

Full Length Research Paper

Effects of leaf harvest and season on the fruit yield of summer squash genotypes in Madagascar

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Summer squash (*Cucurbita pepo* L.) is one of the most popular vegetables in Madagascar, where it is grown for both leaves and fruit. Previous breeding efforts concentrated solely on high fruit yield. In recent years the demand for varieties that can produce edible fresh leaves and high fruits yield has increased. Our objective in this study was to evaluate the effects of leaf harvest and season on fruit yields of summer squash genotypes in Madagascar to identify dual-purpose varieties for the hot-dry and rainy seasons. Two leaf harvest regimes ('no leaf harvest' and 'leaf harvest'), five entries (four summer squash inbred lines S16, S17, S18 and S19, and one local variety 'Vang') and two seasons (hot-dry and rainy) were tested in a randomized complete block design with three replications in Madagascar. The results showed entry effect was significant on yield and fruit length but not on fruit size. Interactions of all the three factors (entry, leaf harvest, and season) were highly significant in all three traits. In the rainy season, significant differences in mean yield occurred between S16 and the local check 'Vang' when leaves were harvested. The percentage in fruit yield reductions between the 'no leaf harvest' and 'leaf harvest' treatments were 45% for S18, and 22% for 'Vang' in the hot-dry season trial, and 15 and 2% reduction in the rainy season for S18 and 'Vang', respectively. S16 gained 3 and 9% in yield when leaves were harvested in the hot-dry and rainy seasons, respectively. Any of the entries will produce good yield in the hot-dry season, while entries S16 and S19 are recommended for high yield in the rainy season for leaf harvests in Madagascar's subhumid tropics.

Key words: Summer squash, Madagascar, leaf harvest, fruit yield.

INTRODUCTION

Traditional leafy vegetables are important source of nutrients and vitamins for the rural African population. Some have medicinal values and are used to treat several ailments in tropical Africa (Mensah et al., 2008).

In southern and western African countries, the leaves of summer squash (*Cucurbita pepo* L.) are consumed as vegetables (Ifon and Bassir, 1979a, b). In Madagascar, the tender leaves of pumpkin and summer squash are eaten in soups and stews and are good source of micronutrients and minerals such as calcium, iron and zinc. Pumpkin fruit is eaten at the mature stage; summer squash mostly refers to squashes whose fruits are harvested at immature stage, before the rinds hardens.

Previous breeding efforts concentrated solely on high fruit yield. In recent years, however, the demand for dual-purpose summer squash and pumpkin varieties that produce high yields of edible fresh leaves and fruits has increased in Madagascar. Breeders in the national agricultural research system and other international projects such as the Vegetable Breeding and Seed System (vBSS) program of AVRDC – The World Vegetable Center in Madagascar are working to develop dual-purpose varieties and provide a steady supply of improved seed. Access to seed of dual-purpose summer squash and pumpkin will help raise the productivity of small-scale farmers, increase their incomes, and enhance the nutritional status of their households and communities.

The objective of this study was to evaluate the effects of leaf harvest and season on edible leaf and fruit yields of summer squash genotypes in Madagascar.

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MATERIALS AND METHODS

Site description

The experiment was conducted at AVRDC's research farm for the Vegetable Breeding and Seed Systems (vBSS) program in the Aloatra Mangoro Region of Madagascar (lat 17° 41' S, long 48° 28' E; alt 755 masl). Annual rainfall is 1160 mm with an annual average temperature of 21 °C. Soils are acidic to neutral ferrasols with low to medium fertility with the following properties: pH = 6.13, C/N = 8.31, % total N = 0.12 and CEC = 15.56 meg/100 g (FOFIFA, 2006).

Plant material

Four summer squash inbred lines, S16, S17, S18 and S19, and one local variety, 'Vang,' were used in the study. The inbred lines were obtained from AVRDC – The World Vegetable Center headquarters in Taiwan. The local variety was purchased from a local seed dealer in Madagascar. Seeds for the five entries were directly sown in plots on 2 October 2008 and 29 January 2009 for the hot-dry and rainy seasons, respectively.

Plot design and trial management

Each plot was a raised bed 2 × 6 m long, with two rows 1 m apart with plants spaced at 40 cm in the row. In each plot, there were 30 plants occupying 12 m² of land. Recommended cultural practices were followed. Irrigation was applied as needed. Fertilizers were applied at the rate of 20 t/ha farm yard manure, 500 kg/ha dolomite, 300 kg/ha of NPK (11:22:16) before planting, and an additional 200 kg/ha of 46% urea in a split application two weeks after planting, and at flowering. Weekly sprays of Cypermethrine (200 ml/ha) and Mancozeb (3 kg/ha) were applied to control insects and fungi.

Experimental design

The experiment used a randomized complete block design with three replications consisting of factorial combinations of two leaf harvest regimes (no leaf harvest, leaf harvest), five entries (S16, S17, S18, S19, and 'Vang') and two seasons (hot-dry and rainy). Treatment combinations were replicated three times in the hot-dry and rainy seasons. In total, 30 plots were tested each season.

Data measurement

Leaf harvest was evaluated three weeks after sowing by harvesting young leaves at weekly intervals until senescence; leaves of control (no leaf harvest) plots were not harvested. The fresh weight of harvested fruit was obtained periodically at each harvest and the total weight calculated at the end of the experiment. Mean fruit size and length were measured from ten fruits selected at random from each plot.

Statistical analysis

Statistical analyses were performed using SAS systems for Microsoft Windows, version 9 (SAS Institute, 2002). Graphs were constructed by means of SigmaPlot for Windows version 10 (Systat Software 2006). Analysis of variance (ANOVA) based on randomized complete block design was used to test factor effects and their interactions. Duncan's multiple range test (DMRT) was performed for the comparison of means (Gomez and Gomez, 1994).

RESULTS AND DISCUSSION

Figure 1 demonstrates the relationship between rainfall and ambient temperature during the study period. Rainfall is unimodal with a single rainy season (December – April). The highest rainfall occurred in January, which also coincided with the highest maximum temperature for the season. Maximum temperature increased steadily until it reached the highest point in January and fell gradually in the subsequent months. The high rainfall recorded in November was quite unusual as records in previous years showed minimal precipitation (FOFIFA, 2006).

Figure 2 shows that mean fruit yield was influenced by season and leaf harvest. Reductions in yield during the dry season from October to November were observed in all entries for leaf harvest compared with the rainy season. During the dry season the highest yield was recorded in 'Vang,' but not in the rainy season, possibly due to high prevalence of diseases such as downy and powdery mildew. In both seasons, S18 gave the best performance in 'no harvest' while S16 out yielded all entries in 'leaf harvest' in the rainy season.

Table 1 shows the results of analysis of variance of yield, fruit length, and fruit size of all tested factors and their interactions. Entry effect was significant on yield and fruit length but not in fruit size. Interactions of all the three factors (entry, leaf harvest, and season) were highly significant in all three traits indicating differences in behavior of entries in seasons and leaf harvest in this study.

Significant difference in fruit length was found between 'Vang' and S18 under 'no harvest' in the hot dry season (Table 2). In the rainy season, significant differences were found between 'Vang' and S19 in both 'leaf harvest' and 'no leaf harvest' plants. Apart from S16 and 'Vang,' fruit sizes in both seasons were smaller in the 'leaf harvest' than the 'no harvest' treatment. Fruit size reduced 70% in 'Vang' in the hot-dry season when leaves were harvested compared with 17% of S19 in the same season. Surprisingly, 'Vang' produced bigger fruits in the rainy season when leaves were harvested compared to no leaf harvest. This might be due to high disease incidence in the rainy season resulting in diseased older leaves in the 'no harvest' compared with several new leaves that emerged in the 'leaf harvest,' which might have photosynthesized more efficiently than older diseased leaves.

Table 2 indicates that significant differences in yield occurred in 'leaf harvest' between S18, 'Vang' and all the other entries in the hot-dry season. However, with 'no harvest,' mean yield was not significant between S18 and 'Vang' in the same season. Similarly, in the rainy season, significant differences in mean yield occurred between S16 and 'Vang' when leaves were harvested, but no significant difference was observed in the same season between them when leaves were not harvested. The percentage in fruit yield reductions between the 'no leaf

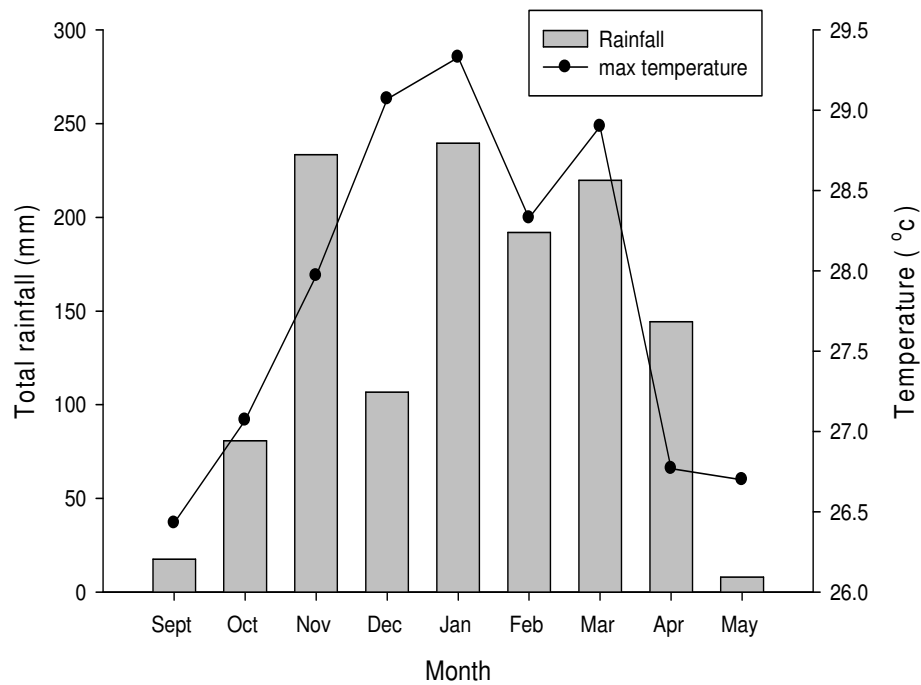


Figure 1. Monthly total rainfall and mean monthly maximum temperature during the period of experimentation (September, 2008 - May, 2009).

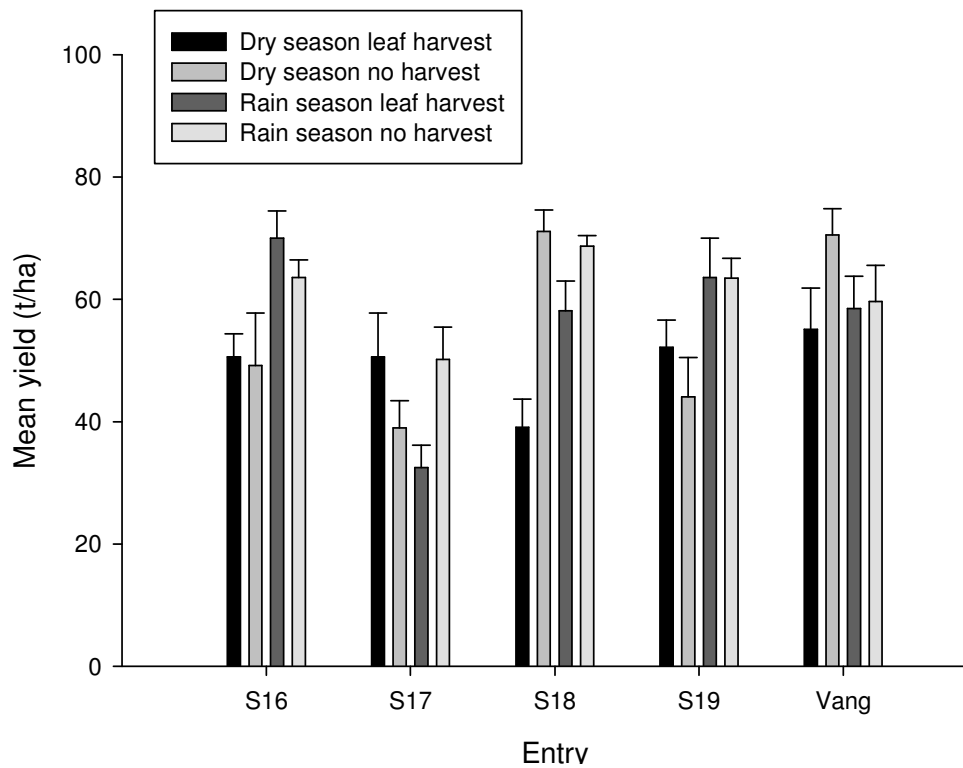


Figure 2. The effects of leaf harvest and season on summer squash in Madagascar.

Table 1. Results of analysis of variance (ANOVA) for effects of entries, leaf harvest, and season on the fruit yield characteristics of summer squash in the subhumid conditions of Madagascar.

Effect	df ¹	Yield (t/ha)	Mean square	
			Fruit length (cm)	Fruit size (kg)
Rep	2	117.40 ns	5.36 ns	0.20 ns
Leaf harvest	4	54.87 ns	0.66 ns	5.02***
Season	1	204.61 ns	679.59 ***	2.26 **
Entry	1	626.35 ***	192.04***	0.50 ns
Leaf harvest x season	4	167.86 ns	32.42 ns	0.06 ns
Leaf harvest x entry	4	665.91 ***	102.79***	0.4 ns
Season x leaf harvest	1	201.14 ns	27.20**	1.12 **
Leaf harvest x season x entry	4	483.79**	70.10***	2.29 ***
Error	38	79.01	6.45	0.23
Total	59			

¹df= degree of freedom ²ns= non significant. *** = p< 0.001, ** p= 0.01, * p=0.05.

Table 2. Interaction effects of entry, season, and leaf harvest on yield and its components of summer squash in the subhumid conditions of Madagascar^a.

Entry	Mean yield (t/ha)				Fruit length (cm)				Fruit size (kg)			
	Hot-dry season		Rainy season		Hot-dry season		Rainy season		Hot-dry season		Rainy season	
	Leaf harvest	No harvest	Leaf harvest	No harvest	Leaf harvest	No harvest	Leaf harvest	No harvest	Leaf harvest	No harvest	Leaf harvest	No harvest
S16	50.58a	49.16b	70.01a	63.56a	17.38b	18.85b	25.43b	27.25c	1.36a	0.97b	1.15b	1.68b
S17	50.57a	38.98c	32.51c	50.14b	17.85b	15.85b	26.01bc	23.61c	0.81b	1.15b	0.99b	1.66b
S18	39.09b	71.06a	58.11b	68.71a	22.46a	19.86b	30.42ac	28.42bc	0.73b	1.21b	1.37ab	2.65a
S19	52.13a	44.04bc	63.55ab	63.44a	26.87a	27.23a	33.01a	32.43b	1.15a	1.38b	1.24b	2.97a
'Vang' (check)	55.09a	70.52a	58.49b	59.65a	26.88a	26.50a	26.22bc	37.59a	0.83b	2.70a	1.75a	0.74c

^a Average of three replications. In each column, means followed by a common letter are not significantly different at 5% level.

harvest' and 'leaf harvest' treatments were 45% for S18, and 22% for 'Vang' in the hot-dry season trial, and 15 and 2% reduction in the rainy season

for S18 and 'Vang,' respectively. When leaves were harvested, S16 gained 3 and 9% in yield in the hot-dry and rainy seasons, respectively. This

corroborates the findings by Asiegbu (1983) that frequent leaf harvest in fluted pumpkin gave more edible yield than no leaf harvest treatment.

S16 and S19 with 70 and 64 t/ha, respectively, of fruit yield in the rainy season for 'leaf harvest' could be recommended for the rainy season, while 'Vang,' S16, S17, and S19 with high but no significant differences in yield when leaves are harvested in the hot-dry season could be recommended for the hot-dry season in Madagascar. Further study is needed to determine if consistently high yields of these recommended entries can be maintained in Madagascar when leaves are harvested in the two seasons.

Conclusion

The results suggest that it is possible to have two plantings per year with summer squash entries 'Vang,' S16, S17, and S19 in the hot-dry season and S16 and S19 in the rainy season in Madagascar to ensure the availability of green leaves and substantial fruit yield for food. This planting regime would be particularly important in the rainy season, when the high prevalence of diseases and pests affects fruit yields of farmers' cultivars.

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