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Effects of residue quality and climate on plant residue decomposition and nutrient release along the transect from humid forest to Sahel of West Africa

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Abstract Field litterbag studies were conducted in the 2000 rainy season and the 2000/2001 dry season along the transect of West African major agroecological zones (agroeco-zones) to measure the decomposition of, and N and P release from 5 plant residues (leaves of woody species) with increasing quality: *Dactyladenia barteri*, *Pterocarpus santalinoides, Alchornea cordifolia, Senna siamea* and *Gliricidia sepium*. The decomposition rate constant (wk^{-1}) ranged from 0.034 (*Dactyladenia*, subhumid zone) to 0.49 (*Gliricidia*, humid zone) in the rainy season, and from 0.01 (*Dactyladenia*, subhumid zone) to 0.235 (*Pterocarpus*, arid zone) in the dry season. The direct correlation between the decomposition rate of plant residues and their quality was only valid in agroeco-zones where there is not moisture stress. Similarly, the direct correlation between the decomposition rate of plant residues and moisture availability was only valid for plant residues with high quality. The decomposition rate of the low quality plant residue could increase from humid to arid zone in West Africa. In the arid zone, the low quality plant residue could also decompose faster than high quality plant residue. The climate-residue quality interactive effects on plant residue decomposition in West Africa were attributed to the feedback of low quality plant residue's mulching effect, soil fauna and appreciable photodegradation in dry regions. A decomposition equation that could be used to predict the decomposition rate of plant residues with various qualities

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across agroeco-zones in West Africa was obtained from this study. The equation was expressed as follow: $k = 0.122 - 0.000747*PRQI^2 - 0.0233*PRQI*CI + 0.00337*CI*PRQI^2$, in which k is the decomposition rate constant (wk^{-1}), PRQI the plant residue quality index, and CI the climate index (ratio of rainfall to sunshine hours cumulative during the entire decomposition). The response of N and P release from plant residues to residue quality and climate was similar to that of residue decomposition. At the late stage of the dry season decomposition, the high C/N and C/P ratio plant residue (*Dactyladenia* leaves) that immobilized N and P in wet zones showed a release of N and P in the dry zone.

Keywords Decomposition rate constant · N and P release · Mulching effect · Soil fauna · Photodegradation · Nigeria · Niger

Introduction

Increasing interest in using plant residues as major nutrient source in low-input agriculture of the tropics has led to greater interest in decomposition studies. The rates of decomposition of plant residues and associated nutrient release are important information for designing a system for achieving nutrient synchronization leading to better utilization of plant nutrients and reduction of nutrient loss. The terrestrial decomposition system is regulated by soil biota, resource quality and climate (Swift et al. 1979). Numerous studies have confirmed that the C/N ratio, and lignin and polyphenol concentrations of plant residues play an important role in residue decomposition in the tropics (e.g. Palm and Sanchez 1990; Tian et al. 1992; Vanlauwe et al. 1994; Teklay and Malmer 2004; Bayala et al. 2005; Hirobe et al. 2005). Tian et al. (1992) developed an equation on the effect of the above chemical parameters on the decomposition rate of plant residues under humid tropical conditions. Ågren and Bosatta (1996) demonstrated that the chemical fractionation into extractives, acid solubles, and acid insolubles provides a useful classification of organic matter into classes of degradability. Tian et al. (1995) developed an equation of the plant residue quality index (PRQI) in the forest-savanna transition zone of West Africa based on the C/N ratio, and lignin and polyphenol concentrations of plant residues, and noted that the decomposition rate of plant residues is positively correlated to the PRQI. Although these equations (Tian et al. 1992, 1995) have been widely used for prediction of the plant residue decomposition, they are limited to the transition zone from the humid to subhumid tropics.

West Africa covers a wide range of agroecological zones (agroeco-zones), which are classified by the length of growing period (LGP). The LGP is determined by rainfall amount, rainfall pattern and potential evaporation. Although solar radiation was not a criterion for dividing West African agroeco-zones, it is the main cause for the variation in evaporation as temperature regimes in West Africa are uniform with little seasonal variation (Jagtap 1995). Since different agroeco-zones have different climatic conditions, the decomposition rate of plant residues varies with agroeco-zones (Swift et al. 1979; Anderson and Swift 1983; Lavelle et al. 1993; Vanlauwe et al. 1997; Coûteaux et al. 2002). The decomposition rate of plant residues is well known to decrease with the decrease in moisture availability largely determined by rainfall amount and solar radiation, thus there is a decreasing gradient of decomposition rates from the humid to arid West Africa.

In West Africa, plant residues are often applied as mulch, leading to an increase in soil moisture, which is called mulching effect (Lal 1978; Tian et al. 1993b). The increase in soil moisture by mulching effect can accelerate the plant residue decomposition, but, the degree of increase in decomposition due to mulching effect would be different in different agroeco-zones of West Africa, and also for different plant residues. The mulching effect-induced decomposition is expected to be greater in the dry than the wet agroeco-zones as the moisture availability is more limited in the dry than the wet agroeco-zones. Also, more enhancement in decomposition of plant residues is anticipated for the low than the high quality residues, as the mulching effect is greater under the low than the high quality residues (Tian et al. 1993b). Yet, the feedback of the mulching effect of plant residues to their decomposition and its interaction with agroeco-zone and residue quality had not been given any attention. And, this would have resulted in the under-estimation of the decomposition and nutrient release rate of some low quality residues in dry agroeco-zones.

Another aspect that needs to be considered in revising the decomposition equation is the interaction of soil fauna contribution to decomposition with environmental stress such as reduction in moisture availability and residue quality. Soil fauna that participate in decomposition of plant residues tend to contribute more to residue decomposition under dry climates (Santos and Whitford 1981; Tian et al. 1997). The contribution of soil fauna is greater to the low than the high quality residues (Coûteaux et al. 1991; Tian et al. 1997). With the decrease in moisture from the humid to the arid zone, there is an increase in stress for decomposer biota. When such stress is coupled with low quality residues, the course of decomposition would be altered.

The objective of the study is to test the following hypotheses:

1. Wet regions provides a conducive microclimate environment for microbial decomposition, hence, the decomposition rate will correlate well to the plant residue quality index.
2. High quality residue is largely decomposable microbially so that there is little interaction with soil fauna and mulching effect. Hence, the decomposition of high quality residues will correlate well to climatic condition.
3. The rate of decomposition and nutrient release of plant residues with low quality is enhanced under dry climatic conditions.

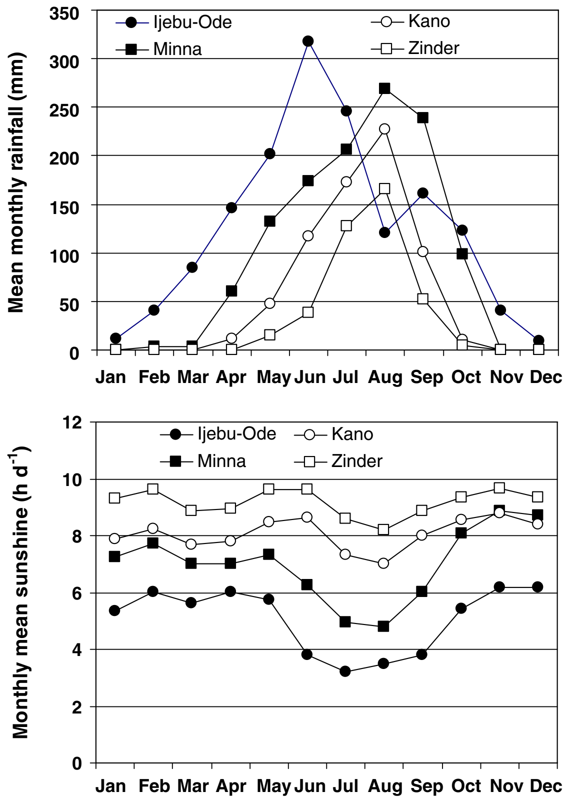

Fig. 1 Mean of monthly rainfall and monthly mean of daily sunshine hour over 30 years (1961–1990) at four agroecological zones of West Africa

Materials and Methods

The site

The study was conducted in the 2000 rainy season and the 2000/2001 dry season at three sites in Nigeria, namely, Ijebu-ode, Minna and Kano and one site in Niger, namely, Zinder, representing major West African agroeco-zones. The 30 (1961–1990) years mean monthly rainfall and sunshine hours, provided by Allmetsat (http://www.allmetsat.com), are shown in Fig. 1. Ijebu-Ode (6°48′N, 3°55′E) belongs to the humid forest agroeco-zone (humid climate, LGP > 270 days) with a mean annual temperature of 26.7°C, rainfall (bimodal) of 1,502 mm and sunshine hours of 1,848. Minna (9°37’N, 6°32’E) is located in the Southern Guinea Savanna agroeco-zone (subhumid climate, LGP = 180–210 days) with a mean annual temperature of 27.4°C, rainfall (bimodal) of 1,188 mm and sunshine hours of 2,553. Kano (12°3′N, 8°32′E) is in the region of Sudan Savanna agroeco-zone (semi-arid climate, LGP = 90–150) with a mean annual temperature of 26.7°C, rainfall (monomodal) of 686 mm and sunshine hours of 2,941. Zinder (13°58′N, 8°53′E) is located in the Sahel agroeco-zone (arid climate, LGP < 90) with a mean annual temperature of 28.7°C, rainfall (monomodal) of 402 mm and sunshine hours of 3,345. With the decrease in rainfall and increase in sunshine hours, moisture available to the decomposition system decreases from humid forest to Sahel in West Africa. Soil fertility also declines from humid forest to Sahel.

The experimental operations

The tested plant materials were leaves collected from following woody species: *Alchornea cordifolia,* *Dactyladenia barteri*, *Gliricidia sepium*, *Senna siamea*, and *Pterocarpus santalinoides*. The plant residue quality index (PRQI) developed by Tian et al. (1995) integrated the effect of the residue C/N ratio, and polyphenol concentration (%) and lignin concentration (%) on the decomposability of the residues, and was defined as: PRQI = [1/(0.423* C/N + 0.439*lignin + 0.138 *polyphenol)]*100. The PRQI as an indicator of residue quality directly correlated with the decomposition rate constant of plant residues in the humid tropics (Tian et al. 1995). As shown in Table 1, the quality of 5 plant residues increased in the following order *Dactyladenia*, *Pterocarpus*, *Alchornea*, *Senna* and *Gliricidia*. Since the materials used in the study were collected from only one location (Ibadan, Nigeria), which is relatively closer (70 km) to Ijebu-ode, the tested materials might have favored the decomposers in the humid zone.

The monitoring of plant residue decomposition and nutrient release was carried out using solid nylon litterbags measuring 30 cm x 30 cm. The mesh size of litterbags was 5 mm, which would allow access of most soil fauna. Air-dry plant materials were placed in litterbags at a rate of 45 g per litterbag, equivalent to 5 Mg ha^{-1}, a rate at which low quality plant residues could create mulching effect (Tian et al. 1993b). In order to prevent compression of plant residues inside the litterbags, pieces of wood 3 cm in diameter were placed inside the four corners of the litterbags. The litterbags were surface-placed in a field between maize rows at Ijebu-ode and Minna, and between sorghum rows at Kano and Zinder in the 2000 rainy season, and without crops in the 2000/2001 dry season. The dates of litterbag placement were June 2 at Ijebu-ode, June 28 at Minna, June 16 at Kano and June 17 at Zinder in 2000, and February 22 at Ijebu-ode, February 24 at Minna, February 27 at Kano and February 28 at Zinder in 2001. Enough litterbags were placed to allow for sampling at 1, 2, 4, 8 and 14 weeks after placement (WAP) with three replicates. At each sampling, plant residues in the litterbags were water-cleansed, oven-dried at 65 °C, and weighed to determine the residue dry matter weight. The residue samples were ground to pass through a 20 mesh sieve to determine the ash-free dry weight, and N and P concentration.

Ash-free dry weight was determined by ashing a plant sample in a muffle furnace at 550°C for 3 h to correct for soil contamination. Total N was analyzed by the micro-Kjeldahl digestion, followed by the distillation and titration. For the determination of P, plant samples were wet-digested with a mixture of $HClO_4$-HNO_3. Phosphorus was measured in a Technicon Auto-Analyzer II (Technicon Scandinavia, Stockholm, Sweden). Lignin was determined by the acid detergent fiber method (Goering and van Soest 1970). Extractable polyphenols were determined by the Folin-Denin method (Anderson and Ingram 1993).

Data analysis

The materials left in a litterbag at a given time were considered as undecomposed materials, though some of mass lost through faunal removal and comminution were not mineralized at that time. Percentage of undecomposed materials was calculated as the remaining relative to initial ash free mass. The single exponential equation, $Y = e^{-kt}$, where Y is the

Table 1 Chemical characteristics and quality index of leaves of woody species

Woody species	N (g kg^{-1})	P (g kg^{-1})	C[a] (g kg^{-1})	Polyphenols (g kg^{-1})	Lignin (g kg^{-1})	C/N	PRQI[b]	C/P
Gliricidia	48.0	2.1	473	22.7	91.2	9.9	11.8	225
Senna	27.8	1.6	440	18.7	71.9	15.8	9.9	275
Alchornea	26.4	1.8	462	54.2	74.9	17.5	8.7	257
Pterocarpus	32.4	1.7	454	26.3	212	14.0	6.4	267
Dactyladenia	15.6	0.9	451	40.2	236	28.9	4.3	501

[a] *Source*: Tian and Kang (1996)

[b] Plant residue quality index, calculated using the formula in Tian et al. (1995) as follow: $PRQI = [1/(0.423 * C/N + 0.439 * lignin + 0.138 * polyphenol)] * 100$

percent undecomposed materials at time t in weeks, was used to calculate the decomposition rate constant (k, wk^{-1}) (Wieder and Lang 1982). Percentage of nutrient remaining was calculated as the remaining relative to initial nutrient amount, which was the product of ash free dry mass and nutrient concentration. The percent undecomposed materials, decomposition rate constant, and percent nutrient remaining were subjected to ANOVA to determine differences among agroeco-zones in decomposition and nutrient release for each of the five plant materials. Stepwise (backward) regression was conducted to find the contribution of plant residue quality index (PRQI), climate index (CI) and their interactions to the decomposition rate constant. The CI was defined as the ratio of rainfall to sunshine hour cumulative during the entire decomposition period. All statistical analyses were performed using SAS software (Littell et al. 1996).

Results

Decomposition pattern

Both plant residue quality and agroeco-zone affected the course of plant residue decomposition (Figs. 2 and 3). During the rainy season decomposition, *Gliricidia* and *Senna* showed a lower litter mass remaining in the wet than the dry zone, but *Pterocarpus* and *Dactyladenia* showed a lower litter mass remaining in the dry than the wet zone (Fig. 2). These

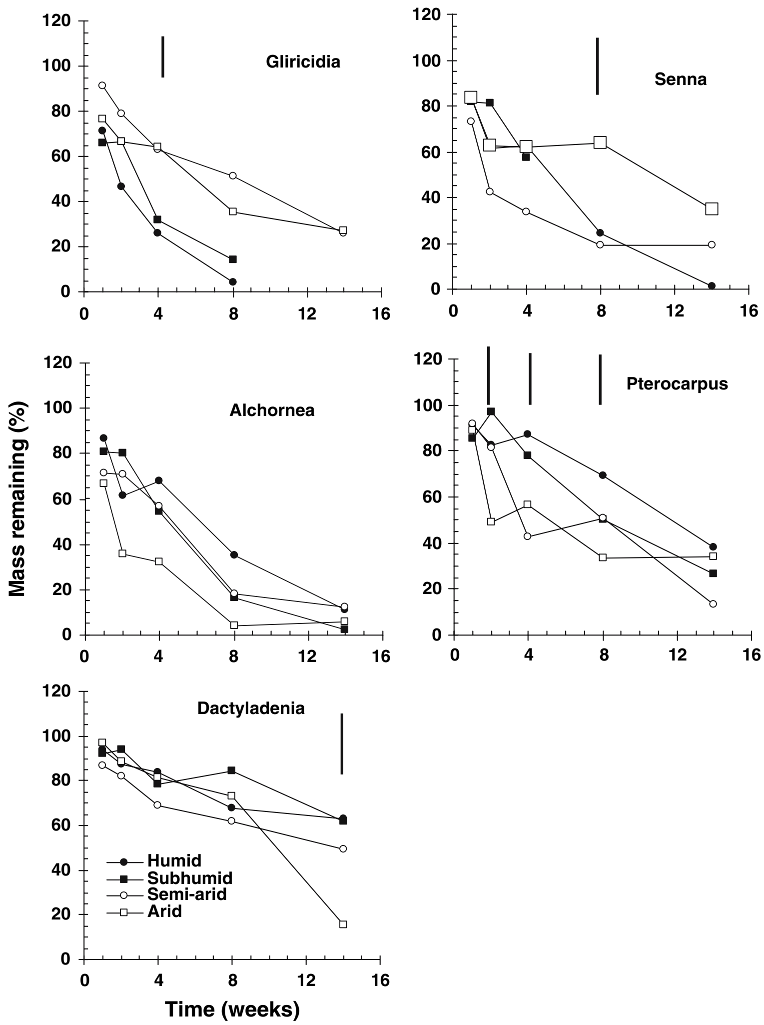

Fig. 2 Decomposition of plant residues of various qualities at four agroecological zones of West Africa during rainy season 2000. Bar represents LSD (0.05)

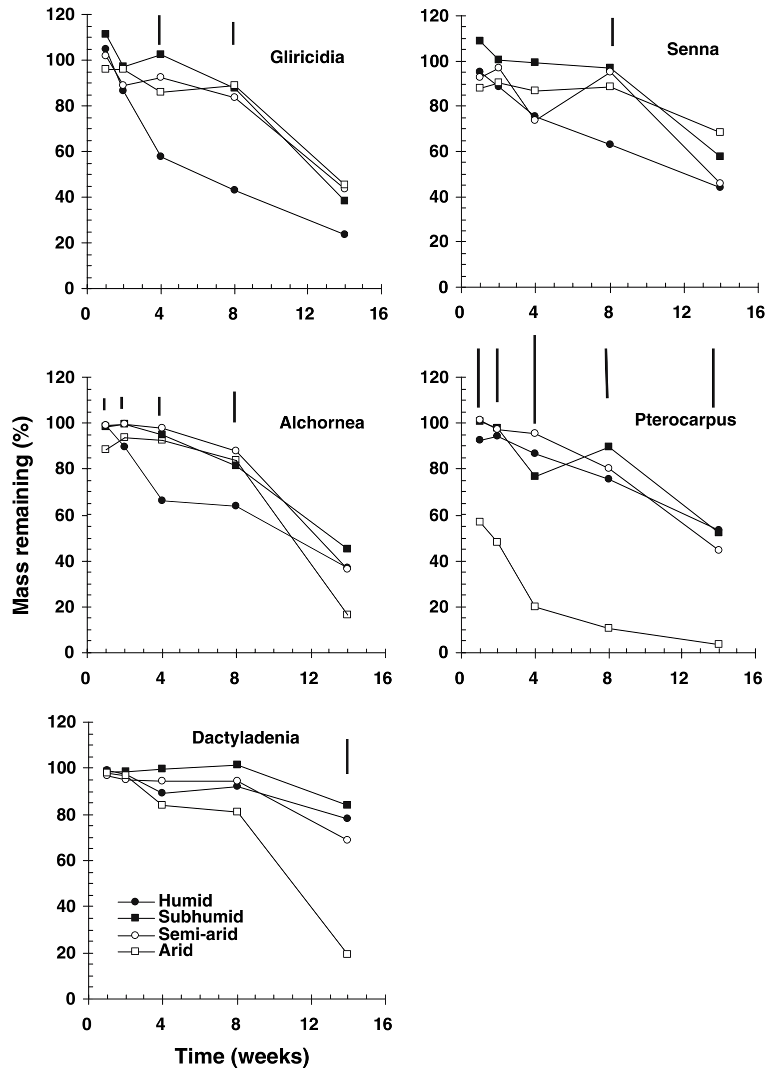

Fig. 3 Decomposition of plant residues of various qualities at four agroecological zones of West Africa during dry season 2000/2001. Bar represents LSD (0.05)

trends were also observed in the dry season decomposition (Fig. 3).

The decomposition rate constant (wk^{-1}) ranged from 0.034 (*Dactyladenia* in the subhumid zone) to 0.49 (*Gliricidia* in the humid zone) in the rainy season, and from 0.01 (*Dactyladenia* in the subhumid zone) to 0.235 (*Pterocarpus* in arid zone) in the dry season (Fig. 4). With the decrease in moisture availability (from humid to arid), the decomposition rate constant decreased only for higher quality residues, and even increased for low quality residues (Fig. 4). Similarly, with the increase in residue quality, the decomposition rate constant increased only in wet zones, and even decreased in dry zones (Fig. 4).

The revision of decomposition equation

In Tian et al. (1992), the decomposition rate constant (k, wk^{-1}) at Ibadan (humid to subhumid transitional zone) was expressed as: k = 0.2736 – 0.0035 C/N – 0.0023 lignin – 0.0188 polyphenols + 0.0068 litterbag mesh-size. While the C/N ratio and lignin concentration (%) and polyphenol concentration (%) refer to the decomposability of plant residues, the litterbag mesh-size (mm) indicates the accessibility of plant residues to soil fauna.

Tian et al. (1995) integrated the C/N ratio and lignin concentration (%) and polyphenol concentration (%) into the plant residue quality index (PRQI), and provided a formula to calculate the PRQI using the

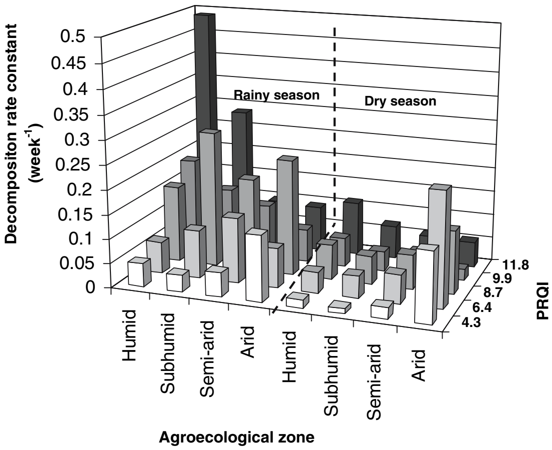

Fig. 4 Decomposition rate constant as function of plant residue quality and agroecological zone of West Africa

above chemical parameters as follow: PRQI = [1/(0.423*C/N + 0.439*lignin + 0.138 *polyphenol)]*100.

As mesh-size of 2 mm is large enough for access to most soil fauna (Tian et al. 1992), the mesh-size should not be a variable when a litterbag with mesh-size larger than 2 mm is used in measuring decomposition. The equation for the decomposition rate constant (k, wk^{-1}) in Tian et al. (1992) was therefore simplified in Tian et al. (1995) as follow:

$$k = 0.024 + 0.026 * PRQI \tag{1}$$

In order to predict the decomposition rate of plant residues across agroeco-zones of West Africa, we need to integrate the climate index into the decomposition equation (1). Although there are variations in many climatic factors such as rainfall, solar radiation, potential evaporation, and humidity across West Africa, the rainfall and solar radiation are main factors which determine climatic differences among West African agroeco-zones. As solar radiation data are often not available for the region, we use the sunshine hours to represent the solar radiation. We therefore define the climate index (CI) in an agroeco-zone of West Africa as follow:

$$CI = CumRain/CumSun \tag{2}$$

Where the CumRain is the cumulative rainfall (mm) received during the entire course of decomposition, and the CumSun is the cumulative sunshine hours (hours) during the same period. As climatic data were incomplete for the study years, we decided to use the monthly means over 30 (1961–1990) years for both sunshine hours and rainfall. For the beginning and ending months of decomposition, when it did not span the entire month, we evenly distributed the monthly rainfall to each individual day of that month for calculating the cumulative rainfall. We believe the 30-year mean climate data are representative of two years as the climate during these two years was normal from the monitoring at the International Institute of Tropical Agriculture's weather station in Ibadan. The actual rainfall of 1,306 mm in 2000 and 1,256 mm in 2001 in Ibadan was very close to 1,278 mm of its 30-year mean.

As we described earlier in Fig. 4, the decomposition rate constant did not show a simple response to agroeco-zone and PRQI, therefore, we did not limit our regression of decomposition rate constant (k, wk^{-1}) against PRQI and CI to a linear equation, instead we constructed a polynomial equation as follow:

$$k = a + b * PRQI + c * CI + d * PRQI * CI + e * PRQI^2 + f * CI^2 + g * CI * PRQI^2 + h * PRQI * CI^2 \tag{3}$$

Table 2 Regression coefficient and probability of variables included in the equation of decomposition rate constants (k, wk^{-1}) as dependent, and plant residue quality index (PRQI), climate index (CI) and their interactions as independent in West Africa

Variable	Regression coefficient	F value	Probability
Intercept	0.122	18.1	0.0001
$PRQI^2$	–0.000747	5.0	0.032
PRQI*CI	–0.0233	8.7	0.006
CI* $PRQI^2$	0.00337	17.9	0.0002

R^2 of the regression model: 0.61 ($P < 0.0001$)

Based on the output (Table 2) of stepwise (backward) regression procedure, the following equation was established for predicting the decomposition rate constant of plant residues across agroeco-zones in West Africa:

$$k = 0.122 - 0.000747 * PRQI^2 - 0.0233 * PRQI * CI + 0.00337 * CI * PRQI^2 \tag{4}$$

Nutrient release

The effect of plant residue quality and agroeco-zone on N release (Figs. 5 and 6) generally followed that on plant residue decomposition. In the dry season decomposition, N remaining in *Dactyladenia* increased from 8 to 14 WAP in humid, subhumid and semi-arid zones (Fig. 6), indicating N immobilization at later stage of decomposition of this high C/N ratio residue. However, N remaining in *Dactyladenia* decreased during the same period in the arid zone (Fig. 6), suggesting no N immobilization.

The increase in P remaining from the humid to the arid zone was observed only for *Gliricidia* (Figs. 7 and 8). And, the P remaining even decreased from the humid to the arid zone for *Dactyladenia* (Figs. 7 and 8). *Senna*, *Alchornea* and *Pterocarpus* tended to have a lower P remaining in drier zones, though this trend was not as pronounced as for *Gliricidia* and *Dactyladenia*. In the 2000/2001 dry season decomposition, high C/P ratio *Dactyladenia* showed P immobilization in the subhumid zone from 8 to 14 weeks of incubation, but P release in the arid zone during the same period.

Discussion

The responses of plant residue decomposition and nutrient release to plant residue species and agroeco-zones observed in this study indicate the intricate interactions of residue quality and agroeco-zone in

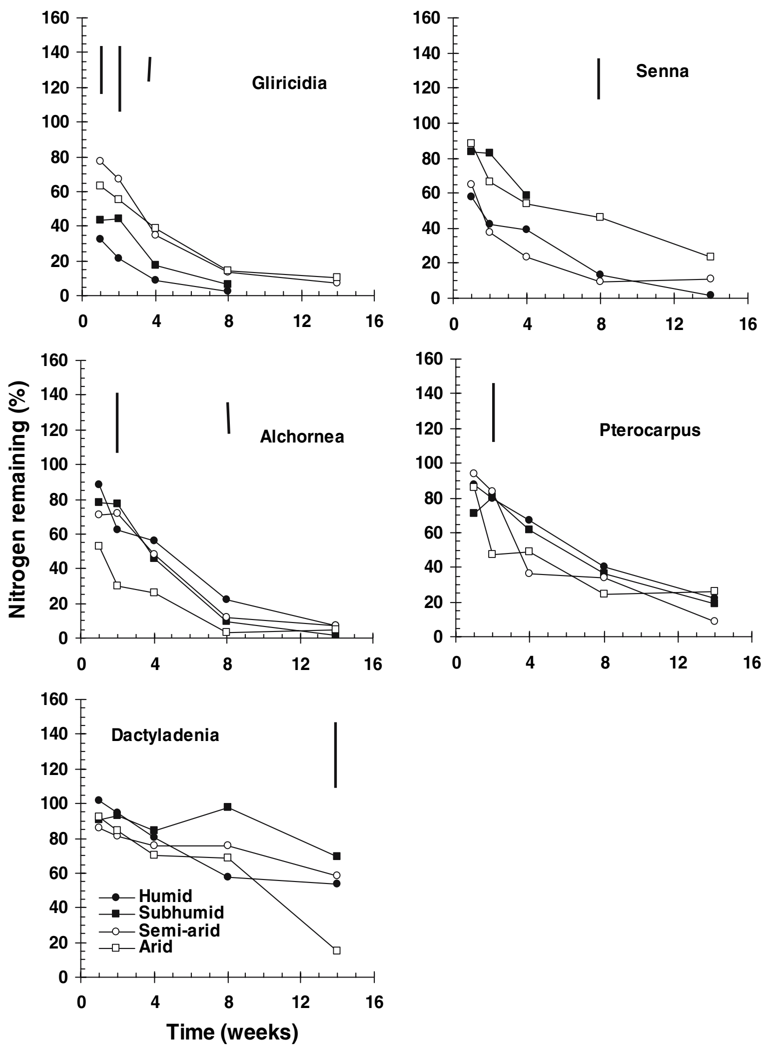

Fig. 5 Nitrogen release from plant residues of various qualities at four agroecological zones of West Africa during rainy season 2000. Bar represents LSD (0.05)

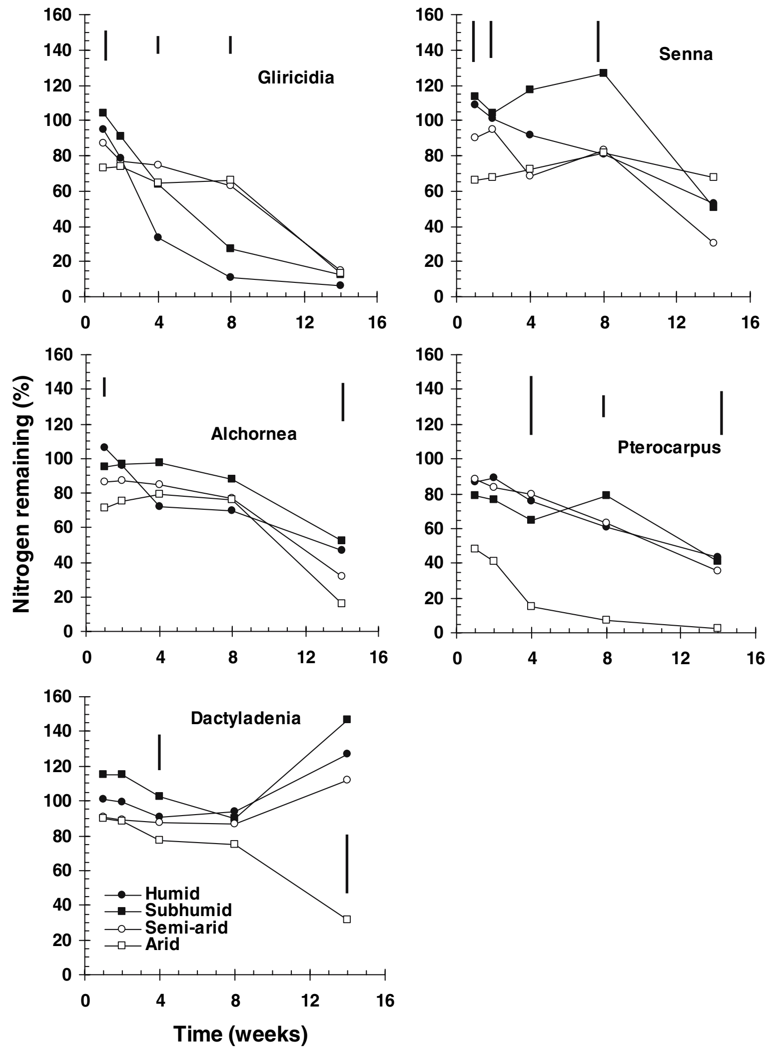

Fig. 6 Nitrogen release from plant residues of various qualities at four agroecological zones of West Africa during dry season 2000/2001. Bar represents LSD (0.05)

determining plant residue decomposition in West Africa. The decomposition of the low quality plant residue in dry climates should be much greater than commonly thought. The uncommon decomposition of the low quality residue under dry climatic conditions might be attributed to several factors, including low quality plant residues' mulching effect, soil fauna and photodegradation, which alters the well-known straight effect of residue quality and moisture availability on the decomposition and nutrient release in terrestrial ecosystems.

Tian et al. (1993b) found the mulching effect of plant residues on soil microclimate was significant only under plant residues of (very) low quality, leading to some compensation for low microbial decomposition of low quality residues. In the wet zones where moisture is generally not limited, such compensation would not alter the control of residue quality on decomposition. However, in the dry zones, the decomposition of all plant residues are retarded due to the moisture stress, and under such circumstance, the compensation of mulching effect only for the decomposition of low quality plant residues might cause the decomposition of low quality residues to be faster than that of high quality residues. Lavelle et al. (1993) noted that although climate regulates decomposition system at the high level and plant residue quality at the low level, they do interact in determining the decomposition rate.

Ouédraogo et al. (2004) reported that without soil macrofauna, 96% of *Andropogon* straw, 70% of cattle

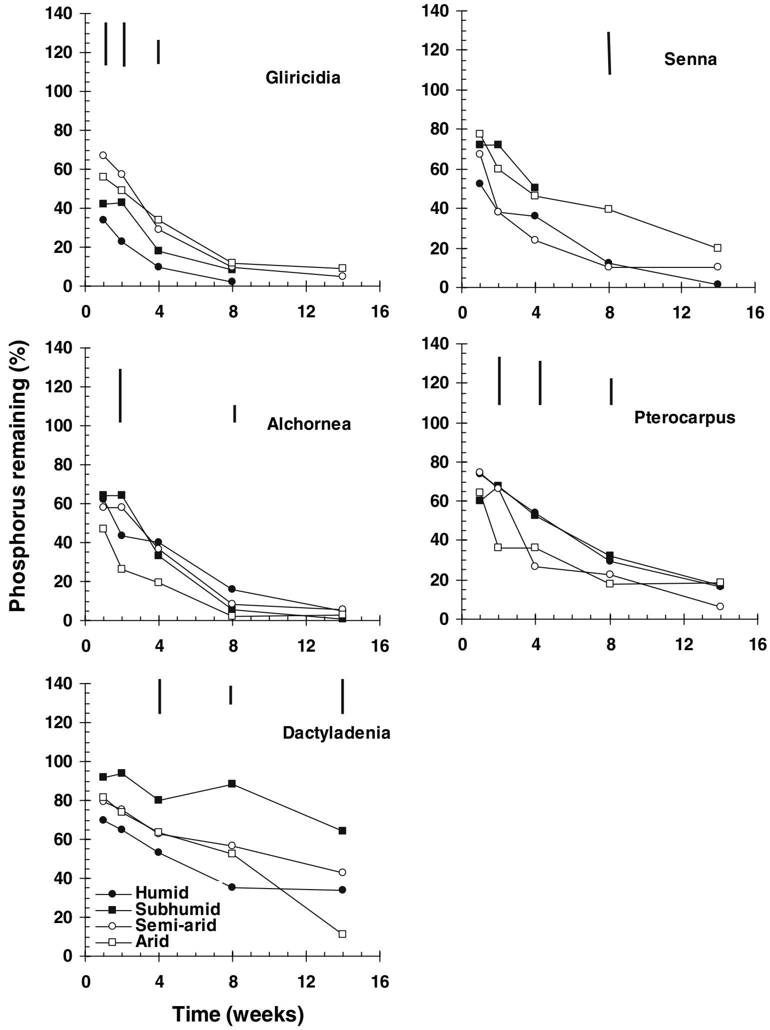

Fig. 7 Phosphorus release from plant residues of various qualities at four agroecological zones of West Africa during rainy season 2000. Bar represents LSD (0.05)

dung and 34% of maize straw were not broken down 3 months after application, whereas in the presence of soil fauna only 19% of *Andropogon* straw, 8% of cattle dung and 5% of maize straw remained 3 months after the application in a semi-arid site of Burkina Faso. The difference between plant species e.g. *Andropogon* and maize straw in decomposition rate was narrower when soil fauna were included, suggesting the modification of soil fauna on the residue quality effect on residue decomposition in this semi-arid site. In semi-arid low-input agricultural systems, soil fauna (termites) determine the rate of decomposition of organic resources (Ouédraogo et al. 2004), and increase water storage (Mando 1997). Anderson and Swift (1983) noted that wood, which is a relatively intractable resource in one site, might decay rapidly in another because of termite activities. The importance of termites in the decomposition of organic materials was also reported in Chihuahuan Desert by Whitford et al. (1988). The low quality residue's mulching effect increases the population of soil microarthropods (Badejo et al. 1995; Adejuyigbe et al. 1999) and termites (Tian et al. 1993a). The increase in the population of these faunal groups would cause the enhanced comminution of the low quality residues, making the substrate better accessible to microbes. The decomposition of the low quality residue, which is resistant to microbial degradation, would therefore be accelerated under dry climates due to enhancement in soil fauna. This faunal effect may have also alleviated N and P immobilization during the late stage of dry season

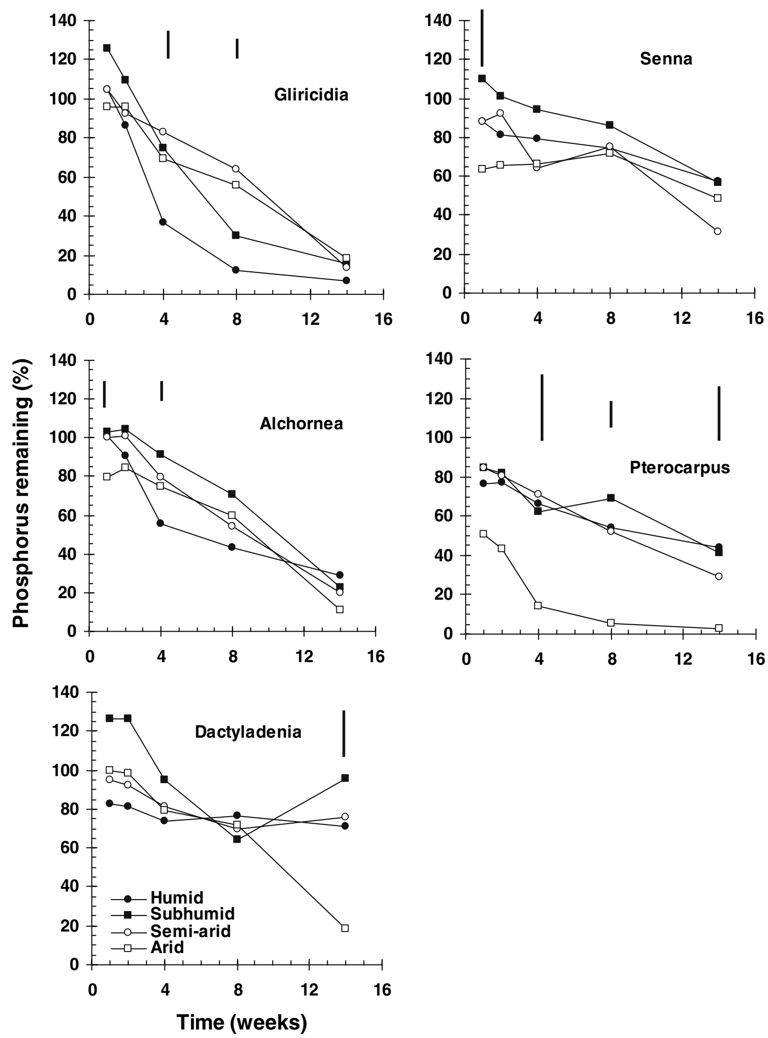

Fig. 8 Phosphorus release from plant residues of various qualities at four agroecological zones of West Africa during dry season 2000/2001

decomposition of high C/N ratio and high C/P ratio plant residue (*Dactyladenia*) in the arid zone.

Coûteaux et al. (1991) incubated leaves of chestnut tree of a high (75) and low (40) C/N ratio with microflora and mesofauna of increasing complexity (Microflora + Protozoa; + Nematodes; + Collembola; + Isopoda) for 24 weeks. They reported that the decomposition was dominated initially by litter quality, showing decomposition rate was higher for low than high C/N ratio, but towards the late stages, the decomposition rate was even higher for high than low C/N ratio in the treatment with fauna of highest complexity, and overall, the litter weight loss, cumulative C–CO_2 production and cumulative C in leachate was greater for high than low C/N ratio litter. Coûteaux et al. (1991) attributed the enhanced decomposition of litter with high C/N ratio at later stage to the contribution of soil animals and white-rot fungi. The white-rot fungi only occurred in the litter produced in a CO_2-enriched atmosphere, and thus, the litter with a low N content might have favored the development of organisms, which were able to degrade resistant compounds during the late decomposition stages. Okoh et al. (1999) reported that the composition and diversity of fungi differed among agroforestry plots, which received litterfall of various qualities. As high C/N ratio residues tend to be low in plant residue quality index, the results of Coûteaux et al. (1991) imply that with the inclusion of soil fauna, it is possible to see a condition in which the decomposition rate of plant residues with low quality could be higher than that with high quality.

Austin and Vivanco (2006) reported that in Argentina litter decomposition rate was reduced by 60% when solar radiation was attenuated, and they concluded that photodegradation is a dominant control on litter decomposition in the dry ecosystem. As the solar radiation (sunshine hours) increases from the humid to the arid zone (Fig. 1), plant residues will receive greater photodegradation in the arid than the humid zone. The higher decomposition rate of low quality residues in the arid zone than in the humid zone might be partially due to greater photodegradation in the arid zone. Therefore, photodegradation may need to be included into the decomposition system for tropical Africa. However, a question still remains to be answered: why the decomposition rate of plant residues increased with the decrease in residue quality in the arid zone, if the residue decomposition in the arid zone is controlled by photodegradation?

Conclusions

The results obtained from this study clearly confirmed our three hypotheses. (1). The increase in rate of decomposition and nutrient release of plant residues with the increase in residue quality can be observed only in wet regions. (2). The decrease in rate of decomposition and nutrient release of plant residues from humid to arid regions of West Africa can be observed only for higher quality residues. (3). The low quality plant residue could decompose and release N and P faster in dry than wet zones, and in dry regions it could decompose and release N and P faster than the high quality plant residue. The decomposition equations of Tian et al. (1992, 1995) have been revised, and the revised equation could be used to predict the decomposition of plant residues of various qualities at various agroeco-zones in West Africa. Further research is needed to verify the proposed mechanisms involved in the climate-residue quality interactive effects on the residue decomposition.

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