Assessing the uptake and disease impact of Napier grass in Kenya

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Assessing the uptake and disease impact of Napier grass in Kenya

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Executive summary

The International Livestock Research Institute (ILRI), in collaboration with Kenya Agricultural Research Institute (KARI), has identified and distributed head smut disease tolerant Kakamega I (KK I) and Kakamega II (KK II) varieties of Napier grass in order to alleviate the negative effects of the disease which has been affecting smallholder farmers through biomass loss. Uptake and preference of these varieties have not been evaluated since their introduction in 2002. This study was undertaken to evaluate the performance of the varieties in terms of smut tolerance with the aim to better understand the dissemination pattern of the varieties and to estimate the current status of both smut and stunt diseases.

The study's target population was Napier grass growing farmers in selected areas of Western Kenya and farmers receiving KK I or KK II in selected areas of Central Kenya. The regions were stratified by levels of incidence (high, medium and low) of smut in Central (three counties) and stunt in Western (three sites) Regions. Geographical random sampling was employed in Western Region while in Central Region pre-selection of targeted farmers who had been growing KK I and KK II was done to identify primary beneficiaries and snowballing to identify secondary beneficiaries. In total, 331 farmers were interviewed from 6 sites.

A major challenge during data collection was farmers' inability to distinguish between the different varieties of Napier grass. Indeed, even Napier grass experts find it difficult to differentiate it phenotypically. This challenge, coupled with farmers' lack of written records about their farming practices, meant that farmers were unable to articulate their preferred variety as well as the reasons. This was especially the case in Western Kenya. In Central Kenya, where lists of KK I and KK II recipients were used, only farmers who received KK I and KK II recently (in 2012 and 2013) could be identified. This restricted the analysis of dissemination pathways, as farmers had not had the opportunity to assess the new varieties and to promote them through their networks.

The highest smut incidence levels were reported in Kiambu (27%), which was consistent with previous studies and expert opinion. The highest stunt incidences were in Vihiga which was contrary to the expectation that it was Bungoma. However, stunt incidence levels were close between Vihiga and Bungoma, which may suggest that stunt is spreading fast in Western Region. Trans Nzoia had the lowest incidence in Western Region which was consistent with the expectation. The study also revealed some level of stunt in Central Region and some level of smut in Western Region. The other common disease noticed in the study area was leaf spot.

Contrary to the expectation that tolerance to smut disease in Central Region would be a major reason for adopting KK I and KK II, the major reasons cited related to yields and the quality of the varieties. Most farmers harvested their grass before the disease attacked their crop. For those who indicated abandoning some varieties, poor regrowth of crops and incompetence of tillers were the main reasons and not the disease vulnerability.

The findings indicated that agronomic practices, planting materials and soil types were not influencing severity of the diseases on the farms.

In all the survey sites, stall feeding dominated during the dry and wet seasons. This result shows the importance of Napier grass in this system. Further, allocation of total land to Napier grass ranged between 8–21% in Western and 17–38% in Central Region, underlining the importance of the fodder in smallholder systems. Quality and yields were the main attributes that farmers emphasized when selecting a variety. Thus there is need to come up with Napier grass varieties that are not only disease tolerant but also higher yielding. There is need to carry out genetic identification of the unknown varieties grown by farmers especially in Western Kenya. Farmers need to be sensitized on the diseases as many were unable to correctly identify the diseases since this would pose a challenge in disease control. Awareness should also be created regarding the varieties because many farmers were not able to identify the varieties they had on their farms.

Introduction

With the growing pressure on land due to population growth, farmers, especially those practicing small-scale farming are being faced by the challenge of meeting two competing needs: producing food for human consumption and feed for livestock. Among the common fodder crops, Napier grass is one of the most important as feed for livestock in Kenya due to its attributes which include ease of management, wide ecological range and high production (Orodho 2006). It also contributes about 40% of the total fodder given to livestock (Mwendia et al. 2006) which highlights its importance in livestock production in Kenya. According to Wouters (1987), the average dry matter yield for the local varieties was 16 t/ha across the country while Schreuder et al. (1993) recorded a range of between 10 and 40 t/ha depending on soil and management.

These positive traits, however, have been threatened by the occurrence of head smut disease which has a tendency to drastically reduce yields (Farrell 2002). There have been concerted efforts by the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI) to select and distribute head smut disease tolerant varieties of Napier grass in order to alleviate the negative effects of the disease on local varieties. Head smut tolerant Kakamega I (KK I) and Kakamega II (KK II) were developed and distributed to farmers in prone areas in Central and Western Kenya since 2002. Mwendia et al. (2007) conducted a survey in the Central Province to determine the effect of head smut on Napier grass yields. Of the surveyed farmers, only 19% were found to be cultivating Kakamega I and he noted that farmers lacked awareness of the variety while levels of smut stood at 62.8%.

In Western Kenya, stunt disease has spread rapidly causing serious loss in biomass. Lusweti et al. (2004) carried out a survey and found that the disease caused damage ranging from 5–90%. Currently, cultivars are being selected in order to discover a variety that is tolerant to the disease. Some varieties showing tolerance to the disease in uncontrolled on-station trials have been disseminated to farmers by KARI (160,000 cuttings in 2012 and 130,000 in 2013 to 11 farmer groups) in partnership with the International Centre of Insect Physiology and Ecology (ICIPE) and the Ministry of Agriculture. Mulaa et al. (2008) found out that there are low levels of smut in four districts in Western Kenya; 5.2% in Busia, 4.8% in Mumias and 1% in Butere and 2.5% in Busia. Similarly low levels of stunt were found in two districts in Central Region with Murang'a recording 12.9% and Kiambu 20%.

The purpose of the study was to evaluate the performance of the introduced varieties, KK I and KK II, in terms of smut tolerance, to better understand the dissemination pattern of the varieties and to estimate the current status of both smut and stunt disease (the latter as a 'baseline' prior to the development and dissemination of tolerant cultivars).

Objectives of the study

The study seeks to establish the incidence levels of smut and stunt diseases in Central and Western Kenya and assess the impact of the introduction of KK I and KK II varieties.

The specific objectives are to:

1. Assess major dissemination pathways for KK I and KK II, from those originally receiving from KARI, and range of dissemination
2. Assess adoption rates of recipients of KK I and KK II Napier grass compared with other varieties
3. Evaluate incidence levels for smut and stunt disease in the study areas
4. Assess and compare preference of farmers for KK I, KK II and other varieties

Methodology

The study's target population covered Napier grass growing farmers in selected areas of Western Kenya and to farmers receiving KK I or KK II in selected areas of Central Kenya. The selection was based on expert opinion provided by KARI scientists. The study applied qualitative and quantitative approaches of data collection which included: focus group discussions (FGD) with farmers, key informant interviews with agricultural officers involved in livestock and/or fodder production and smallholder household questionnaires.

Table 1. Proposed sites and location

Region	Multiplication centre / Bulking site (distribution centre for KK I / II)	County (locations)	Reported levels of Smut (C) and Stunt incidence (W)
Central	Muguga	Kiambu (Komothai, Thakwa, Githunguri)	High
		Muranga (Kanyanyaini, Muringaine, Muguru)	Medium
		Nyeri (Ruguru, Itiati, Ngorano)	Low
Western	Kitale/Kakamega	Bungoma (Khasoko, Misikhu, Sitikho)	High
		Vihiga (North Bunyore, South Maragoli, Wodanga)	Medium
		Trans Nzoia (Kiminini, Matisi, Saboti)	Low

* (C) – Central; (W) – Western

Figure 1. Map for sites in Central Kenya.

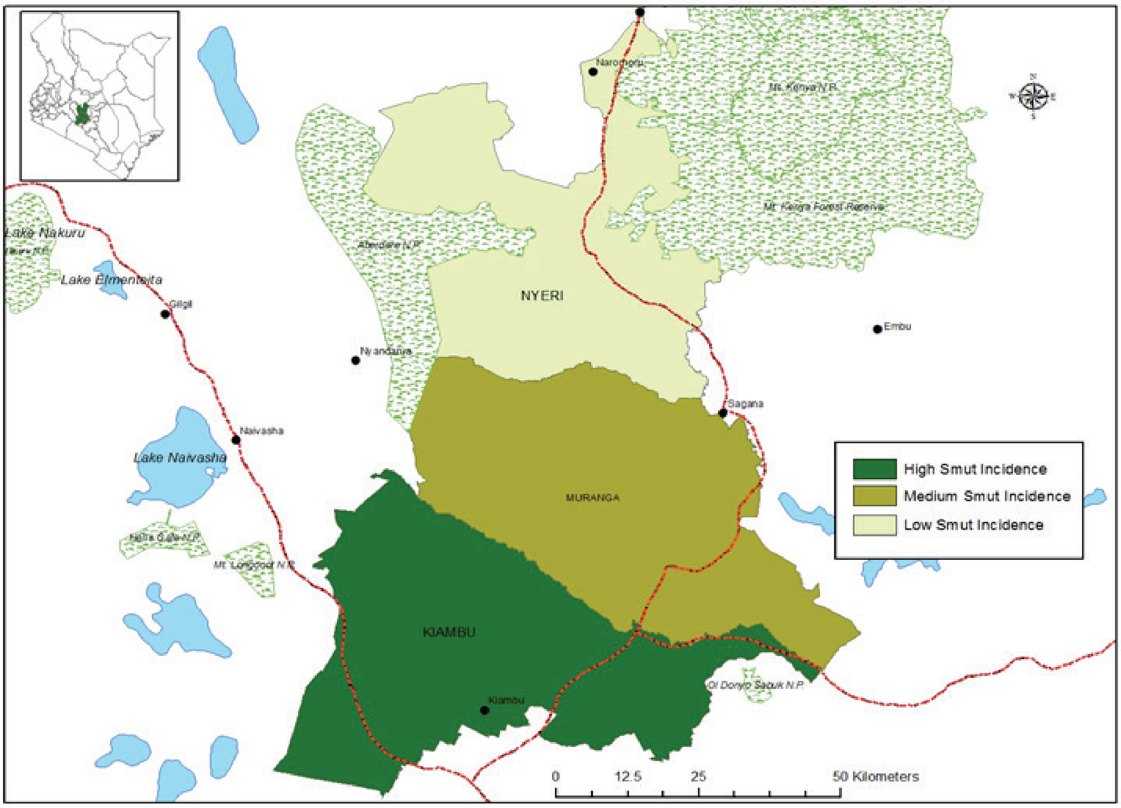
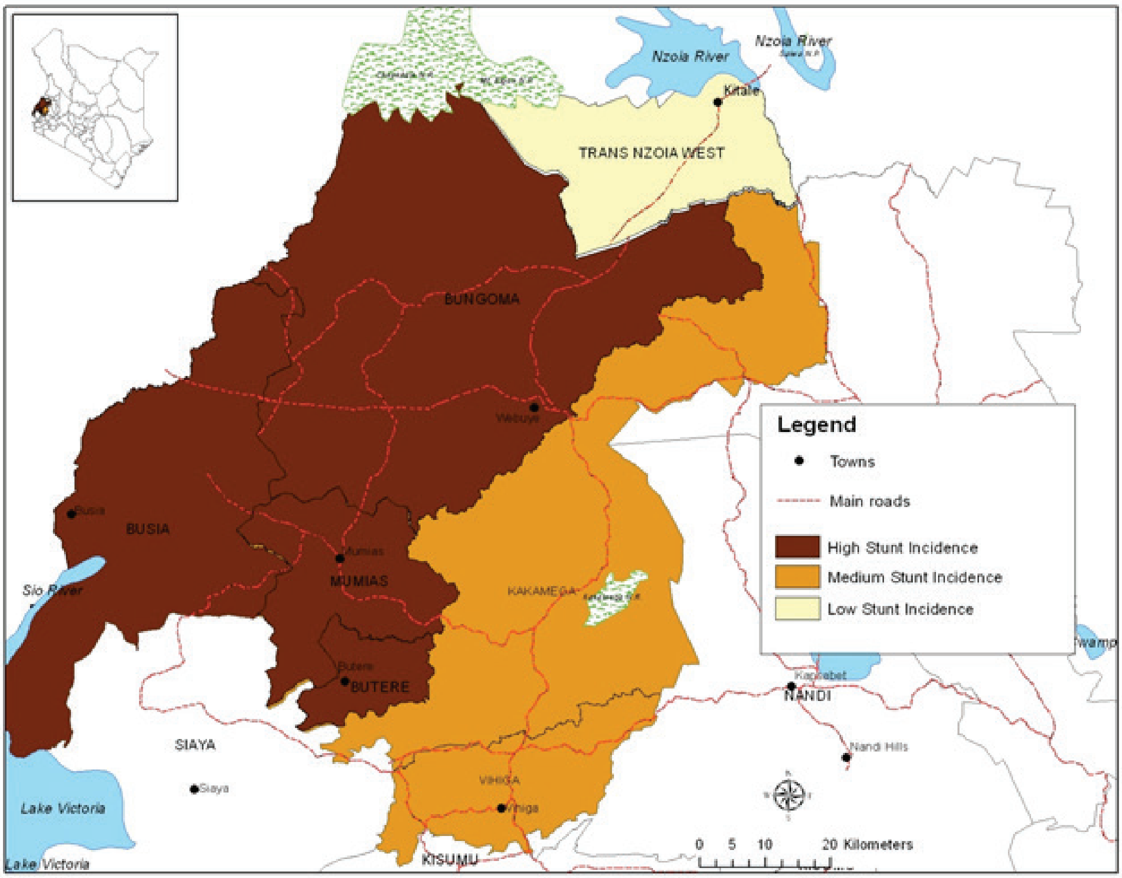


Figure 2. Map for sites in Western Kenya.



Geographical area

The survey was conducted in three sites in Western Kenya and three in Central Kenya. Each area was at the level of the Location Administrative Unit.

Sampling method

The regions had initially been stratified by expected levels of incidence of smut (Central) and stunt (Western) as shown on Table 1. Previous work by KARI provided, as seen in Map 1 and 2 above, an overview of expected levels of incidence of the diseases in their respective regions. The study used this to stratify the sampling to ensure that we capture (and measure) levels of adoption of KK I and KK II and farmers preference under different conditions of the disease incidence. One county was selected in each level of incidence as presented in Table 1 above in each region.

In Western Kenya, within each county, 3 locations were randomly selected and thereafter households growing Napier grass were randomly selected using geographical random sampling.

In Central Kenya, a list of households who received KK I and KK II was obtained from each multiplication centre / bulking site Appendix 1, from livestock production officers and a random selection of these farmers made to be included in the survey.

For Central Region, because the study expected tracking the dissemination pathways for KK I and KK II, snow balling was used to track secondary beneficiaries

To generate the sampling frame for Central Region, a preliminary visit was organized with ILRI staff and livestock officers to identify potential farmers for the survey. The pre-selection targeted farmers who had been growing Napier for at least 5 years; however, the sampling frame generated recent farmers making it difficult to ascertain the impact as envisioned.

Sample size

The sample size (n) was calculated for each site as below.

$$n = \frac{\left(Z_{\frac{\alpha}{2}} \sqrt{p(1-p)} \right)^2}{d^2}$$

$Z\alpha/2$ is the significance level – set at the level of 5% (1.96).

p = hypothesised proportion (expressed as decimal – e.g. 10% = 0.1)

d = the level of precision we want to estimate the incidence / adoption to (expressed as decimal).

Table 2 below summarizes the sample size calculations. Equal sample size using the highest n was adopted in each site.

Table 2. Sample size calculations

Variable	Hypothesised level (from literature)	Level of precision required	n
Smut incidence (Central)	40%	+/– 15%	41
Stunt Incidence (Western)	80%	+/– 10%	62
KK I / KK II Adoption	50%	+/– 15%	43

Compromise sample size n = 60 per Site

(40 initially selected with at least 20 to be 2nd receiver households in Central Kenya. If there are no 2nd receiver households 20 more randomly selected Napier grass OR KI/KII households were interviewed)

Data collection

Quantitative data was collected using questionnaires while qualitative data was collected through FGD's and Key Informant Interviews. The household questionnaire was administered using personal digital assistants (PDAs). At each site, at least one focus group and one Key informant interview was conducted. It was expected that farmers in Central had received KKI and KII varieties earlier but a majority just received cultivars in 2013 as per the recipients' lists that were available.

Data analysis

Descriptive statistics were used to analyse the quantitative data and qualitative data used to complement the quantitative analysis.

Factors influencing adoption were not analysed as most farmers in western could not identify the varieties grown while in central, most of the farmers had just started growing KKI and KKII.

Bar graphs were generated to look at relationships between some variables and disease incidence levels. Further, to establish if a relationship exists statistically between the dependent and the independent factors, chi square tests were run.

Results and discussions

Respondents distribution

Total number of Napier grass farmers surveyed in the 6 sites was 331 farmers. Their distribution is as per Table 3 below. The low numbers in most sites were as a result of difficulties locating farmers using the global positioning systems (GPS) in Western Kenya and in Central difficulty in getting farmers who have or are currently growing Kakamega I (KKI) or Kakamega II (KKII) varieties.

Table 3. Sample sites and distribution of respondents

Region	County (severity)	Number of households
Central	Kiambu (High)	56
	Murang'a (Medium)	51
	Nyeri (Low)	56
Western	Bungoma (High)	60
	Vihiga (Medium)	52
	Trans Nzoia (Low)	56
	Grand total	331

Socioeconomic characteristics

The distribution of the farmers surveyed in terms of gender, recipient status, highest education level of the household head, average age and average family size is as presented in Table 4 below.

From the results shown below, the survey was dominated by Female respondents ranging from 45% in Murang'a to 60% in Kiambu. Secondary level education was the most common highest level obtained by farmers in all sites except for Bungoma and Vihiga.

Table 4. Descriptive statistics of sample

County	Respondents (%)		Mode highest education (%)	Average age (s d)
	Male	Female		
Kiambu	40	60	Secondary(44)	50 (13)
Murang'a	55	45	Secondary (43)	49 (16)
Nyeri	46	54	Secondary (41)	53 (16)
Bungoma	38	62	Primary (45)	41 (15)
Vihiga	48	52	Primary (32)	46 (17)
Trans Nzoia	53	47	Secondary(35)	45 (14)
Total	47	53		48 (16)

Information access

Information type and source

The mode of dissemination of new varieties was other farmers, including neighbours, friends, relatives, and community leaders. However, for the process to start, farmers recognized the fact that it has to come from an extension worker or a seminar before it is transferred from farmer to farmer as displayed in the Table 5 below. Other information sources included farmer groups and agricultural shows. It should be noted that only two farmers received information regarding fodder markets in Trans Nzoia and Vihiga.

Table 5. Information source

County	Information type	% of information source					
		Radio	Extension worker	Fliers	TV	Field day	Others
Bungoma	Napier varieties		33				67
	Other fodder varieties			100			
	Pests and disease management		100				
Kiambu	Napier varieties		56	4	32	8	
	Other fodder varieties				100		
	Pests and disease management		100				
	Planting materials and inputs				100		
Murang'a	Napier varieties		54	3	25.7	8.6	8.6
	Other fodder varieties	33.3			33.3		33.3
	Pests and disease management		66.7		33.3		
	Planting materials and inputs				100		
Nyeri	Napier varieties	4.4	43.5	30.4	4.3	17.3	
	Other fodder varieties		50			50	
	Planting materials and inputs				100		
Trans Nzoia	Napier varieties		25	37.5	25	12.5	
	Other fodder varieties		50			50	
	Fodder Markets			100			
	Planting materials and inputs	25				75	
Vihiga	Napier varieties					100	
	Fodder Markets					100	
	Planting materials and inputs					100	

Source of information on fodder production

Table 6 below shows that information on fodder production is vastly spread in central compared to western region. In Vihiga only 9% of the Napier grass farmers in the survey received information as opposed to 96% in Kiambu which was the highest among all sites.

Table 6. Dissemination of information on fodder production

County	% receiving information	N
Kiambu	96	50
Murang'a	88	49
Nyeri	75	42
Bungoma	12	7
Vihiga	9	5
Trans Nzoia	37	19
Grand total	52	172

Objective 1: Assess the major dissemination pathways for KK I and KK II, and range of dissemination

Findings show that Napier grass varieties are not easily distinguishable phenotypically. Most farmers were unable to differentiate KKI and KKII from other varieties. We therefore had to use list of recipients of KKI and KKII from various bulking centres and Division Livestock Production offices to identify KKI and KKII farmers. Only recent lists (2012 and 2013) were available, reducing considerably the scope of the analysis. These 2 varieties are disseminated in Central Province only, as smut tolerant varieties through KARI stations bulking centres and farmers. Among KKI recipients in Central region, farmers got them from farmer group (27%), other farmers (34%) and KARI (29%). While those who received KKII 31% received from farmer groups, 26% received from other farmers and 31% from KARI Table 7. The most shared variety that farmers could recognize was KKI (24%), however 50% of the farmers passed on a variety to other farmers which they could not positively identify, only 6% who shared KKI were able to identify the variety.

Table 7. Source of planting materials

Variety	Source of variety (%)			
	Farmer groups	Other farmers	KARI	Others
KKI	27	34	29	10
KKII	31	26	31	12

Objective 2: Assess the levels of adoption of KK I and KK II Napier grass compared with other varieties

In central where the two varieties were mainly disseminated, most of the farmers were found to be growing KKI and KKII, which occupied most of the land under Napier as shown in table 8. This was due to the survey design as beneficiaries were purposively selected. Most farmers only started planting the varieties recently.

The case was different in western region since KKI and KKII varieties were not targeting the region. Inability of farmers to differentiate the varieties made it difficult to ascertain the most common variety in farmer fields. For instance in Bungoma, Vihiga and Trans Nzoia districts, 98%, 90% and 85% of the farmers respectively have planted an unknown variety. Consequently, a large proportion of their land is under the unknown variety. However in Trans Nzoia, 12% of the Napier grass farmers were growing Bana grass variety while in Vihiga it was 3%. French Cameron variety was grown by 7% of farmers in Vihiga.

Table 8. Level of adoption of KKI and KKII compared to other varieties

County	Variety	Percentage HH's growing (N)	Average land per farmer acres
Kiambu	KK I	56 (48)	0.6
	KK II	18 (15)	0.5
	Bana	2 (2)	0.3
	Uganda Hairless	1 (1)	0.8
	Unknown	23 (19)	0.6
Murang'a	KK I	35 (30)	0.4
	KKII	14 (12)	0.2
	French Cameroon	34 (29)	0.4
	Bana	4 (3)	0.2
	Unknown	13 (11)	0.6
Nyeri	KK I	31 (25)	0.4
	KK II	19 (15)	0.3
	French Cameroon	10 (8)	1.1
	Bana	1 (1)	1
	Unknown	40 (32)	0.9
Bungoma	KKI I	2 (1)	0.1
	Unknown	98 (59)	0.5
Vihiga	French Cameroon	7 (4)	0.5
	Bana	3 (2)	0.1
	Unknown	90 (52)	0.4
Trans Nzoia	KK I	4 (2)	3.5
	Bana grass	12 (6)	2.7
	Unknown	85 (44)	1.5

Objective 3: Evaluate the incidence levels for smut and stunt disease in the study areas

Data regarding disease level was collected through a carefully set question to capture the plants that have been affected by the disease. The farmers were requested to rate the severity of diseases in their infected plots. If in a set of four randomly selected plants a single plant was affected the severity was ranked at 25%, if two plants were affected the rank is at 50%, and if all four plants were affected severity was ranked as greater than 75%.

From Table 9 below, out of the 331 Napier grass farmers in the survey, 99 farms reported noticing various diseases. Although in some instances some farmers were unable to differentiate between malnourished Napier grass and Stunt. In Smut prone areas also most farmers harvested early thus did not notice the disease.

The highest smut incidence level was reported in Kiambu which was consistent with previous studies and expert opinion (see Figure 1). The highest stunt incidence was in Vihiga which was contrary to our expert opinion, as it was meant to be in Bungoma Figure 2. However, the incidence levels were close between Vihiga and Bungoma, which may suggest that Stunt is spreading fast in Western. Trans Nzoia had the lowest stunt incidence in Western which was consistent with expert opinion. The study also revealed some level of Stunt in Central and some level of Smut in Western. Other common disease noticed was leaf spot.

Table 9. Incidence of Napier grass disease

County	Farmers who noticed Napier grass disease (n)	Number of farmers who noticed		
		Smut	Stunt	Other
Kiambu	27% (14)	14	0	0
Murang'a	14% (8)	3	5	0
Nyeri	36% (20)	15	4	1
Bungoma	40% (24)	2	22	1
Vihiga	39% (22)	0	22	0
Trans Nzoia	22% (11)	2	6	3
Grand total	30% (99)	37	57	5

Severity by county

Bungoma noticed smut in 1990, however, since then the severity remains averagely less than 25%. Stunt was mostly seen as from 2012, and severity levels were between 25% and 50%. Other main disease noticed was leaf spot in 2013, with a severity similar to stunt Table 10.

Trans Nzoia also noticed Smut disease, around 2010 and 2011 with a severity of less than 25%. Stunt was noticed later, in 2011 and 2012, with a severity of between 25% and 50%. Another disease that was noticed was leaf spot, with a severity of between 50% and 75%.

Vihiga had stunt only which was noticed in 2012 with a severity of less than 25% at the time of the study. The average number of cuts before disease was noticed in Western ranged between 2 and 8.

Kiambu had smut incidence only, mostly noticed between 2008 with a severity still of less than 25% at the time of the study.

Murang'a had both smut and stunt. Smut was first noticed in 2013, with a severity of less than 25% and stunt was noticed in 2011 with a severity still of less than 25% at the time of the study.

Smut in Nyeri was noticed in 2008 and the severity was less than 25% on farm. Stunt was first noticed in 2002 and the severity was between 25%–50%. Other diseases were noticed from 1990 with a severity of between 25%–50%. The average number of cuts before a disease is noticed was 1 to 4 cuts.

Table 10. Severity of diseases per county

County	Disease	Year noticed locality	Overall severity (percentage reported)	Average cuts
Kiambu	Smut	2008	< 25% (86%)	5 (4)
Murang'a	Smut	2013	< 25% (75%)	3 (2)
	Stunt	2011	< 25% (80%)	2 (1)
Nyeri	Smut	2008	< 25% (67%)	4 (4)
	Stunt	2002	25–50% (75%)	2 (1)
	Other	1990	25–50% (100%)	1
Bungoma	Smut	1990	< 25% (100%)	4 (2)
	Stunt	2012	25–50% (48%)	4 (3)
	Other	2013	25–50% (100%)	3
Vihiga	Stunt	2012	<25% (82%)	6 (4)
Trans Nzoia	Smut	2010	< 25% (50%)	8
	Stunt	2011	25–50% (67%)	2 (2)
	Other	1990	50–75% (33%)	4 (5)

Disease levels and production change before and after introduction of KKI and KKII

In Central province, a majority of those who received KKI or KKII had the severity at less than 25% before and after receiving the variety Table 11. They reported that yields also increased after adopting the varieties indicating that the disease was negatively affecting productivity.

Table 11. Varieties grown before and changes after adopting KKI and KKII

County	Mode Severity before at <25%	Mode Severity after at <25%	Mode Yield increase
Kiambu	78%	47%	100%
Murang'a	50%	50%	50%
Nyeri	75%	50%	50%

Objective 4: Assess and compare the attributes that farmers consider when planting the varieties

Table 12 below shows the reasons for adopting. Quality was the major attribute that farmers cited as the driver to adoption of KKI and KKII contrary to the expectation that resistance to diseases would be a major reason for adopting the varieties especially in Central. Overall farmers were more concerned with better yields, quality and regrowth of the varieties.

Table 12. Reasons for adopting, abandoning and not adopting a variety

Variety	Percentage (%) of farmers citing the reason						
	More tillers	Not prone to diseases	Better quality	Better regrowth	Short maturity period	Drought resistant	Palatable
KKI	18	12	23	21	17	3	4
KKII	18	15	19	16	20	7	1
French Cameroon	19	7	20	19	19	7	7
Bana grass	18	11	7	21	14	4	7
Clone 13	0	0	0	0	0	0	0
Pakistan hybrid	23	4	19	19	13	7	8
Uganda hairless	18	12	23	21	17	3	4

Napier grass role in smallholder dairy systems

Table 13 below shows that in all the survey sites, stall feeding dominated both in the dry and in the wet seasons. This result emphasizes the need for a fodder providing more biomass for dairy farming like Napier grass. This result also shows expected increase in level of adoption of Napier grass. Combined with the results in Table 12, Napier grass varieties will be needed that are of better quality, more yields, resistant to drought and diseases.

Table 13. Feeding systems

County	Wet season	Percentage practicing	Dry season	Percentage practicing
Kiambu	Mainly stall feeding	94	Mainly stall feeding	92
Murang'a	Mainly stall feeding	87	Mainly stall feeding	85
Nyeri	Mainly stall feeding	66	Mainly stall feeding	60
Bungoma	Mainly stall feeding with some grazing	33	Mainly stall feeding with some grazing	37
Vihiga	Mainly stall feeding	65	Mainly stall feeding	47
Trans Nzoia	Mainly grazing with some stall feeding	35	Mainly grazing with some stall feeding	39

Napier grass allocation to land relative to other fodder crops

Table 14 below shows the allocation of the area under fodder to the specific fodder types. In most the counties, Napier grass was allocated significant acreage which shows the important role of the grass in all counties. From the survey, Murang'a was the only county with no fodder diversity with Trans Nzoia having the highest number of fodder varieties as well as acreage allocation.

Table 14. Allocation of land under fodder

County	Fodder	Average land under fodder in acres	Standard deviation
Kiambu	Napier grass	0.9	0.8
	Planted pasture e.g. Rhodes grass	1.0	
	Natural pasture	0.7	0.4
	Desmodium (*Desmodium velutinum*)	0.1	
Murang'a	Napier grass	0.6	0.5
Nyeri	Napier grass	0.9	1.0
	Planted pasture e.g. Rhodes grass	0.3	0.1
	Natural pasture	0.4	0.3
	Others	0.5	
Bungoma	Napier grass	0.6	1.8
	Planted pasture e.g. Rhodes grass	0.5	
	Natural pasture	3.1	10.1
	Desmodium (*Desmodium velutinum*)	0.1	
	Others	0.2	0.1
Vihiga	Napier grass	0.4	0.5
	Natural pasture	0.3	0.1
	Desmodium (*Desmodium velutinum*)	0.5	
	Grand Total	1.6	5.5
Trans Nzoia	Napier grass	3.2	8.2
	Planted pasture e.g. Rhodes grass	4.9	4.6
	Natural pasture	6.1	11.0
	Desmodium (*Desmodium velutinum*)	2.6	2.7
	Lucern (*Medicago sativa*)	1.1	1.3
	Fodder trees/shrubs	30.3	42.1
	Oats (*Avena sativa*)	0.1	
	Others	0.7	0.5

Disease awareness and management strategies

Table 15 below shows the various disease management strategies. Napier grass farmers mostly remove the infected tillers or the whole plant, with some in Kiambu for instance burning the infected plant. Some farmers do nothing to manage the disease and this could be detrimental to the healthy stools. Therefore there is need to sensitize farmers on appropriate diseases management to avoid possible spread of the disease to the rest of the field.

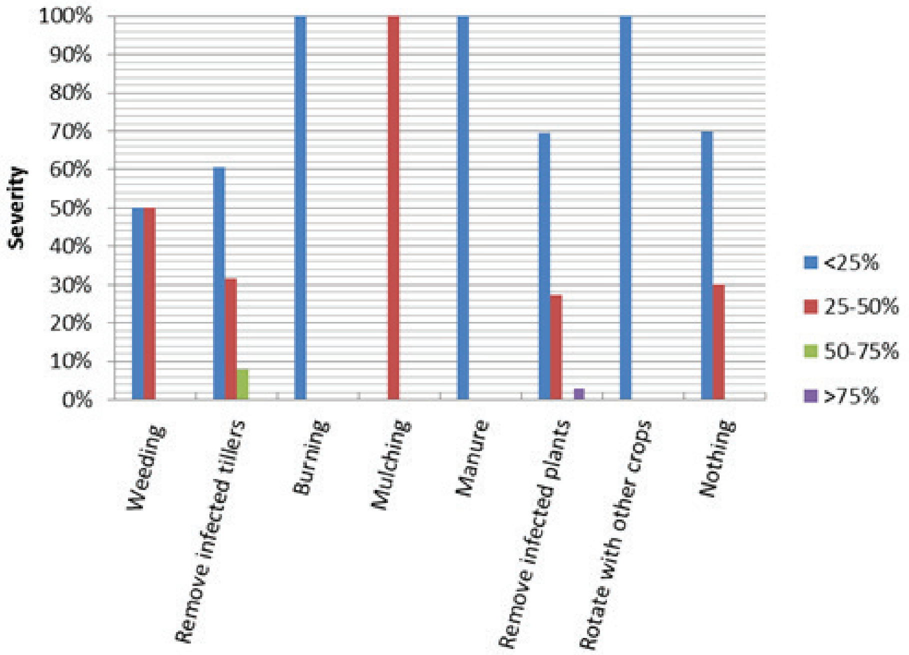
Table 15. Disease management strategies and sources of information on disease

County	Disease	Percentage of farmer practicing disease management strategy						
		Remove infected plants	Remove infected tillers	Remove and burn infected tillers	Weeding	Crop rotation	Manure	Do nothing
Kiambu	Smut	38		19	19			
	Stunt		67				33	
Murang'a	Smut	36	45		9			
	Stunt	33	67					
Nyeri	Smut	40	47			7		
	Stunt	20	40				20	
	Others							100
Bungoma	Smut	25	50					25
	Stunt	28	38		21			
	Others	50	50					
Vihiga	Stunt	27	32					14
Trans Nzoia	Smut	25	50					50
	Stunt	22	30		22			
	Others				20			80

Disease management strategies and effect on severity

From Chart 1 below the strategies that farmers employ do not help control or manage the disease. Chi square test was done to ascertain if there exists a relationship between disease management and severity, the two-tailed p value associated with the chi-squared value was 0.953 (see appendix 2). Therefore there exists no relationship between the two variables. Further, 83.3 % of the cells had expected frequencies less than 5. However, Yates correction which prevents overestimation of statistical significance for small data set was been accounted for.

Chart 1. Severity against disease management strategy.



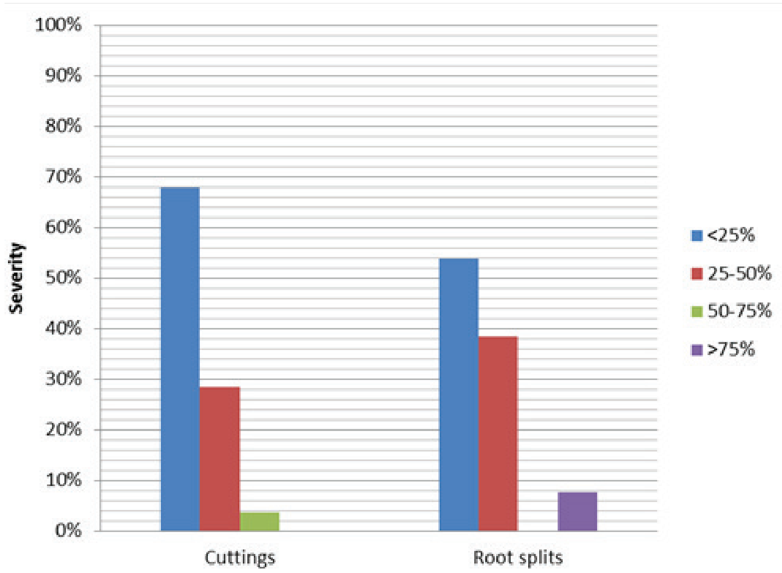
Farmers agronomical practices and disease severity levels

Propagation materials and effect on severity

Owing to the fact that Napier grass is an open-pollinated species with low seed production, vegetative propagation is mostly done, farmers mainly used Napier grass cuttings and in few cases root splits.[1]

From Chart 2, regardless of the planting material used, there was some level of disease. The Chi square test Appendix 3 showed that there was no effect on level of severity by planting material.

Chart 2. Severity against planting material used.

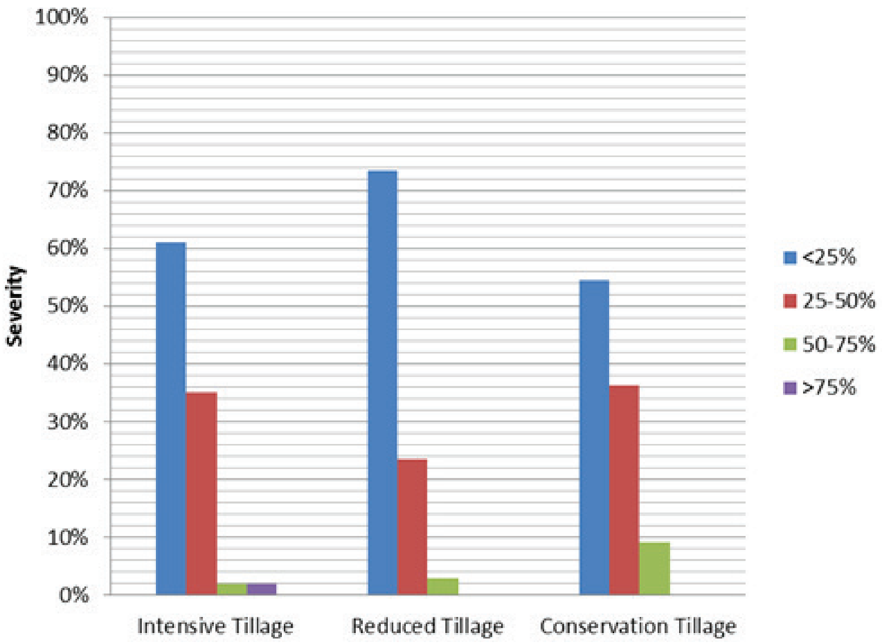


1. Cuttings are derived from the cane while root splits are from the uprooted stool that is split into pieces for propagation.

Land preparation and severity level

Most farmers practiced intensive or conventional tillage that leaves less than 15% crop residue on the ground. This means that most residues are removed from the soil. Regardless of the land preparation method, there was some level of infection as seen in Chart 3. Further, chi square tests results showed a p value of 0.661 which is greater than 0.05 indicating that there exists no relationship between land preparation and severity of disease as shown in appendix 4.

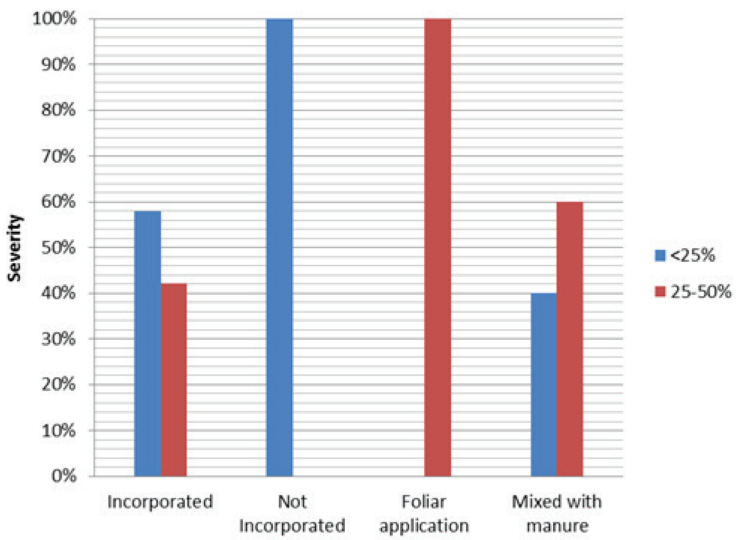
Chart 3. Severity against land preparation methods.



Fertilizer application method and severity level

Fertilizer was either incorporated into the soil or mixed with manure. The severity is shown in Chart 4, where the two main forms of fertilizer application show similar patterns where the level of infection is almost at the same level. Therefore there was no difference in severity between the fertilizer incorporation methods. This was further supported by the chi-square p value of 0.288 which is also greater than 0.05 shown in Appendix 5.

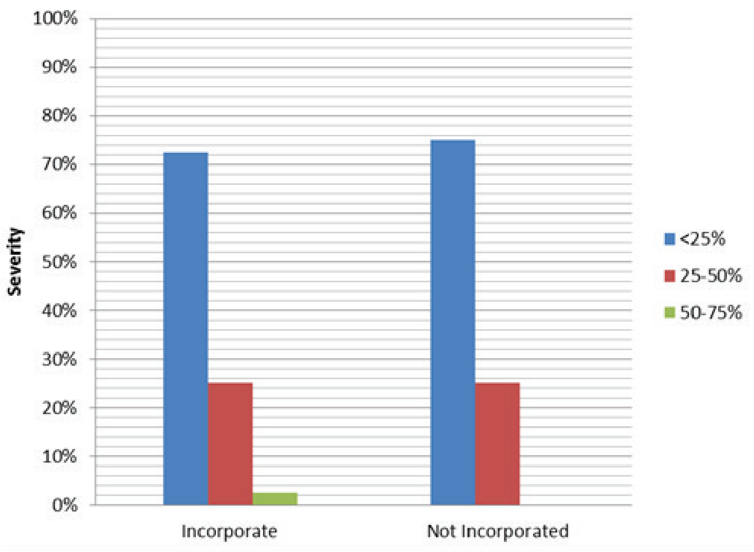
Chart 4. Severity against fertilizer application.



Manure application method and severity level

Manure was mainly incorporated into the soil. Some farmers mentioned manure as a way of controlling disease. However, looking at Chart 5 which compared manure application methods against disease levels, there was no significant difference in severity levels. A chi square p value of 0.739, greater than 0.05, confirmed this observation as seen in appendix 6.

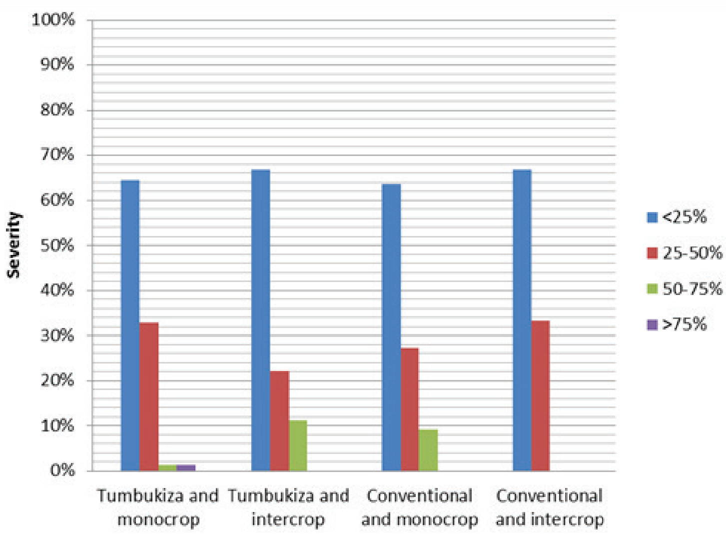
Chart 5. Severity against manure application.



Cropping patterns and severity level

Cropping patterns varied from county to county, with most preferring Napier grass as a monocrop with tumbukiza as a method of planting against the conventional method. Severity was plotted against planting methods in Chart 6. Similar patterns were observed which indicate no difference in the categories with respect to severity. Chi square test displayed in appendix 7 yielded a p value of 0.847 and there was no relationship between planting methods and severity.

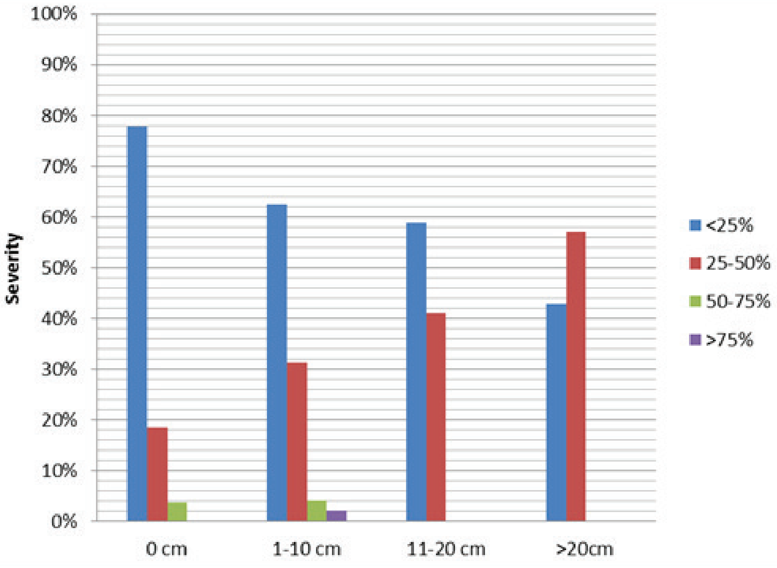
Chart 6. Severity against cropping and planting methods.



Harvesting heights and severity level

Harvesting heights varied by county. A majority of the Napier grass farmers harvested between 1–10 centimetres against the recommended 5–10 cm, others cut at the ground level, leaving small tillers. Severity was plotted against harvesting levels in Chart 7. Similar patterns were observed, and a chi square p value of 0.655 in appendix 8 indicated that there was no relationship between the two.

Chart 7. Severity against cutting height.

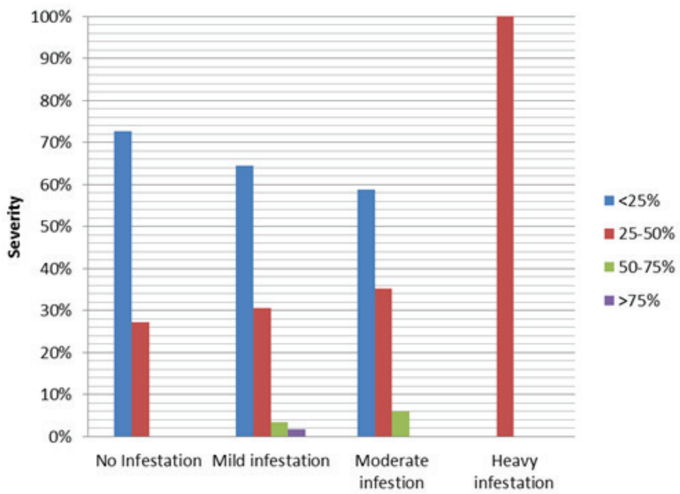


Weed infestation and severity level

Weed infestation was generally mild, and this may be partly explained by the fact that Napier grass is a dominant crop.

Crop stress as a result of competition with weeds has been known to increase the severity of disease. Chart 8 below shows severity against weed infestation. From the pattern observed, chi square test was conducted as shown in appendix 9 and a p value of 0.873, which is greater than 0.05 lead to the conclusion that weed infestation was not related to severity.

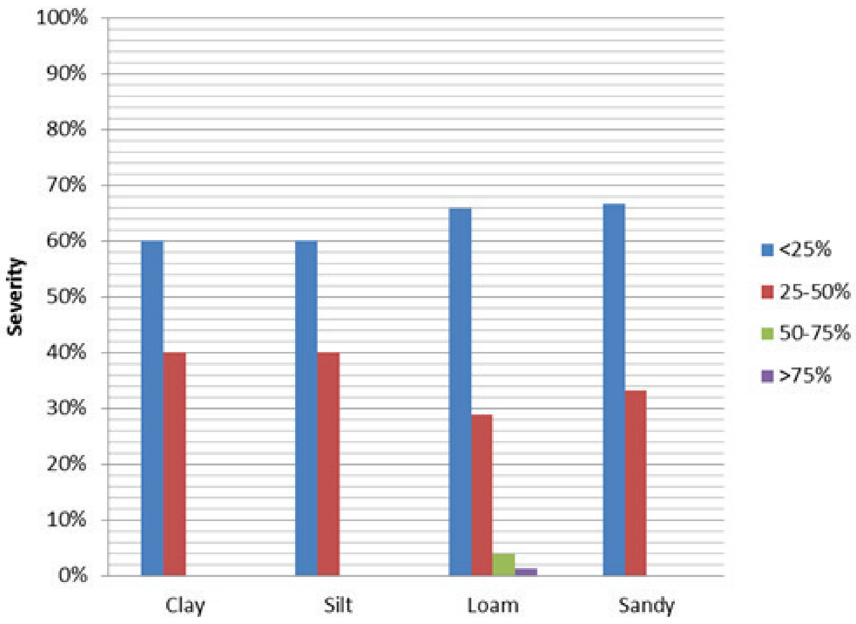
Chart 8. Severity against weed infestation.



Soil type and severity level

In all sites, Napier grass was mostly grown in loamy soils. Severity was plotted against soil conditions in Chart 9 and a chi square test conducted to test if soil type influence severity of disease appendix 10. From the pattern observed, and a chi square p value of 0.993, the conclusion was that soil conditions did not affect severity of disease.

Chart 9. Severity against plot soil condition.



Appendices

Appendix 1. List of distribution centres

Multiplication/distribution centres
KARI Muguga
Mathira West district livestock office
Wambugu ATC farm
Kangema district livestock office
New KCC bulking plot Kangema
Rwathia girls secondary Kangema
Ichichi chiefs camp Kangema
Githunguri district livestock office

Appendix 2. Chi-square test for severity against disease management strategy

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	13.690[a]	24	0.953
Likelihood ratio	16.164	24	0.882
Linear-by-linear association	0.915	1	0.339
N of valid cases	99		

a. 30 cells (83.3%) have expected count less than 5. The minimum expected count is 0.01.

Appendix 3. Chi-square test for severity against planting material used

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	9.866[a]	6	0.130
Likelihood ratio	7.646	6	0.265
Linear-by-linear association	2.191	1	0.139
N of valid cases	99		

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .05.

Appendix 4. Chi-square test for severity against land preparation methods

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.114[a]	6	0.661
Likelihood ratio	4.106	6	0.662
Linear-by-linear Association	0.023	1	0.879
N of valid cases	99		

a. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .11.

Appendix 5. Chi-square test of severity against fertilizer application methods

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	3.763[a]	3	0.288
Likelihood ratio	4.912	3	0.178
Linear-by-linear association	1.072	1	0.300
N of valid cases	32		

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is 0.47.

Appendix 6. Chi-square test for Severity against manure application

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	3.538[a]	6	0.739
Likelihood ratio	4.170	6	0.654
Linear-by-linear association	3.016	1	0.082
N of valid cases	92		

a. 7 cells (58.3%) have expected count less than 5. The minimum expected count is 0.09.

Appendix 7. Chi-square test of severity against planting methods

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	4.847[a]	9	0.847
Likelihood ratio	4.217	9	0.897
Linear-by-linear association	0.001	1	0.971
N of valid cases	99		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is 0.06.

Appendix 8. Chi-square test for severity against cutting height

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	6.824[a]	9	0.655
Likelihood ratio	7.842	9	0.550
Linear-by-linear association	1.551	1	0.213
N of valid cases	99		

a. 10 cells (62.5%) have expected count less than 5. The minimum expected count is 0.07.

Appendix 9. Chi-square test for severity against weed infestation

Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	4.534[a]	9	0.873
Likelihood ratio	5.573	9	0.782
Linear-by-linear association	1.731	1	0.188
N of valid cases	99		

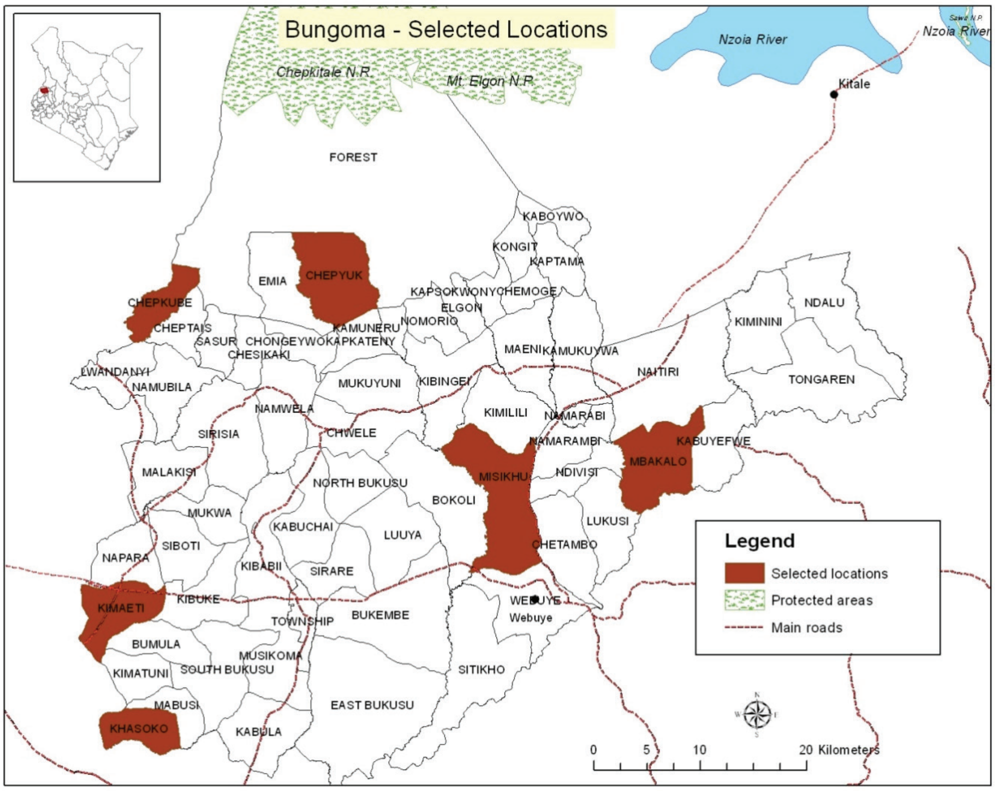
a. 10 cells (62.5%) have expected count less than 5. The minimum expected count is 0.01.

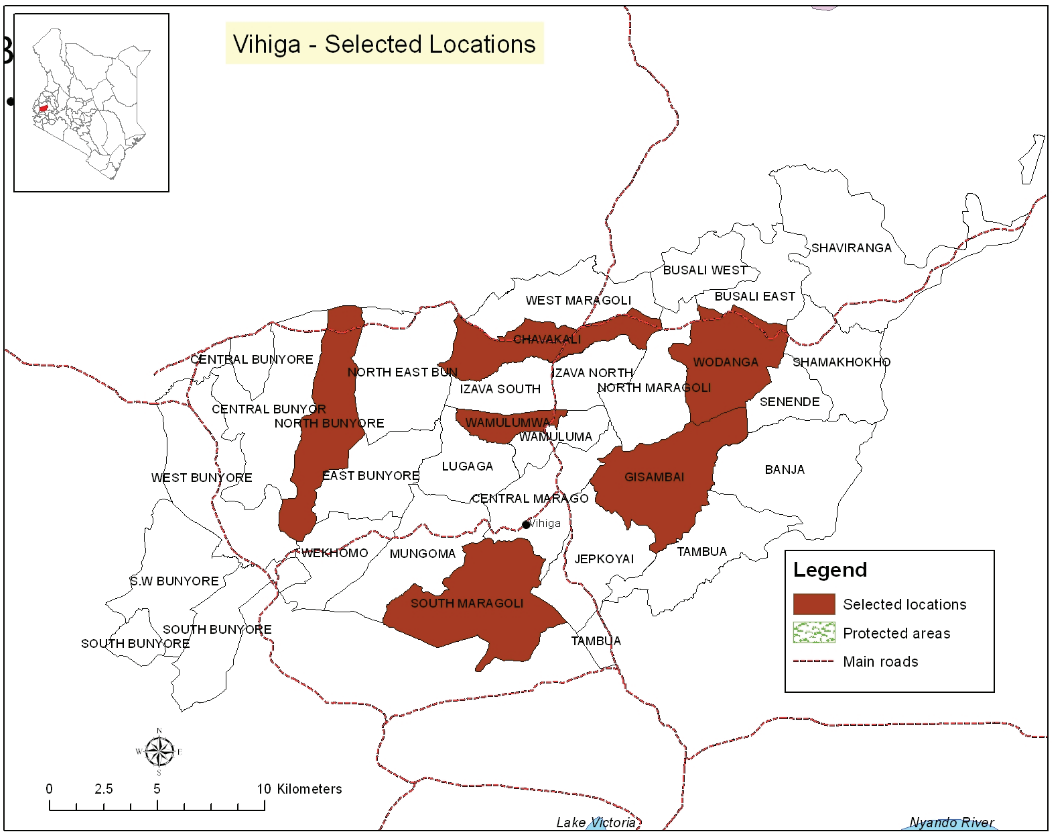
Appendix 10. Severity against plot soil condition

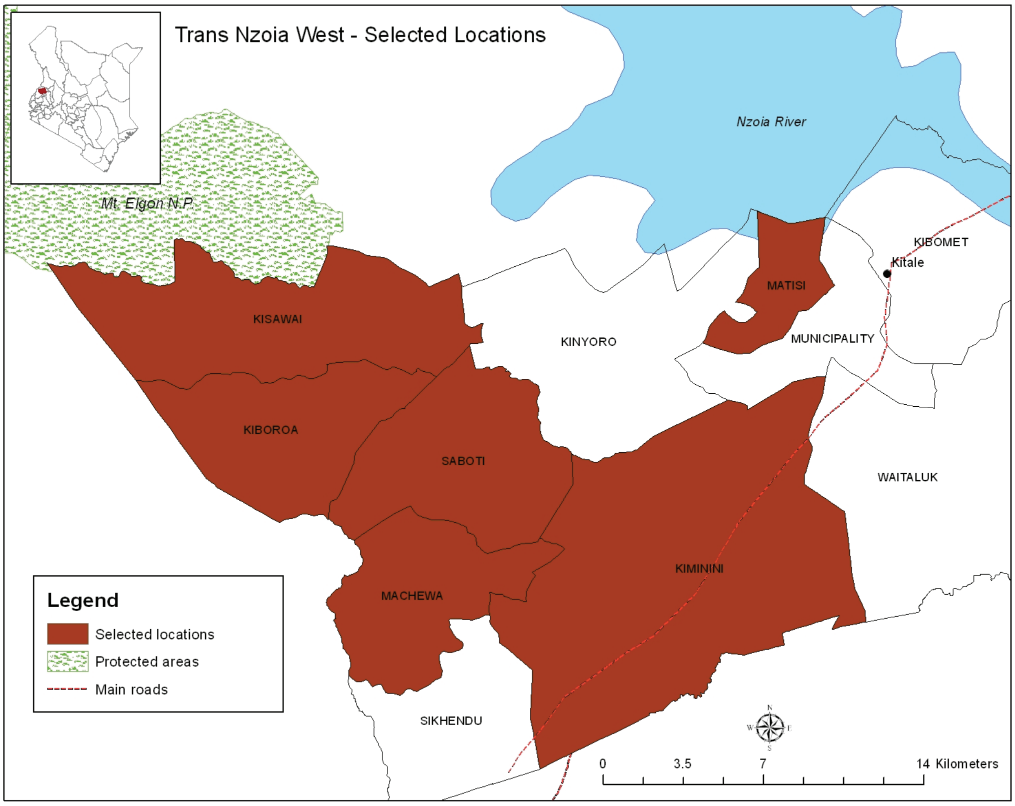
Chi-square tests	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	1.916[a]	9	0.993
Likelihood ratio	2.787	9	0.972
Linear-by-linear association	0.000	1	0.988
N of valid cases	99		

a. 13 cells (81.3%) have expected count less than 5. The minimum expected count is 0.03.

Appendix 11. Maps with selected locations—Western Kenya






Trans Nzoia West - Selected Locations
Nzoia River
Mt. Elgon N.P.
KIBOMET
Kitale
MATISI
KISAWAI
KINYORO
MUNICIPALITY
KIBOROA
SABOTI
WAITALUK
KIMININI
MACHEWA
SIKHENDU
Legend
Selected locations
Protected areas
Main roads
0 3.5 7 14 Kilometers

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