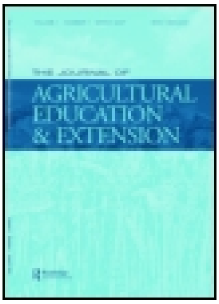

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Using Plant Clinic Registers to Assess the Quality of Diagnoses and Advice Given to Farmers: A Case Study from Uganda

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Using Plant Clinic Registers to Assess the Quality of Diagnoses and Advice Given to Farmers: A Case Study from Uganda

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ABSTRACT Purpose: *This study developed a framework for quality assessment of diagnoses and advice given at plant clinics.*
Design/methodology/approach: *Clinic registers from five plant clinics in Uganda (2006–2010) were used to develop quality assessment protocols for diagnoses and advice given by plant doctors. Assessment of quality of diagnoses was based on five validation criteria applied on the ten most common crops. Quality of advice was assessed for the four major problems considering efficacy and feasibility.*
Findings: *The quality of diagnoses varied between crops, from 68% completely validated in maize to 1% in tomato. Complete and partially validated diagnoses were 44% of all queries. The remaining 56% were rejected. Several basic weaknesses were found in data recording and symptom recognition. A greater consistency and precision in naming diseases would increase the number of completely validated diagnoses. The majority of recommendations (82%) were assessed 'partially effective'. 'Best practice' was recommended for 10% and ineffective advice was given in 8% of the cases with considerable variation between diseases.*
Practical implications: *Plant doctors need more training in symptom recognition, pest management and record keeping as well as better technical backstopping to solve unknown problems. Common standards and procedures for clinic data collection and analysis should be established, and roles and responsibilities clearly defined.*
Originality/value: *This is the first time plant clinic registers have been used to systematically assess quality of plant clinic services. Apart from being a valuable tool for quality assessment of extension, the plant clinic registers constitute a novel source of regular information about pests, diseases and farmer demand that can help improve decision-making of extension service providers, researchers, plant health authorities as well as information and technology providers.*

KEY WORDS: Agricultural extension, Plant clinics, Diagnostics, Plant doctors, Quality assessment, Clinic register

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Introduction

Assessing the performance of any agricultural advisory service is essential for the establishment of accountable, well-managed services that respond to the needs of the clients (Christoplos and Kidd, 2000; Aflakpui, 2007). Impact can only be achieved if the advisory services have an influence on farmers' decision-making leading to a change of existing practices (Birner et al., 2006). Since 2003, 16 countries across Africa, Asia and Latin America have introduced community-based plant clinics to give advice on plant health problems to small-scale farmers (Boa, 2009). Plant clinics need an internal quality control system with suitable quality standards so that organisations can regularly measure staff performance and client (farmer) outcomes.

Performance indicators of pest management extension in developing countries focus mainly on technology adoption, cost effectiveness and farmers' perceptions of pests and diseases and management practices (Palis, 2006; Ricker-Gilbert et al., 2008; Rustam, 2010). All are useful ways to assess the effectiveness of farmer training and suitability of technologies, yet the resources required to monitor and measure performance are often limited and assessments are therefore irregular. In human health, quality assessment is a routine practice, commonly done in a systematic and standardised way (WHO, 2000). This is an essential practice to maintain quality of community-based health services (Hermann et al., 2009). We have found only a few examples of routine quality assessment of agricultural extension services.

A framework for quality assessment of plant clinics has been developed with plant clinic staff from several countries (Danielsen and Kelly, 2010). The quality criteria include access, coverage, timeliness, staff attitude, technical quality and feasibility and are similar to those used in human health (Arah et al., 2006).

This article develops the quality framework for plant clinics further by analysing plant health queries recorded in clinic registers and examining the quality of diagnoses and advice given to farmers at plant clinics in Uganda from 2006–2010. We discuss the implications of the findings for plant doctor training and operation of plant clinics. We argue that analysis of data from plant clinic registers can be used to improve the quality of advice provided to farmers while providing reliable information on the incidence and severity of plant health problems in a plant clinic catchment area.

Ugandan plant clinics

Uganda started five plant clinics in 2006 through collaboration between the Global Plant Clinic (GPC) of CABI (Centre for Agricultural Bioscience International), the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), local governments (LG) and non-governmental organisations (NGOs) in three districts (Mukono, Iganga, Soroti). Plant clinics were run fortnightly by extension workers ('plant doctors') and lead farmers ('nursing aids') who had received basic training from CABI on how to recognise and interpret symptoms (field diagnosis) and operate a plant clinic. 'Plant doctor' is not yet an official title with formal skills requirements, yet it is widely used in Uganda and other countries to signal what type of service the plant clinic offers. The extension workers were government extension staff employed by LGs supported by local NGO extension workers, especially in Soroti.

They attended the plant clinics jointly as part of their day job. In this article the term 'extension worker' refers to both LG and NGO staff.

The plant clinic consists of one or more tables with chairs and shade in a public venue, typically a market place, with photographs and published material to help identify causes and solutions. The plant doctors record client and crop details on a single sheet with handwritten notes on symptoms observed, other information provided by the farmer (e.g. severity of problem, when first observed) and recommendations. A copy of the form is retained by the plant clinic and details collated in the plant clinic register. The early successes of the plant clinics led MAAIF to include them in their five-year development strategy and investment plan in 2010, with the aim of reaching more farmers and improving national pest and disease surveillance (Danielsen and Mutebi, 2010).

Methodology

Analysis of plant clinic registers

Plant clinic register data were obtained from five plant clinics operating from 2006–2010: Nkokonjeru and Nakifuma in Mukono district, Kawete in Iganga district; and Katine and Ocapa in Soroti district. A total of 142 clinic sessions were held and 1693 individual farmer queries recorded. The queries were hand written on a standard form and contained information about farmers and where they lived. An additional 110 queries were excluded because the crop name was missing. Each query described a single plant health problem, the suggested cause (diagnosis) and recommendation given to the farmer. A few queries noted more than one problem and we included those where it was possible to identify a predominant cause. The data were merged into an Excel spreadsheet, spelling mistakes were corrected and crops and place names were harmonised. Descriptive statistics on plant clinic coverage, gender and crops were generated.

The quality of the diagnosis was assessed for 1278 queries, representing the ten most frequently presented crops, using a five-step validation procedure.

1. Specificity: does the 'diagnosis' represent a clearly identified pest or disease or abiotic problem? (no, yes)
2. Plausibility: is the suggested cause a credible or recognisable problem on the host? (no, yes)
3. Likelihood: does the suggested problem occur on this host in Uganda? (no, yes)
4. Consistency and completeness: do the recorded symptoms support the diagnosis and is there enough information to identify the suggested cause? (no, partial, yes)
5. Ambiguity: are the symptoms associated with more than one type of problem? (no, yes)

The following selected examples briefly illustrate the validation procedure. Banana bacterial wilt is a known disease and a specific diagnosis (Step 1). Although 'banana wilt' is non-specific it is still a plausible diagnosis (Step 2). Non-specific diagnoses included 'nutrient deficiency' as well as names of pest groups ('fungus') or symptoms which did not clearly identify a known problem (e.g. 'wilt'). Potassium deficiency is specific. Early blight on tomatoes, a fungal disease caused by *Alternaria solani*, is specific. Tomato blight is non-specific since it could also refer to *Phytophthora infestans* (late blight). Local pest and disease names (Bentley et al., 2009) were also analysed. 'Kayongo' in maize and other crops is *Striga* and specific.

Bacterial wilt, often associated with *Ralstonia solanacearum*, occurs on a wide range of crops and is a specific diagnosis. However, there is no known bacterial wilt affecting coffee so it is implausible. All diagnoses were judged likely to occur in Uganda (Step 3). Yellowing and death of plant is a partial description of banana bacterial wilt (Step 4) and ambiguous; the symptoms could refer to a fungal wilt (Step 5). Validation had three possible outcomes: complete—available information reliably supports the diagnosis; partial—information incomplete but broadly supports the diagnosis; rejected—insufficient information to validate the diagnosis.

A complete diagnosis enables a plant doctor to identify the best possible advice for managing a problem. A partial diagnosis identifies broadly useful advice. For example 'soil borne fungus' might suggest crop rotation.

The recommendations given to farmers were categorised and their quality assessed on the four most frequently presented plant health problems for efficacy (does it work) and by comparing them with published recommendations. The three possible outcomes were 'best practice', partially effective and ineffective. We also discuss the feasibility of recommendations for small-scale farmers in Uganda.

Plant clinic use 2006–2010

The 1693 queries (average 12 queries per session) received at the plant clinics were brought by 1088 clients (average 7.5 clients per session) from 399 villages, with 21–42 different crops presented at individual clinics, and 55 different crops overall (Table 1).

The three most common crops for all plant clinics were banana, orange and cassava, representing 38% of all queries (Table 2). Other examples included maize, sorghum, cabbage, tomatoes, other vegetables, fruit crops and pulses.

Around 400 different plant health problems were recorded, mostly pests and diseases. The eight most commonly recorded problems in each district accounted for about one-third of all queries (Table 3). Banana bacterial wilt (BXW) was the most commonly reported problem overall, followed by *Striga*, coffee wilt disease (CWD) and cassava mosaic disease (CMD). Vurro et al. (2010) reported that BXW, *Striga* and CWD are among the most damaging and widely distributed plant diseases in East Africa. CWD is the most serious problem of Robusta coffee production in Uganda according to Musoli et al. (2009).

The plant clinics recorded many important African arthropod pests noted by Abate et al. (2000), including maize stem borer, armyworm, aphids in bean, cowpea flower thrips, banana weevil and cassava green mite. Almost half the problems recorded were either insects and mites (25%) or fungi (20%), which probably reflects the ease of observation of damage and symptoms associated with these groups (Table 4) Bacteria (14%) and viruses (11%) were well represented because of the widespread occurrence of BXW and CMD. Most weed problems (95 of 100 weed queries) were due to *Striga*, a parasitic plant. Few nematode problems were diagnosed. Undiagnosed problems accounted for 9% of all queries.

Table 1. Summary of 1693 queries presented at five plant clinics in three districts of Uganda from 2006–2010

Plant clinic and district	# Queries	# Clients	# Villages[a]	# Crops
Kawete, Iganga	620	252	80	42
Katine, Soroti	287	180	70	23
Ocapa, Soroti	172	132	89	21
Nakifuma, Mukono	178	189	69	23
Nkokonjeru, Mukono	436	335	91	35
Total	*1693*	*1088*	*399*	*55*

Notes: [a]Although spelling of village names was harmonised there is probably still some duplication.

Quality of diagnoses recorded in the plant clinic register

We validated 1278 queries representing the ten most frequently presented crops (77% of all queries). Ten queries on agronomy or general enquiries were excluded. Table 5 summarises the number of complete, partial and rejected validations using the five-step procedure. A complete validation for a diagnosis has only one combination of results: specific, plausible, complete/consistent and unambiguous.

Most partial diagnoses were specific (99%) and all were plausible, but only 9% had complete/consistent descriptions. All were ambiguous. There were five different combinations of results for partial diagnoses, though most were specific, plausible, likely, partially complete/consistent and ambiguous. Of the rejected diagnoses, 52% were specific and plausible yet 71% had inconsistent and incomplete descriptions. A substantial proportion of rejected diagnoses (29%) were non-specific and implausible.

The key steps in validating a diagnosis are ‘plausibility’ (Step 2) and ‘complete/consistent’ descriptions (Step 4). There was some doubt about the confirmed presence (Step 3) of some problems in Uganda but no clear grounds for rejecting any diagnosis. It is still a useful step, however, and could identify potentially new pests and diseases.

Table 2. Crop queries presented at five plant clinics in three districts of Uganda from 2006–2010

Rank	Crop	# Queries	%
1	Banana	270	16
2	Orange[a]	185	11
3	Cassava	180	11
4	Maize	136	8
5	Tomato	128	8
6	Coffee	116	7
7	Groundnut	94	5
8	Cabbage	71	4
9	Sorghum	59	4
10	Eggplant	48	3
11–55	45 other crops	415	23
	Total	*1693*	*100*

Notes: [a]Including other citrus species.

Table 3. The eight most frequent diagnoses of plant health problems recorded at five plant clinics from 2006–2010, by district and overall

	Iganga (one clinic)		Soroti (two clinics)		Mukono (two clinics)		Overall (five clinics)	
Rank	Problem	#	Problem	#	Problem	#	Problem	#
1	*Striga*, cereals	86	Leaf miner, orange	36	BXW	125	BXW	178
2	CWD	43	Fruit fly, orange	36	CWD	37	*Striga*, cereals	95
3	BXW[a]	42	Stalk borer, sorghum	29	CBSD	28	CWD	80
4	Groundnut rosette	39	CMD	23	Banana weevil	22	CMD	63
5	Fusarium wilt, tomato	31	Scab, orange	23	CMD	20	Groundnut rosette	45
6	CMD	20	Fungus[b], orange	23	Tomato wilt[c]	15	Leaf miner, orange	39
7	Aphids, watermelon	15	Cassava root rot	15	Coffee stem borer	12	Fruit fly, orange	36
8	Black rot, cabbage	14	BXW	11	Fruit fly, pawpaw	12	CBSD	34
	% of 620 queries in district:		% of 459 queries in district:		% of 614 queries in district:		% of all 1693 queries:	
	47%		43%		44%		34%	

Notes: BXW—banana xanthomonas wilt (syn. banana bacterial wilt); CWD—coffee wilt disease; CMD—cassava mosaic disease; CBSD—cassava brown streak disease. [a]Another 24 cases of unspecified 'banana wilt' were recorded in Iganga; [b]Not specified, could be *Pseudocercospora angolensis*; [c]Wilt diagnoses could be bacterial or fungal.

The highest proportion of complete validations occurred for maize (68%), groundnut (44%) and banana queries (32%). Overall 21% of the top ten crop queries were completely validated and 44% of all queries if partial diagnoses are included.

Table 4. Diagnoses recorded at plant clinics for all crops by type of cause from 2006–2010

Diagnosis recorded	# Queries	Percentage
Insects and mites	422	25
Fungi	336	20
Bacteria	228	14
Viruses	190	11
Weeds	100	6
Nutrient deficiency	45	3
General agronomy advice	32	2
Abiotic stress	13	1
Rodents	11	1
Nematodes	7	<1
Phytoplasma	7	<1
Symptom description, no specific pest	155	9
Not diagnosed	147	9
Total[a]	*1693*	*100*

Table 5. The quality of 1278 diagnoses representing the top 10 crops presented at plant clinics from 2006–2010 using five validation criteria[a]

Validation criteria[a]					Top ten crops[b]										Total	
S	P	L	C	U	Ban	Cab	Cas	Cof	Egg	Gnt	Mze	Ora	Sor	Tom	No.	%[c]
Complete validation																
y	y	y	y	y	85	6	15	7	0	40	92	8	9	1	263	100
Total (% by crop)					*32%*	*9%*	*8%*	*6%*	*0%*	*44%*	*68%*	*4%*	*15%*	*1%*	*21%*	
Partial validation																
y	y	y	y	n	19	0	0	1	0	1	0	2	0	0	23	8%
n	y	y	y	n	2	0	2	0	0	0	0	0	0	0	4	1%
y	y	y	p	n	7	20	50	62	7	8	8	52	14	43	271	91%
n	y	y	p	n	0	0	0	1	0	0	0	0	0	0	1	<1%
Total (no.)					28	20	52	64	7	9	8	54	14	43	299	100
Total (% by crop)					*11%*	*29%*	*29%*	*56%*	*15%*	*10%*	*6%*	*29%*	*24%*	*34%*	*23%*	
Reject diagnosis																
y	y	y	n		105	15	56	36	19	15	21	69	19	16	371	52%
n	y	y	n		32	13	30	1	11	6	3	4	1	38	139	19%
y	y	n			0	0	0	0	0	0	0	0	0	0	0	0.0
n	y	n			0	0	0	0	0	0	0	0	0	0	0	0.0
y	n				0	0	2	0	0	0	0	0	0	0	2	<1%
n	n				17	16	25	6	11	21	12	50	16	30	204	29%
Total (no.)					154	44	113	43	41	42	36	123	36	84	716	100
Total ((% by crop)					*58%*	*63%*	*63%*	*38%*	*85%*	*46%*	*27%*	*67%*	*61%*	*66%*	*56%*	
Grand total					267	70	180	114	48	91	136	185	59	128	1278	

Notes: [a]S—specific; P—plausible; L—likely (of occurring); C—complete/consist; U—unambiguous; Y = yes; N = no; P = partial (used for complete/consistent). For further explanation of criteria see text. [b]Ban(ana), Cab(bage), Cas(sava), Egg(plant), Gnt (Groundnut), Mze (Maize), Ora(nge), Sor(ghum), Tom(ato). [c]Percentage of, by category of validation.

This still leaves 56% of all queries with rejected diagnoses and clearly indicates the need for more training and information on how to recognise and interpret symptoms.

Table 5 highlights which crops and problems pose the greatest difficulties for plant doctors. For example, they had particular difficulty with cabbage, eggplant and tomato. Black rot of cabbage, a bacterial disease, also appeared as 'cabbage rot', 'collar rot' and 'cabbage wilt' according to the symptom description. On tomato, 14% of queries were diagnosed as 'tomato wilt', a symptom associated with bacterial and fungal pathogens.

Validated diagnoses of CWD (complete and partial) accounted for 71% of all coffee queries, yet most were partially validated because the descriptions consistently failed to mention darkening and death of the main stem, the distinguishing feature of this widespread disease. Only 47% of tomato problems were given a specific and plausible diagnosis. Groundnut rosette virus is a well-known disease in Uganda yet plant doctors often talked vaguely of 'plants not growing' rather than noting stunting or compressed growth of plants. On banana, many plant doctors noted the premature ripening of fruit (a distinctive feature of BXW) but others gave yellowing and wilting of leaves only, which could be confused with Fusarium wilt.

Part of the reason for low validity rates is poor record keeping. We have observed many plant doctors in action and they are better at diagnosing than the analysis presented in Table 5 suggests. A greater consistency and precision in describing symptoms and naming diseases would increase the number of completely validated diagnoses.

A definitive validation would require the original sample and full information on the conditions and circumstances in which a crop was grown. The validation procedure described here is a pragmatic attempt to gain as much useful information from a remote event as possible (the interview with the farmer and subsequent diagnosis by the plant doctor). The most useful outcome of the validation procedure is to indicate where plant doctors have problems in recognising and interpreting symptoms. Further discussion with plant health authorities on setting acceptable standards of proof is needed before definitive diagnoses of named pests and diseases can be used in official lists of pests and diseases.

The plant clinic data give a unique opportunity to map the incidence and severity of a problem, yet some caution is necessary. Why was CBSD (cassava brown streak disease) only recorded in Mukono when it is a widespread problem? Why were there so few examples of groundnut rosette virus from Soroti (7) compared to Iganga (39)? Why were so few weeds apart from *Striga* brought to the plant clinics? Why so few diagnoses of low soil fertility when this is a common problem facing smallholder farmers in Uganda? Clearly much depends on who uses the plant clinics and the problems they perceive to be important. In addition, each extension staff member has his or her own bias.

Some common pests and diseases on crops in Uganda were rarely if ever received by plant clinics. These included millipedes in sweet potato, groundnut and maize in Soroti (Ebregt et al., 2005), banana burrowing nematode (Price, 2006), bollworm and thrips on tomato (Tumwine et al., 2002) and cowpea viruses and thrips (Edema et al., 1997; Adipala et al., 2000). Sweet potato virus disease (SPVD) is reported to be the most serious disease of sweet potato in Africa (Gibson et al., 2004) yet only two examples were diagnosed out of 31 sweet potato queries. Perhaps the symptoms are not as well known as other virus diseases or the plant clinics are revealing new information about the distribution and incidence of pests and diseases.

There may be several reasons why common pests and diseases are not brought to plant clinics: *First*, the problems are absent or insignificant in the area close to the plant clinic; *Second*, these problems are already addressed by other projects or service providers; *Third*, farmers do not recognise a problem or think it is unimportant or do not require advice; *Fourth*, the problem is misdiagnosed. We do not have enough information to answer these questions but we can make some preliminary assumptions.

Plant diseases and pests vary in severity and incidence over time and space, yet major examples are persistent and ubiquitous. Sweet potato viruses were undoubtedly present in Mukono, Iganga and Soroti from 2006–2010 when farmers also had access to extension support through several active projects. Yet CMD, CBSD, *Striga* and BXW were commonly brought to plant clinics despite massive on-going attention from extension projects and researchers, suggesting that further work is needed to publicise the symptoms of sweet potato viruses.

Farmers have difficulty recognising and understanding plant diseases, and are more familiar with damage caused by visible causes such as vertebrates, grasshoppers, ants, termites, stalk borers and *Striga* (Tinzaara and Tukahirwa, 2002; Kalule et al., 2006; Obopile et al., 2008). Problems caused by micro-organisms and tiny insects (thrips, mites) are difficult to identify. In a study from the Central African Highlands, Trutman et al. (1996) found that farmers rarely mentioned diseases as a direct cause of crop losses. They attributed symptoms associated with diseases to the effects of rain, soil fertility or varietal traits. Rusts and powdery mildews are more likely to be recognised as important (fungus) diseases by farmers (Kiros-Meles and Abang, 2008).

Extension workers in general have limited access to quality information (Mubangizi et al., 2004) and their diagnostic skills are weak. Knowledge is often restricted to the most common pests and diseases (Erbaugh et al., 2007). CABI has trained plant doctors in Uganda on field diagnosis (the recognition and interpretation of symptoms) yet clearly more assistance is required. The broad nature of the queries brought to the plant clinics is a major challenge for even the most experienced extension worker or scientist.

Quality of advice—general overview

Farmers were given several options for managing a problem, usually two to four separate pieces of advice (not shown). The recommendations they received are summarised in Table 6 under the categories: ‘pesticides’, ‘fertiliser’, ‘agronomic practices’ and ‘unsolved and other’. For 9% of the queries no diagnosis or recommendations were given. This includes 20 queries where a sample was sent to a lab and 34 cases where the client was asked to come back with a sample. In most cases no results were received from the labs due to ineffective procedures. Overall, 59% of the recommendations were preventative and 41% curative.

Plant doctors recommended traditional practices and modern technology. Agronomic practices were most common (65%) including: ‘destroy infected material’, ‘plant clean planting material’, ‘plant resistant/improved variety’ and ‘practice crop

Table 6. Recommendations given at the five plant clinics by category (number and frequency). Summary of all plant health problems

Category/recommendation	Prev/Cur[b]	# Queries	% of all
Pesticides			
Insecticide	Cur	412	13
Fungicide	Cur	223	7
Pesticide, generic[a]	Cur	38	1
Homemade pesticides, soapy water, repellent plants	Cur	22	<1
Herbicide	Cur	1	<1
Sub-total		*696*	*23*
Fertilisers			
Organic fertiliser (mulch, manure, other, rhizobium)	Prev/Cur	57	2
Fertiliser	Prev/Cur	53	2
Sub-total		*110*	*4*
Agronomic practices			
Destroy/uproot/burn infected material	Cur	451	15
Plant clean seed/healthy planting material, incl. seed treatment	Prev	303	10
Plant resistant/improved variety	Prev	269	9
Practice crop rotation or intercropping	Prev	261	8
Disinfect tools	Prev	143	5
Remove male bud	Prev	140	5
Planting time and/or plant distance	Prev	107	4
Other agronomy advice (incl. grafting, pruning, non spread)	Prev	95	3
Weeding/clean/remove rubbish	Prev	84	3
Rest land under Silverleaf Desmodium (*Striga* control)	Prev	58	2
Weed before flowering (*Striga* control)	Prev/Cur	51	2
Insect traps	Prev	28	<1
Soil and nursery preparation	Prev	13	<1
Water management	Prev	12	<1
Sub-total		*2015*	*64*
Unsolved and other			
'No advice given'/'unsolved'/blank (169 entries)		208	7
'Bring a sample'		34	1
Sample sent to lab test (MAAIF, CABI, other)		20	<1
'Not a serious problem', 'it is normal', 'don't do anything'		5	<1
General advice, e.g. 'control insects', 'crop protection'		4	<1
'No cure'		2	<1
Sub-total		*273*	*9*
Total[c]		*3094*	*100*

Notes: [a]For example, 'spray with pesticide'. 'Pesticide' and 'insecticide' were often used as synonyms. [b]Prev—Preventative; Cur—Curative. [c]The total is higher than the number of queries, since multiple recommendations were given for many problems.

rotation'. Pesticides featured in 23% of all recommendations of which 13% were insecticides and 7% fungicides. Pesticides were mainly suggested, in descending frequency, for orange, tomato, cabbage, groundnut, watermelon, banana, coffee, papaya, maize and eggplant. Little mention was made of homemade and biological remedies (plant extracts, animal waste) or herbicides. The use of fertiliser was recommended for only 4% of all queries.

Fifty-five percent of the recommendations were incomplete (data not shown). Missing information included how to use products, which crop or variety to plant, and in 72 cases the name (or active ingredient) of the pesticide or fertiliser. More information may have been written in a separate prescription given to the farmer or conveyed verbally.

Eleven out of the 140 recommendations on BXW control said 'female bud' instead of 'male bud'. This could be a transcription error or the plant doctor confusing the two. The plant clinic data help reveal gaps in knowledge and identify training needs, including accurate recording of information.

Quality of advice—four major pests

We examined the technical quality and feasibility of recommendations given for the four most commonly presented pests. BXW, *Striga*, CWD and CMD all cause major losses in Uganda and they accounted for 25% of all queries (Table 3).

The recommendations given at the plant clinics were compared with advice currently suggested in Uganda (Table 7). The listed practices reflect scientifically validated and other published management options recommended by different programmes and institutions, including MAAIF. These 'best practices' are not absolute standards. New, but not yet widely available practices, as well as locally adapted practices may be equally useful or better.

The recommendations given by plant doctors for the four major pests were categorised as: 'best practice', 'partially effective' and 'ineffective/blank' (Table 8). A partially effective recommendation will reduce spread and severity of the disease to some extent.

For most pests and diseases a combination of practices is necessary for effective prevention and control (Adipala et al., 2000; Leena et al., 2009). Farmers may not be able to apply the best solution but they can still adopt certain practices to limit losses. Therefore they need more than one option for managing pests and diseases. Appropriate advice depends on the agricultural conditions and socio-economic circumstances under which farmers live. Key determinants of acceptability and feasibility include availability and costs of inputs and value of the crops to the farmer. Measuring opportunity costs is an implicit part of farmers' decision-making. Often they are forced to compromise between the conflicting requirements of large and/or early yields, and food security (Gibson et al., 2004). Resistant varieties may have higher yield potential yet lack favourable traits such as market acceptability, early cropping or preferred taste.

Banana bacterial wilt (BXW)

BXW was detected in Uganda in 2001 and vast efforts have been made to manage this major threat to food security (Tripathi et al., 2009). Mass campaigns have been carried out across the country to promote the 'ABCC practices' listed in Table 7 (A—Avoid planting infected suckers; B—Break off male bud; C—Cut and bury infected plants; C—Clean tools). The ABCC practices were recommended in 16% of the plant clinic cases, 78% were a partial combination of these practices and 6% were either blank or ineffective advice, such as 'plant resistant variety', 'apply insecticide', 'use banana traps', 'pour bleach on plants' (Table 8). Although the recommendations

Table 7. 'Best management practices' (widely recommended) of the top four diseases

BXW	Striga	CWD	CMD
1. Avoid planting sick suckers 2. Break off male bud 3. Cut and bury infected plants 4. Clean tools	1. Rotation with non-cereals[a] 2. Plant Desmodium[b] (improved fallow or intercropping) 3. Remove before flowering 4. Add manure or fertiliser 5. Plant early 6. Plant clean seed[c] 7. Avoid moving infected soil to clean fields[c]	1. Destroy infected plants 2. Avoid moving diseased plant parts 3. Plant disease free seedlings (e.g. clonal coffee/elite seeds) (*4. Plant resistant varieties*)[d]	1. Destroy infected plants 2. Plant resistant varieties 3. Plant disease free planting material

Notes: BXW—banana xanthomonas wilt (syn. banana bacterial wilt); CWD—Coffee wilt disease; CMD—Cassava mosaic disease. [a]For example, soybean, groundnut, cowpea. [b]Part of 'push-pull' technology (Khan et al., 2008). [c]Was not recommended by any of the plant clinics. [d]Resistant varieties partially released in 2009.

given at plant clinics were often incomplete, the key messages for BXW were well known.

The ABCC practices need to be carefully reviewed in the light of what is feasible. 'Avoid planting sick suckers' is useful advice if the farmer knows how to spot the BXW symptoms. Many plant suckers from their own fields. Healthy planting material is not readily available and certification systems of micro-propagated (tissue culture) or macro-propagated (suckers) planting material are still being developed (Vurro et al., 2010).

Some farmers already remove male buds to increase fruit size, while others claim that de-budding gives weaker beer (G. Tusiime, personal communication). Kagezi et al. (2006) reported that farmers were still confused about why they should de-bud and only some had adopted this practice. Disinfecting tools requires fire, bleach or hot water and may not be feasible. Farmers are unlikely to do it consistently since it is impractical and enhances work load. If ABCC is done meticulously, the second 'C' (disinfect tools) might not be essential, yet burying and burning plant material ('B') is

Table 8. Efficacy of advice given at the plant clinics for the four major plant health problems

	Best practice		Partially effective		No effect/blank	
Pest/disease	#	%	#	%	#	%
BXW (n = 178)	29	16	138[a]	78	11	6
Striga (n = 98)	0	0	95	97	3	3
CWD (n = 80)	2	3	73[b]	91	5	6
CMD (n = 74)	11	15	48	65	15	20[c]
Total (n = 430)	*42*	*10*	*354*	*82*	*34*	*8*

Notes: BXW—banana xanthomonas wilt (syn. banana bacterial wilt); CWD—coffee wilt disease; CMD—cassava mosaic disease. [a]Five of these cases included ineffective advice such as 'improved variety' or 'rest land for two years'. [b]'Plant resistant/tolerant varieties' was mentioned 43 times; Ineffective advice was given 22 times ('disinfect tools', 'crop rotation', 'rest land' and 'spray with Dimethoate'). [c]Ineffective advice included: 'spray with Dimethoate', 'plant early', 'whitefly fungicide', 'rest land', 'spray with Milstin (fungicide), 'crop rotation'.

time-consuming and there is little evidence of individual farmers following this practice consistently (G. Tusiime, personal communication). Despite the massive effort and publicity given to controlling BXW, many farmers still brought samples to plant clinics. Further research is needed to find out which farmers have received the official recommendations and if they are applied and working.

Striga

Often when farmers present *Striga* at the plant clinics it is already well-established in the field. There is even a risk that the clients spread *Striga* seed as they carry the 'patient' to the clinic! *Striga* seeds are very persistent and once the seed bank in the soil has reached a critical level, control becomes difficult. Early prevention and limiting of build-up is crucial. The 'best practices' listed in Table 7 represent commonly recommended practices to improve soil fertility, reduce the soil seed bank and prevent further spread (Oswald, 2005). New and more effective technologies such as imazapyr-coated herbicide-resistant maize (IR maize) still fail to become widely adopted (Vanlauwe et al., 2008). It is not easy to define 'best practice' for *Striga* management unequivocally. Efficacy and adaptability under different growing conditions, as well as availability, accessibility and affordability of the technologies determine what advice is appropriate under given conditions.

Table 8 shows that 97% of the recommendations given at the plant clinics included different combinations of some of the 'best practices'. 'Plant clean seeds' and 'avoid moving infected soil to clean fields' were not recommended by any of the plant clinics although these are important measures. Only 3% were blank or ineffective advice (e.g. 'Apply dimethoate', an insecticide) suggesting that the plant doctors in general have some level of knowledge about *Striga* control.

More than half of the recommendations (55%) included 'plant *Desmodium*' as part of the package (data not shown). This practice is part of the push-pull technology designed to control *Striga* and stem borer in maize-based cropping systems (Khan et al., 2008). The planting of *Desmodium* either as a cover crop (improved fallow) or an intercrop is effective since it induces suicidal germination of *Striga* seed. But it is unfeasible for most farmers. *Desmodium* is a fodder legume so it is mainly an option for farmers with animals. More importantly, the seed is not widely available. Land scarcity and labour requirements may also be a reason for farmers' reluctance to plant *Desmodium*.

Coffee wilt disease (CWD)

'Best practices' to control CWD in Uganda currently include 'destroy infected plants', 'avoid moving diseased plant parts' and 'plant disease free seedlings' (Table 7). Farmers might be willing to uproot infected trees but many would be reluctant to burn them in situ. They would rather bring them home and use them for firewood, which is a valuable resource. However, by doing this the disease is spread by spores as they carry the tree home (Rutherford, 2006). The list also includes 'plant resistant varieties' as a fourth item in brackets. The use of genetic resistance is generally regarded as the most important means to effectively control CWD (Rutherford, 2006; Musoli et al., 2009). However, despite the recent (2009) partial release of resistant varieties developed by the Coffee Research Center of Uganda, their availability is still so low that they cannot be regarded as a real control option for Ugandan coffee growers. 'Best practice' was recommended in 3% of the plant clinic cases, 91% was 'partially effective' and 6% of the records were either blank or included ineffective advice, such as 'disinfection of tools', 'crop rotation', 'rest land' and 'spray with insecticide'.

More than half of the recommendations included 'plant resistant varieties' (43) as part of the advice despite the limited feasibility of this option. The plant clinic registers also reveal some confusion regarding the terms 'clonal coffee'/'elite seed' versus 'resistant/tolerant varieties'. In some cases these are erroneously used as synonyms. 'Clonal coffee' and 'elite seed' refer to the way the material has been produced rather than the variety (S. Kyamanywa, personal communication). So if no other specification is given, such advice may be incorrect and confusing. In any case, the availability of clonal/elite seed is a challenge. Many farmers are still planting volunteer plant seedlings.

Cassava mosaic disease (CMD)

The recommended 'best practices' (destroy infected plants, plant resistant varieties and disease free planting material, Table 7) can be regarded as a 'gold standard' for controlling CMD since they apply to all agro-ecological conditions provided that the recommended varieties fit the specific locality. This advice was given by the plant doctors in 15% of the cases, two-thirds (65%) comprised a partial mix of these practices, while ineffective or undocumented advice was given in 20% of the cases.

Although the use of 'best practices' will ensure effective control of the disease, the adoption rate of these practices has been limited (Thresh and Cooter, 2005). Availability of clean planting material is very low and effective removal of diseased plants is only feasible as long as labour is available and farmers know how to recognise the disease.

Varieties tolerant to CMD and CBSD are available to some extent although consumer preferences limit the uptake of new varieties. A district agricultural officer from western Uganda explained some of the dilemmas they face:

> TME 14 is a very good CMD tolerant cassava variety—we recommend it and give it to farmers so they can compare and observe for themselves. However, the TME varieties are not popular here. They are not starchy and not good for flour. They are stony and short-seasoned. Farmers don't like that because they want to be able to keep the cassava in the field for as long as possible as food storage. With the TME varieties you cannot do that because the roots turn hard and rot after maturing. We keep on bringing in new varieties and take their complaints!

Implications for plant clinic operations

Training of plant clinic staff

Diagnostic capacity is a critical component of a plant health care system (Miller et al., 2009) yet it is difficult to measure. The plant clinic data are a new way to assess the ability to identify the cause of problems. Our analysis highlights specific training needs for plant doctors on certain crops in order to improve field diagnosis and identification of pest management options.

Prior to setting up the plant clinics, the staff received a three-day course on the broad principles of field diagnosis (recognition and interpretation of symptoms) and how to run a plant clinic (Boa, 2009), including mock interviews with farmers and filling out forms. Plant clinic staff had not yet received a follow-up course on making recommendations and relied on their existing knowledge and experience. Most plant clinic staff had been practising extension workers for some years and were therefore familiar with many of the problems presented by farmers. Furthermore, the four major diseases addressed here, BXW, *Striga*, CWD and CMD, have received a lot of public attention and project support, yet Table 8 shows patchy knowledge of key symptoms and, more worryingly, weak awareness of the best control options.

Our findings confirm those of Erbaugh et al. (2007) who found gaps in the ability of Ugandan extension workers to diagnose problems and give appropriate advice to farmers. They also found that extension workers had limited ability to absorb and adapt local and scientific knowledge. Okorley et al. (2009) suggest that training of agricultural extension staff should encourage an attitude of searching for new knowledge. This is of particular importance to plant doctors who frequently receive queries they cannot resolve during the plant clinic session and who have to deal with unfamiliar crops and their problems.

Register management

There were many gaps, omissions and imprecise descriptions in the available plant clinic register data that limited the scope of the quality assessment. Incomplete symptom descriptions made it difficult to assess the validity of the diagnosis. A query on sweet potato identified as 'sweet potato weevil' was described as 'insect attack'. Plant clinic data were kept in register books and rarely looked at later. The weaknesses found in plant clinic register management reflect general weaknesses in monitoring and reporting of many extension organisations (government and NGO) (Birner et al., 2006).

Plant clinic data are a unique source of regularly updated information on plant health problems. It is important not to underestimate the effort required to collect and validate these data. Most of the records had to be transcribed from written records and considerable time was needed to collect forms from different plant clinics, enter data accurately into a spreadsheet and harmonise spellings and entries. The plant clinic registers are a useful management and decision-making tool for extension providers. Data should be collected and analysed using common standards and procedures, with roles and responsibilities for handling these data clearly stated. When plant clinics were established in Uganda register management was not prioritised. It was only later that it became clear how useful the registers are as a means to monitor the quality of advisory services, document progress and support decision-making (Danielsen and Kelly, 2010).

Correct filling of the plant clinic register should be a more prominent part of the training of plant doctors and plant clinic supervisors. Strengthening capacity and raising awareness about the importance of good register management are essential to improve plant clinic performance.

Technical backstopping and organisational challenges

The plant clinic registers show the need for better links and access to reliable sources of information and technical support in diagnosing unknown problems. After five years, the plant clinics are still weakly connected to diagnostic labs, research institutes and universities (Danielsen and Mutebi, 2010). Only 20 samples were sent for laboratory testing and few results were sent back. Uganda remains vulnerable to new and emerging pests and diseases (Smith et al., 2008) yet despite major investments and donor support over many years, diagnostic services are underused. There is currently no functional referral system between the plant clinics and the laboratories of MAAIF, Makerere University and The National Agricultural Research Organisation (NARO).

Apart from being a valuable tool for quality assessment of plant clinics, the clinic registers constitute a novel means to gather regular information about pests, diseases and farmer demand that can help inform researchers, plant health authorities as well as technology providers. The register data raise many new questions that should be investigated further and for which the involvement of expert institutions and other stakeholders in plant health is essential. Such wider stakeholder engagement implies a range of organisational challenges, which turned out to be difficult to solve during the pilot phase. These include institutional fragmentation and widespread ‘project mentality’, which limit cross-institutional collaboration (Danielsen and Matsiko, 2010). As the plant clinic initiative in Uganda evolves under a ‘plant health systems’ approach (Danielsen et al., 2011; MAAIF, 2011), it is important to ensure that the value of plant clinic registers is recognised and that they are used to their full potential.

Concluding remarks

The results presented here are a first attempt to quantify the quality of the diagnostics and advice given to farmers by analysing plant clinic registers. Such analyses will help define the scope of the plant clinics, delimit the plant clinic ‘jurisdiction’, create realistic expectations as to what plant doctors can do themselves, and identify straightforward measures to improve, for example, skills and knowledge of plant clinic staff and technical support and advice. Plant clinic data can also be used to monitor the relative success of previous projects in disseminating specific technologies and messages on key plant health problems such as BXW and *Striga*. Our data suggest weaknesses in dissemination that need addressing in project design and implementation.

Recording is an important element in plant health care and the registers are an essential tool to keep track of plant clinic performance. By analysing the registers we can make inferences about plant clinic operations and quality of diagnostics and advice. However, to discover whether these inferences or assumptions are true, they need to be tested to truly understand the relation between register management, clinic performance and outcomes (Donabedian, 1978). Quality of plant health care as assessed by register analysis is not necessarily a proxy for plant health outcomes and therefore it cannot stand alone. A more comprehensive assessment requires a combination with other methods, such as monitoring visits to observe plant clinic staff—client interactions, occasional tests of plant doctor skills, as well as gathering of feedback from farmers and field observations (Danielsen and Kelly, 2010).

This study shows that well-kept plant clinic registers have a big potential to support decision-making on technical, operational and strategic matters. Regular and systematic analysis of plant clinic registers should be part of the standard operations.

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