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NUTRIENT FLOWS FROM HARVESTED BANANA PSEUDOSTEMS

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ABSTRACT

Management of harvested (senescent) banana pseudostems has implications for efficiency of nutrient use for sole cropped as well as intercropped bananas. Two studies were conducted on aspects of nutrient flows from senescent pseudostems. Sixty one and 55% of the initial N and P, respectively, in standing senescent pseudostems were determined to be translocated to attached growing pseudostems at six weeks after harvest. Lesser proportions of the initial K, S, Fe, Zn, Cu and B were translocated; translocation of Ca, Mg and Mn was negligible. Over 50% and 70% of the initial N, K and Mg were released from the mulch of cut and shredded pseudostems by six and nine weeks after harvest, respectively. Other nutrients were released more slowly from the mulch.

Key Words*: *Musa, nutrient cycling

RÉSUMÉ

La gestion des fausses tiges de bananes après récolte ou tiges senescentes a des implications sur l'usage efficient de nutriments par les plants de bananiers en monocultures ou en cultures croisées. Des études ont été conduites sur le flow de nutriments des fausses tiges senescentes. On a observé que respectivement 61 et 55% de l'azote et phosphate initial des tiges senescentes debout, passeraient aux tiges en croissance six semaines après récolte. Le transfert de K, S, Fe, Zu, Cu, et B etait en quantité moindre; celui de Ca, Mg et Mn était négligeable. Plus de 50 et 70% de l'N, K et Mg ont été produits par les coupes de paillis et les lambeaux de fausses tiges respectivement six et neuf semaines après récolte. D'autres nutriments ont été produits plus lentement du paillis.

***Mots clés*: *Musa*, recyclage de nutriments.**

INTRODUCTION

Highland cooking (Musa type AAA) and beer bananas (Musa types AAA, ABB and AB) are important staples for the East African highlands, but the productivity of banana based systems has been declining in many areas (Karamura *et al.*, 1993). Primary banana production constraints include low soil fertility and a pest complex (INIBAP, 1986; Gold *et al.*, 1993). Increasing land pressure has reduced crop rotation and fallow as means of managing both soil and pest problems.

Rates of nutrient application are insufficient to meet the needs of these banana-based systems because of scarcity of organic manures and high costs of inorganic fertilizers. Maximizing response to applied and otherwise available nutrients is important to the sustainability and profitability of these systems.

Components of nutrient use efficiency are efficiency of capture and efficiency of conversion (Trenbath, 1986). Capture efficiency refers to the crop's ability to gather scarcely available nutrients. Efficient capture of N, for example, results in more N uptake by the plant and less loss to leaching and volatilization. Similarly, efficient capture of P might be reflected in a greater P uptake with less P sorption. With efficient conversion, the crops yield more consumable product per unit of nutrient uptake. In addition, rapidly recycled nutrients are less subject to loss. Bananas are commonly intercropped with beans (*Phaseolus vulgaris* L.) and other crops in Eastern Africa. While the associated crops compete for nutrients, nutrient use efficiency is often improved by intercropping. Wortmann *et al. (1992)* found the improved nutrient use efficiency in the banana-bean system to be primarily due to improved nutrient capture efficiency.

In bananas, substantial amounts of nutrients may be translocated from standing senescent pseudostems to growing pseudostems (Turner and Barkus, 1973). However, nutrient release from the mulch of cut and shredded pseudostems, and its subsequent availability to the root systems of growing plants, is also likely to occur rapidly. Alternative nutrient management strategies may affect the relative competitiveness of the associated crops. Therefore, a critical understanding of post-harvest residue management on the recycling of nutrients within banana fields is necessary for developing efficient soil management strategies.

Two studies were conducted to compare nutrient flows from senescent pseudostems, as practiced by many farmers, with the flows from mulch of shredded banana pseudostem residues. The first study tested the hypothesis that nutrients are rapidly translocated from senescent pseudostems to attached growing pseudostems, thereby "feeding" the growing pseudostems. In the second study, rates of nutrient loss from the mulch of shredded pseudostems were evaluated.

MATERIALS AND METHODS

Two studies were conducted at Kawanda Agricultural Research Institute (1190 m asl), near Kampala, Uganda (O°19'N, 32°35'E). The soil is a red sandy clay loam classified as a Mollic Kandhapludalf. The plantation of the highland banana variety, *Nfuuka* (Type AAA-EA), had been established four years previously. Plant tissue samples were analyzed by the CIAT Analytical Services Unit for N (Bremner, 1965), P (Murphy and Riley, 1962) and cations (Chapman and Pratt, 1961; Baker and Smith, 1973).

Study 1. Nutrient flow from senescent pseudostems. Nutrient flows were determined by monitoring changes in the nutrient concentrations in the lower 1.5 meters of uncut pseudostems over a period of six weeks following harvest of the fruit. Samples were collected over a nine month period in 1992 as fruits were harvested. Sixteen, 14, 8 and 6 harvested pseudostems were destructively sampled at 0, 2, 4 and 6 weeks, respectively, after harvest. Samples were dried at 60°C for 48 hours, ground and analyzed for nutrient concentrations. Pseudostem dry matter changes due to respiration were inferred over a period of six weeks following harvest of the fruit. from the increase in Mn concentration, as well as from the mean increase in Ca and Mg concentrations, of the senescent pseudostems. The nutrient flow estimates from the senescent stems are dependent on the assumption that there was no net movement of Mn, Ca or Mg into the harvested stem, and that the increased concentrations of these nutrients were due to carbohydrate loss through respiration.

Study 2. Nutrient flow from mulched pseudostem residues. This study determined the rate of nutrient release from mulch of shredded pseudostems over a nine week period during the second rainy season of 1992. Immediately after harvest, stems were cut at the corm, quartered lengthwise and cut into pieces of 15 cm length. The pieces were put into plastic litter bags with 5 x 5 mm openings and placed on the ground surface. Six replications of samples were taken 0, 1, 2, 3, 5, 7 and 9 weeks after harvest. Samples were dried at 60°C for 48 hours, weighed and ground after brushing away all visible soil, and analyzed for nutrient content. Rates of dry matter and nutrient loss from the mulch were determined.

RESULTS

Study 1. The various nutrients were removed from the senescent pseudostems at varying rates as indicated by changes in dry matter concentrations: N and P concentrations decreased and Ca, Mg and Mn concentrations increased ($P < 0.05$), while K, S, Fe, Zn, Cu and B concentrations were unchanged. The changes in nutrient concentrations in the senescent pseudostems are represented by the following equations with weeks after harvest (WAH) as the independent variable.

$\% N = 0.472 - 0.077* WAH + 0.009* WAH^2, R^2 = 0.34$
$\% P = 0.0619 - 0.0018* WAH, R^2 = 0.34$
$\% Ca = 0.395 + 0.0149* WAH, R^2 = 0.11$
$\% Mg = 0.405 + 0.0165* WAH, R^2 = 0.14$
$mg\ kg^{-1}\ Mn = 188.6 + 26.16* WAH, R^2 = 0.32$

Mn concentration increased most. Assuming no increase in total Mn in the senescent pseudostem, 45.4% of the dry matter of the pseudostems was lost over the six week period (using this assumption for Ca and Mg, the dry matter loss over six weeks was 23.5%).

TABLE 1. The initial concentrations of nutrients in senescent banana pseudostems, and the estimated removal of nutrients from the pseudostem at six weeks after harvest

Nutrient	Original concen-tration	Percent removed based on	
		Mn[1]	Ca and Mg[2]
N	0.472%	61	46
P	0.062%	55	37
K	3.84%	45	23
Ca	0.395%	33	0
Mg	0.405%	32	0
S	0.039%	45	23
Fe	361 mg kg^{-1}	45	23
Mn	189 mg kg^{-1}	0	–
Zn	26.2 mg kg^{-1}	45	23
Cu	4.7 mg kg^{-1}	45	23
B	11.2 mg kg^{-1}	45	23

[1,2]Based on the assumption that the total Mn, Ca and Mg in the pseudostems was unchanged over the six week period.

TABLE 2. Percent of initial amounts of nutrients from mulch samples of cut and shredded pseudostems of bananas

Nutrients	% removal from mulch samples		R^2 of equation
	6 weeks	9 weeks	
N	52.6	71.1	0.61
P	41.2	61.7	0.76
K	50.6	76.0	0.74
Ca	43.0	64.5	0.72
Mg	56.8	85.3	0.53
S	44.3	66.4	0.49
Fe	–	–	ns
Mn	37.0	55.5	0.29
Zn	33.7	49.1	0.14
Cu	–	–	ns
B	–	–	ns

Estimated removal of nutrients from the pseudostems over a six week period is presented in Table 1. Substantial and significant amounts of N, P, K, S, Fe, Zn, Cu, and B were lost from the senescent pseudostems. While part of the N and S could have been lost by volatilization, and P, B, and cations could have been lost to exudation and leakage, it was assumed that these nutrient losses were minimal. Because of this, it is further assumed that the removal of these nutrients is primarily due to translocation to the growing pseudostems.

Study 2. Litter bag samples lost dry weight over a nine week period according to the following equation:
$\%dry\ matter\ remaining = 1.00 - 0.083* WAH, R^2 = 0.88$. Six weeks were required for 50% loss of the initial mass of the litter. Nutrient concentrations did not change much with time and nutrient release was generally closely related to dry matter loss (Table 2). Macro- and secondary nutrients were released from the litter at relatively high rates. Changes in concentrations of micro-nutrients and their estimated rates of release from the litter were inconsistent over time.

DISCUSSION

Rates of nutrient translocation from the harvested pseudostems were similar to the rates of removal containing the decomposing pieces of cut and shredded pseudostems. However, the nutrients removed from the mulch were not all immediately available to the growing plants, as some nutrients were tied-up in the form of small pieces of mulch lost from the litter bag and in soil microbial biomass.

Direct translocation of nutrients from the harvested pseudostems is expected to give immediate nourishment to the growing pseudostems, and to result in efficient nutrient use through high capture efficiency. Some nutrient loss due to leaching, volatilization and fixation after release from the mulch is expected. In banana sole crop, translocation of nutrients from harvested pseudostems is expected to result in rapid nutrient recycling and to be especially beneficial to plants that have poor root systems due to nematode damage or other problems.

If the bananas are intercropped, translocation of the nutrients from the harvested pseudostems is expected to favor the bananas over the associated crop. Cutting of harvested pseudostems to produce mulch is likely to favor the associated crop whose extensive rhizosphere would be relatively more competitive in nutrient uptake.

The results of this study have application to organic resource management in banana-based cropping systems. On the one hand, the translocation of nutrients from senescent to developing tissues is an efficient physiological process, but one that is selective toward specific nutrients and limited in magnitude. Decomposition of the same pseudostem residues is an ecological process which is expected to result in some nutrient losses from the agroecosystem, but one that offers opportunity to transfer nutrients from banana to associated crops. Effects of senescent pseudostems on banana pest dynamics, the benefits of mulching in weed suppression and water conservation, and the possible use of pseudostem residues to feed livestock need consideration.

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