Farmers' information on sweet potato production and millipede infestation in north-eastern Uganda. II. Pest incidence and indigenous control strategies.

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Abstract

Sweet potato (*Ipomoea batatas* (L.) Lamk) is an important staple food for the people of north-eastern Uganda. Crop yields per unit area are low partly because of biological constraints, including pests like millipedes. The objective of this study was to generate information on pest incidence and control strategies of millipedes by interviewing farmers in different districts. The respondents associated the dying of planting material with drought. However, millipedes also damaged planting material planted early in the rainy season. The sweet potato butterfly (*Acraea acerata*, Lepidoptera: Nymphalidae) was present, but considered by farmers to be insignificant. Measures to control sweet potato pests, like sanitation, were hardly implemented and insecticides were not used at all. Most respondents performed piecemeal harvesting. Whenever farmers delayed the harvest, they risked severe damage of their sweet potato crops by weevils (*Cylas* spp., Coleoptera: Curculionidae) and millipedes (Diplopoda). Millipedes pierce and tunnel the storage roots, especially when harvesting is delayed. The farmers did not mention specific natural control agents for millipedes. Knowledge about pests was generally limited, so control strategies were poorly developed, understood and applied.

Additional keywords: biological control measures, botanical pesticides, damage symptoms, Diplopoda, *Ipomoea batatas*, piecemeal harvesting, tolerant varieties

Introduction

In Uganda, sweet potato (*Ipomoea batatas* (L.) Lamk) is grown as a subsistence crop for food security and as a cash crop (Ewell & Mutuura, 1994; Scott *et al.*, 1999; Abidin, 2004).

Cropping systems in north-eastern Uganda are diverse. The agro-ecological growing conditions and sweet potato cropping systems have been discussed recently (Abidin, 2004). In sweet potato production, cassava is often the crop preceding sweet potato, while millet, groundnut, and maize are usually the after-crop (Ebregt *et al.*, 2004).

Sweet potato storage roots are mainly grown for home consumption (Smit, 1997a; Abidin, 2004). For that reason, and because of low quality demands, a high level of tolerance of farmers to pests can be expected. Because the storage roots can only be stored for a short time, farmers practise 'in-ground storage on the plant'. As a result sweet potato crops can be found in the field throughout the year (Smit, 1997b).

The yield per unit area in Uganda is low (Anon., 2002) due to several biological, physical and socio-economic constraints. In order for the potential of sweet potato to be fully realized, these constraints must be removed. Insect pests were identified by farmers to be the most important biological constraint (Bashaasha *et al.*, 1995). For Uganda, crop losses due to sweet potato weevils (*Cylas brunneus* and *C. puncticollis,* Coleoptera: Curculionidae) of up to 73% have been reported (Smit, 1997a). Second in importance are the caterpillars of the sweet potato butterfly (*Acraea acerata*, Lepidoptera: Nymphalidae) (Bashaasha *et al.*, 1995; Smit, 1997a). Recently, the damage in sweet potato by millipedes was brought to attention (Abidin, 2004). Millipedes also attack crops like cassava, maize, groundnut and beans (kidney bean or other grain legumes), which all are part of the sweet potato cropping systems in north-eastern Uganda, and often grown in direct succession (Ebregt *et al.*, 2004). The level of damage caused by millipedes in these crops is not known, but farmers intimate that the impact is serious, especially in groundnut. Separation of plots over time and in space is often neglected and might be another factor contributing to the occurrence of millipedes (Ebregt *et al.*, 2004).

In a companion paper Ebregt *et al.* (2004) reported that millipede incidences were not statistically different for the three agro-ecological zones in the research area. It was also noted that the patterns of weevil and millipede incidences in the sweet potato cropping systems were interrelated and associated with the frequency of sweet potato. It was suggested that weevils enhance millipede attacks.

The subsistence farmers of north-eastern Uganda, and eastern Africa as a whole, cannot afford pesticides for a low-value crop like sweet potato. So control strategies based on cultivation practices are presently the most promising component of an integrated pest management strategy against many pests for small-scale sweet potato farmers (Smit, 1997a).

This paper presents the results of farmers' interviews about the relevance of pests occurring in the crop, and about pest management and its constraints. The paper focuses on the millipede problem.

Materials and methods

Interview area and methodology of collecting farmers' information on sweet potato production and millipede infestation have been described in a companion paper (Ebregt *et al.*, 2004).

Questionnaire

A standard, partly structured and partly open questionnaire for individual interviews and focused on the millipede problem was designed and administered. The following issues were targeted: (1) harvest practices, (2) pest management and its constraints, (3) ranking (incidence of) pests and damage symptoms caused by millipedes, and (4) state of planting material of sweet potato two weeks after planting.

Data collection and processing

Farmers were asked which pest caused a decline in yield or quality of their sweet potato and the rate of severity of damage they experienced by that pest. From here, the ranking of severity and the ranking of the incidence of each pest could be established by giving them a score, using a 4-nominal rating scale. For ranking the severity of the pest (incidence), scores were made as follows: score 4 = severe/serious, score 3 = moderate, score 2 = slight, and score 1 = no damage/no pest. Next, for each district, the relative ranking for each variable was calculated by using the formula $(\Sigma n_i s_i) / n_t$; where n_i is the number of farmers who gave ranking 1 to 4, s_i is the score 1 to 4 and n_t is the total number of farmers interviewed.

Genstat (Anon., 1997) was used for general analysis of variance to determine the ranking of pest (millipedes, weevils, rats and sweet potato butterfly) occurrence in sweet potato.

Results and discussion

Harvesting practices

Piecemeal versus one-time harvesting

When a farmer expects part of his crop to be ready, he may start to uproot the mature storage roots. A crack in the mound indicates the place where he can expect a storage root, ready to be eaten. This part by part removing the roots from plants without uprooting the plant itself is called piecemeal harvesting. Table 1 shows that piecemeal harvesting, which extends the availability of food, starts in May for those who planted early, with most of the farmers digging for their meals from June/July up to November. The majority of the respondents practised both piecemeal and one-time harvesting, confirming earlier findings by Bashaasha *et al.* (1995), Smit (1997a) and Abidin (2004).

Table 1. Number of farmers in north-eastern Uganda (by agro-ecological zone – AEZ) indicating month for piecemeal harvesting of sweet potato. n = number of respondents.

Agro-ecological zone[1]	n	Month of harvesting											No. of piecemeal harvests	Piecemeal only	Whole harvest only	Both types of harvesting
		May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March				
AEZ I	61	4	6	15	11	7	9	7	5	2	2	3	71	3	18	40
AEZ II	38	0	5	8	8	7	7	3	3	0	1	0	42	0	9	29
AEZ III	26	0	8	3	6	11	3	4	2	1	0	0	38	0	3	23
Total	125	4	19	26	25	25	19	14	10	3	3	3	151	3	30	92

[1] AEZ I = Northern Moist Farmlands; AEZ II = North Central Farm-Bush Lands with sandy soils; AEZ III = Southern Lake Kyoga Basin.

According to Smit (1997b), the practice of piecemeal harvesting has a positive effect on the control of weevil infestation. On the other hand, millipedes hardly damage the storage roots until 5 months after planting (Abidin, 2004), i.e., the storage roots are not damaged by millipedes whether farmers practise piecemeal or one-time harvesting. So the piecemeal practice cannot be considered a control strategy.

Period of harvesting and possible delays

According to the respondents in all agro-ecological zones, the final harvest was generally done in two steps, namely during July/August and December/January. There was a tendency to delay harvesting. Reason for this delay was that many respondents waited for a better market price or hoped that some more rain would come so that the storage roots would increase in size. Another reason is that during this period the rains normally have disappeared and everybody in the village is busy slicing storage roots for sun-drying in order to prepare chips (amukeke) for storage or for immediate consumption.

Respondents who planted after August often left the storage roots during the dry season in the soil, in order to harvest when food supply runs short. Weevils, however, will have heavily worked on the storage roots by now, as they are very active during dry periods (Bashaasha *et al.*, 1995; Smit, 1997a). Some farmers interviewed even left the storage roots 'in-ground on the plants' up to May/June. In this way, so the respondents claimed, there was a risk of millipede damage, especially when the rains returned and these hungry creatures returned to the topsoil from lower depths and humus-rich hiding places.

Pest management and its constraints

Susceptible and tolerant varieties

Asked about the tolerance of their varieties to weevils farmers indicated that Osukut is more or less susceptible to this pest, but that Araka Red and Araka White (whole research area) and Tedo Oloo Keren (Lira District) have some tolerance. Six respondents, five from Kamuda Sub-county (Soroti District) and one from nearby Kalaki (Kaberamaido District), reported that also Opaku (syn. Esegu), a less important variety, has some tolerance to weevils (Table 2). Research on varieties susceptible to weevils has also been described by Abidin (2004).

Additionally, farmers also mentioned 11 varieties that, according to their perception, were 'tolerant' to millipedes. These were the common varieties Araka White, Tedo Oloo Keren, Latest and Lira Lira and the less common ones Odupa, Ajara, Bibi, Chapananca, Odyong Bar, Josi-Josi and Acan-Kome-Tek. All of them were mentioned only once.

Pest control measures

As can be seen from Table 3, 85% of the respondents reported to implement a form of pest control management in their crops. The use of insecticides, especially in Kumi District, was the main pest control option, namely 55%. This is a high figure for resource-poor farmers. During the turmoil in the period 1980 – early 1990, when

Table 2. Number of farmers in north-eastern Uganda (by agro-ecological zone (AEZ) and district) who considered a sweet potato variety tolerant to sweet potato weevil (*Cylas* spp.). n = number of respondents.

Agro-ecological zone[1] / District	n	Variety										Times a tolerant variety was identified
		Araka Red	Araka White	Esegu[2]	Ateseke	Keren[3]	Osapat	Ibiolot	Osukut	Lira Lira	Okuja[4]	
AEZ I												
Soroti	18	5	2	0	1	0	0	0	1	0	0	9
Kaberamaido	23	2	1	1	1	0	0	0	0	0	1	6
Lira	30	1	1	0	0	4	0	0	0	4	2	12
Total AEZ I	71	8	4	1	2	4	0	0	1	4	3	27
AEZ II												
Soroti	25	5	3	5	2	0	0	0	1	0	0	16
Katakwi	24	1	1	0	2	0	1	3	0	0	0	8
Total AEZ II	49	6	4	5	4	0	1	3	1	0	0	24
AEZ III												
Kumi	28	4	2	0	0	0	4	0	2	0	0	12
Total AEZ I–III	148	18	10	6	6	4	5	3	4	4	3	63

[1] See Table 1.

[2] Esegu is synonym for Opaku.

[3] Keren = Tedo Oloo Keren.

[4] Okuja is synonym for Namuhenge.

many people lost their lives and properties, important traditional information and working knowledge on agricultural technologies declined. In that situation, pesticide agents, often through extension officers, easily obtained a foothold to promote and sell their products, which were mostly Ambush (a.i. permethrin) and Fenkill (a.i. fenvalerate). Both are mainly used against aphids in legumes. The re-introduction of cotton, with its extraordinarily high use of subsidized insecticides, consolidated the idea under many smallholders that these chemicals were the only control measures against pests. So other pest control strategies were neglected.

Mechanical control, which followed the use of insecticides in importance, was mostly done by means of uprooting (mainly cassava with Cassava Mosaic Virus) and killing pests by hand. The use of insecticides in sweet potato was not reported, which is in contrast to other districts in Uganda (Bashaasha *et al.*, 1995). The use of an extract of the neem tree (*Azadirachta indica*) leaves was only mentioned once.

Table 3. Number of farmers practising pest control measures in north-eastern Uganda (by agro-ecological zone (AEZ) and district). n = number of respondents.

Agro-ecological zone[1] / District	n	Control measures								
		In general					In sweet potato			
		Yes	Insecticides		Hand-picking	Use of botanicals	Destruction of debris		Resistant varieties	Other
			Yes	No			Vines	Roots		
AEZ I										
Soroti	18	13	10	8	10	0	3	2	10	4
Kaberamaido	23	19	7	16	15	10	8	2	7	3
Lira	30	28	16	14	14	3	10	5	16	1
Total AEZ I	71	60	33	38	39	13	21	9	33	8
%	100	84	46	54	55	18	30	13	46	11
AEZ II										
Soroti	25	20	15	10	11	4	9	4	11	1
Katakwi	24	19	11	13	18	11	2	1	13	0
Total AEZ II	49	39	26	23	29	15	11	5	24	1
%	100	80	53	47	59	31	22	10	49	2
AEZ III										
Kumi	28	27	23	5	13	2	1	1	13	1
%	100	96	82	18	46	7	4	4	46	4
Total AEZ I–III	148	126	82	66	81	30	33	15	70	10
%	100	85	55	45	55	20	22	10	47	7

[1] See Table 1.

According to the respondents, leaving most of the crop residues including the small or badly affected storage roots in the field immediately after harvesting, is common practice in sweet potato production especially in Kumi District. Crop residues are left for cattle to feed on and for vine regeneration. Often the small roots were buried to stimulate the development of volunteer plants. So weevils and millipedes could survive in the storage roots during the dry season. At the beginning of the next growing season, the excess of volunteers and affected storage roots is usually piled in heaps outside the field, from where millipedes can easily affect after-crops like groundnut, beans (kidney bean or other grain legumes), cassava and maize, besides sweet potato. Sometimes, the infested tubers are taken home, after which the bad parts are cut off and thrown away. The weevils and millipedes will still survive in them. Only eight respondents reported destroying millipedes manually or by burning them.

Use of botanical pesticides

Botanical insecticides were hardly used, with the exception of ash (Table 4). One farmer used a mixture of extracts of leaves from the neem tree, tobacco and chillies. Other plants used were a pine tree called 'ajerabos' and the Lira tree (*Melia azedarach*), which is a member of the same family (Meliaceae) as the neem tree. Striking during the discussions was that one or two generations back the use of botanicals was quite normal, but they have been 'forgotten' in spite of the fact that the technique of preparing botanical pesticides is based on a simple technology (Stoll, 1992).

Table 4. Number of farmers in north-eastern Uganda (by agro-ecological zone (AEZ) and district) using botanical pesticides. n = number of respondents.

Agro-ecological zone[1] / District	n	Botanical pesticide				
		Neem	Tobacco	Chillies	Ash	Other
AEZ I						
Soroti	18	0	0	0	0	0
Kaberamaido	23	0	0	0	10	0
Lira	30	0	0	0	3	0
AEZ II						
Soroti	25	0	0	0	0	0
Katakwi	24	3	1	1	8	3[2]
AEZ III						
Kumi	28	1	0	0	2	1[3]
Total	148	4	1	1	23	4

[1] See Table 1.
[2] Ajerabos, Lira tree and pine trees.
[3] Ajerabos.

Exceptional control measures

Exceptional control methods were prompt harvesting and avoiding harvesting in March/April. One respondent reported the use of a trap plant, amalakwang (*Hibiscus sabdariffa*), a common wild vegetable in the area, for attracting weevils and sweet potato butterflies, after which he killed them.

Natural control agents

Many respondents mentioned that farm animals like chickens, ducks, turkeys and pigs feed on millipedes. It was not clear whether these animals really eat millipedes as part of their diet, or whether it was out of hunger. As it so happens, the influx of millipedes coincides with the beginning of the first rains (Ebregt *et al.*, 2004), when livestock is lacking feed.

Four respondents observed true crickets (Gryllidae) feeding on millipedes. At least in a number of cases the remains of a millipede were found near the entrance of a cricket's underground burrow. Three other farmers informed us about army ants, while two others saw scorpions predating on millipedes, as had also been observed before by Lawrence (1984) and Herbert (2000). However, in Murchison Falls National Park, Uganda, it has also been noticed that millipedes in turn fed on dead scorpions (E. Ebregt, personal observations). Furthermore, farmers saw a crow, an owl and an Abdim's stork (*Ciconia abdimii*) feeding on millipedes, although no literature could be found to confirm this. Probably due to the lack of knowledge about birds, no other birds were mentioned. Maclean (1993), however, lists a number of bird predators of millipedes in South Africa, and singles out Hadeda ibis (*Bostrychia hagedash*), Grey heron (*Ardea cinerea*), Helmeted guinea fowl (*Numida meleagris*), Crested guinea fowl (*Guttera pucherani*), Woodland kingfisher (*Halcyon senegalensis*), Rufous-naped lark (*Mirafra africana*), Fawn-coloured lark (*Mirafra africanoides*), Schalow's wheatear (*Oenanthe oenanthe*) and the Spectacled weaver (*Ploceus ocularis*). All of these birds are also a part of the natural ecosystem, permanently or during migration, of north-eastern Uganda (Williams & Arlott, 1995). However, none of them is known to make a habit of destroying millipedes by choice or of making them the main item of their diet (Lawrence, 1984). Small burrowing animals might also feed on them (Lawrence, 1984) and numerous eggs must also form the meals of soil scavengers (Hopkin & Read, 1992), but according to the latter authors there is little quantitative information on the number of millipedes that fall victim to predators.

Unfamiliarity with pests and their life cycles

During the exercise of identifying sweet potato weevils, rough sweet potato weevils, tortoise beetles and small (Odontopygidae) and big (Spirostreptidae) millipedes, the respondents in most cases were familiar with both kinds of millipedes. In 87% of the interviews (92 respondents; n = 106), the small millipede was identified as the culprit, piercing the storage roots of sweet potato. During this exercise it generally appeared that the respondents had a poor working knowledge of other pests and of general control measures, the importance of which was not completely understood. Smit (1997a) suggested that life cycles and behaviour of the major pests should be explained to the farmers, so that they better understand the insects' mode of dispersal.

Unintentional control measures

Many control strategies, such as shallow ploughing, were implemented without the full awareness of their importance. Even hand-picking and roguing were probably done on a larger scale. A number of control methods based on cultivation practices are difficult to implement, especially in sweet potato. For instance, planting early in the growing season is rarely done. Mainly the commercial farmers do this as they try to fetch the best price for their produce. Respondents claimed that early-planted vine cuttings risk to be attacked by millipedes and many farmers also preferred first to plant millet and groundnut in the relatively weed-free field previously used for growing sweet potato. Simultaneous planting and legislation on not growing sweet potato in a certain period of the year are not feasible in Uganda. And harvesting without delay is often not an option, as many respondents still want to await some more rain and target the best market for their produce, and so wait till the price suits them. Farmers also preferred to leave some of the crop in the field to supplement their scarce diet during the dry season. In this period the sweet potato weevil will cause a lot of damage in the storage roots.

Damage symptoms caused by millipedes

Importance of millipedes in sweet potato

In all districts, the respondents indicated weevils as the most important pest (Table 5), confirming earlier studies by Bashaasha *et al.* (1995) and Smit (1997a). Millipedes and rats follow as second, the former playing a less significant role in Soroti District, according to farmers' information. This is in contrast to earlier reports by Lawrence (1984) stating that millipedes are not pests of primary importance. The caterpillars of the sweet potato butterfly are largely considered of less importance, which contrasts with findings in other parts of Uganda (Bashaasha *et al.*, 1995) and in Rwanda (Hitimana, 2001). However, according to farmers' information this pest can occasionally become a nuisance, entirely defoliating sweet potato fields, especially during dry spells. Literature shows outbreaks to be seasonal, and usually to occur at the beginning of the dry season (Skoglund & Smit, 1995; Ames *et al.*, 1997). Lugojja (1996) and Smit (1997a) suggested that one complete defoliation does not have much effect on yield. The latter author even hinted that farmers might overrate the nuisance.

It is generally assumed that millipedes merely aggravate the damage initiated by some other agents (Lawrence, 1984; Blower, 1985; Hopkin & Read, 1992). Weevils often affect storage roots, especially during dry spells. If storage roots are kept too long in the soil, weevil injuries can attract millipedes (Ebregt *et al.*, 2004). Results from our study show that 78% of the respondents experienced that the weevils attack storage roots before the millipedes.

In the case of planting material, the millipedes might be attracted by newly planted vine cuttings because of the injury and because of the easily available digestible material. A number of respondents were reasoning in this way.

Millipede damage in sweet potato

Out of the 148 farmers interviewed, 126 respondents experienced damage in sweet potato caused by millipedes. Farmers in all districts reported that the onset of the damage could start, although very slightly, when the storage roots were 2 months old. Most farmers experienced the start of the impact on storage roots when these were 5 months old. After this, millipede activity tended to slow down. Based on our farm-walk observations and the daily experience of our farmers in the field, the periods of

Table 5. Mean scores[1] of ranking pests and their incidence in sweet potato, in 5 districts of north-eastern Uganda. n = number of respondents.

Pest	District									
	Soroti (n = 43)		Kumi (n = 28)		Katakwi (n = 24)		Kaberamaido (n = 23)		Lira (n = 30)	
	Ranking	Incidence	Ranking	Incidence	Ranking	Incidence	Ranking	Incidence	Ranking	Incidence
Millipedes	2.4c[2]	2.4b	2.5b	2.8b	2.8b	2.7b	2.4b	2.3bc	2.8b	2.5b
Weevils	3.6a	3.5a	3.7a	3.5a	3.7a	3.7a	3.6a	3.5a	3.6a	3.7a
Sweet potato butterfly	1.0d	1.5c	1.2c	2.1c	1.0d	1.8c	1.6c	1.9c	1.2d	1.7c
Rats	2.8b	2.7b	2.3b	2.5b	2.4c	2.4b	2.6b	2.6b	2.2c	2.4b
Other vertebrates[3]	1.4d	1.4c	1.3c	1.4d	1.2d	1.4d	1.2c	1.3d	1.0d	1.0d
F-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
LSD[4] ($P = 0.05$)	0.4	0.3	0.4	0.4	0.4	0.4	0.6	0.5	0.4	0.4

[1] Importance and incidence were scored on a scale of 1–4 (1 = unimportant and low, respectively; 4 = very important and high, respectively).

[2] Mean scores in the same column, followed by a common letter are not statistically different ($P > 0.05$).

[3] Goats, pigs, cows, baboons and velvet monkeys.

[4] LSD = least significant difference.

low millipede activity and re-activation correspond with the dry season and the onset of the rains, respectively. In contrast, the respondents of Lira District experienced another pattern. Here the less active period started early, when the crops were at least 2 months old.

Most farmers complained about pierced and burrowed storage roots, and often found millipedes inside them. Tunnels are filled with the insects' excrements and with trash, causing the roots to rot. This damage may heal if it takes place in a very early stage of root development.

Millipede damage in groundnut

Seventy percent of the respondents indicated to have problems with millipedes in groundnut. According to the farmers, damage can occur in the seedling stage and/or during pod development and pod filling. The cotyledons of the seedlings are partly pierced or completely eaten, often only leaving behind the testa, and/or the radicle may be consumed so that germination will fail. During pod development and pod filling millipedes pierce the young pegs and destroy the young seeds, which will leave the plant with empty pods. Ebregt *et al.* (2004) showed that 20% of the respondents did not grow groundnut after sweet potato for these reasons. Many other farmers are aware of the problem, but still grow groundnut after sweet potato. One farmer in Kaberamaido District even indicated that it was not an economically worrying problem for her, although she was aware of the fact that the millipede incidence in her sweet potato was severe and that germination and pod filling of her groundnut crop were affected. An intensive survey of soil insects in approximately 100 groundnut fields in Malawi, Zambia, Zimbabwe, Tanzania and Botswana showed that millipedes were generally present, but rarely in sufficient numbers to warrant concern (Wightman & Wightman, 1994). In the cropping season of 1996 in Mali, Burkina-Faso, Niger and Nigeria, it was found that 9.3% of the surveyed groundnut fields were attacked by millipedes (Umeh *et al.*, 1999). However, in Uganda, following an outcry from farmers in Gweri Sub-county (Soroti District) in 1999 about millipedes attacking sweet potato, groundnut and other crops, a follow-up survey did not show that millipedes contributed to the death of plants. This problem of the millipede being an economic pest in groundnut has been studied further (Ebregt *et al.,* submitted).

Millipede damage in other crops

A relatively long list of crops not favoured to be planted after sweet potato has been published by Ebregt *et al.* (2004). According to farmers' information, over-mature cassava roots can be burrowed and millipedes can eat the young sprouts of cassava cuttings, especially in the period March–May. Millipedes are also attracted by injuries created on cassava roots due to weeding or foraging rats. Germinating maize, beans, soya bean, bambara groundnut and green gram are also hosts, especially at the onset of the early rains. The respondents also reported millipedes burrowing banana pseudo-stems and cabbage. Even germinating cotton and sunflower seeds were mentioned. In all situations moisture content of the soil or the host plant, like in the case of the pseudo-stem of banana, should be high enough.

State of planting material of sweet potato two weeks after planting

The need for infilling after two weeks

Farmers claimed that not all vine cuttings will have established within two weeks after planting. For that reason infilling, if vines were available, was often done after 2 weeks. Especially in Kumi and Katakwi Districts, and to a lesser extent in Soroti, planting material does not establish well. The survival of vine cuttings was more or less related to the conditions in the agro-ecological zones, with an exception of Soroti District (Table 6).

Table 6. Number of farmers in north-eastern Uganda (by agro-ecological zone (AEZ) and district) who had suffered non-establishment of sweet potato vine cuttings 2 weeks after planting. n = number of farmers.

Respondents	Agro-ecological zone[1] and district						Total
	AEZ I			AEZ II		AEZ III	
	Soroti (n = 18)	Kaberamaido (n = 23)	Lira (n = 30)	Soroti (n = 15)	Katakwi (n = 24)	Kumi (n =28)	(n = 138)
Number	0	16	13	4	0	0	33
%	0	70	43	27	0	0	24

[1] See Table 1.

Causes of vine cuttings failing to establish

The respondents mentioned drought as the most common cause for planting material failing to take off, confirming earlier reports by Bashaasha *et al.* (1995) and Smit (1997a). The farmers stated that the most important biological constraints are millipedes, weevils, rats and other (unknown) pests. Unhealthy planting material, wrong planting methods and roaming farm animals are other causes (Table 7). Table 8 shows that only 30% of the farmers interviewed 'inspect' the inside of the mounds, enabling soil pests like millipedes to hide unnoticed. On top of that, many respondents pull the remains of the planting material out of the mound, without thoroughly inspecting the vines. During our own inspections, the mound was opened carefully around the remains of the planting material. In this way we often found the millipede coiled around the remains or in the vicinity of it. For this reason it may be expected that the actual incidence of millipedes could have been much higher had farmers used this method of inspection. Sweet potato weevils were hardly reported by our respondents. But due to the fact that most farmers are not familiar with the insect's life cycle, weevils may have been overlooked. In this study, rats were mentioned as a minor problem. Rats have a marked habit of collecting vine cuttings as nesting material. Smit (1997a) warned for the possibility that farmers overrate rat damage, as it looks more dramatic than weevil damage.

Table 7. Causes of failure of sweet potato vine cuttings to establish, in 5 districts in north-eastern Uganda. n = number of respondents[1].

Cause of failure	District					Total
	Soroti (n = 39)	Kumi (n = 28)	Katakwi (n = 24)	Kaberamaido (n = 16)	Lira (n = 13)	(n = 120)
Drought	24	24	15	15	11	89
Millipedes	11	2	3	1	2	19
Weevils	1	2	2	0	2	7
Rats	5	0	0	0	0	5
Farm animals	3	0	0	0	0	3
Unknown pest	3	5	4	3	3	18
Poor planting material	2	2	2	1	0	7
Wrong planting method	2	2	2	0	0	6
Other	1	0	0	0	1	2
Unknown	2	3	5	0	1	11

[1] Only respondents with crop establishment problems are considered; more than one reaction per farmer is possible.

Table 8. Farmers' methods of checking sweet potato vine cuttings for pests, in 5 districts of north-eastern Uganda. n = total number of farmers inspecting.

District	n	Farmers pulling up plants		Farmers inspecting inside of mound	
		Number	%	Number	%
Soroti	36	23	64	13	36
Kumi	31	24	77	7	23
Katakwi	24	17	71	7	29
Kaberamaido	19	14	74	5	26
Lira	15	10	67	5	33
Total	125	88	70	37	30

Damage symptoms of 2 weeks old dying planting material

According to the respondents, the aboveground parts of non-established planting material often showed symptoms of desiccation, though in many cases the cuttings tried to take off. Frequently the underground parts of dying vine cuttings were rotten or dried up. However, 12 out of the 120 respondents who inspected their vine cuttings reported that the planted material started to develop roots, but that 'something'

Table 9. Number of farmers in north-eastern Uganda (by district) rating millipedes, weevils and drought as stress factors for establishing sweet potato vine cuttings, and period when millipedes were considered a problem. n = total number of farmers.

District	n	Stress factor			Period most important for millipedes		
		Millipedes	Weevils	Drought	1st planting	2nd planting	Both plantings
Soroti	43	10	2	2	10	0	0
Kumi	28	2	1	2	0	1	1
Katakwi	24	3	2	2	1	2	0
Kaberamaido	23	1	0	1	1	0	0
Lira	30	2	1	1	2	0	0
Total	148	18	6	8	14	3	1

chewed away the new developing roots. In this way water uptake was blocked, resulting in wilting and finally rotting of the planted cutting. Six of these farmers inspected the inside of the mound and 3 of them pointed out the millipede as the culprit.

Eighteen respondents reported millipedes to be responsible for the destruction of planting material, often in combination with drought (Table 9). Moreover, more than 75% of the respondents appeared to have experienced this impact of millipedes on sweet potato planting material during the early rains of the first rainy season. This tallies with earlier reports from farmers (Abidin, 2004).

We will soon report in detail on the identification of the millipede species involved (Ebregt *et al.,* submitted).

Concluding remarks

Farmers take the presence of millipedes in sweet potato for granted. Certain control strategies based on cultivation practices and implemented by the farmers in north-eastern Uganda actually enhance the incidence of millipedes in the sweet potato cropping system. Furthermore, farmers' knowledge on this issue is limited, and so is their understanding of the life cycles of the most common sweet potato pests. Attention has to be paid to these issues if sweet potato production is to be increased.

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