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Performance of sweet potato varieties across environments in Kenya

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Abstract

Sweetpotato is an important food, feed and cash crop in Eastern Africa but its adoption as a dual purpose crop has not been exploited. Varieties giving high tuber and vine yields would be ideal for small scale farmers who are the predominant producers. The objective of the study was to evaluate and identify farmer-preferred adapted sweetpotato varieties which are high yielding in relation to food and feed. Sweetpotato varieties were evaluated in three sites at the coast between May 06 and February 07, one in Kilifi (KARI-Mtwapa) and two on farm sites in Lukore and Mwaluvanga locations, Kwale district. The experimental trials were laid out as randomised complete block design (RCBD). Ground cover was determined. Sweetpotato virus disease (SPVD) incidence was monitored. The yield data was partitioned into marketable and non-marketable tubers, vine and tuber yield on weight basis. The yield of the disease tolerant varieties was stable in seasons and sites. Varieties with farmer and market desired traits such as high tuber yield and vine mass were identified. Dissemination of disease tolerant sweetpotato varieties coupled with building farmers capacity to maintain clean vines can sustain sweetpotato productivity.

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Introduction

The sweetpotato, *Ipomoea batatas* L. is a dicotyledonous plant belonging to the family Convolvulaceae and is indigenous to tropical America from where it dispersed to other regions (O'Brien, 1972; Lusweti, 1994). Sweetpotato is among the most important food crops in the world, ranked seventh (based on total production), cultivated in more than 100 countries and is fifth most important crop in terms of consumption in developing countries (FAO, 2005). It grows well in a wide range of soil types with minimal fertilizer and pesticide inputs and has higher yields than cereals (Onwueme, 1978). It is grown in Eastern Africa in a wide range of environmental conditions (Onwueme, 1978). It is tolerant to adverse weather conditions and total crop failure rarely occurs hence farmers plant it as an insurance crop (CIP, 1996). Sweetpotato tubers are a carbohydrate source, leaves contain proteins and vitamin C and orange-fleshed tubers provide vitamin A. The crop plays a vital nutritional role and also used as source of starch, alcohol and animal feed (Woolfe, 1992). Sweetpotato is a potential source of biofuel and plastic (Anonymous, 2007). The crop is grown largely by smallholder farmers (Carey *et al*., 1996).

Sweetpotato production constraints include economic, abiotic and biotic factors. The economic constraints include proximity to markets and lack of marketing standards. The inability of some of the varieties to serve as a dual purpose crop creates a dilemma to the farmers because of insufficient land. The abiotic constraints include low soil fertility and drought. The biotic factors include nematodes, weevils and viruses (Alfred *et al.*, 2000). Sweetpotato viruses are the major disease constraint and they reduce yield significantly (Njeru *et al*., 2004). The most devastating disease is the sweetpotato virus disease (SPVD), which is caused by dual infection with sweetpotato feathery mottle virus (SPFMV) and the sweetpotato chlorotic stunt virus (SPCSV) (Geddes, 1990; Gibson and Aritua, 2002). The sweetpotato virus disease has been reported to occur in all areas where the crop is grown and coastal Kenya is a hot spot of SPVD and farmers have limited knowledge of the disease (Ateka *et al.,* 2004). The objective of the study was to determine sweetpotato productivity across environments where SPVD is prevalent and identify varieties which can serve as a dual purpose as source of animal feed and human food.

Materials and methods

Seventeen sweetpotato genotypes were tested in three sites between May 2006 and January 2007. The three sites were Kenya Agricultural Research Institute (KARI)-Mtwapa farm in Kilifi district, which is located at an altitude of 30 m above sea level, Lukore and Mwaluvanga in Shimba hills, Kwale district both located at an altitude of 46m above sea level. The soils are sandy and sandy loams in Kilifi and Kwale respectively (Michieka, *et al*., 1978). The mean annual rainfall in the region is 1200 mm in Mtwapa and 1400 mm in Kwale with mean monthly maximum temperature of 33 ^{o}C in Mtwapa and 27 ^{o}C in Kwale and a minimum of 22 ^{o}C and 16 ^{o}C in Mtwapa and Kwale respectively (Jaetzold *et al*., 1983). The 17 varieties were either improved (obtained through breeding) or local landraces. The flesh colour was white, cream, yellow or orange. The skin colour was red, cream white or brown. Climatic factors namely temperature and rainfall in the growing season were monitored.

The clean planting materials were obtained from the International Potato Centre (CIP) and Kenya Agricultural Research Institute (KARI). The experimental design was randomised complete block design (RCBD) with three replications in each site. The land was ploughed, harrowed and ridged in the three sites before planting. The sweetpotato clones were planted at a spacing of 0.8 x 0.3 m on plots measuring 4 x 3 m accommodating 56 (4rows x 14) plants. Weeding was done twice a month in the first two months and once after. The following data was collected: disease incidence, ground cover, tuber yield, vine yield and harvest index..

Table 1. List of sweetpotato varieties evaluated.

Variety	Category	Flesh colour	Skin colour
Jonathan	Improved	Light cream	Cream white
Japonese	Improved	Orange	Cream white
Zapallo	Improved	Orange	Cream white
Kemb10	Improved	Cream	Cream white
Jewel	Improved	Orange	Orange
Mugande	Local landrace	White	Red
Marooko	Local landrace	Light cream	Brown
Ex-shimba	Local landrace	White	Red
Jubilee	Local landrace	Orange	Orange
Ejumula	Local landrace	Orange	Orange
SPK004	Improved	Orange	Red
440015	Improved	Orange	Red
K135	Improved	Orange	Cream
Salyboro	Local landrace	Orange	Cream white
Muibai	Local landrace	White	Red
Bungoma	Local landrace	Yellow	Red
Sponge	Local landrace	Orange	Red

Disease incidence was assessed in the middle two rows of each plot. The number of the diseased plants was expressed as a percentage of the total number of plants sampled in the two rows to get the disease incidence. Data on ground cover was collected fortnightly at 10,12,14,16 and 18 weeks after planting. The vine fresh mass, tuber yield and harvest index were determined at harvest (four and half months after planting the crop). Ground cover was assessed using a string with beads spaced 10 cm. The string was stretched diagonally on each plot and counts of beads under which there was a leaf made and average of counts on the two diagonals was determined by diving with 2 (Klingman, 1971). The average counts of beads were expressed as a percentage of the total number of beads on the string to get percent groundcover. Vines from one square metre in each plot were harvested and the fresh weight measured using a Salter Scale 4 months after planting.

The tubers were harvested from middle rows of each plot and grouped into marketable and non-marketable tubers which were weighed to get tuber mass (kg). The vines of the two middle rows were weighed to get vine mass (kg). Data was subjected to analysis of variance using Genstat software and means separated by least significant difference at 5 % probability level.

Results and discussion

Rainfall and temperature patterns in the two seasons

Rainfall was well distributed in the long rain season (May-September 2006) whereas in the short rain season (October 2006-January 2007) it was only high in the first two months after which it reduced and a dry spell dominated (Fig 1). Rainfall was slightly higher in Kwale than Mtwapa but the distribution pattern was comparable. Temperatures were higher in Mtwapa than in Kwale and there were no dramatic changes in temperature in both seasons. However it was slightly higher in the short rain than in the long rain season.

Ground cover

Groundcover (%) varied significantly ($P<0.01$) between seasons and among sites and varieties. It was highest in the long rain season and lowest in the short rain season (Fig 2). This difference can be attributed to the favourable climate conditions such as high rainfall in the long rain season.

Table 2. Sweetpotato vine yield in t/ha across three sites in Coastal Kenya during the short and long rain seasons in 2006/2007.

	Vine fresh mass in t/ha						
	Long rain season			Short rain season			
Variety	**LKR**	**MTW**	**MWLV**	**LKR**	**MTW**	**MWLV**	**Mean**
Zapallo	8.9	17.4	9.8	6.4	8.3	4.6	9.2
Kemb10	11.1	16.9	21.3	14.2	9.9	5.9	13.2
Japonese	17.0	20.0	18.6	10.3	14.9	4.9	14.2
SPK004	18.1	33.6	17.9	4.5	16.1	4.4	15.8
Jewel	18.4	28.1	21.9	8.6	13.7	7.3	16.3
Jubilee	24.1	37.0	26.1	10.0	8.2	6.7	18.7
Salyboro	17.9	45.8	22.0	11.4	15.5	5.7	19.7
440015	16.1	43.0	34.4	7.2	12.9	6.9	20.1
Ejumula	14.3	45.9	29.2	9.6	16.2	6.7	20.3
Bungoma	20.9	37.9	30.2	9.4	16.9	8.7	20.7
K135	20.3	44.2	34.2	7.2	15.7	7.3	21.5
Ex-shimba	26.6	36.8	30.0	12.8	18.5	7.4	22.0
Mugande	22.8	32.8	47.8	13.7	13.4	6.2	22.8
Muibai	21.8	48.4	43.3	7.6	12.3	6.1	23.3
Marooko	33.2	41.9	36.6	9.5	16.5	9.4	24.5
Sponge	29.4	55.8	30.7	14.2	18.5	6.9	25.9
Jonathan	32.2	38.3	46.4	20.6	18.6	6.3	27.1
Mean	20.8	36.7	29.4	10.4	14.5	6.6	19.7
LSD	12.7	16.7	13.6	9.9	8.7	2.7	
CV (%)	14.4	2.2	7.8	27.7	27.7	6.4	

Key: LKR-Lukore; MTW-Mtwapa; MWLV-Mwaluvanga

Table 3. Yield variation within sites between Long and Short rain season, 2006/2007.

Site	Season	Tuber yield (t/ha)	Marketable yield (%)	Harvest index
Lukore	LR	13.3	80	0.39
Lukore	SR	6.9	61	0.42
Mwaluvanga	LR	18.3	71	0.39
Mwaluvanga	SR	5.1	42	0.39
Mtwapa	LR	19.3	78	0.36
Mtwapa	SR	6.6	66	0.31

Key: LR-Long rain season (May-September 2006); SR-Short rain season (October 2006-February 2007)

There was a steady increase in ground cover in the three sites in both seasons. It was highest in Mtwapa and lower in Lukore in the long rain season (Fig 3). In the short rain season it was lower in Mtwapa in the first 12 weeks after planting after which it was comparable in the three sites (Fig 3). This may be attributed to variation in disease pressure and soil moisture among sites. Virus disease lead to reduced leaf size (Gutiérrez *et al.*, 2003**)**, whereas under excessive soil water content canopy production is high (Wiryawan et al., 1983).

Groundcover (%) was comparable among varieties in the three sites over time in the long rain season whereby it was slightly higher in Mtwapa. It's probable that the varietal response in the three sites was similar due to consistency in rainfall distribution (Fig 1). However, in the short rain season variation was significant ($P<0.01$) among sites. It was highest in Mwaluvanga and lowest in Lukore and comparable among varieties (Fig 3). This can be attributed to variation in temperature in the three sites.

Table 4. Fresh tuber yield (t/ha) among varieties across three sites in coastal Kenya during long and short rains in 2006.

	Tuber yield in t/ha						
	Season			Site x season			
Variety	**LR**	**SR**	**Mean**	**LKR**	**MLV**	**MTW**	**Mean**
440015	9.3	2.9	6.1	5.2	7.4	5.9	6.7
Bungoma	17.4	4	10.7	10.2	9.6	12.2	10.9
Ejumula	12.0	3.5	7.8	5.8	10.7	6.8	8.8
Ex-shimba	26.5	12.1	19.3	16.4	20.3	21.2	20.8
Japonese	14.6	10.4	12.5	10	11.6	15.9	13.8
Jewel	16.5	3.8	10.2	8.1	11.1	11.2	11.2
Jonathan	30.9	12.6	21.8	22.4	21.4	21.3	21.4
Jubilee	12.8	4.2	8.5	6.2	11.3	7.9	9.6
K135	10.4	3	6.7	7.5	5.4	7.2	6.3
Kemb10	23.6	9.3	16.5	14.9	18.9	15.6	17.3
Marooko	13.0	4.5	8.8	7.7	8.9	9.8	9.4
Mugande	12.3	8.4	10.4	7.6	6.7	16.6	11.7
Muibai	13.0	3.6	8.3	6.7	8.3	9.9	9.1
Salyboro	18.8	3.7	11.3	10.1	10.4	13.4	11.9
SPK004	23.8	5	14.4	11.2	15.6	16.4	16.0
Sponge	14.9	4.1	9.5	10.6	8.4	9.5	9.0
Zapallo	7.9	10	9.0	11.4	12	18.5	15.3
Mean	16.4	6.2	11.3	10.1	11.7	12.9	12.3
LSD	4.2	3.0		4.4	4.6	5.4	
CV (%)	9.5	9.4		11.5	12.2	16.8	

LR-Long rain season (May-October 2006); SR-Short rain season (October 2006-January 2007); LKR-Lukore; MLV-Mwaluvanga; MTW-Mtwapa.

Though there was no significant difference on ground cover (%) over time, varieties Jonathan, Ex-shimba, Marooko, Sponge, Ejumula and Bungoma had highest ground cover over time and varieties Zapallo, Japonese and Kemb10 had the lowest across the three sites. Varieties with high groundcover had broad leaves and the plant was less erect most of it spreading on the ground with thick stems, whereas those with low groundcover had narrow leaves and the plant was more erect with thin stems. As result varieties with high ground cover can serve dual purpose i.e. source for human food and animal feed. In addition they are of great importance in soil and moisture conservation hence they can be intercropped with other crops. They can also be adopted by breeders when breeding for high ground cover, which is a prerequisite in photosynthetic efficiency. Variation in disease incidence due to variation in groundcover was negligible. It is clear that the ground cover was less affected by the disease than the tuber yield consequently leading to relatively low harvest index in varieties with high ground cover.

Vine yield

The vine fresh biomass differed significantly between seasons and among sites and cultivars. Vine yield was approximately 3 times higher in the long rain season compared to short rain season (Table 2). The yield was highest in Mtwapa (26 t/ha) and lowest in Lukore (15.6 t/ha) in both seasons. It was 1.4 and 1.6 times higher in Mtwapa than in Mwaluvanga and Lukore respectively. It is notable that yields were lowest in Mwaluvanga and comparable in Lukore and Mtwapa in the short rain season. Probably the dry spell, which prevailed in the region when coupled with other underlying factors, was more severe in Mwaluvanga than in Lukore and Mtwapa.

Table 5. Sweetpotato marketable and non marketable tuber yield (t/ha) in three sites in coastal Kenya in the short and long rain seasons, 2006/2007.

	Long rain season						Short rain season					
	LKR		MTW		MWLV		LKR		MTW		MWL	
VARIET	**MK**	**NON-MK**	**MK**	**NON-MK**	**MK**	**NON-MK**	**MK**	**NON-MK**	**MK**	**NONMK**	**MKT**	**NON-MK**
Jubilee	3.4	2.2	8.4	4.7	14.2	5.4	2.3	4.5	2	0.8	0.5	2.5
440015	4.1	2.1	6.0	4.3	8.7	2.9	1.4	1.8	1.3	0.2	1.1	2.1
Mugande	4.7	1.2	21.3	3.6	4	2.8	8.3	1.4	9.8	0.5	6.1	0.6
Ejumula	5.1	2.6	6.6	3.7	13.2	4.9	1.5	1.5	2.4	0.8	0.4	2.9
Muibai	7.0	1.7	15.3	1.9	11.8	1.4	1.5	3.2	2.2	0.5	0.3	3.0
Jewel	7.7	4.0	13.4	5.2	9.9	9.3	0.9	2.2	2.4	2.5	2.0	1.0
Marooko	8	2.0	12.3	3.2	10.7	2.9	1.5	3.8	2.6	0.3	1.4	2.9
K135	8.6	1.9	9.1	2.7	5.0	4.0	0.4	4.1	1.8	0.9	0.4	1.5
Japonese	9.0	2	15.2	3.4	8.9	5.3	7.8	1.2	12.7	0.6	7.8	3.8
Zapallo	10.7	3.6	19.2	4.8	10.2	5.2	7.2	1.2	12.4	0.8	7.5	1.0
Sponge	12.5	2.9	10.7	3.8	8.4	6.3	1.4	4.4	3.2	1.4	0.3	1.7
Salyboro	12.6	2.9	17.9	5.5	12.2	5.4	1.6	3.0	3.1	0.3	0.7	2.3
Bungoma	13.4	2.2	16.9	4.6	11.8	3.1	2.4	2.4	2.4	1.6	0.6	3.7
Kemb10	16.3	2.9	18.1	3.3	23.7	6.6	8.8	1.8	9.7	0.5	5.1	2.4
Ex-shimb	17	2.7	20.2	4.4	28.8	3.2	11.1	1.1	13.6	1.1	7.8	0.9
SPK004	17.5	2	19.9	4.1	14.4	3.6	3.1	2.3	8.1	1.7	0.7	2.5
Jonathan	25.9	4.5	21.1	5.9	25.1	7.1	10.0	4.4	11.8	1.0	8.3	2.3
Mean	10.8	2.6	14.8	4.1	13	4.7	4.2	2.6	4.5	2.2	3.0	4.1
LSD	5.5	1.8	5.9	2.2	5.3	2.7	2.2	2.1	3.7	1.0	2.1	2.8
CV (%)	25.0	16.0	14.2	19.3	13.7	2.1	14	9.1	6.7	24.3	24	26.0

Key: LKR-Lukore; MTW-Mtwapa; MWLV-Mwaluvanga; MKT-Marketable tubers; NON MKT-Non-marketable tube.

Table 6. Marketable and non-marketable tuber counts among three sites during the Long and Short rain seasons in 2006/2007.

	Marketable tubers/ 6 M2						Non-marketable tubers/ 6 M2					
Variety	**Lukore**		**Mtwapa**		**Mwaluvanga**		**Lukore**		**Mtwapa**		**Mwaluvanga**	
	LR	**SR**	**LR**	**SR**	**LR**	**SR**	**LR**	**SR**	**LR**	**SR**	**LR**	**SR**
440015	15	5	16	7	29	6	37	15	68	15	51	8
Bungoma	36	11	39	3	36	4	23	15	44	19	48	7
Ejumula	17	8.3	19	4	50	7	30	12	37	24	60	6
Ex-shimba	40	31	35	17	52	10	22	10	32	6	40	3
Japonese	28	22	28	13	24	8	22	5	25	6	71	4
Jewel	36	9	32	7	47	6	79	24	52	30	133	13
Jonathan	60	33	42	16	77	13	64	11	58	10	105	4
Jubilee	14	9	22	3	47	3	27	14	56	18	66	7
K135	29	6	20	4	20	3	22	17	21	23	73	5
Kemb10	43	29	29	14	64	12	30	8	32	6	87	3
Marooko	17	5	21	3	29	7	19	14	20	14	30	8
Mugande	18	12	40	5	14	10	13	6	42	16	5	18
Muibai	11	9	29	3	24	3	20	15	19	15	19	5
Salyboro	40	9	47	4	41	3	28	11	57	19	58	4
SPK004	47	16	28	4	34	7	27	10	30	18	45	3
Sponge	44	8	28	4	39	5	37	16	52	19	110	5
Zapallo	32	22	28	13	25	7	35	9	21	4	71	2
Mean	31	14	30	7	38	7	31	12	39	15	64	6
LSD	13.1	12.8	14.2	9.4	15.3	6.1	10.7	8.3	20.4	9.2	25.8	5.2
CV (%)	12.2	10.5	18.2	20.2	16.4	14.6	16.0	20.8	17.3	16.9	21.2	12.4

Key: LR-long rain season (May-September 2006); SR-short rain season (October-February 2000)

Averaged over the two seasons, varieties Jonathan, Sponge, Muibai, Mugande and Ex-shimba had the highest vine yield whereas Zapallo, Kemb10 and Japonese had the least (Table 2). Varieties 44015, Salyboro, SPK004, K135 and Ejumula showed vine yield variability among sites whereby yields were comparable in Mtwapa and Mwaluvanga but very different in Lukore.

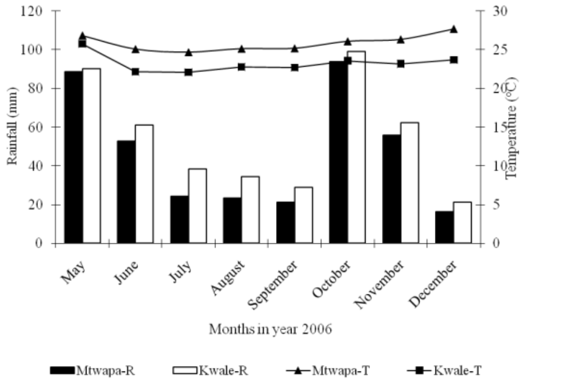

Fig. 1. Total monthly rainfall and mean monthly temperature Rainfall. Mtwapa-R and Kwale-R- Mean rainfall (mm) in Mtwapa and Kwale in Long and Short rain seasons respectively; Mtwapa-T and Kwale-T- mean daily temperature (oC) in Mtwapa and Kwale respectively.

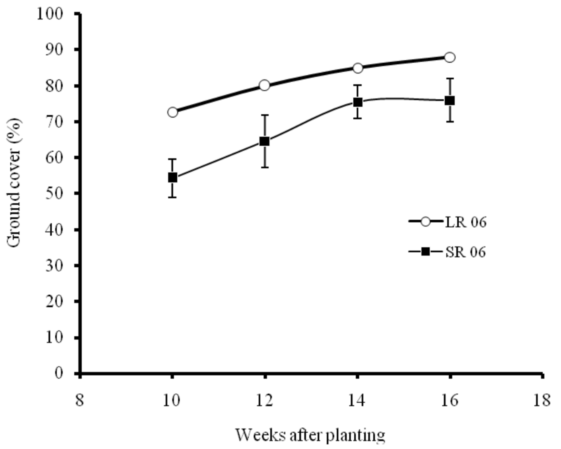

Fig. 2. Seasonal variation of sweetpotato ground cover (%) averaged in 3 sites (standard error difference bars inserted).

Tuber yield

Tuber yield varied significantly (P<0.01) between seasons and among sites and varieties. Averaged among varieties and seasons, tuber yield was highest in Mtwapa and lowest in Lukore (Fig 4). Mwaluvanga and Mtwapa had the highest root tuber yield (>18 tonnes/ha) and Lukore had the lowest yield (13 tonnes/ha) in long rains (Table 3). During the short rains yield did not differ significantly (P≤0.05) in Lukore, Mwaluvanga and Mtwapa with yield of 5, 6 and 7 tonnes/ha respectively (Table 3). The difference in yield between long rain and short rain seasons in Lukore, Mwaluvanga and Mtwapa was 1.9, 2.9 and 3.9 times respectively. Marketable yield (%) also varied within sites and the difference between the long and short rain season in Lukore, Mwaluvanga and Mtwapa was 19 %, 29 % and 12 % respectively (Table 3). Tuber yield was 2.6 times higher in long rain season compared to short rain season (Table 3). Marketable yield (%) and harvest index were comparable in both seasons.

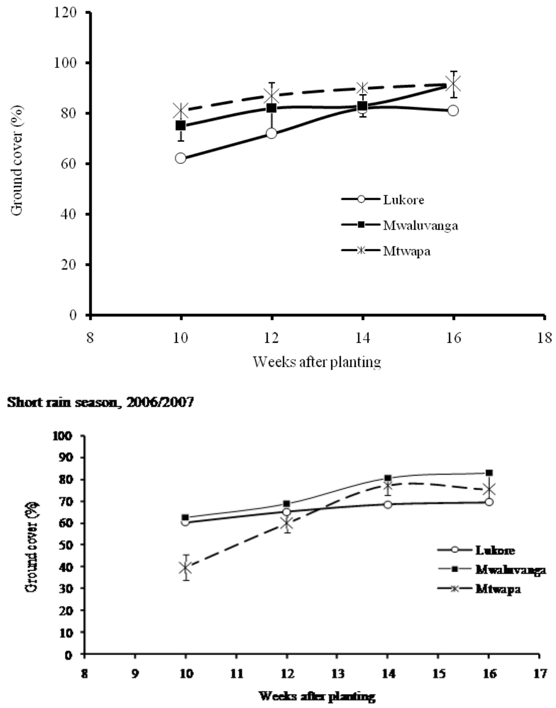

Fig. 3. Ground cover (%) variation in three sites during the Long and Short rain seasons (standard error difference bars inserted).

The significant difference in yield between seasons among sites can be attributed to differences in climatic conditions (rainfall and temperature) (Fig. 1) and sweetpotato virus disease pressure as well (Fig 5). The sweetpotato virus disease was present in the three sites and the incidence varied significantly between seasons and among sites and varieties. Averaged across sites disease incidence was slightly higher in the short rain season than in the long rain season (Fig. 5).

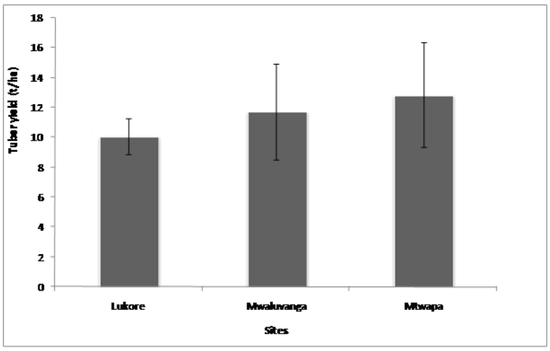

Fig. 4. Mean tuber yield in three sites averaged in two seasons.

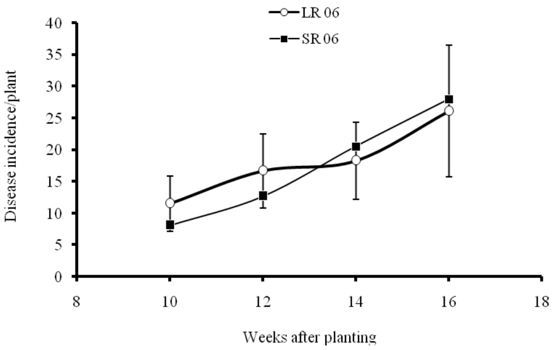

Fig. 5. Season effects on disease incidence among varieties and sites (standard error difference bars inserted). Key:LR 06-Long rain season (May 2006-September 2006); SR 06-Short rain season (October 2006-February 2007)

Averaged across sites and seasons there was a 3.5 fold difference between the highest and lowest yielding variety. Jonathan and 440015 had the highest (21.7 t/ha) and lowest (6.2 t/ha) yield respectively. Japonese, Zapallo, SPK004, Kemb10 and Jonathan had high yields whereas 440015, K135, Ejumula and Muibai had the lowest in comparison to the local check (Ex-shimba). The variety and season x site effects were comparable i.e. 3.4 fold differences between the highest and low yielding variety (Table 4). However, K135 had the lowest yield whereas there was no variation in the ranking of the high yielding varieties (Table 3). Varieties which had low SPVD incidence gave the highest yield across the three sites (Jonathan, Zapallo, Japonese, Ex-shimba) whereas those with high incidence had lower yields (Jewel, 440015). Variety Jewel, which was the most susceptible, had the highest number of unmarketable roots. Similarly variety 440015, which had high incidence, also had low yield (Table 4). The reduction in yield can be attributed to high disease pressure and variety genetic factors.

As expected there was a negative relationship between disease incidence and tuber yield and variation in incidence explained 35% variation in yield (Fig 6). Other factors such as soil fertility, rainfall distribution and temperature probably cater for the other percentage of variation leading to variation in tuber yield.

Varieties Jewel and 440015 had the highest disease incidence and were among those with low yields. The results also corroborate previous reports that the SPVD cause a significant loss in marketable tuber yield in susceptible varieties (Gibson *et al.*, 1998; Njeru *et al.*, 2004). Variety Mugande had high disease incidence and tuber yield hence need for further work on this variety to establish the mechanism of tolerance.

However, some of the moderately susceptible varieties (Ex-shimba, Kemb 10, SPK004) had high yields. The results of this study are consistent with those of earlier studies that indicated that some susceptible sweetpotato varieties are often high yielding than the resistant ones (Aritua *et al.*, 1998; Gibson *et al.*, 2000). This gives a satisfactorily explanation why farmers continue to grow and rank highly their local and popular susceptible varieties in areas where the sweetpotato virus disease is prevalent (Aritua *et al.*, 1998; Gibson *et al.*, 2000). The results also corroborate previous reports that the SPVD cause a significant loss in marketable tuber yield (Gibson et al., 1998, Njeru *et al.*, 2004) in susceptible varieties. This gives clear objective for any breeding programmes to follow that observed variety based tolerance to SPVD can be used as a basis of improvement of the high yielding but susceptible farmer landraces in the region. Out scaling of the tolerant varieties can reduce impact of SPVD in the farmers' fields thus improving yield.

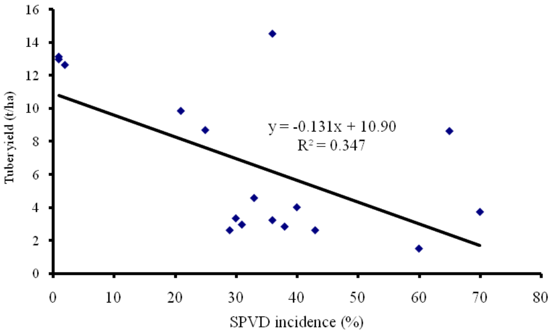

Fig. 6. Effect of SPVD incidence on sweetpotato tuber yield.

Marketable and non-marketable tuber yield

The marketable yield varied significantly among varieties, sites and between seasons. It was highest in the long rain season and reduced by more than 50 % in the short rain season (Table 5). Mtwapa had the highest in the long rain season and Lukore the lowest. There was no significant ($P<0.01$) difference in marketable yield among sites in the short rain season.

Varieties Jewel, Marooko, Japonese and K135 had high yield of non-marketable tubers in the long rain season (Table 5). In the short rain season there was variation on the yield of non-marketable tubers among varieties. This can be attributed to impairment in photosynthetic rate and assimilate partitioning due to lack of adequate water in all the varieties. Tuber yield reduction has been reported in water stressed potato crop (Kawakami *et al*., 2006).

The marketable and non-marketable tuber numbers varied significantly among varieties and between seasons. They were both high in the long rain season and few in the short rain season (Table 6). Mwaluvanga had the highest marketable tuber numbers in the long rain season while they were comparable in Lukore and Mtwapa (Table 6). In the short rain season the marketable tubers were comparable in the three sites. The short rain season was characterised by a dry spell (Fig. 1) and the highly susceptible varieties (Jewel, 440015) were greatly infected and had the least percentage of marketable tubers. The highly disease tolerant varieties (Jonathan, Zapallo, Japonese) had high percentage of the marketable tubers and similarly were the moderately susceptible varieties (Ex-shimba, Kemb10, SPK004).

However varieties Zapallo and Japonese had slightly lower percentage of marketable tubers in the long rain season but on average they had high yield (t/ha). Low numbers in Japonese and Zapallo can be attributed to less ground cover over time site (Brown, 1991; Kuo and Chem, 1991). Averaged across sites and seasons variety Jonathan had highest ground cover (%) and the number of marketable and non-marketable tuber were comparable, but on average marketable yield (t/ha) was higher. Although variety Mugande had high SPVD incidence it maintained high percent of marketable tubers hence it is clear that it posses a unique aspect of varietal tolerance. It is probable that the virus infection does not have effect on photosynthetic efficiency and photo-assimilate translocation within the crop. Varieties K135 and Jubilee had high vine mass and the low number of tubers can be attributed to either more diversion of carbohydrates to vegetative growth (Anon, 1991) or starch accumulation on leaves (source site) which lead to reduction on photosynthetic rate (Tsubone *et al*., 1997).

The variation in yield among varieties can be attributed to climatic factors (rainfall and temperatue), sweetpotato virus disease pressure and or genetic make up of the crop. Adverse environmental conditions (inadequate rainfall amounts, high SPVD incidence) impair photosynthetic rate and efficient assimilate partitioning (Roitsch *et al*., 2003) and this translates to low harvest index, which is an indicator of assimilate partitioning and translocation. Sweetpotato harvest index has been reported to be low in SPVD infected plants (Njeru *et al*., 2004).

Conclusions

Some varieties which had farmer desirable traits like high yield and high dry matter coupled with high groundcover and vine mass were identified and these can be used as dual purpose crops. This would maintain sustainable sweetpotato production and boost the importance of sweetpotato in enhancing food security. Rainfall and temperature played an important role in disease expression and yield among varieties hence these are key climatic factors in variety selection process to establish those resistant to SPVD and stable in terms of tuber yield among environments.

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