Sugarcane (*Saccharum officinarum*) variety evaluation for quantitative characters (Pure obtainable cane sugar, sucrose content and cane yield)

Anand P. Tyagi[1] and Prem Naidu[2]

ABSTRACT

The purpose of this study was to evaluate the relative performance of fourteen promising newly developed varieties and three commercially grown cultivars (as control) for adaptability and suitability for growing in different climatic conditions in Fiji. All varieties were tested across five locations that represented different soil types and climatic conditions where sugarcane is grown in Fiji to identify varieties that could be widely adapted and provide stable cane and sugar yield when released for cultivation. The presence of genotype x environment interactions complicates selection when the relative ranking of genotypes changes from one location to another particularly for the desired traits such as cane yield (tons cane per hectare - tch) and sugar yield (tons sugar per hectare - tsh). The positive interpretation of varieties x locations interactions implies developing cultivars for their environments rather than modifying the environment to fit new cultivars. Most of the selection work in breeding programs is carried out under uniform and favourable conditions with high inputs and cultivars developed under these conditions are not likely to perform well in all environments. Therefore varieties, based on their interaction with location were identified to be released for specific climatic conditions. The performance of the promising varieties over locations was highly significant (ANOVA) and this was reflected by the change in ranks of pure obtainable cane sugar (pocs), tch and tsh of varieties at different locations.

Key words: genotype x environment interaction, cane yield, sucrose content, analysis of variance and adaptability

INTRODUCTION

Sugarcane is one of the most important agricultural crops planted on both Viti Levu and Vanua Levu of the Fiji Islands. Sugarcane was introduced in late 1880's and the revenue generated through the sugar industry has dominated Fiji's commercial agricultural sector and contributed significantly to the Fijian economy and still continues to be a major foreign exchange earner.

The quest for new sugarcane varieties is paramount for the success of the Fiji breeding program and sustainability of the sugar industry. Currently Mana, a mid to late season maturing variety, is the dominant variety grown in Fiji and accounts for approximately 70% of the total production (Sugar Research Institute of Fiji, 2009). New sugarcane varieties are needed in Fiji due to widespread cultivation of sugarcane. Commercial varieties have characteristics that distinguish them from one another. In Fiji, a commercial cane variety is selected on its ability to produce high cane and sucrose yield, has resistance to pests and diseases and good ratooning ability. While other characteristics may not be included in the selection procedure to any great extent, they may influence a grower's choice of variety. It is desirable to grow improved varieties that produce more cane and higher sugar yield and to have proper and effective harvest scheduling to provide quality cane to sugar-mills during the crushing session. Continuous efforts are being made to develop, evaluate and release superior sugarcane varieties suitable for varying soil and climatic conditions of Fiji.

[1]Department of Biology, Faculty of Science, Fiji National University, Natabua Campus Lautoka.
[2]Sugar Research Institute of Fiji, Lautoka, Fiji Islands.
*corresponding author: anad.tyagi@fnu.ac.fj

New varieties are being developed and made available to the Fiji sugarcane industry by plant breeders at Sugar Research Institute of Fiji. Varieties available to plant in any particular area is restricted to varieties suitable for planting and recommended for the area. New improved sugarcane varieties are developed through inter and intra-specific hybridisation and recurrent selection. A sugarcane breeder needs to know the characteristics of the clones available in the germplasm collection so that he/she can select the best parents (Roach, 1972). The need for increased genetic diversity in sugarcane germplasm is vital for the success of a cane breeding programme. Per cent pure obtainable cane sugar (pocs), cane-yield (tons of cane per hectare - tch) and sugar yield (tons of sugar per hectare - tsh) are the three basic selection criteria of most sugarcane breeding programmes. Sugarcane breeders need to develop varieties that will ultimately result in increased sugar production.

The first four locally bred varieties were released for commercial cultivation in Fiji during the years 1962–63, followed by another eight varieties from 1967–90. The improvement in sugar yields due to the release of the new varieties has been marginal, but their adaptability has expanded sugarcane growing areas to limited potential land that includes hilly areas with shallow soils.

In any plant breeding programme determining the genotype x environment (GxE) interaction is of major importance. The relative performance of varieties differs in different environments due to the GxE interaction. The magnitude of these interactions differs among countries and in the growing regions within a country. Large GxE interaction poses difficulties for selecting superior stable varieties (Eberhart and Russell, 1966). Reducing the GxE interaction is very difficult but selection of stable genotypes that interact less with the environment is possible. Genotype x environment interaction complicates selection and testing of new varieties. Determining or measuring the GxE is important in order to apply an optimum strategy for selecting varieties with adaptation to specific environments.

Multi-locational (environmental) trials are essential in plant breeding programs for the recommendation and release of superior varieties. Such trials allow comparison of mean yield and stability of genotypes. Secondary variety adaptation trials has been a major component of the sugar cane breeding program in Fiji for many years, but the magnitude of GxE interactions has not been studied and documented. Yield and its stability depend on the genetic constitution of the cultivar and the intensity of the environmental constitutions (Bradshaw, 1965; Borojevic, 1990). Thus, to select high yielding and stable cultivars, it is essential to test them under the target production environments in a range of growing (soil and climate) conditions. Different stability parameters have been proposed but the choice of any of these parameters depends on whether one considers stability over a wide range of environments or the relative stability of a group of cultivars in a specific environment. The Eberhart-Russel regression analysis (Eberhart and Russel, 1966) and the Lin and Binn (1988) superiority measure are among the commonly used stability parameters. The parameter of Ebenhart-Russel is based on the regression of each genotypes yield on the environmental index (the mean at each environment). According to Eberhart and Russel (1966), a stable cultivar has a regression coefficient close to unity (b=1), with a minimum deviation from the regression and high mean yield.

The ultimate goal of any sugarcane breeding and selection program is the development of new varieties capable of producing increased cane and sugar yield per unit area and other products of economic importance such as bagasse and molasses at a lower cost than that attained with existing varieties. However, even without increased yield potential, new varieties may lower the cost of production because of improved milling and agronomic characteristics. The present focus of the Fiji breeding program is to develop stable varieties that have broad adaptation with increased cane and sucrose yield.

The main aim of this study was to evaluate the relative performance of cane and sucrose yields of 14 new varieties (as compared to 3 existing commercially cultivated varieties) to be released for cultivation by the farmers of Fiji.

MATERIALS AND METHODS

Seventeen sugarcane varieties, including three commercially cultivated (LF57-5104 - Aiwa, LF60-3917 - Mana, and LF73-229 - Mali) and 14 newly developed (LF79-640, LF79-1052, LF79-2964, LF80-127, LF82-1577, LF82-2031, LF82-2122, LF82-2244, LF82-2715,

LF83-998, LF83-1058, LF83-2189, LF84-252, LF84-8077) varieties were planted in replicated secondary variety adaptation trials in 2010 at five different locations to i) evaluate sucrose content, cane and sucrose yield for the plant crop, ii) determine the magnitude of GxE interactions and iii) study the adaptation of varieties using stability parameters. The trial locations were: Labasa (Location1), Legalega (Location 2), Comboni (Location 3).Rarawai, (Location 4) and Waqadra (Location 5) represented the different soil types of Fiji's sugar belt. Soil samples were taken from each site prior to planting and analysed for fertilizer application recommendations (Table 1). The trials were planted in a randomised complete block design (RCBD) during April-May of 2010. Each trial had three replications and the plot size was six rows by eight metres long. The between row spacing was 1.40m. The varieties were placed randomly in the blocks (replications) and each block consisted of three controls (commercial varieties) and 14 new varieties totalling 17 treatments per block. The trials received well-distributed rainfall, which contributed to a healthy cane growth and were harvested between 14-15 months of age (plant crop only). The commercial varieties Aiwa, Mana and Mali are early, mid and late season maturing varieties respectively. The inner four rows were harvested for measuring cane yield (Plot area calculation 4 rows x 6 metres long x 1.37 metres wide = 32.88m^2) converted hectare. A 6 stalk sample was randomly collected from each plot and shredded. The shredded sample was thoroughly mixed and a sub-sample of 500g was placed in a core and pressed at 100psi to extract the juice for Pol and Brix determination. The pressed sub-sample was used for fibre analysis.

Procedures to determine pocs, tch and tsh:

The method used to determine POCS and Purity are that used by Sugar Research Institute of Fiji, Central Laboratory. The procedures are presented in respective sections below.

Table 1: Soil analysis data for trial sites and rainfaill in mm for duration of trial

Location	pH	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Soil Type*	Rainfall (mm) Apr 2010-Jun 2011
Legalega	6.5	21	95	521	49	F. L	3580
Waqadra	6.4	122	523	4077	781	A	2052
Rarawai	5.3	71	322	1496	400	A	2535
Comboni	6.4	120	276	6801	1880	G	3005
Labasa	5.9	8	320	4398	896	A	2155

** F.L – Ferruginous latosols, A- Alluvial, G- Gley*

Sampling

Six millable stalks were selected at random and harvested from every plot.

Preparation of Sample

The cane stalks from each sample were shredded through the cane disintegrator to obtain fine fibre that was mixed thoroughly. A representative sub-sample (500g) of the shredded fibre was taken and packed in a compression core that was pressed at 100psi to extract the cane juice until juice is completely extracted. The extracted juice was collected and used for pocs.

POCS and Purity Calculation

POCS is the pure obtainable cane sugar and purity is the percentage ratio of sucrose (Pol) to the total soluble solids (brix). The following equations were used in calculating POCS and purity:

POCS calculations from polarimeter recordings as follows:

1 % Cane Sugar in Juice =

$$\frac{\text{(Pol reading*)} \times 26.00}{99.718 \times \text{App sp gravity } 20/20°\text{C**}}$$

Where:

26.00 g is the normal weight when the polarimeter used is fitted with the international scale.

99.718 x app. sp gravity 20/20°C is equal to the weight in grams of 100 mL solution.

**Apparent specific gravity 20/20°C is obtained from Cane Sugar Handbook (1993).

* "Pol reading" is the reading obtained from polarimeter.

(i) % Cane Sugar in Cane =

$$\text{\% cane sugar in juice} \times \frac{100 - (\text{\%Fibre})}{100}$$

(ii) % Soluble Solids in Cane =

$$\text{Brix of juice} \times \frac{100 - (\text{\%Fibre})}{100}$$

(iii) % Impurities in Cane =

%Sol solids (ii) - %Cane sugar (i)

(iv)% POCS =

% Cane Sugar (i) - ½(% Impuritie(iii)

Cane Yield and Sucrose Yield Calculation

2 Cane yield (tch)

Cane yield tons per hectare (tch) was estimated by recording plot yield and plot size and converting plot size to hectare (thus getting total cane yield per hectare) multiplying the plot area the weight of cane stalks from the four inner rows of each plot.

3 Sucrose yield (tsh)

Sucrose yield (tsh) was calculated as follows

$$tsh = \frac{tch \times \text{\%POCS}}{100}$$

Analysis of variance was carried out on the data collected from each of the trials separately and on the data combined over the locations using the Statistix (1985) software.

To assess stability Eberhart and Russell's (1966) joint regression model was used and the yields of each genotype were regressed on the mean environmental yields. Accordingly, a cultivar was considered stable when showing regression coefficient (b_i) close to unity and a deviation from regression residual variance ($\Sigma S^2 di$) close to zero.

According to them the regression of each variety in an experiment on an environmental index and a function of the squared deviations from this regression would provide estimates of the desired stability parameters. The parameters were defined using the following model:

$$Yij = mi + biIj + dij$$

Where:

Yij is the variety mean of the ith variety at the jth environment.

mi is the mean of the ith variety over all environments.

bi is the regression coefficient that measures the response of the ith variety to varying environments.

Ij is the environmental index obtained as the mean of all varieties at the jth environment minus the grand mean.

dij is the deviation from regression of the ith variety at the jth environment.

The deviations from regressions suggest the degree of reliance that should be put on linear regression in interpretation of the data. If these values are significantly deviating from zero, the expected phenotype cannot be predicted significantly. When deviations are not significant, the conclusion may be drawn by the joint consideration of mean yield and regression values (Eberhart and Russell, 1966) as below:

Regression	Stability	Mean yield	Remark
b=1	Average	High	Well adapted to all environments
b=1	Average	Low	Poorly adapted to all environments
b>1	Below average	High	Specifically adapted to favourable environments
b<1	Above average	High	Specifically adapted to unfavourable environments

The data obtained from these trials were analysed to identify suitable varieties for commercial cultivation at various locations in Fiji.

RESULTS:

Analysis of variance - individual locations

POCS (pure obtainable can sugar

The average variety pocs values ranged from 10.0 to 14.1 and 10.3 to 13.6 at locations 1 and 2, respectively. At locations 3 and 5 the pocs values were lower with the low and high values being 8.3 to 12.9 and 8.7 to 12.1 respectively and there were no significant differences among the varieties at these locations. However, at location 4 significant differences were observed for the pocs values, which ranged from

Cane yield - tonnes cane per hectare (tch)

The average cane yield per hectare (tch) values ranged from 68 to 135, 63 to 123, 59 to 133, 64 to 122 and 66 to 122 at locations 1, 2, 3, 4 and 5 respectively. It was noted that there were highly significant differences among the varieties at all the locations except location 3 (Table 2).

Sugar yield - tonnes sugar per hectare (tsh)

The average sugar yield per hectare (tsh) values ranged from 7.7 to 19.0, 6.8 to 16.6, 5.4 to 17.2, 7.4 to 15.0 and 6.1 to 14.8 at locations 1, 2, 3, 4 and 5 respectively and there were highly significant differences among the varieties at all the locations except location 3, 4 and 5 (Table 3).

Table 2: Analysis of variance for tonnes of cane per hectare (tch) for each of the five locations.

		Labasa			Legalega			Comboni			Rarawai			Waqadra		
Source	*DF*	*SS*	*MS*	*F*	*SS*	*MS*	*F*	*SS*	*MS*	*F*	*SS*	*MS*	*F*	*SS*	*MS*	*F*
Rep	2	2.63	1.314		9.69	4.843		21.020	139.45		69.74	26.39		13.196	21.020	
Variety	16	2521.3	157.6	7.73**	2334.4	145.9	8.98**	42.04	21.020	11.43**	1958.3	122.95	11.43**	969.65	60.61	4.25**
Error	32	652.04	20.4		519.65	16.3		1958.3	122.95		342.63	10.707		455.88	14.23	
Total	50															

Table 3: Analysis of variance for tonnes of sugar per hectare (tsh) for each of the five locations.

		Labasa			Legalega			Comboni			Rarawai			Waqadra		
Source	*DF*	*SS*	*MS*	*F*	*SS*	*MS*	*F*	*SS*	*MS*	*F*	*SS*	*MS*	*F*	*SS*	*MS*	*F*
Rep	2	17.964	8.9826		3.2263	1.6131		1.761	0.8806		32.2663	18.13		8.557	4.2778	
Variety	16	113.56	7.0975	4.41**	97.739	6.1087	5.36**	136.72	8.5448	3.61**	67.126	4.195	2.47*	97.305	6.0816	4.78**
Error	32	51.456	1.608		36.440	1.1388		75.765	2.3677		54.327	1.698		40.704	1.2720	
Total	50															

Pooled analysis of variance

The analysis of variance of the pooled data for yield components - tonnes cane per hectare (tch) and tonnes sugar per hectare (tsh) over the five locations are presented in Table 4 and 5.

There were significant differences % pocs in varieties, locations and reps x locations, but the variety x location interactions was not significant. For tch and tsh the analysis of variance suggested highly significant differences among varieties, locations, reps in locations and variety by location interactions. The relatively high variety mean square for tch indicated that the varieties differed in their potential for cane yield.

The variety by location (GxE) interactions provides an important source of variation and the term stability can be used to characterise a variety that shows a relatively constant yield independent of changing environmental conditions Since the varieties x location (GxE) interactions were found highly significant for cane (tch) and sugar (tsh) yields these traits were further processed for estimating the stability parameters.

Table 4: Pooled ANOVA for tonnes of cane per hectare (tch)

Source	*DF*	*SS*	*MS*	*F*
Varieties	16	85398.3	5337.39	96.06**
Locations	4	2267.9	566.98	10.20**
Reps in locations	10	2617.0	261.70	4.71**
Varieties x locations	64	8411.8	131.43	2.37**
Error	160	8889.7	55.56	
Total	254			
Grand Mean	83.33		CV	8.94

Table 5: Pooled AVOVA for tonnes of sugar per hectare (tsh)

Source	*DF*	*SS*	*MS*	*F*
Varieties	16	1543.65	96.4778	58.72**
Locations	4	203.91	50.978	31.03**
Reps in locations	10	34.08	3.4081	2.07*
Varieties x locations	64	210.30	3.2860	2.00**
Error	160	262.89	1.6430	
Total	254			
Grand Mean	9.380		CV	13.67

Tonnes cane per hectare (tch)

Large variation was observed for tch as determined from the range of the environmental indices (-2.592 to 5.369) Table 6. The stability parameters for tch are presented in Table 7 and Figure 1. The variety LF82-2122 with a mean of 127 had the highest tch and the variety LF83-998 with mean of 66 had the lowest tch. The average tch over all the environments was 83. The regression coefficient value of the commercial varieties LF57-5104, LF60-3917 and promising varieties LF80-127 and LF82-2244 were less than one and the mean tch of these varieties were higher than the grand mean of all varieties over all the environments. These varieties are specifically adapted to unfavourable environments. The variety LF84-252 had a regression coefficient of 0.936 and was ranked one that implied that this variety is well adapted to all environments but the mean tch of this variety (68) was much lower than the grand mean (83).

Based on the standard deviation values the variety LF82-2244 was ranked 1 and the tch of this variety (107) was higher than the grand mean (83). The mean tch of this variety over all the environments was ranked 3. Combining the mean tch of this variety with the regression coefficient and standard deviation values this variety was the most stable for producing good cane yields.

Table 6: Mean, range and environmental index for pocs, cane (tch) and sugar (tsh) yields among 14 advanced stage clones and 3 commercial varieties tested at 5 locations.

Trait			Mean			All location mean
	Labasa	Legalega	Comboni	Rarawai	Waqadra	
%pocs	12.2	11.8	10.5	11.6	10.0	11.22
Cane yield (tch)	89	81	84	82	81	83
Sugar yield (tsh)	11.6	11.3	10.1	11.2	9.6	10.76
			Range			
	Labasa	Legalega	Comboni	Rarawai	Waqadra	
%pocs	10.0 – 14.1	10.3 – 13.6	8.3 – 12.9	9.1 – 13.1	8.7 – 12.1	
Cane yield (tch)	68 - 135	63 - 123	59 - 133	64 - 122	66 - 122	
Sugar yield (tsh)	7.7 -19.0	6.8 – 16.6	5.4 – 17.2	7.4 – 15.0	6.1 – 14.8	
			Environmental index			
	Labasa	Legalega	Comboni	Rarawai	Waqadra	
%pocs	0.946	0.596	-0.730	0.408	-1.220	
Cane yield (tch)	5.369	-2.592	0.623	-0.945	-2.455	
Sugar yield (tsh)	0.859	0.519	-0.684	0.430	-1.124	

Table 7: Stability parameters for cane yield (tch) among 14 advanced stage clones and 3 commercial varieties tested at 5 locations.

Varieties	Mean	Rank	b_i	Rank	δ^2_{di}	Rank
LF57-5104 (commercial)	98	4	0.836	3	35.830	6
LF60-3917 (commercial)	121	2	0.890	2	38.122	7
LF73-229 (commercial)	85	5	2.381	14	102.024	16
LF79-640	71	11	1.796	8	76.940	13
LF79-1052	77	9	2.593	15	111.107	17
LF79-2964	71	11	1.237	4	53.007	9
LF80-127	82	7	-1.222	17	-52.342	10
LF82-1577	79	8	2.280	13	97.692	15
LF82-2031	83	6	1.895	10	81.192	14
LF82-2122	127	1	1.760	7	75.410	12
LF82-2244	107	3	0.027	11	1.165	1
LF82-2715	74	10	1.489	6	63.810	11
LF83-998	66	17	-0.118	12	-5.068	2
LF83-1058	69	14	0.476	5	20.404	4
LF83-2189	70	13	0.279	9	11.971	3
LF84-252	68	16	0.936	1	40.111	8
LF84-8077	69	14	-0.535	16	-22.924	5
Population mean	83					

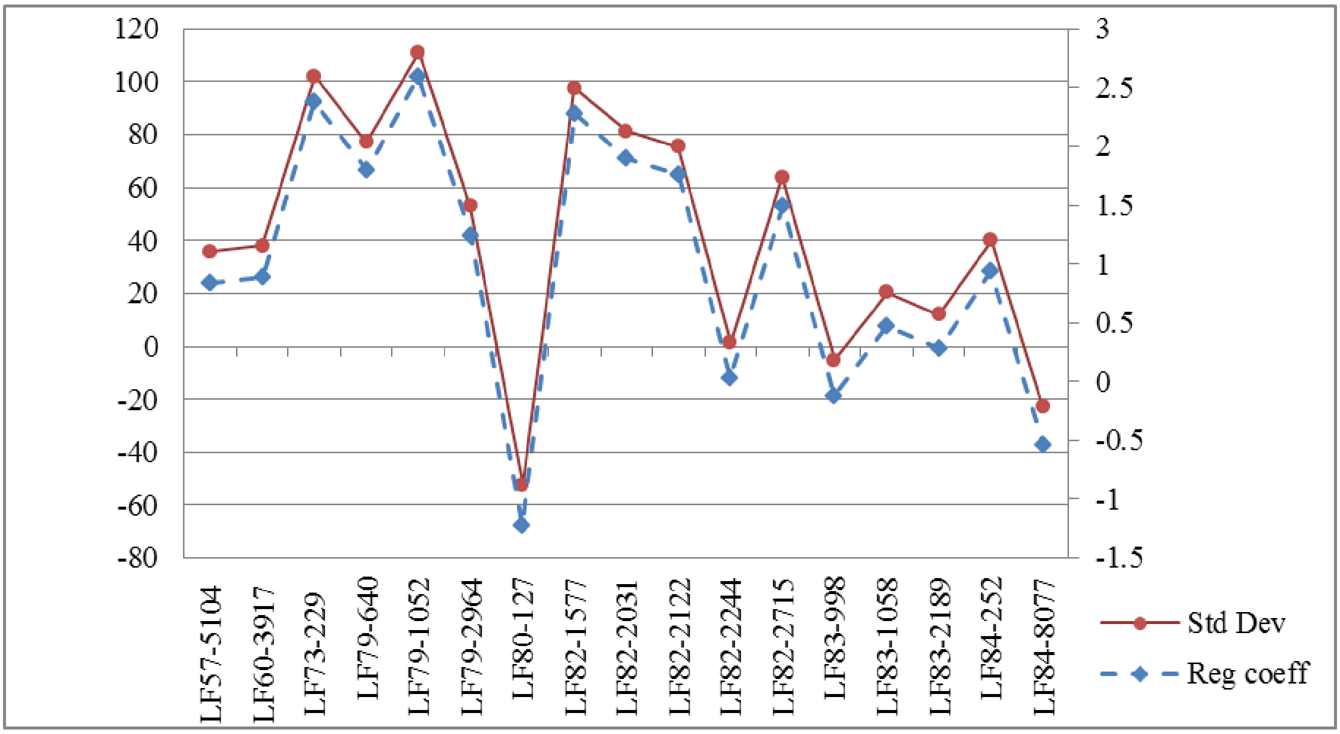

Figure 1: Regression coefficient and standard deviation values for tonnes of cane per hectare of seventeen sugarcane varieties in Fiji.

Tonnes sugar per hectare (tsh)

Five locations showed wide variation for tsh as noted from the range of the environmental indices (-1.124 to 0.859) Table 6. The stability parameters for tsh are presented in Table 8 and Figure 2. The variety LF82-2122 with a mean of 16.5 had the highest tsh and the variety LF57-5104 with mean of 8.9 had the lowest tsh. The average tsh over all the environments was 10.76. The regression coefficient value of the commercial varieties LF73-229 and promising varieties LF79-1052, 2964, LF82-1577, 2122 and 2244, were less than one and the mean tsh of these varieties were on par and higher than the grand mean of all varieties over all the environments. These varieties are specifically adapted to unfavourable environments. The variety LF83-1058 had a regression coefficient of 0.963 and was ranked one that implied that this variety was well adapted to all environments but the mean tsh of this variety was 10.3 and lower than the grand mean (10.76).

Based on the standard deviation values the variety LF84-252 was ranked 1 and the tsh of this variety (10.3) was lower than the grand mean (10.76). The mean tsh of this variety over all the environments was ranked 10. Similarly the standard deviation of the variety LF79-640 was ranked 2 but this variety also had lower tsh (10.1) compared to the grand mean tsh (10.76). Combining the mean tsh with regression coefficient and standard deviation values the varieties LF82-2122 and 2244 were the most stable across a range of environmental conditions.

The deviation from regression (δ^2_{di}) values of all the varieties ranged from -52.342 to 111.107. The δ^2_{di} of the variety LF82-2244 was not significantly different from zero that indicated stability of performance of this variety across all locations. The δ^2_{di} values of all the other varieties were much higher and below zero and thus these varieties yield would not be stable across all the locations. The high mean yield across all locations, the regression coefficient (b_i= 0.027), and mean square deviation from regression (δ^2_{di}= 1.165) value of the variety LF82-2244 that was closest to zero made this variety the most stable across the range of environments.

Table 8: Stability parameters for sugar yield (tsh) among 14 advanced stage clones and 3 commercial varieties tested at 5 locations.

Varieties	Mean	Rank	b_i	Rank	δ^2_{di}	Rank
LF57-5104 (commercial)	9.3	4	0.566	12	1.655	3
LF60-3917 (commercial)	13.9	2	1.087	4	3.180	12
LF73-229 (commercial)	9.2	5	0.842	7	2.461	8
LF79-640	8.0	10	0.554	13	1.621	2
LF79-1052	9.1	6	0.938	2	2.742	9
LF79-2964	8.0	10	0.738	10	2.159	5
LF80-127	9.1	6	1.101	5	3.220	13
LF82-1577	9.1	6	0.826	8	2.415	7
LF82-2031	8.7	9	1.061	3	3.103	11
LF82-2122	16.5	1	0.785	9	2.296	6
LF82-2244	12.4	3	0.571	11	1.671	4
LF82-2715	8.0	10	2.277	17	6.657	17
LF83-998	7.9	13	1.693	16	4.951	16
LF83-1058	7.5	15	0.963	1	2.815	10
LF83-2189	7.5	15	1.378	15	4.031	15
LF84-252	7.5	15	0.493	14	1.440	1
LF84-8077	7.6	14	1.126	6	3.294	14
Population mean	9.4					

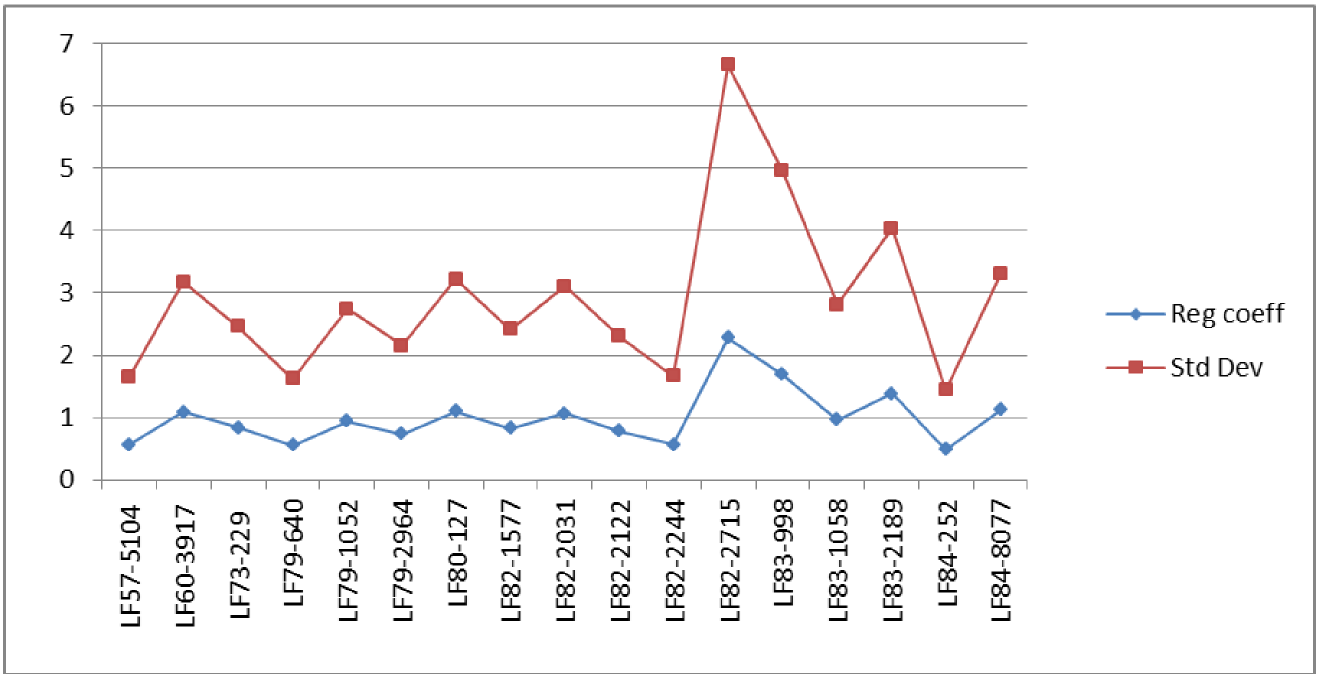

Figure 2: Regression coefficient and standard deviation values for tonnes of sugar per hectare of seventeen sugarcane varieties in Fiji.

Rank

The rank values 1-17 have been assigned to the mean, regression coefficient and standard deviation values for tch and tsh where rank 1 is highest value for mean and rank 17 is the lowest value respectively. For regression coefficient rank, 1 was assigned to a variety with regression coefficient value equal to or closest to one (b @ 1) and rank 17 was assigned to a variety with regression coefficient value furthest from one (b>1 or <1). Similarly for standard deviation, rank 1 was assigned to a variety with standard deviation value equal to or closest to zero and rank 17 was assigned to a variety with standard deviation value furthest from zero. The ranks of the varieties varied among locations and are shown in Tables 7 (tch) and 8 (tsh).

DISCUSSION

Crop varieties may show wide fluctuations in their yielding ability when grown over varied environments or agro-climatic zones. This can cause difficulty in demonstrating the superiority of a particular variety over sites. Besides yield potential, yield stability over a range of environments is of major importance for plant breeders and this has direct bearing on the adoption of the variety, productivity and total production of the crop. Each genotype may have a specific environment for its maximum performance (Gilbert *et. al.* 2005).

Successful new varieties must show high performance for yield and better essential agronomic traits over existing commercial variety. Moreover, their superiority in performance should be reliable over wide range of environments (Kennedy, 1978). The basic cause of differences between genotypes in their yield stability is the occurrence of genotype x environment interactions. These interactions of genotypes with environments can be partly understood as a result of a differential reaction to environmental factors like drought or disease and consequently resistance breeding assumes significance in improving yield stability (Becker and Leon, 1988).

Depending on the goal and on the character under consideration, two different concepts of stability exist, which are termed as the static concept of stability and the dynamic concept of stability. Both concepts of stability are valuable, but their application depends on the trait considered (Becker & Leon, 1988). For yield, we need to select genotypes which are stable as well as high yielding. Stability evaluated by means of the static concept, however is usually associated with a relatively poor yield (Kimbeng *et. al*. 2009).

Frequently with quantitative traits like yield, most genotypes react similarly to favourable or unfavourable environmental conditions. This average response to environments results in varying mean trait levels among genotypes. Varietal stability in performance should be considered as an important aspect of yield trials. Researchers need a statistic that provides a reliable measure of stability or consistency of performance of genotypes across range of environments. According to dynamic concept only the deviations of a genotype from the general reaction are considered as a contribution to instability. All stability procedures based on quantifying GxE interaction effects belong to the dynamic stability concept (Galvez, 1980).

The most stable genotype is least dependent on climatic conditions and performs well under favourable and unfavourable climatic conditions. The main objective of the present investigation was to identify the stable genotype(s) over the five locations for yield and yield related traits in sugarcane. Stability analysis was carried out by employing the linear regression model developed by Eberhart and Russell (1966).

The two promising varieties LF82-2122, LF82-2244 and two commercials LF57-5104 and LF60-3917 recorded higher tch at all the locations and were ranked within the top four at each site. The highly significant interaction between varieties by location revealed that locations differed considerably in their effects on the performance of the promising varieties. Similar results were reported by Soliman (2006).

There were highly significant differences in the tsh across all the locations. Changes in the ranks of tsh were present and two promising varieties LF82-2122 and LF82-2244 were ranked in the top four varieties at all the locations. These two promising varieties had significantly higher tsh across all the locations and was adapted to all environmental conditions. The tsh of most of the varieties at Labasa was generally higher compared to the other locations. The changes in the ranks of tsh across the different locations was mainly due to the effect of the environment. It could also be due to varietal differences and their performance at different locations.

CONCLUSION

The positive interpretation of varieties x locations interactions implies selecting cultivars for their environments rather than modifying the environment to fit new cultivars. The analysis of variance was highly significant for yield related components (tch and tsh). The overall performance of the promising varieties over locations revealed that the sites were highly variable and this was reflected by the change in the ranks of tch and tsh of the same varieties at different locations. Based on a stability model for traits poc, tsh and tch and GxE interaction, the following five varieties: LF82-2244, LF83-998, LF83-2189, LF83-1058 LF84-8077 were selected for further trials and multiplication and distribution to farmers.

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