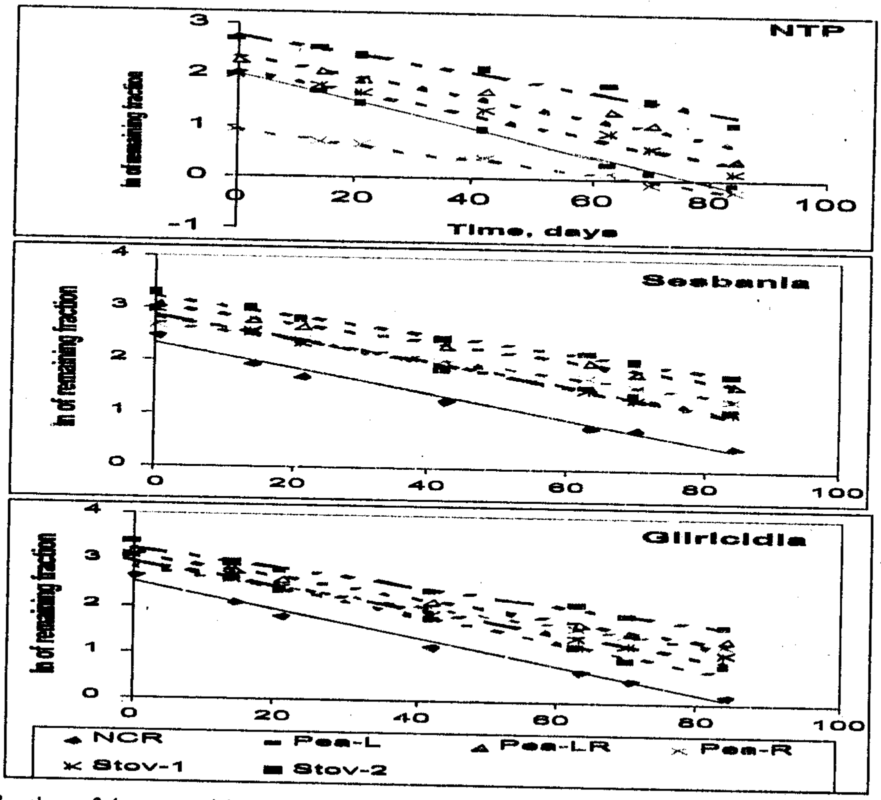

Fig. 1. Derivation of decomposition constants of tree prunings, crop residues and their mixtures from the relation of the natural log of remaining mass fraction and time (days).

The average decomposition rate constants of the organic materials for the whole period are given by gradient of the linear regression lines and are tabulated in Table 8. A decomposition rate constant per day of pure materials was highest for Gs (2.93%) followed by Pea-L (2.64%), sesbania (2.28%), while that for Stover-2 (1.80%) was lowest. Decomposition rate constants of mixtures of tree prunings and crop residues were somewhere in between the decomposition rate constants of the individual components but not necessarily their average. The decomposition rate constant of Stover-2 was less than that of Stover-1 despite that the materials were from the same source.

Expected mean decomposition constants for the mixtures were derived from expected remaining amounts of dry matter in the mixtures (Table 8). The measured decomposition rate constants were on average 89% of the expected values.

Table 8. Decomposition rate constants (%day^{-1}) of tree prunings, crop residues and their mixture in litterbag, as derived from Fig. 2.

	NTP	Sesbania	Gliricidia
NCR		2.28	2.93
Pea-L	2.64	2.11	2.83
Pea-LR	2.01	1.69	2.21
Pea-R	1.38	1.63	1.98
Stover-1	2.14	2.19	2.50
Stover-2	1.80	1.73	1.96
***Expected mean decomposition constants**			
Pea-L		2.42	2.82
Pea-LR		2.14	2.45
Pea-R		2.05	2.52
Stover-1		2.22	2.58
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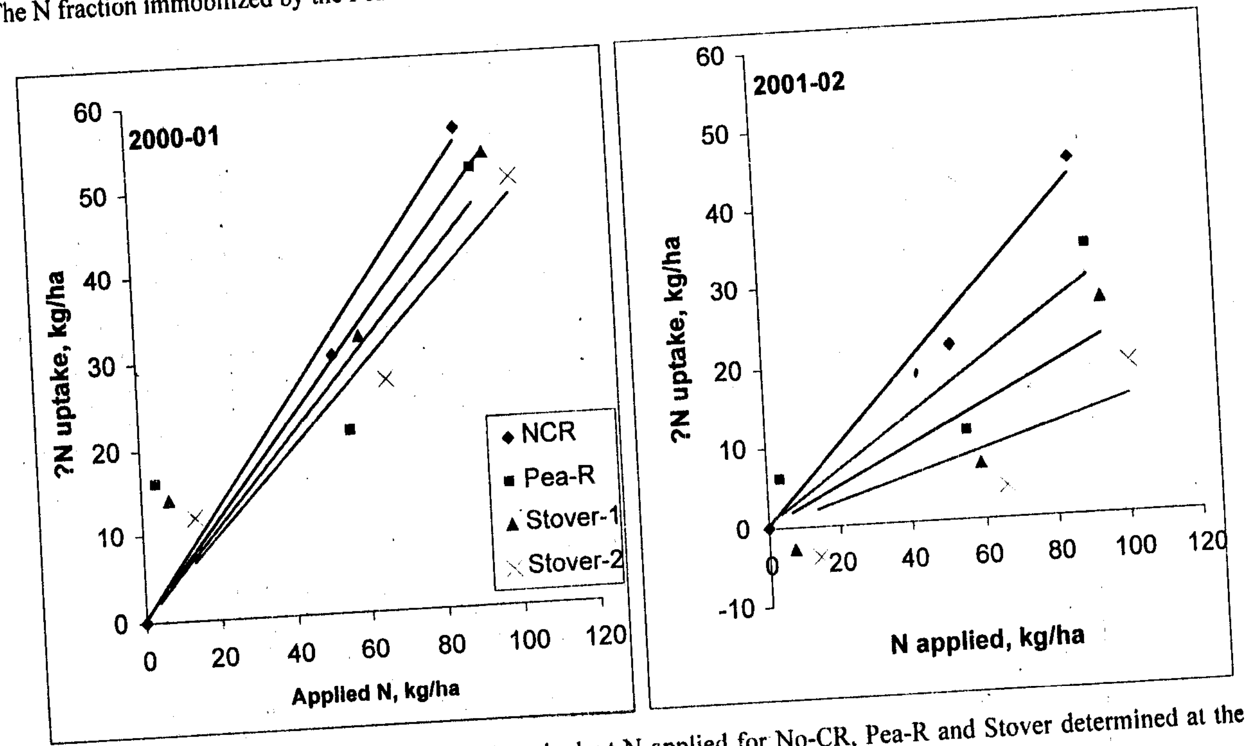
Fractions of N immobilized

The N fraction immobilized by the Pea-R and Stover were determined graphically (Fig. 2)



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	Regression coefficient a	R-square	Fraction of N immobilized
2000-01			
NCR	0.63	0.99	

Pea-R	0.51	0.62	0.14
Stover-1	0.56	0.87	0.06
Stover-2	0.47	0.93	0.15
2001-02			
NCR	0.49	0.93	
Pea-R	0.33	0.79	0.17
Stover-1	0.24	0.93	0.26
Stover-2	0.14	0.68	0.35

Table 10. Absolute fraction of immobilized N

	Ss	Gs	Mean
2000-01			
Pea-R	0.17	0.10	0.13
Stover-1	-0.04	0.06	0.01
Stover-2	0.06	0.12	0.09
2001-02			
Pea-R	0.21	0.13	0.17
Stover-1	0.29	0.21	0.25
Stover-2	0.35	0.30	0.32

Interaction between maize stover and tree prunings

Tables 4 and 5 showed a significant TP*CR. We assumed this was because pea leaves and roots were quite different materials than maize stover. Maize stover had low N content and wide C:N ratio, and gave the lowest decomposition rate constants. Therefore, an analysis of variance was done separately for tree prunings and maize stover. Table 11 shows that the interaction between tree prunings and maize stover for the yields and uptake parameters was not significant in 2000-01 season, it was significant in 2001-02 season. In the second season N immobilized early in the season might not have been remineralized yet within the time course of crop's demand because of low rainfall, and hence yields, and N uptake are reduced by stover. The difference between stover-1 and Stover-2 is depending on the type of tree pruning treatments. Such a relation is not seen in season 2000-01.We believe that the interaction observed in the second season was due to the influence of rainfall. Lack of statistical interaction between stover and tree prunings on maize yield parameters in the first season is due to the fact that N immobilized early in the season had been released within the time of demand by the crop to such an extent that the difference between Stover-1 and -2 has not been affected any more by the tree pruning treatments.

Table 11. Two way ANOVA testing the interaction between tree prunings and maize stover on the maize yield parameters.

		2000-01 season				2001-02 season			
s.v.	d.f.[a]	s.s.	m.s.	f	signfi.	s.s.	m.s.	f	signfi.
Grain									
Rep (R)	2	0.13	0.07	0.86		0.004	0.002	0.15	
Tree pruning (TP)	2	17.10	8.55	110.37	<0.001	9.57	4.78	414.71	<0.001
Stover (St)	2	0.71	0.36	4.61	0.028	3.34	1.67	144.74	<0.001
TP x St	4	0.31	0.08	0.99	0.442	0.83	0.21	18.04	<0.001
Error	15(1)	1.16	0.08			0.18	0.01		
Total	25(1)	17.92				13.93			
Dry matter									
Rep (R)	2	0.59	0.29	0.87		0.26	0.13	0.78	
Tree pruning (TP)	2	73.08	36.54	108.87	<0.001	36.27	18.13	109.82	<0.001
Stover (St)	2	3.23	1.61	4.81	0.024	14.29	7.14	43.26	<0.001
TP x St	4	1.22	0.31	0.91	0.483	3.57	0.89	5.41	0.006
Error	15(1)	5.03	0.34			2.64	0.17		
Total	25(1)	76.57				57.03			
N uptake									
Rep (R)	2	299	149	1.33		66	33	1.87	
Tree pruning (TP)	2	9303	4652	41.33	<0.001	4923	2461	139.10	<0.001
Stover (St)	2	132	66	0.58	0.570	1120	560	31.66	<0.001
TP x St	4	312	78	0.69	0.608	399	100	5.64	0.005
Error	15(1)	1688	113			283	18		
Total	25(1)	11017				6792			

[a]Stover-1 treatment, replicate 2 for the first season had an out liar hence the data was pulled out and was treated as missing data. In 2001-2002 there was no missing data therefore the d.f. of Error and Total should be equal to 16 and 26 respectively.

DISCUSSION

Decomposition rates

The decomposition rate constants of the tree prunings obtained in this study (Table 8) are among highest decomposition rates reported earlier by other authors. Decomposition rate constants for gliricidia have been found to range between 2.40% and 3.10% day^{-1} (Budelman, 1988; Mwiinga *et al.*, 1994; Hartemink and Sullivan, 2001), while for sesbania a rate constant of 2.10% day^{-1} has been reported by Mwiinga *et al.* (1994). The rate constants of gliricidia seem to be related to the pretreatment of the prunings. Budelman (1998) and in our study fresh materials were used, yielding relatively high (3.10% and 2.93% day^{-1}, respectively) whereas some researchers (*e.g.* Mwiinga *et al.*, 1994; and Hartemink and Sullivan, 2001) used oven dried prunings. The rate constants of the tree prunings tended to decline with time. Apparently, the high N content of the tree prunings and the easily decomposable compounds facilitated the initial fast decomposition of the leafy materials and since the remaining twigs were more lignified and recalcitrant to decomposition the decomposition rate decreased. Berg and Meentemeyer (2002) alluded the decrease in decomposition rate constant of organic materials to chemical changes in the substrate itself and the succession in microorganisms able to compete for substrate with a given chemical composition. On the other hand the decomposition of the crop residues was low initially but tended to increase from 63 days onwards. The initial slow decomposition could be influenced by the N deficiency in crop residues that might have affected the rapid colonization of the soil microbes.

The lower N recoveries in 2001-02 than in 2000-01 suggest that decomposition, mineralization, immobilization and remineralization were dependent on the amount of rainfall. In the first season, 2000-01, when the rainfall was 1200 mm N uptake by maize in mixtures of tree prunings with Pea-R and Stover were not significantly different from tree prunings/NCR whereas during the drier season, 2001-02 (800 mm), N uptake in Pea-R and Stover mixtures was significantly ($P = 0.05$) lower than in tree prunings/NCR. We suggest that this effect was the influence of the drier conditions retarding the processes of decomposition, mineralization and remineralization, and it was not a special interaction between crop residues and tree prunings.

Increasing the rate of stover in the mixtures with tree prunings reduced maize grain and dry-matter yields. The decomposition by Stover-2 might have been slower and hence remineralization of N came too late for the crop demand thus jeopardizing the synchrony of the N release and uptake by the crop. The slow remineralization of N by Stover-2 is reflected by the high fraction of N immobilized at harvest (Table 8). Also as found earlier in a pot experiment the fraction of N immobilized increased when the proportion of stover in the mixture was increased. Becker *et al.* (1994) showed that increasing rice straw in the sesbania-rice straw mixture decreased the net N mineralization. In a pot experiment Handayanto *et al.* (1997) also found that N recovery by maize decreased when the proportion of low quality peltophorum prunings in the gliricidia-peltophorum pruning mixture was increased. These results suggest that mixture of 3 t ha^{-1} gliricidia prunings with 2.5 t ha^{-1} maize stover (or 2:1 prunings: stover ratio) would better synchronize the N release by the organic materials and N demand by maize than the higher rate of 3 t ha^{-1} stover.

In the second season (2001-02) the decomposition might not have been complete because of the drier conditions.

CONCLUSION

The decomposition pattern of the tree prunings and crop residues followed the order: Gs>Pea-L>Ss > mixtures (tree prunings/crop residues)>Stover-1>Stover-2>Pea-R. The decomposition rate constants of the mixtures of the high quality tree prunings and crop residues decreased with the increasing amount of crop residues. There was no special interaction between high quality tree prunings and maize stover; the apparent statistical interaction can be expected as an effect of rainfall.

Remineralization of N immobilized early in the season was related to the amount of rainfall. During the drier season Pea-R, Stover-1 and Stover-2 immobilized 17, 26 and 35% N, respectively resulting in reduction of maize N uptake and yield whereas in the wetter season N fraction immobilized was 4 to 7 times lower than in the drier season and N uptake and maize yield were relatively high. This result confirms our second hypothesis.

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