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Assessment of farmers' knowledge and preferences for planting materials to fill-gaps in banana plantations in southwestern Uganda

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Abstract

Banana (*Musa* spp.) plantations in central Uganda used to be productive for 30-100 years. Due to prevalence of the banana weevil (*Cosmopolites sordidus* L.), life spans have fallen to only ≤5 years. This forces farmers to establish new plantations or replant existing ones, usually using infested materials. To determine farmers' knowledge and sources of planting materials and the cleaning techniques used, a household survey was conducted in southwestern Uganda. Up to 99% of the farmers reported *C. sordidus* as their major pest, and at least 50% reported gap-filling mainly due to land and banana weevil pressure. Most farmers (>80%) obtained planting materials from home/neighbours' gardens. Corm paring (recommended for cleaning) was minimal, with 87% of farmers just trimming a few roots from the suckers. Most (90%) farmers preferred maiden suckers for gap-filling, believing that they establish and mature faster, and withstand weevil damage compared with other planting materials. Based on farmers' experience and the results of an on-station study at the National Agricultural Research Laboratories (NARL), Kawanda, we recommend the use of maiden suckers when replanting in already infested plantations or those at risk.

Key words: Banana weevil, *Cosmopolitus sordidus*, *Musa* spp.

Introduction

Banana (*Musa* spp.) is the most important food crop in Uganda; supporting both rural and urban populations. However, because of the banana weevil, *Cosmopolites sordidus*, plantations in the traditional banana-growing regions of central Uganda, which used to last 30-100 years, are now deteriorating after 5 or less years (Gold *et al*., 1993, 1999). Larvae of *C. sordidus* are the most damaging stage as they bore into the corm and sometimes the pseudostem, reducing nutrient and water uptake, and thus weakening stability of the plant (Gold *et al.*, 2002). Weevil attack may cause sucker loss, poor crop establishment, snapping and toppling, reduced bunch weight, mat death and shortened stand life leading to 40-100% yield loss (Rukazambuga *et al.*, 1998; Gold *et al.*, 2002; 2004). Thus, farmers often have to either establish new plantations or/and replant in existing ones (Barekye *et al.*, 2005).

Bananas are vegetatively propagated from suckers developing from the main plant. Sucker development consists of three distinct stages: peer (small sucker appearing just above the ground and bearing scale leaves only), sword sucker (large sucker with lanceolate type leaves) and maiden suckers (large sucker with foliage leaves) (Swennen and Ortiz, 1997). Though research and extension recommend and encourage farmers to use sword suckers, corms or tissue culture plantlets, the latter continue to use maiden suckers (Speijer *et al.*, 1995; Gold *et al.*, 1998a; Barekye *et al.*, 2005; Niere *et al.*, 2014). In most cases, farmers obtain these planting materials from already weevil-infested banana plantations (Barekye *et al.*, 2005). Thus, this acts as the initial source of infestation (Gold *et al.*, 1998a) since banana weevil is generally sedentary and rarely flies (Ragama *et al.*, 2012).

Currently, research and extension recommend and encourage farmers to pare (removal of all roots and peel from the corm) and then dip the material in hot water as a way of cleaning the planting material (Gold *et al.*, 1998a,b; Barekye *et al.*, 2005). Paring eliminates most eggs and first instar larvae and also exposes weevil galleries, thus allowing farmers to reject heavily damaged material (Gold *et al.*, 1998b, 2002). However, larvae located deep within the corm are not easily removed and also, since banana weevils are attracted to cut corm materials, they may quickly re-infest the pared corms if left exposed (Gold *et al.*, 2002). Hot water treatment destroys the remaining eggs and larvae but does not eliminate them entirely (Gold *et al.*, 1998a,b). Also, the labour and costs requirements attached to these technologies may limit adoption of these procedures by farmers (Gold *et al.*, 2002; Barekye *et al.*, 2005). On the other hand, farmers usually clean their planting materials by removing part of the upper section of the pseudostem and paring of few roots which puts these materials at a risk of carrying with them banana weevils and nematodes (Barekye *et al.*, 2005).

Use of micro-propagated (tissue cultured) plantlets ensures that farmers start with clean planting material. These plantlets establish faster, grow more vigorously, have a shorter and uniform production period, and produce higher yields than conventional planting materials. However, they are prone to weevil damage during the young stage and need to be planted in pest free areas for faster establishment (Robinson, 1996). Secondly, these materials are viewed by farmers as relatively expensive and their supply and market still limited. They are also delicate and require greater care during handling (Bauer *et al.*, 2009).

Thus, the objective of this study was to assess farmers' knowledge on the planting materials used for gap-filling their banana plantations in southwestern Uganda.

Materials and methods

Description of the study area

The study was conducted in Kabwohe (Sheema district) and Bunyaruguru (Rubirizi district), both in southwestern Uganda, in May 2012. These sites are located at 00^0 34' 53''S, 30^0 22' 48''E, 00^0 16'S, 30^0 0'E, respectively, and 1490, 1300m above the sea level (a.s.l). These two sites were purposively selected because they are among the popular banana growing areas with high land pressure (Karamura *et al.*, 2004).

Sample selection and data collection

The two sites and villages sampled were conveniently selected basing on the presence of banana plantations and willingness of farmers to provide information. These were identified during household surveys conducted in 2009 in those areas (Mulumba *et al.*, 2012). In each site, five villages (Ntungamo, Rwenkarabo, Rubare andNyamirima in Kabwohe and Kyambuzi A, Kyambuzi B, Katara A and Katara B in Bunyaruguru) were selected. In each village, 10 households were also selected giving a total of 40 per site. A semi-structured questionnaire with both open and close-ended questions was administered to the households. The questionnaire elicited the socioeconomic structure of the interviewed households and their knowledge on major pests of banana, replanting and gap-filling, planting materials used in gap-filling, treatment of these materials before planting and tolerance of these materials to banana weevil attack.

Statistical data analysis

Data for the two study sites were pooled together and then analysed using descriptive statistics including means and percentages. Data analysis was performed using SAS v. 9.2 (SAS, 2008). Simple linear regression analysis was done to define the relationship between farmers' experience in growing banana and age of plantations. A simple logistic linear regression analysis was used to examine whether age of respondent, land allocated to banana production, age of plantation and farmers' experience in banana growing were determinants of whether the farmer gap-fills or not. Similarly, a simple logistic regression analysis was used to determine whether farmers' knowledge on gap-filling depended on their sex, age, level of education and marital status.

Results

The results are presented in Tables 1 - 6 and Figure 1.

Socio-demographic characteristics of respondents

The number of males and females sampled was equal, yet at least 70% of the farmers had not studied beyond primary level (Table 1). More than 75% of the farmers were married and 66% of them were between 22-50 years, with an average of 46 years. The amount of land allocated to banana production generally averaged of 1.5 acres. The banana plantations had an average age of 46 years. Farmers' experience in banana farming was 26 years (Table 1). Simple linear regression analysis showed that farmers' experience in growing banana was positively and significantly ($R^2 = 0.5$, $p<.0001$) related to age of banana plantations. Most (65%) of the farmers reported that they had planted their plantations, while less than 35% had inherited them from their parents (Table 1).

Table 1. Socio-demographic characteristics of respondents (n=80) interviewed in 8 villages in Sheema and Rubirizi districts, southwestern Uganda. Values ≥50% are in bold

Parameter		Respondents (%)
Sex	Females	**53.2**
	Males	46.8
Educational level	None	1.3
	Primary	**73.6**
	Secondary	18.0
	Tertiary	1.2
Marital status	Single	1.0
	Married	**78.5**
	Divorced/separated	3.8
	Widow/widower	10.1
	Mean± Standard deviation	Range
Age of respondents	45.9±14.9	22-80
Size of banana plantation (hectares)	0.6±0.5	0.1-4.1
Age of banana plantation (years)	45.9±14.7	2-100
Period of growing bananas (years)	25.8±16.5	1-75
How the famer obtained the banana plantation	From parents	34.2
	Planted by farmer	**65.8**

Table 2. Replanting status of banana plantations as reported by respondents (n=80) interviewed in 8 villages in Sheema and Rubirizi districts, southwestern Uganda. Values ≥50% are in bold

Parameter	Respondents (%)
Replanting in banana plantations	
Replanted in existing plantation	**65.8**
Never replanted in existing plantation	34.2
Method of replanting	
Gap-filled in existing plantation	**58.2**
Planted in new plots	26.6
Planted in new plots and gap-filled	15.2
Reason for employing that method of replanting	
Gap-filled because of not enough land	**67.1**
Planted in new plots due to excess land	16.5
No reason	16.5

Table 3. Age of respondent, land allocated to banana cultivation, age of banana plantation and farmers' experience in banana growing as determinants of the probability of replanting or gap-filling in banana plantations in Sheema and Rubirizi districts, southwestern Uganda

Parameter	DF	Standard Estimate	Wald Error	Ch-Square	Pr > ChiSq
Replanting					
Intercept	1	-1.0151	0.5747	3.1194	0.0774
Plantation size	1	-0.2168	0.2529	0.7344	0.3915
Plantation age	1	0.00695	0.0184	0.1429	0.7054
Experience in farming	1	0.0174	0.0208	0.6966	0.4039
Gap-filling					
Intercept	1	-2.1900	0.6744	10.5448	0.0012
Plantation age	1	0.0163	0.0198	0.6756	0.4111
Plantation size	1	-0.1039	0.2540	0.1671	0.6827
Experience in farming	1	0.0290	0.0226	1.6433	0.1999

Replanting status of banana plantations

Majority (99%) of farmers reported banana weevil as the most devastating pest infesting their banana in the region (Fig. 1). At least 60% of the farmers reported having replanted in their banana plantations; particularly by gap-filling (>50%) due to lack of enough land (67%; Table 2). A simple logistic regression analysis showed that the decision of a farmer to gap-fill or not was neither dependant on amount of land allocated to banana growing, age of respondent and banana plantation, nor farmers' experience in banana growing (Table 3).

Gap-filling and planting materials used by farmers

The banana weevil was reported by most (70%) farmers as the major biotic factor leading to gap-filling. Most (90%) farmers preferred to use maiden suckers for gap-filling because they establish and mature faster than other planting materials. At least 40% of the farmers reported that they obtained planting materials from their home gardens and/or from neighbors' fields. Paring of corms, which is recommended by research and extension for cleaning banana planting materials, was rarely practiced (only 2.5% of the farmers). Most (87%) farmers trimmed off a few roots from the corms, a traditional way of cleaning the planting materials. However, at least 70% of the farmers appreciated the advantages of using clean planting materials including increasing banana yields. At least 35% of the farmers reported having obtained information on planting materials from parents, seminars and own (Table 4). Simple logistic regression analysis showed that farmers' knowledge on gap-filling did not depend on sex, age, level of education nor marital status. However, respondents who reported that maiden suckers establish and mature faster depended on their marital status (Table 5).

Table 4. Gap-filling and planting materials used by respondents (n=80) interviewed in 8 villages in Sheema and Rubirizi districts, southwestern Uganda. Values ≥50% are in bold

Parameter	Percentage of respondents
Why farmers gap-fill their banana plantations	
Due to banana weevil damage	**72.2**
Due to nematode damage	27.8
Type of planting material utilized in gap-filling	
Maiden suckers	**92.4**
Sword suckers	3.8
Tissue culture plantlets	1.5
Maiden and sword suckers	2.5
Why farmers prefer maiden suckers for gap-filling	
Establish and mature faster	**89.9**
Normal practice inherited from parents	6.3
Require less management	3.5
Resistant to banana weevils	2.5
Source of planting materials used for gap-filling	
Home gardens	**58.2**
Neighbours/friends/relatives	40.5
NGO's	1.2
Treatment of planting materials for gap-filling	
No treatment	10.1
Pare off a few roots	**87.3**
Pare off all the roots	2.5
Whether respondents know the advantage of using clean planting materials	
Yes	**87.3**
No	12.7
Whether using good planting materials increases yield	
Yes	**74.7**
No	20.3
Respondent does not know	5.1
Source of information on planting material	
Parent	38.0
Seminars	26.6
Own	22.8
Own and seminars	11.4
Extension service	1.3

Table 5. Sex, age, level of education and marital status of respondents as determinants of their knowledge on gap-filling in Sheema and Rubirizi districts, southwestern Uganda

Parameter	DF	Standard Estimate	Wald Error	Ch-Square	Pr > ChiSq
Using maiden suckers for gap-filling					
Intercept	1	-26.8519	439.2	0.0037	0.9513
Sex	1	13.4144	219.6	0.0037	0.9513
Age	1	-0.1412	0.0805	3.0776	0.0794
Level of education	1	0.1416	0.9986	0.0201	0.8872
Marital status	1	1.7283	1.0301	2.8151	0.0934
Maiden suckers establish and mature faster					
Intercept	1	-3.6121	2.0972	2.9663	0.0850
Sex	1	1.3283	0.8785	2.2863	0.1305
Age	1	-0.0790	0.0429	3.3896	0.0656
Level of education	1	0.0283	0.7382	0.0015	0.9694
Marital status	1	1.2268	0.6186	3.9323	**0.0474**
Pare off a few roots for cleaning the planting materials					
Intercept	1	-3.5461	1.9802	3.2069	0.0733
Sex	1	1.4069	0.8351	2.8382	0.0920
Age	1	0.00175	0.0281	0.0039	0.9502
Level of education	1	-1.1782	0.8432	1.9525	0.1623
Marital status	1	0.2289	0.5147	0.1977	0.6566
Advantages of using clean planting materials					
Intercept	1	-3.8026	1.9293	3.8845	0.0487
Sex	1	0.9517	0.7748	1.5086	0.2193
Age	1	-0.0161	0.0300	0.2879	0.5916
Level of education	1	-0.5463	0.7440	0.5392	0.4628
Marital status	1	0.7697	0.4916	2.4518	0.1174
Using clean planting materials increases banana yields					
Intercept	1	-1.3884	1.4234	0.9515	0.3293
Sex	1	-0.6015	0.5759	1.0908	0.2963
Age	1	0.00391	0.0220	0.0316	0.8590
Level of education	1	-0.1152	0.5117	0.0507	0.8219
Marital status	1	0.4990	0.4042	1.5244	0.2170

Table 6. Farmers' perspectives on tolerance of different planting materials used in gap-filling to banana weevil attack as reported by respondents (n=80) interviewed in 8 villages in Sheema and Rubirizi districts, southwestern Uganda. Values ≥50% are in bold

Parameter	Respondents (%)
Tolerance of planting materials to banana weevil damage	
Sword suckers	45.6
Maiden suckers	45.6
Tissue culture	1.3
Why sword suckers are tolerant to weevil damage	
Grows with high vigor	**66.7**
Small corms are not liked by weevils	19.4
Respondent does not know	11.1
Not liked by weevils because they have chemicals	2.8
Why maiden suckers are tolerant to banana weevil damage	
Bigger corms which grow faster	**88.9**
Bigger corms which are not easily destroyed by weevils	2.8
Grows with high vigor	2.8
Can withstand shade effects	2.8
Respondent does not know	2.8

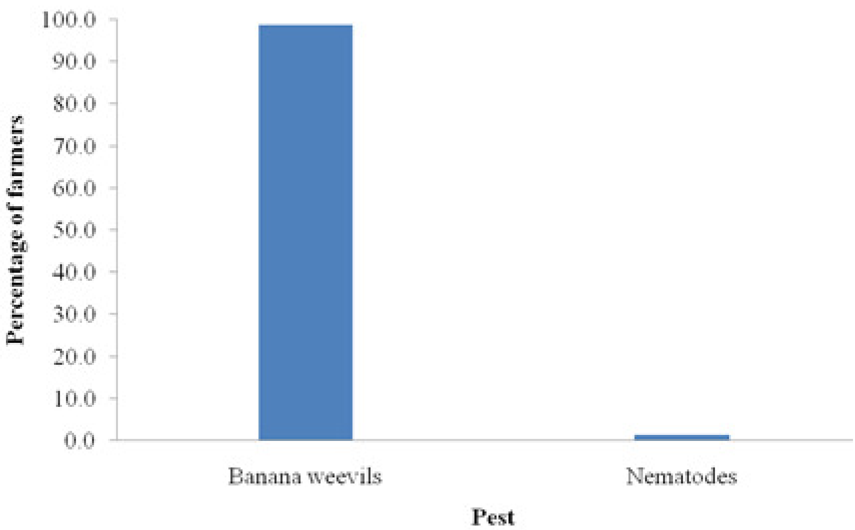

Figure 1. Major pests hindering banana production as reported by respondents (n=80) interviewed in 8 villages in Sheema and Rubirizi districts, southwestern Uganda.

Tolerance of planting materials to banana weevil attack

About 45.6% of the farmers reported that both maiden and sword suckers were the most tolerant planting material to banana weevil attack. Most (>65%) farmers reported that sword suckers are tolerant because they grow with high vigor, while 85% reported that maiden suckers are tolerant because they have bigger corms which grow fast (Table 6).

Discussion

In this study, we interviewed equal number of female and male farmers; supporting the fact that banana growing is an enterprise where females and males have equal participation irrespective of the gender (Karamura *et al.*, 2004; Edmeades *et al.*, 2006). Low level of education observed in this study implies that most people involved in agricultural activities in this region drop out of school at lower levels. These findings are in agreement with Edmeades *et al.* (2006). Most farmers belonged to age range of 22-50 years which represents the most economically active section of the community (Kagezi *et al.*, 2010). Farmers allocated small portions of land to banana growing probably due to land pressure problems which is common in the region (Edmeades *et al.*, 2006; Lwandasa Hannington, Unpublished data).

Most banana plantations were fairly old (>40 years) (Edmeades *et al.*, 2006). This is probably in part because this region is located at higher altitudes where pest and disease pressures are low compared to lowland of central Uganda (Gold *et al.*, 1993, 1999a; Bagamba *et al.*, 2005). Additionally, farmers in this region often gap-fill their existing plantations (Edmeades *et al.*, 2006; Smale *et al.*, 2006); probably, this also contributes to the longevity of their plantations. Farmers' experience in banana growing averaged 26 years and was positively related to plantation age. This emphasises the importance farmers attach to bananas in the region (Karamura *et al*, 2004; Okech *et al.*, 2005; Edmeades *et al.*, 2006). Most farmers reported having planted their banana plantations as opposed to inheriting them from their parents and/or relatives as reported in other studies in the region (Edmeades *et al.*, 2006). However, considering the average farmers' experience (26 years) in growing banana observed in this study, the banana plantations in the area would also have been generally young. This contradicts our results which show that the plantations were fairly old (>40 years). This could have been in part due to the fact that many farmers usually prefer buying already established banana plantation from their neighbors (Lwandasa Hannington, personal observation). At the time of purchase, age and general appearance of the plantations are the most important factors considered by the farmers. Also, farmers prefer buying older plantations because they think it is easier to tell whether the land is fertile or not (Lwandasa Hannington, personal observation).

The banana weevil was reported by the majority of farmers as the most important banana pest in the area. This is in line with earlier surveys conducted in this region (Okech *et al.*, 2005) and in other parts of Uganda (Gold *et al.*, 1993, 1999; Bagamba *et al.*, 2005). However, farmers do not often fully understand the bio-ecology of this pest (Gold *et al.*, 2002), although this was not captured in our study. This limited knowledge has been reported to partly contribute to farmers' low adoption levels of control methods, particularly cultural control methods (Okech *et al*., 2005). On the other hand, though very few farmers reported parasitic nematodes as a major banana pest in this study, they are also capable of causing significant damage to bananas (Speijer and Kajumba, 1996). In fact, in most cases farmers' banana plantations are infested with both weevils and nematodes (Gold *et al*., 1993; 1999). But, farmers usually underestimate nematode damage because the symptoms are not easily recognizable, and in most cases confused with banana weevil attack (Hauser *et al*., 2010). Thus, farmers' diagnosis for drawing scientific conclusions, particularly where the cause of infestation is not easily visible, needs to be accompanied by other empirical measurements for a full accurate picture of plantation damage (Grossman, 2003).

Our results show that most farmers replanted in existing banana plantations, particularly by gap-filling. Most farmers reported lack of enough land as the major socioeconomic reason for gap-filling. Similar findings were reported by Bagamba *et al*. (2005) and Edmeades *et al*. (2006). This is supported by the fact that farmers allocated relatively small plots of land to banana production despite the importance attached to this crop in this area (Karamura *et al*., 2004; Okech *et al*., 2005; Edmeades *et al*., 2006). However, the simple logistic regression analysis showed that the amount of land under banana was not a determinant of whether a farmer gap-fills or not. The banana weevil was mentioned by most farmers as the most important biotic factor causing them to undertake gap-filling. This is in line with various surveys conducted in different regions of Uganda (Gold *et al*., 1993; 1999a; Bagamba *et al*., 2005) and experimental trials both on-station and on-farm (Gold *et al*., 2002, 2004; McIntyre *et al*., 2002; Okech *et al*., 2005).

Most farmers preferred maiden suckers for gap-filling because they establish and mature faster than other planting materials. This agrees with results from an on-station trial (Lwandasa Hannington, Unpublished data) as well as earlier findings by Swennen and Ortiz, (1997). However, these results contradict recommendation by research and extension of using sword suckers, corms and tissue culture plantlets (Speijer *et al*., 1995; Gold *et al*., 1998a,b; Barekye *et al*., 2005; Niere *et al*., 2014). There is, therefore, need for the national research system to refocus and redefine research on the best planting material to be used in gap-filling already infested banana plantations. Farmers' perceptions and knowledge should also be taken into consideration (Marcia and Katrina, 2000). In fact, recent trends in agricultural research and development emphasise the need for farmer participation in experimental set up and decision making (Gurung, 2003). Farmers should not be just passive recipients of technologies developed by other people in other areas (Oladele and Fawole, 2007).

The source of the planting material used by farmers should be pest and disease-free (Barekye *et al*., 2005). Most farmers obtained planting materials from their home gardens and/or neighbors' plantations as reported in a number of studies elsewhere (Karamura *et al*., 2004; Barekye *et al*., 2005; Edmeades *et al*., 2006; Smale *et al*., 2006). These plantations are in most cases infested with banana weevils and nematodes (Speijer *et al*., 1995; Barekye *et al*., 2005; Hauser *et al*., 2010). Thus, planting materials originating from such plantations serve as a principal means of dispersal for the banana weevil (Rukazambuga *et al.*, 1998)

Paring of corms (removal of all roots and peel) which is the recommended method of cleaning banana planting material by research and extension (Gold *et al.*, 1998a,b) was rarely practiced in the study sites as observed by Gold *et al.* (2002) and Barekye *et al.* (2005). Most farmers were simply trimming off a few roots from the corms and they considered this as their traditional way of cleaning the planting materials. Paring has not been widely adopted by farmers because most of them believe that suckers will not perform well if most or all roots are removed (Gold *et al.*, 2002). Nevertheless, most farmers appreciated the advantages of using clean planting materials in banana production including increasing banana yields. This is in line with Speijer *et al.* (2001), who reported that more than 50% of the farmers they interviewed acknowledged that clean planting material resulted in plants that flowered earlier. They also, produced more suckers, had a longer life span, showed increased vigour and bunch size, less prone to toppling and had a better food quality. Farmers usually obtain information on agricultural-related activities from multiple sources. In this study, most farmers revealed that they obtain it from their parents (farmer-to-farmer; Katungi, 2007).

Different banana planting materials have varying levels of resistance to banana weevils (Kiggundu *et al.*, 2003). The number of farmers who reported that maiden and sword suckers were the most tolerant planting materials to banana weevil attack was the same though farmers rarely used the latter for gap-filling. This shows that farmers' preference of planting materials might not necessarily depend on their tolerance to banana weevil attack (Table 4) as indicated by Lwandasa Hannington (Unpublished data). Most farmers reported that sword suckers were tolerant to banana weevil attack because they grow with high vigor (Speijer *et al.*, 1995; Gold *et al.*, 1998; Barekye *et al.*, 2005; Niere *et al.*, 2014). On the other hand, maiden suckers were tolerant because they had big corms, which established and matured fast, thereby enabling the plant to withstand weevil attack (Kiggundu *et al.*, 2003; Lwandasa Hannington, Unpublished). It might also be possible that the big corms possessed by the maiden sucker provides enough food for the feeding larvae which molt to non-destructive stage (pupa and adult) before destroying the whole plant tissue (Lwandasa Hannington, Unpublished).

Conclusion

Our study clearly showed that gap-filling existing banana plantations is commonly practiced by farmers in the area. This was mainly due to land pressure and banana weevil, the most important pest of banana in the region. The use of maiden suckers for gap-filling is preferred by the majority of farmers. This contrasts with the National Agricultural Research Organisation (NARO) recommendation of using sword suckers, corms and tissue culture plantlets when gap-filling. Therefore, there is a need for the national research system to refocus and re-define its research in general taking into account the farmers' perceptions and knowledge for sustainable management of banana plantations.

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References

Bagamba, F., Karamura, E., Gold, C.S., Barekye, A., Blomme, G., Tushemereirwe, W.K. and Tinzaara, W. 2005. Socioeconomic assessment of pest management practices in Lwengo sub-county, Uganda. In: G. Blomme, C. Gold and E.B. Karamura (Editors), *Farmer participatory testing of integrated pest management options for sustainable banana production in Eastern Africa*, Proceedings of workshop on Farmer-participatory testing of IPM options for sustainable banana production in Eastern Africa, Seeta, Uganda, December 8-9, 2003, pp. 17-25.

Barekye, A., Tushemereirwe, W.K., Ragama, P., Karamura, E.B. and Blomme, G. 2005. The ffect on nematodes of clean planting materials and fertiliser in Masaka district, Uganda. In: G. Blomme, C. Gold and E.B. Karamura (Editors), *Farmer participatory testing of integrated pest management options for sustainable banana production in Eastern Africa*, Proceedings of workshop on Farmer-participatory testing of IPM options for sustainable banana production in Eastern Africa, Seeta, Uganda, December 8-9, 2003, pp. 9-16.

Bauer, V.B.M., Burkart, S., Abele, S., Kahangi, E., Dubois, T., Coyne, D. and Hoffmann, V. 2009. Financing, handling, hardening and marketing of tissue culture-derived planting material through nurseries: The case of banana in Kenya, Uganda and Burundi, *Natural Resource Management and Rural Development*, Conference on International Research on Food Security, University of Hamburg, October 6-8, 2009.

Edmeades, S., Smale, M. and Karamura, D. 2006. Genetic resource policies, *Promising Crop Biotechnologies for Smallholder Farmers in East Africa: Bananas and Maize*, International Food Policy Research Institute and the International Plant Genetic Resources Institute, Brief 24, pp. 1.

Gold, C.S, Kagezi, G.H, Night, G., Ragama, P.E. 2004. The effects of banana weevil, *Cosmopolites sordidus* (Germar) damage on highland banana growth, yield and stand duration in Uganda, *Annuals of Applied Biology* 145:263-269.

Gold, C.S., Karamura, E.B., Kiggundu, A., Bagamba, F. and Abera, A.M.K. 1999. Geographic shifts in highland cooking banana (Musa spp., group AAA-EA) production in Uganda, *International Journal of Sustainable Development and World Ecology* 6:45-59.

Gold, C.S., Night, G., Speijer, P.R., Abera, A.M.K. and Rukazambuga, N.D.T.M. 1998a. Hot-water treatment for the control of the banana weevil, *Cosmopolites sordidus* Germar (Coleoptera : Curculionidae), in

Uganda, *African Entomology* 6(2):215-221.

Gold, C.S., Night, G., Speijer, P.R., Abera, A.M.K., Rukazambuga, N.D.T.M. 1998b. Infestation levels of banana weevil, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae), in banana plants established from treated propagules in Uganda, *African Entomology* 6(2):253-263.

Gold, C.S., Ogenga-Latigo, M.W., Tushemereirwe, W., Kashaija, I., Nankinga, C. 1993. Farmer perception of banana pest constraints in Uganda: results from a rapid rural appraisal. In: Gold, C.S. and B. Gemmill (Editors), *Biological and Integrated Control of Highland Banana and Plantain Pests and Diseases*, Proceedings of a Research Coordination Meeting, IITA Cotonou, Benin, November 12–14, 1991, pp. 3-23.

Gold, C.S., Pinese, B. and Pena, J.E., 2002. Pests of banana. In: Pena, J.E., J., Sharp and M. Wysoki (Editors), *Pests and Pollinators of Tropical Fruit*, CABI International, Wallingord, U.K, pp. 13-56.

Grossman, J.M. 2003. Exploring farmer knowledge of soil processes in organic coffee systems of Chiapas, Mexico, *Geoderma* 111:267-287.

Gurung, B.A. 2003. Insects – A mistake in God's creation? Tharu farmers' perception and knowledge of insects: A case study of Gobardiha village development committee, Dang-Deukhuri, Nepal, *Agriculture and Human Values*, 20(4):337-370.

Hauser, A., Amougou, D., Bengono, B., Ngo Kanga, F. and Pekeleke, M. 2010. On-farm demonstration, testing and dissemination of boiling water treatment for plantain (*Musa* spp.) sucker sanitation in southern Cameroon, *Acta Horticulturae* 879:509-515

Kagezi, G.H., Kaib, M., Nyeko, P. and Brandl, R. 2010. Termites (Isoptera) as food in the Luhya community (Western Kenya). *Sociobiology* 55(3): 831-845.

Karamura, D., Mgenzi, B., Karamura, E. and Sharrock, S. 2004. Exploiting IK for the management and maintenance of Musa biodiversity on farm, *African Crop Science Journal* 12(1):71-78.

Katungi, E. 2007. Social capital and technology adoption on small farms: the case of banana production technology in Uganda. Ph.D. Thesis. University of Pretoria, South Africa.

Kiggundu A, Pillay M, Viljoen A, Gold C, Tushemereirwe W, Kunert K. 2003. Enhancing banana weevil (*Cosmopolites sordidus*) resistance by genetic modification: A perspective, *African Journal of Biotechnology* 2:563-569.

Marcia, M. and Katrina, B., 2000. Colonist farmers' perceptions of fertility and the frontier environment in eastern Amazonia, *Agriculture and Human Values* 17:371-384.

McIntyre, B.D., Gold, C.S., Kashaija, I.N., Ssali, H., Night, G and Bwamiki, D.P. 2002. Effects of legume intercrops on soil-borne pests, biomass, nutrients and soil water in banana, *Biology and Fertility of Soils* 34: 342–348.

Mulumba J.W., Nankya, R., Adokorach, J., Kiwuka, C., Fadda, C., De Santis, P., Jarvis, D.I. 2012. A risk-minimizing argument for traditional crop varietal diversity use to reduce pest and disease damage in agricultural ecosystem of Uganda, *Agriculture, Ecosystems and Environment* 157:70–86.

Niere, B., Gold, C.S., Coyne, D., Dubois, T. and Sikora, R. 2014. Performance of tissue-cultured versus sucker-derived East African highland banana (Musa AAA-EA) under high and low input systems in Uganda, *Field Crops Research* 156:313-321.

Okech, S.H., Gold, C.S., Bagamba, F., Masanza, M., Tushemereirwe, W.K. and Ssenyonga, J. 2005. Cultural control of banana weevils in Ntungamo, southwestern Uganda. In: G. Blomme, C. Gold and E.B. Karamura (Editors), *Farmer participatory testing of integrated pest management options for sustainable banana production in Eastern Africa*, Proceedings of workshop on Farmer-participatory testing of IPM options for sustainable banana production in Eastern Africa, Seeta, Uganda, December 8-9, 2003, pp. 116-128.

Oladele, O.I and Fawole, O.P. 2007. Farmers' perception of the relevance of agricultural technologies in South Western Nigeria, *Journal of Human Ecology* 21 (3):191-194.

Ragama, P.E., Gold, C.S. and Kagezi, G.H. 2012. A Spatial movement of banana weevils in the field in Uganda. *Research and Innovation for Sustainable Development*, Annual International Scientific Conference, Kabarak University, Kenya, October 16-18, 2012.

Robinson, J.C., 1996. Bananas and plantains. CAB International. Wallingford, UK, 238 pp.

Rukazambuga, N.D.T.M., Gold, C.S. and S.R. Gowen, S.R., 1998. Yield loss in East African highland banana (*Musa* spp., AAA-EA group) caused by the banana weevil, *Cosmopolites sordidus* Germar, *Crop Protection* 17:581-589.

SAS, 2008. SAS/STAT Software: Version 9.2, Cary, NC: SAS Institute Inc. Cary, NC, USA.

Smale, M., Kikulwe, E., Edmeades, S., De Groote, H., Byabachwezi, M., Nkuba, J., 2006. Crucial determinants of adoption material systems for banana and maize, *Promising Crop Biotechnologies for Smallholder Farmers in East Africa: Bananas and Maize*, Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT). Brief 20.

Speijer, P.R. and Kajumba, C. 1996. Yield loss from plant parasitic nematodes in East African Highland banana (*Musa* AAA), *Musafrica* 10:26.

Speijer, P.R., Gold, C.S., Kajumba, C. and Karamura, E.B. 1995. Nematode infestation of clean banana planting material in farmers' fields in Uganda, *Nematologica* 41:344.

Speijer, P.R., Nampala, P.M., Elsen, A., Ekwamu, E. and De Waele, D. 2001. Reinfestation by nematodes and performance of hot-water-treated East African Highland cooking bananas as perceived by farmers in Ikulwe, Iganga district, Uganda, *African Plant Protection* 7(2): 85-89.

Swennen, R. and Ortiz, R., 1997. Morphology and growth of plantain and banana. IITA Research Guide 66. Training Program, IITA, Ibadan, Nigeria. 32 pp.