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REACTION OF SWEETPOTATO LANDRACES TO SWEETPOTATO VIRUS DISEASE IN UGANDA

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ABSTRACT

Sweetpotato is an important root crop in Uganda after cassava. It is mainly grown as a food staple and source of cash income by the majority of the rural communities. However, sweetpotato production is constrained by a number of factors especially sweetpotato virus disease. Sweetpotato virus disease caused by dual infection of sweetpotato feathery mottle virus (SPFMV) and sweetpotato chlorotic stunt virus (SPCSV) occurs throughout the major sweetpotato growing areas of Uganda. Ten sweetpotato landraces collected from areas of low (4) and high (6) sweetpotato virus disease (SPVD) incidences were evaluated for resistance to SPVD for three seasons at Namulonge in central Uganda. In general, the landraces from low incidence areas recorded the highest incidences of SPVD compared to those from the high SPVD infection areas. The highest SPVD incidences of 91.5, and 46% were recorded at harvest on Araka and Ombivu, respectively. Similarly, genotypes with higher incidences recorded the highest AUDPC. These results suggest that sweetpotato landraces from low SPVD incidence areas are not necessarily resistant but should be evaluated at disease "hotspots" areas to confirm their resistance and yield potential.

Key Words: Disease resistance, hotspots, infection areas, *Ipomoea batatas*, SPVD

RÉSUMÉ

La patate douce est une importante plante en Ouganda après le manioc. Elle est plantée comme aliment de base et une source de revenue pour la grande majorité des communautés rurales. Cependant, la production de patate douce est contrainte par un certain nombre de facteurs notamment par le virus de la patate douce. Le virus de la patate douce est provoqué par une double infection du virus motte et du virus chlorotique causant le rabougrissement et ceux-ci sont fréquents dans les aires de cultures de patate douce en Ouganda. Dix variétés locales de la patate douce rassemblées à des endroits à faible (4) et forte (6) incidence étaient évaluées pour la résistance au SPVD pour trois saisons à la station de Namulonge au centre de l'Ouganda. En général, les variétés locales des zones à faible incidence de SPVD ont enregistré une haute incidence de SPVD comparées à celles des zones de hautes infections. La forte incidence de SPVD de 91.5 et 46% étaient enregistrée à la récolte à Araka et Ombivu. De façon similaire, les génotypes avec une forte incidence ont enregistré un haut AUDPC. Ces résultats suggèrent que les variétés locales de la patate douce ne sont pas nécessairement résistantes plus que les variétés de la zone à faible incidence de SPVD mais devront être évaluées dans la zone à faible incidence pour confirmer leur résistance et leur rendement potentiel.

Mots Clés: La résistance de la maladie, zones à haute incidence, régions d'infection, *Ipomea batatas*, SPVD

INTRODUCTION

Globally, sweetpotato virus disease (SPVD), caused by dual infection of *sweetpotato feathery mottle virus* (SPFMV) and *sweetpotato chlorotic virus* (SPSCV), is the most important biological constraint to sweetpotato (*Ipomoea batatas* L. (Lam) production in Africa (Geddes, 1990). Although, several control strategies have been suggested against SPVD, host plant resistance remains the most economical and cheapest way of controlling SPVD as for most other plant diseases (Hahn *et al.*, 1981; Buddenhagen, 1992; Parlevliet, 1994). Nevertheless, although demand for sweetpotato varieties resistant to SPVD has long been recognised in eastern and central Africa (Aldrich, 1963), to date few such varieties have been released (Mwanga *et al.*, 1995; 2001) and their dissemination is limited. Consequently, the majority of farmers still grow local landraces because of their taste, adaptability and tolerance to a number of abiotic stresses. But often, these landraces have low yields and are late-maturing (Aritua *et al.*, 1998a,b). However, several sweetpotato landraces occur in the region and differ in resistance to SPVD (Aritua *et al.*, 1998a; Karyeija *et al.*, 1998). For example, Mwanga and Mateeka (1992) reported that the cultivars *Tanzania* and *New Kawogo* supported moderate and low levels of SPVD incidences, respectively.

For most crop species, high-yielding genotypes with good resistance to pests and diseases can be identified by evaluating both existing local landraces and introductions both on-station and on-farm (Mcharo *et al.*, 2001). Hahn *et al.* (1989) suggested that the first step in breeding root and tuber crops that are resistant to pests and diseases is to identify the factors determining the incidence of such diseases and pests. For SPVD, emphasis in developing resistance to SPVD has been to develop resistance to SPFMV, the most widespread of all the swetpotato viruses. However, the existence of different strains of SPFMV makes breeding for resistance to SPVD in this way very difficult. Nevertheless, Hahn *et al.* (1981; 1989) observed that the high heritability of resistance to SPVD enables an early identification of resistant and susceptible genotypes. Similarly, Mwanga *et al.* (2000), reported that the high selection rate in the early cycles of selection increased the efficiency of advancing genotypes with SPVD resistance. Recently, Aritua *et al.* (1998b) reported low incidences of SPVD in some districts of Uganda especially Busia and Soroti, and higher incidences in others, e.g. Mpigi and Rukungiri. It is however, unclear whether the low incidences were associated with resistance to SPVD and whether this might explain the cultivation of such cultivars in those regions. We hypothesize that cultivars prevalent in the low infection areas are resistant and would maintain low SPVD incidences even in high SPVD pressure zones and outyield susceptible cultivars grown in high-pressure zones.

The objective of this study therefore was to assess the reaction of sweetpotato landraces collected from differing SPVD infection areas when grown to SPVD "hotspot" areas of Uganda.

MATERIALS AND METHODS

The experiment was conducted at Namulonge Agricultural and Animal Research Institute (NAARI) in central Uganda during the first (March-July) and second season (September-December) growing seasons of 2001 and repeated during (March-July) of 2002. These seasons are subsequently referred to as 2001A, 2001B and 2002A, respectively. Namulonge (0^{0}32'N, 32^{0}35' E; 1150 metres above sea level) lies in the warm, moist tall grasslands agro-ecological zone and it is considered a "hotspot" area for SPVD where resistant genotypes can be naturally selected in the field without artificial inoculation (Mwanga *et al.*, 2000). The experimental design was the randomised complete block design (RCBD), with three replications.

Ten sweetpotato landraces (Table 1) were collected from different areas of Uganda, namely low infection zones (Arua, Lira, Kumi and Busia) and high infection zones (Wakiso, Kasese, Kabarole and Rukungiri) basing on the results of earlier studies (Bashaasha *et al.*, 1995; Aritua *et al.*, 1998a, b). All these landraces represented the most commonly grown genotypes in each district.

Land used for the experiments was previously under yams (*Dioscorea* spp.), fallow and cotton for 2001A, 2001B and 2002 seasons, respectively. Vines of each landrace (20 to 30 cm long) were planted in plots of 3 m x 10 m and 3 m x 6 m for the 2001 and 2002 seasons, respectively. In all cases, the vines were spaced at 1 m x 0.5 m following the procedure of Ngeve and Boukamp (1991). To increase inoculum pressure, infector rows consisting of a mixture of two diseased plants of cultivars (Tanzania and Naspot 5) were planted along the borders of each plot. New Kawogo was included as a resistant check in each trial. Each season, plants were hand-weeded two to three times depending on the weed intensities. Neither fertiliser nor pesticides were applied.

For each trial, data were collected monthly from one to five month after planting (MAP). For each season, SPVD incidence and severity were rated on all plants in a plot. Disease severity was based on a visual estimation of diseased plants as manifested by the different symptoms on a scale of 1-5 where 1=no symptoms and 5=> 75 % of the leaf infected (Hahn *et al.*, 1981). Disease incidence data for each season were used to compute areas under disease progress curves (AUDPC) (Campbell and Madden, 1990).

Harvesting was done 5 MAP and records were taken on fresh tops weights per 10 plants, weight and number of tubers per plant, non-marketable (<100 g), marketable yield (>100 g), total yield (t ha^{-1}), and harvest index (HI). Harvest index (HI) was calculated as the ratio of the total tuber weight to total biomass (Otoo *et al.*, 2001) . Yield data were obtained by harvesting all the plants in the middle row of each plot and the data extrapolated to estimate total yield per hectare. The fresh tops and tubers of two plants per plot were oven-dried at 60^{0}C for 72 hours to obtain the dry shoots and tubers weights, respectively.

The reaction and yield of the landraces were analysed separately using the analysis of variance (ANOVA) of Genstat 5 release 3.22 Statistical Package. Where ANOVA indicated significant differences, Fisher Least Significant Difference was used to separate the variety means at 5% probability level. Relationships among variables were assessed using regression analysis (Steele *et al.*, 1997).

RESULTS

Significant differences (P<0.05) in marketable and non-marketable yields and in HI occurred only during 2002A season. Similarly, varietal effects significantly (P<0.05) influenced fresh shoot weights, non-marketable and marketable yields and AUDPC. In addition, season by variety interactions significantly (P<0.05) affected AUDPC, fresh shoot weights and marketable yields (Table 2).

In the three trials, there were progressive increases in the incidences of SPVD over time. In trials 2001 A and 2001 B, highest SPVD incidence of 37.6 and 29.1% at 1 MAP were recorded in landraces Araka and Kalyamoi, and the lowest (0%) in Kachindo and New Kawogo. During the subsequent months, there were significant increases in the incidences of SPVD among the sweetpotato landraces to maxima at final observation 5 MAP although most of the landraces recorded low to moderate SPVD infection. In trials of 2001A and 2002A, the highest SPVD incidences of 91.5 and 86.8% were recorded in Araka and lowest incidences of 1.1 and 2.7% were recorded in New Kawogo. In contrast, during the trial of 2001B, the highest and the lowest SPVD incidence of 46 and 0.8% at 5 MAP were

TABLE 1. Origin, SPVD status, skin and flesh colour of sweetpotato landraces grown at Namulonge, 2001/2002

Entry	Origin	SPVD status	Skin colour	Flesh colour
Kalyamoi	Busia	Low	Purple	White
Araka	Kumi	Low	Cream	White
Liralira	Lira	Low	Purple	White
Ombivu	Arua	Low	Cream	White
Kachindo	Kabarole	High	Purple	White
Mugurusi	Rukungiri	High	Purple	Yellow
Sinia	Kasese	High	Purple	White
Silk	Wakiso	High	Purple	White
Dimbuka	Wakiso	High	Cream	White
New Kawogo	NAARI	High	Purple	White

TABLE 2. Incidences and areas under disease progress curves (AUDPC) of SPVD on 10 sweetpotato landraces grown at Namulonge for three seasons

Entry and season	[a]1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	[b]AUDPC
Trial 2001A						
Kalyamoi	14.6	18.9	22.3	30.4	57.3	27.0
Liralira	0.6	10.5	16.8	26.3	32.8	17.7
Araka	37.6	51.5	56.8	73.8	91.5	61.9
Ombivu	0.6	14.9	31.4	47.2	69.1	32.4
Kachindo	0.0	5.3	16.5	27.2	31.8	16.4
Mugurusi	4.2	7.2	12.6	16.7	25.5	12.9
Sinia	3.4	4.9	13.6	22.5	31.3	14.7
Silk	1.3	6.6	11.1	19.3	28.5	13.1
Dimbuka	8.0	16.1	20.1	20.3	31.5	19.2
New Kawogo	0.0	0.0	1.1	1.1	1.1	0.8
Mean	7.0	13.6	20.1	28.5	40.1	21.6
LSD (5%)	10.9	13.6	12.3	13.6	18.7	9.7
Trial 2001B						
Kalyamoi	29.1	32.1	35.2	39.9	39.9	52.4
Liralira	9.7	19.1	23.1	25.8	29.9	31.6
Araka	9.1	20.1	29.0	33.0	40.2	38.1
Ombivu	20.0	32.5	38.5	41.6	46.0	53.0
Kachindo	12.6	16.1	22.5	22.5	21.8	28.8
Mugurusi	13.6	12.8	13.3	14.0	19.7	20.9
Sinia	6.1	6.1	12.3	14.1	20.2	16.3
Silk	2.5	3.1	8.5	11.0	20.1	11.6
Dimbuka	3.3	6.4	11.2	14.0	18.6	15.0
New Kawogo	0.0	0.0	1.8	2.2	2.3	1.8
Mean	10.6	14.8	19.5	21.8	25.8	26.9
LSD (5%)	17.1	19.4	13.4	9.6	10.8	20.1
Trial 2002A						
Kalyamoi	14.6	29.9	34.7	40.3	48.6	34.1
Liralira	22.9	27.1	33.4	40.3	72.9	37.1
Araka	23.6	32.5	37.5	50.7	86.8	43.8
Ombivu	22.9	36.1	45.8	52.1	78.5	46.1
Kachindo	11.1	11.8	14.6	20.8	32.6	17.1
Mugurusi	4.6	7.0	11.8	20.1	27.8	13.7
Sinia	9.4	16.0	19.8	26.4	42.0	21.9
Silk	5.6	13.9	17.4	20.8	30.0	17.4
Dimbuka	5.4	9.7	11.8	14.6	28.5	13.2
New Kawogo	1.0	1.4	2.2	2.4	2.7	1.9
Mean	12.1	18.8	23.5	29.3	46.0	27.9
LSD (5%)	12.0	16.9	15.1	13.6	12.0	11.9

[a] Incidences recorded 1-5 month after planting
[b] Area under disease progress curve (AUDPC) computed from disease incidences recorded 1,2,3,4 and 5 months after planting

recorded on Ombivu and New Kawogo, respectively (Table 2).

The highest and lowest marketable yields during the two 2001 trials were obtained from New Kawogo and Kalyamoi, respectively (Table 3). In the 2002 a trial, the highest and the lowest marketable yield were obtained from Dimbuka and Ombivu, respectively. Overall, the results of the combined season analysis showed that higher fresh vine weights, non-marketable, marketable and total tuber yields were recorded in trial 2001 A compared to the two other trials (Table 4).

TABLE 3. Marketable, non-marketable, fresh and dry foliage weight; total tuber yield and harvest index of ten sweetpotato landraces grown at Namulonge in each of the three trials

Entry and season	Marketable yield/plant (g)	Non marketable yield/plant (g)	Fresh foliage weight/plant (g)	Dry foliage weight (g)	Total tuber yield (t ha^{-1})	Harvest index (HI)
Trials 2001A						
Kalyamoi	253	267	700	90	10.9	0.42
Liralira	807	127	853	178	18.7	0.52
Araka	533	110	527	102	12.9	0.55
Ombivu	527	100	933	111	12.5	0.39
Kachindo	660	100	1127	356	15.2	0.43
Mugurusi	793	227	907	187	20.4	0.53
Sinia	640	127	1067	166	15.3	0.42
Silk	507	143	1207	220	13.7	0.44
Dimbuka	800	253	1160	284	24.8	0.49
New Kawogo	980	227	1020	297	20.3	0.52
Mean	650	168	950	199	16.5	0.47
LSD (5%)	343	143	468	141	8.4	0.21
Trial 2001B						
Kalyamoi	360	190	573	88	10.9	0.48
Liralira	440	230	577	153	13.5	0.54
Araka	430	220	453	99	13.0	0.57
Ombivu	340	150	687	122	9.9	0.39
Kachindo	480	200	600	161	13.9	0.52
Mugurusi	740	190	600	147	18.6	0.60
Sinia	740	260	487	68	20.1	0.66
Silk	450	290	527	129	14.9	0.58
Dimbuka	420	320	400	94	14.7	0.65
New Kawogo	560	140	987	280	14.1	0.41
Mean	340	220	589	134	14.4	0.54
LSD (5%)	350	220	310	140	8.6	0.18
Trial 2002A						
Kalyamoi	270	333	460	177	4.0	0.42
Liralira	770	800	1970	123	4.4	0.47
Araka	1700	1000	260	91	5.3	0.93
Ombivu	100	333	150	46	1.7	0.17
Kachindo	1230	533	289	104	5.6	0.51
Mugurusi	1470	767	420	136	4.7	0.77
Sinia	1870	600	1030	131	6.3	0.69
Silk	270	167	930	179	10.3	0.24
Dimbuka	3930	2300	390	98	6.8	0.92
New Kawogo	830	100	300	148	3.3	0.35
Mean	1440	764	840	123	5.8	0.62
LSD (5%)	1421	900	200	113	6.9	0.36

In the trial of 2001A, the highest and lowest total yields were recorded from Dimbuka and Kalyamoi, respectively. In contrast, the highest and lowest total yields in trial 2001B were obtained from Sinia and Ombivu, respectively. In 2002A, the highest and lowest total yields were recorded from Silk and Ombivu, respectively. In general, it was apparent that the best yielding genotypes were from the high SPVD infection areas compared to those from low SPVD infection areas except one landrace (Liralira) which performed relatively better than all the entries from low infection areas and even better than three of the entries from the high infection areas. Notably, in trial 2001A, there were no significant differences in yield amongst the entries from both the low and high SPVD incidence areas although the highest total yield was from Sinia originating from SPVD high infection areas. In the 2002A trial, total tuber yields were generally low (Table 3).

The HIs were not significantly different ($P>0.05$) except in trial 2002 A. The highest and lowest harvest indices in 2001A and 2002A was recorded from Araka and Ombivu, respectively. In contrast, in trial 2001B, the highest HI was recorded from Sinia although this did not differ significantly from Mugurusi and Dimbuka. However, the lowest HI was recorded from Ombivu but this also did not differ significantly from New Kawogo. In general, higher HIs were recorded in 2002A compared to the two trials of 2001. Comparatively, most of the entries from high SPVD infection areas recorded higher fresh shoots weights than those from low infection areas (Table 3). Significant correlations were observed between yield and SPVD incidences ($P=0.001$, $r=-0.781$) and AUDPC ($P=0.01$, $r=-0.670$) in trial 2001A. Similarly, during 2002A, a significant correlation occurred between AUDPC and marketable yield ($P=0.001$, $r=0.49$).

DISCUSSION

Sweetpotato landraces from low SPVD infection areas succumbed more easily to SPVD infection than those from high SPVD infection areas. This corroborates with earlier findings by Aritua *et al.* (1998a, b) who reported that the incidences of SPVD depended on the type and source (origin) of the cultivars as well as the relative abundance of the insect vectors responsible for the transmission of the component viruses. In addition, Byamukama *et al.* (2002) reported that the susceptibility of sweetpotato genotypes to SPVD largely depends on the genotypes and asserted that exotic genotypes were inherently more susceptible to SPVD than the indigenous genotypes irrespective of whether the disease pressure was low or high. Similarly, results of previous studies in Uganda showed that landraces are relatively resistant to SPVD compared to new introductions (Mwanga *et al.*, 1995; 2001; 2002).

According to Mcharo *et al.* (2001), sweetpotato landraces with high yield and good resistance to pests and diseases can be identified by evaluating both existing local landraces and introductions. The implication of this result is that the selection of SPVD resistant varieties must be done in "hotspots areas". Thus, sweetpotato landraces from low SPVD infection areas must be evaluated in SPVD "hotspots" to determine if they can be

TABLE 4. Fresh vine weights, non-marketable, marketable, total tuber yield and AUDPC of SPVD on sweetpotato landraces grown at Namulonge in each of the three trials

Season	Fresh vine weight/plant (g)	Non marketable yield/plant (kg)	Marketable yield/ plant (kg)	Total tuber yield (t ha^{-1})	AUDPC*
2001A	950	2.88	1.61	16.47	21.47
2001B	572	0.22	0.49	14.35	18.60
2002A	597.	0.67	1.35	5.59	29.54
Mean	707	1.26	1.15	12.14	23.20
LSD (5%)	112	0.64	0.38	2.45	3.79

*AUDPC=Area under disease progress curve deployed effectively in other areas. In addition, these landraces must be evaluated for a number of seasons and locations under high disease pressure to avoid the phenomenon of apparent resistance due to "escapes" and break down in resistance (Mwanga *et al.*, 1991; Turyamureba *et al.*, 1997). The results of this study suggest that landraces from high SPVD infection areas are more likely to provide better sources of resistance to SPVD than those from low infection areas. Thus, Kanua and Floyd (1988) recommended that varieties must be selected in response to major production constraint of sweetpotato in the area, in this case SPVD.

Although there was SPVD spread early during the two trials of 2001, there was generally low disease spread among the landraces from the high SPVD infection. The low disease incidence or spread would signify field resistance and thus genotypes which exhibited low disease spread could further be improved for enhanced resistance to SPVD (Mwanga *et al.*, 2000; 2002). Although, it has long been recognised that the efficacy of virus-resistance in limiting virus spread in the field is rare there are reports which indicates that the incidence of virus is less in virus-resistant sweetpotato cultivars (Gibson *et al.*, 1997; Aritua *et al.*, 1998a; Alicai *et al.*, 1999; Mwanga *et al.*, 2000; 2001). Furthermore, although farmers or breeders have long selected SPVD-resistant cultivars, there are several releases and as a result of this, several factors may favour the selection of resistant cultivars. For example, many farmers often grow many mixtures of sweetpotato genotype, which may allow direct competition and selection among cultivars. Farmers also select asymptomatic plants and therefore relatively virus-resistant genotypes from which to obtain cuttings (Karyeija *et al.*, 1998). These practices may have helped to contain SPVD at low epidemic levels in the eastern Africa region.

Earlier observations by Aritua *et al.* (1998a, b) indicated that sweetpotato landraces resistant to SPVD tend to be low yielding, and late maturing. In this study however, resistant sweetpotato landraces performed relatively better than the early-maturing but susceptible genotypes when harvested at 5 MAP. The generally low tuber yields in trial 2002A was attributed to the combined effects of prolonged drought and high SPVD incidences in the experiment. According to Aldrich (1963), Robert and Andrew (1989), and Wolfe (1992), sweetpotato tuber yields depend on the amount of rainfall during the growing period. Recently, Schulties *et al.* (1999) asserted that the yield of sweetpotato is dependent on a number of biotic and abiotic factors. According to Geddes (1990), biotic factors especially pests are the most important production constraints of sweetpotato in Africa. Similarly, Hahn (1979) attributed reduced root yield of sweetpotato to decrease in size of the photosynthetic organs resulting from severe stunting and other symptoms of SPVD. In addition, Hahn *et al.* (1981) indicated that the physiology of resistant genotypes was less affected even though the virus may distort the leaves. Nonetheless, the low total tuber yields recorded from landraces such as Kalyamoi could be attributed to high non-marketable tuber yields resulting perhaps from poor assimilate partitioning between the foliage and roots. Thus, it can be concluded that SPVD significantly reduce total tuber yields by increasing the proportion of non-marketable tubers. In general, the yields obtained were very comparable to those reported in most of the previous trials (Hakiza *et al.*, 2000). These yields would provide the basis for further improvement for resistance to SPVD and emphasises the need for long-term screening of local varieties for SPVD resistance.

Similarly, although entries from low SPVD infection areas had higher SPVD and moderate yield, it is notable that their yields over the three trials were relatively stable compared to those from high SPVD incidence areas. Thus, it is recommended that some of these materials be advanced for further improvement before release to the farming communities. Unfortunately, none of the sweetplotato landraces evaluated was immune to SPVD indicating that although use of resistant varieties is the most economical and cost-effective means of controlling SPVD and other diseases, immunity is not available as a means of crop improvement (Buddenhagen, 1992; Parleviet, 1994).

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