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Stability analysis and performance of promising sugarcane varieties for yield and quality traits

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Abstract

Four promising varieties of sugarcane, along with the commercial variety, GT54/9 were evaluated for yield, yield components, and quality traits. The environments were different ages of harvest time (11, 12, and 13 months old) of two plant cane crops (2-years) at El-Mattana Agriculture Research Station farm during (2018-2019 and 2019-2020 seasons). The stability analysis of studied traits was performed. The results indicated that the promising varieties, environments, and their interaction had a highly significant effect on all studied traits in both the seasons except the age at the harvest time on purity in both seasons, the effect of the interaction on sucrose as well as a pol in second season only and on fiber in the first season only. It is obvious from the results that none of the tested varieties was superior to GT 54/9 for cane and sugar yield and stable implying the necessity of widening the genetic base to produce improved promising varieties. The stability analysis showed that GT 54/9 variety was stable for stalk height, stalk diameter, brix, reducing sugar, and fiber and recorded the highest cane yield and sugar yield. G2003/49 was stable for cane yield, sugar yield, brix, pol, and fiber. It ranked third in cane yield and the second sugar yield. The variety G2003/47 was stable for stalk diameter, sucrose, sugar recovery, and fiber and ranked fourth for cane yield and the third rank for sugar yield. G2004/26 was stable for stalk diameter, cane yield, reducing sugar, and fiber. It occupied the second and third ranks for cane yield and sugar yield respectively. G84/47 variety was stable for cane yield, sugar yield, brix, sucrose and fiber and ranked last for cane and sugar yield.

Key words: Sugarcane, stability analysis, promising varieties, performance.

INTRODUCTION

Sugarcane is the main field and cash crop in upper and middle Egypt governorates. It plays an important role in the development of these regions by creating a sustainable source of employment and income generation. It is cultivated in 325 thousand feddan (fed=4200 m^2) which produced 15.2 million tons of cane, crushing at eight sugarcane factories and producing 0.9 million tons of sugar (Annual report of sugarcane council, 2020). Cane and sugar yield and their components were the essential criteria in the selection process of all sugarcane breeding programs of developing high yielding sugar cane promising varieties by evaluating the performance and stability of these traits in advanced promising varieties under specific locations or environments in which they are grown and to identify their responses to the environmental variation (Cruz *et al.,* 2012).

Age at harvest is the most important factor that determines cane yield, sugar yield, and their components and represents the environmental variation within a year (season) and/or among years (seasons). Knowledge on the response of tested promising varieties to different harvest times is essential to analyze the varied performance of these promising varieties in varying ages of harvests to determine the appropriate age of harvesting for each variety which is usually determined by monitoring sugar yield parameters, i.e. brix, sucrose, purity, recovery sugar, fiber, and cane yield.

Several methods have been developed, practised and recommended by different researchers for stability analysis. Cruz *et al*. (2012) reported that the choice of a method for the analysis depends on experimental data, the number of available environments, required accuracy, and the type of desired information. Tai (1971) model has been widely used in studying the stability of promising varieties wherein, in this model the variety x environment interaction effect on varieties is portioned into linear responses to environmental effect which is measured by statistic (α) and the deviation from linear response which is measured by a statistic (λ). A perfect stable variety has (α,λ)= (-1,1), and a variety with average stability has (α,λ) = (0,1), whereas a variety which has (α,λ) significantly > 0,1 referred as above-average stability. Relative performance and stability of sugarcane promising varieties in varying environments was extensively studied and significant differences in performance and significant variety x interaction were reported earlier by many sugarcane workers (Tai *et al*., 1982; Rea *et al*., 2014; Guddadamath *et al*., 2014; Prema *et al*., 2017 and Ali *et al*., 2020). The objective of this study to investigate the stability analysis and the yield performance of four sugarcane promising varieties along with check cultivar (GT 54/9) in two plant cane crops seasons grown under three harvesting dates.

MATERIALS AND METHODS

The present study was conducted at Mattana Agricultural Research Station Farm duringthe 2018-2019 and 2019-2020 crop seasons to evaluate the performance and stability of four sugarcane promising varieties in two plant cane seasons under three harvesting dates. The commercial variety used in this study were: GT 54/9 which its fuzz (seed) was introduced from Taiwan and was selected in Egypt and four promising varieties from the Egyptian sugarcane breeding program, namely G2003/47, G2003/49, G84/47, and G2004-25. Planting was done during March 2018 and 2019 seasons and the three harvesting dates were 11, 12, and 13 months from planting.

The selected sugarcane varieties were evaluated over six-environments (2 seasons x 3 harvesting dates). The trial was laid in a randomized complete block design with three replications arranged in a split-plot system. Harvesting dates were allocated in the main plots and the varieties in sub plots. The subplot was 5 rows, 7 meter-long and 1 meter apart. The recommended cultural practices of sugarcane production were adopted throughout the growing seasons. At each harvesting date, the experimental plots were individually harvested and 30 stalk samples from each plot were chosen at random and the following traits *viz*., stalk length (cm), stalk diameter (cm) and cane yield (t/fed) were recorded.

At each harvesting date, one row from each sub-plot was chosen at random, a sample of clean cane was used for quality analysis and the following traits viz., Brix (%), Sucrose (%) and Reducing sugar (%) were measured as per the procedure given by A.O.A.C. (2005). The purity (%) was calculated using the following formula described by Meade and Chen (1977). Fiber (%) was determined as described in the official methods of chemical control and analysis for Mauritious sugar factories in 1970. Pol (%) was calculated according to the following formula described by Meade and Chen (1977). Sugar recovery (%) and sugar yield (t/fed.) were calculated according to the following formula described by Yadav and Sharma (1980).

The combined analysis of variance was completed according to Federer (1963). Stability analysis was performed according to Tai (1971). The variety-environment interaction effect of a variety is partitioned into two components. They are the linear response to environmental effects, which is measured by a statistic α, and the deviation from the linear response, which is measured by another statistic λ. The data of plant crops was subjected to stability analysis as outlined by Tai (1971). The two seasons with three ages at harvest comprised 6 different environments.

RESULTS AND DISCUSSION

Data presented in **Table 1** indicated that promising varieties, age at harvest and their interaction had a significant influence on stalk height, stalk diameter and cane yield in both seasons. Data revealed that the commercial variety i.e. GT 54/9 recorded the tallest stalks (265.11 and 284.00 cm) in the first and second seasons, respectively, while G.2003/49 variety was short and recorded stalks of 220.44 cm in the first season and G84/47 variety recorded the shortest stalks (243.11 cm) in the second season.

Furthermore, GT 54/9 variety recorded the maximum value of stalks diameter (2.72 and 2.68 cm) in the first and second season, respectively, while G2003/49 variety recorded the minimum value of stalk diameter (2.41 cm) in the first season and the minimum value of this trait (2.52 cm) was recorded by G2004/27 variety in the second season.

The variety GT 54/9 variety was superior to the other promising varieties for cane yield in both the seasons and recorded (48.74 t/fed.) in the first season and (42.50 t/fed.) in the second season (Table 1). On the other hand, the lowest value of cane yield was recorded by variety G2003/47 (38.62 and 39.47 t/fed.) and by G84/47 variety (38.68 and 39.00 t/fed.) in the first and second season, respectively.

Stalk height, stalk diameter and cane yield increased gradually by delaying the harvest time up to 13-months of age in both seasons. In addition, stalk height, stalk diameter and cane yield of all the promising varieties gradually increased with an increase in their age at

Table 1. Performance of varieties for stalk height, stalk diameter and cane yield at three ages of harvest in two plant crop seasons.

Age at harvest	First season				Second Season			
	11	12	13	Mean	11	12	13	Mean
Promising varieties	**Stalk height (cm)**							
GT 54/9	250.67	267.00	277.67	265.11	276.00	285.00	291.00	284.00
G2003/49	216.67	217.67	227.00	220.44	252.33	255.33	264.33	257.33
G2003/47	215.33	238.67	248.00	234.00	240.67	246.33	251.33	246.11
G2004/ 27	216.00	220.67	236.33	224.33	237.00	241.33	252.33	243.56
G84/47	216.67	245.33	254.33	238.78	223.33	246.33	259.67	243.11
Means	223.07	237.87	248.67	236.54	245.87	254.87	263.73	254.82
Rev. LSD 5%								
Varieties (V)	5.00				5.55			
Age at harvest (A)	2.46				1.62			
V x A	5.585				3.76			
	Stalk diameter (cm)							
GT 54/9	2.57	2.73	2.87	2.72	2.60	2.69	2.77	2.68
G2003/49	2.33	2.43	2.47	2.41	2.43	2.51	2.67	2.54
G2003/47	2.47	2.59	2.73	2.60	2.50	2.53	2.63	2.56
G2004/ 27	2.52	2.58	2.65	2.58	2.48	2.53	2.56	2.52
G84/47	2.61	2.63	2.80	2.68	2.58	2.60	2.63	2.61
Means	2.50	2.59	2.70	2.60	2.52	2.57	2.65	2.58
Rev. LSD 5%								
Varieties (V)	0.05				0.07			
Age at harvest (A)	0.03				0.03			
V x A	0.09				0.08			
	Cane yield (ton/fed.)							
GT 54/9	47.97	48.80	49.47	48.74	40.00	41.60	45.90	42.50
G2003/49	43.07	42.43	43.30	42.93	34.60	39.27	41.90	38.59
G2003/47	37.10	39.20	39.57	38.62	37.40	39.90	41.10	39.47
G2004/ 27	40.33	41.87	42.30	41.50	37.90	39.40	43.80	40.37
G84/47	38.30	39.00	38.73	38.68	37.90	39.00	40.10	39.00
Means	41.35	42.26	42.67	42.10	37.56	39.83	42.56	39.98
Rev. LSD 5%								
Varieties (V)	2.38				1.70			
Age at harvest (A)	0.61				0.97			
V x A	1.90				3.02			

harvest up to 13 months which indicates that these varieties growth continues up to 13 months resulting in the formation of new tissues and joints thereby resulting in increasing of stalk height, stalk diameter and subsequently increase in cane yield. It is interesting to note that GT54/9 variety recorded significantly higher stalk height and stalk diameter resulting in higher cane yield values under the 11, 12 and months harvest time compared to the other test varieties indicating that none of these test varieties could replace the commercial variety (GT54/9) and could be acceptable by sugar cane grower, therefore, much emphasis should be taken to widen the genetic base of Egyptian sugarcane breeding program to enable the breeder to develop high yielding sugarcane promising varieties acceptable to replace the GT54/9 variety. The significant difference in stalk height, stalk diameter, and cane yield under different ages at harvested was also reported earlier (Osman *et al.,* 2011; Abd El-Razek and Besheit, 2012; Hagos *et al.,* 2014; Hamam *et al.,* 2015 and Ali *et al.,* 2020).

Brix, sucrose, reducing sugar and purity per cent were significantly responded to promising varieties, the age at harvest time and their interaction in both seasons except the effect of the interaction between varieties and the age at harvest on sucrose content in the second season and the effect of the age at harvest on purity per cent in both seasons.

The highest value of brix (19.52 %) was recorded by both GT54/9 variety and G2003/47 variety, in the first season, while the highest values of brix (20.07 % and 20.48%) were recorded by GT54/9 variety and G2004/27 variety, respectively in the second season (**Table 2**). The lowest values of brix (18.53 % and 18.60%) were recorded by the promising varieties G2003/49 and G84/47 in the first season, while the lowest value of brix (17.66%) was recorded by G.2003/47 variety in the second season. In both seasons, brix value was significantly increased by delayed harvest up to 13-month-old. Also, the brix % of all test varieties increased by delaying the harvest time and achieved the maximum values at harvest time of 13 months.

In the first season, GT54/9, G2003/47 and G.2003/49 varieties were recorded almost similar sucrose values

Table 2. Performance of quality traits of promising varieties at different harvest times in two crop seasons.

Age at harvest	First season				Second Season			
	11	12	13	Mean	11	12	13	Mean
Promising varieties				Brix%				
GT 54/9	18.17	19.50	20.90	19.52	19.40	19.97	20.83	20.07
G2003/49	17.80	18.40	19.40	18.53	17.73	18.77	19.83	18.78
G2003/47	18.83	19.50	20.23	19.52	16.90	17.73	18.33	17.66
G2004/ 27	17.67	18.60	20.57	18.94	19.67	20.27	21.50	20.48
G84/47	17.27	18.37	20.17	18.60	17.40	18.63	20.67	18.90
Means	17.95	18.87	20.25	19.02	18.22	19.07	20.23	19.17
Rev. LSD 5%								
Varieties (V)		0.81				0.54		
Age at harvest (A)		0.26				0.33		
V x A		0.75				1.06		
				Sucrose %				
GT 54/9	14.80	15.77	17.10	15.89	14.47	15.47	15.93	15.29
G2003/49	15.10	15.60	16.43	15.71	15.50	16.80	17.27	16.52
G2003/47	15.10	15.60	16.83	15.84	15.37	15.93	16.73	16.01
G2004/ 27	14.35	15.10	16.43	15.29	15.35	15.90	17.50	16.25
G84/47	14.10	15.27	15.93	15.10	14.40	15.13	15.13	14.89
Means	14.69	15.47	16.55	15.57	15.02	15.85	16.51	15.70
Rev. LSD 5%								
Varieties (V)		0.42				0.41		
Age at harvest (A)		0.21				0.38		
V x A		0.70				non		
				Reducing sugars%				
GT 54/9	0.47	0.44	0.41	0.44	0.46	0.43	0.42	0.44
G2003/49	0.49	0.44	0.41	0.45	0.48	0.43	0.40	0.44
G2003/47	0.48	0.42	0.39	0.43	0.46	0.43	0.40	0.43
G2004/ 27	0.37	0.38	0.48	0.41	0.39	0.40	0.44	0.41
G84/47	0.39	0.37	0.45	0.40	0.42	0.40	0.49	0.44
Means	0.44	0.41	0.43	0.43	0.44	0.42	0.43	0.43
Rev. LSD 5%								
Varieties (V)		0.01				0.01		
Age at harvest (A)		0.01				0.01		
V x A		0.02				0.02		
				Purity %				
GT 54/9	81.47	80.88	81.83	81.39	74.58	77.44	76.45	76.16
G2003/49	84.87	84.78	84.70	84.78	87.40	89.54	87.07	88.00
G2003/47	80.17	80.00	83.22	81.13	90.96	89.87	91.28	90.70
G2004/ 27	81.24	81.19	79.95	80.79	78.06	78.45	81.48	79.33
G84/47	81.71	83.14	79.02	81.29	82.76	81.22	73.23	79.07
Means	81.89	82.00	81.74	81.88	82.75	83.30	81.90	82.65
Rev. LSD 5%								
Varieties (V)		1.91				2.38		
Age at harvest (A)		Non				Non		
V x A		3.31				3.76		

which were 15.89, 15.84 and 15.71 per cent, respectively which were significantly higher than the values recorded by G2004/27 and G84/47 varieties (**Table 2**). However, in the second season the sucrose per cent of G2003/49, G2004/27 and G.2003/47 promising varieties were significantly higher than that of GT 54/9 variety or G84/47 variety. The sucrose content in the crop increased gradually by delaying the harvest time and recorded the maximum values when the harvesting was conducted at the age of 13 months in both seasons. In the first season, the sucrose content of all test varieties recorded the highest values when the harvest time was 13 months. However, the response of the sucrose per cent to the interaction in the second season was non-significant. This might be attributed to the favorable microclimatic conditions for sucrose accumulation in the first season which was unfavorable in the second season.

Reducing sugar values of G2003/49 variety was the highest (0.45) in the first season and the reducing sugar of the variety G84/47 was the lowest (0.40) while in the second season, GT 54/9 variety, and the promising varieties G3003/49 and G84/47 had equal reducing sugar (0.44) and G2004/27 variety recorded the lowest reducing sugar (0.41). Sugarcane crops accumulated high reducing sugar at 11-months of harvest time and the reducing sugar values below 11-months (0.44) were equal in both seasons. The lowest value of reducing sugar was recorded when canes were harvested at 12 months of age either in the first season or in the second season. Results showed that significant differences existed among promising varieties for reducing sugar during each harvest time and under different harvest times.

During the first season, the G2003/49 variety recorded the highest value for purity (84.78%) which was significantly higher than those of the other test promising varieties which were on par with each other for the trait. However, in the second season G2003/47 variety recorded the highest purity (90.70 %) and G84/47 variety recorded the lowest value of purity (79.07%). Purity per cent did not show response to their age at harvest time in both seasons. This means that the non-sugar soluble solids and sucrose accumulation were in the same rate under the three ages at harvesting time. In the first season G2003/49 variety recorded the highest value of purity at 11, 12 and 13 months of age at harvesting time while, in the second season, G2003/49 variety recorded the highest value of purity in all the ages and harvesting time. Alarmelu *et al.* (2021), Rakkiyappan *et al*. (2009), Abu-Ellail *et al.* (2020,) Hagos *et al*. (2014) and Ali *et al*. (2020), reported that the quality parameters *viz*., brix, sucrose, and purity were significantly affected by varieties, harvesting dates and their interaction.

Fiber content, pol per cent, sugar recovery and sugar yield were significantly influenced by the promising varieties, age at harvest time and their interaction in both seasons except the effect of the interaction between the varieties and the age at harvest on fiber in the first season and on pol per cent as well as on sugar recovery in the second season (**Table 3**).

The highest value of fiber was recorded by G2003/47 and G2003/49 promising varieties in first and second seasons, respectively, while the lowest value of fiber was recorded by G2004/27 variety in both the seasons. It is obvious from the data that fiber value decreased gradually by delaying the harvest time up to 13 month-old in both seasons. The fiber content of test varieties was different under the three ages at harvest time in the first season only (**Table 3**).

In the first season, G2004/27 and G84/47 varieties had significantly lower pol per cent than that of GT 54/9 variety. In the second season, G2003/49, G2003/47 and G2004/27 varieties recorded non-significant differences for pol value compared to G84/47 varieties . In the first season, pol per cent gradually increased by delaying the harvest time up to the age of 13 months and significant differences for pol content at three ages of harvest were observed. The lowest pol per cent was recorded by G84/47 variety when it was harvested at 11months of age while the highest value of pol was recorded by GT 54/9 variety when it was harvested at 13 months of age. In the second season, there was not much significant response for pol per cent among the test varieties at harvest time up to 13-months.

In the first season, G2003/49 and G2003/47 and G2004/27 varieties gave statistically similar values of sugar recovery values (11.40,11.21 and 10.63 %, respectively) which were significantly higher than those of other test varieties (Table 3). However, in the second season, GT 54/9 and G84/47 varieties recorded the lowest sugar recovery and G.2003/49 as well as G2003/47 promising varieties recorded the highest values of sugar recovery. Sugar recovery increased by delay in the harvesting time up to 13 months in both seasons and all the test varieties recorded an increase in sugar recovery by delaying the harvesting time up to 13 months.

The highest sugar yield was recorded by GT 54/9 variety (4.16%) in the first season and the variety G2003/47 (4.43%) in the second season while the lowest value of the sugar yield (3.78%) was recorded by G84/47 in both seasons. GT 54/9 variety was superior for sugar yield in the first season due to maximum cane yield value (**Table 3**) while the superiority of G2003/47 variety in the second season for sugar yield was due to maximum sugar recovery value (**Table 3**). Also, these results indicate that high sugar yield varieties require improvement for cane yield and/or sugar recovery. Sugar yield increased by delaying the harvest time up to 13 months in both seasons. All the test varieties recorded a gradual increase in sugar yield by delaying the harvest time up to 13 months of age. These results indicate that the sugar yield is mainly determined by the promising varieties and their

Table 3. Performance of varieties for fiber content, pol per cent, sugar recovery and sugar yield at three ages at harvest in two plant crop seasons.

Age at harvest	First season				Second Season			
	11	12	13	Mean	11	12	13	Mean
Promising varieties				**Fiber %**				
GT 54/9	12.67	12.27	11.37	12.10	12.13	11.27	10.57	11.32
G2003/49	13.80	12.93	12.03	12.92	12.61	12.20	11.77	12.19
G2003/47	14.07	12.60	12.10	12.92	13.03	12.18	11.60	12.27
G2004/ 27	12.03	11.50	10.50	11.34	11.60	11.12	10.28	11.00
G84/47	13.17	12.33	11.03	12.18	12.13	11.93	11.85	11.97
Means	13.15	12.33	11.41	12.30	12.30	11.74	11.21	11.75
Rev. LSD 5%								
Varieties (V)		0.29				0.38		
Age at harvest (A)		0.14				0.37		
V x A		0.39				Non		
				Pol %				
GT 54/9	12.08	13.00	13.58	12.89	12.47	13.46	14.75	13.56
G2003/49	12.72	13.98	14.57	13.75	12.63	13.13	13.92	13.22
G2003/47	12.56	13.33	14.10	13.33	12.54	13.13	14.29	13.32
G2004/ 27	12.95	13.52	15.11	13.86	12.19	12.92	14.24	13.11
G84/47	11.94	12.71	12.96	12.54	11.87	12.90	13.48	12.75
Means	12.45	13.31	14.06	13.27	12.34	13.11	14.14	12.19
Rev. LSD 5%								
Varieties (V)		0.38				0.41		
Age at harvest (A)		0.33				0.17		
V x A		Non				0.50		
				Sugar recovery %				
GT 54/9	9.12	9.98	10.20	9.77	9.82	10.42	11.37	10.54
G2003/49	10.66	11.69	11.86	11.40	10.23	10.57	11.13	10.65
G2003/47	10.77	11.11	11.75	11.21	9.93	10.25	11.30	10.49
G2004/ 27	9.95	10.33	11.61	10.63	9.51	10.00	10.79	10.10
G84/47	9.64	10.03	9.43	9.70	9.37	10.24	10.40	10.00
Means	10.03	10.63	10.97	10.54	9.77	10.30	11.00	10.36
Rev. LSD 5%								
Varieties (V)		0.36				0.34		
Age at harvest (A)		0.35				0.19		
V x A		Non				0.62		
				Sugar yield (ton/fed.)				
GT 54/9	3.64	4.16	4.69	4.16	4.71	5.08	5.63	5.14
G2003/49	3.68	4.59	4.97	4.41	4.41	4.48	4.81	4.57
G2003/47	4.03	4.43	4.83	4.43	3.69	4.02	4.47	4.06
G2004/ 27	3.77	4.07	5.08	4.31	3.84	4.19	4.56	4.19
G84/47	3.65	3.91	3.78	3.78	3.59	3.99	4.03	3.87
Means	3.75	4.23	4.67	4.22	4.05	4.35	4.70	4.37
Rev. LSD 5%								
Varieties (V)		0.290				0.240		
Age at harvest (A)		0.140				0.100		
V x A		0.390				0.280		

age at harvest. These results are in harmony with those reported by Abu-Ellail *et al.* (2019), Rakkiyappan *et al.* (2009), Hamam *et al.* (2015), Priyanka *et al.* (2016) and Mebrahtom *et al.* (2017).

Assuming a fixed model for various effects and random model for both replicates and environmental effect, the data of the studied traits of five sugarcane promising varieties in two seasons of plant cane crop were subjected to stability analysis as outlined by Tai (1971). The three ages at harvest and two seasons of plant cane crops (two years) comprised six different environments. The analysis of variance for this model is presented in **Table 4**. If the mean square of the promising varieties x environments interaction is significant, this term could be further separated into two parts, *i.e.* the mean square due to linear responses (α) and the mean square due to deviation from linear responses (λ). The mean and stability parameters of the studied varieties are shown in **Table 5**.

The combined analysis in **Table 4** showed that the environments, promising varieties and the interaction had a highly significant effect on all studied traits except the effect of environments on purity per cent. The highly significant interaction of varieties x environments except for the effect of fiber content revealed that the relative ranks of the varieties differed from one environment to another. Therefore, stability analysis was performed.

The linear responses of stalk height of all the test promising varieties to the environmental effects (α)

Table 4. Mean squares of the combined analyses of variance of the data for all studied characters.

Source of variance	d.f	Stalk height	Stalk diameter	Cane yield	Brix per cent	Sucrose per cent	Reducing sugar	Purity per cent	Fiber per cent	Pol per cent	Sugar recovery	Sugar yield
Environments	5	2957.531**	0.085**	60.393*	14.3138**	8.814**	0.002**	5.812	7.661**	8.834**	3.778**	1.997**
Rep/ Envir.	12	22.933	0.002	1.767	0.186	0.251	0.0003	4.267	0.202	0.210	0.197	0.072
Promising varieties	4	4822.650**	0.138**	134.608**	6.466**	3.321**	0.002**	232.859**	6.472**	2.191**	4.256**	1.752**
Promising varieties x Envir.	20	225.136**	0.011**	10.659**	1.759**	0.603**	0.004**	42.036**	0.219	0.454**	0.683**	0.346**
Error	48	15.322	0.002	2.310	0.273	0.206	0.0002	3.883	0.137	0.150	0.148	0.046

*, **significant at 0.05 and 0.01 level of probability, respectively.

Table 5. Mean of eleven characters and genetic parameters (λ) and (α) in two seasons

Promising varieties	Stalk height (cm)			Stalk diameter (cm)			Cane yield (ton/ fed.)			Brix%		
	×	λ	α	×	λ	α	×	λ	α	×	λ	α
GT 54/9	274.56	0.39	0.01	2.70	0.64	0.47	45.62	4.69*	0.8	19.79	1.43	-0.01
G2003/49	238.89	31.63*	0.25	2.47	11.91*	-0.16	40.76	1.73	0.6	18.66	0.47	-0.15
G2003/47	240.06	5.36*	-0.14	2.58	0.76	0.27	39.04	2.65*	-0.61	18.59	16.07*	-0.46
G2004/ 27	233.94	2.68*	-0.07	2.55	1.06	-0.32	40.93	1.01	-0.01	19.71	8.25*	0.19
G84/47	240.94	29.09*	-0.05	2.64	4.64*	-0.26	38.84	0.43	-0.78	18.75	0.49	0.43
	Sugar recovery%			Sucrose %			Reducing sugar %			Purity%		
	×	λ	α	×	λ	α	×	λ	α	×	λ	α
GT 54/9	10.15	7.39*	0.02	15.59	4.12*	0.04	0.44	7.40	-0.28	78.78	68.06*	60.79
G2003/49	11.02	3.17*	0.09	16.12	2.76*	-0.02	0.44	15.99*	0.66	86.39	13.62*	-27.41
G2003/47	10.85	2.45	0.2	15.93	0.22	-0.08	0.43	14.25*	0.50	85.91	79.10*	-61.89
G2004/ 27	10.36	2.55	0.36	15.77	3.61*	0.32	0.41	28.03*	-1.25	80.06	36.84*	45.70
G84/47	9.85	3.68*	-0.66	15.00	1.93	-0.27	0.42	30.53*	0.37	80.18	12.86*	-17.18
	Sugar yield (ton/ fed.)									Pol%		
	×	λ	α							×	λ	α
GT 54/9	4.65	14.92*	0.51							13.22	4.78*	0.09
G2003/49	4.49	2.17	0.14							13.49	2.49	-0.07
G2003/47	4.24	6.37*	-0.19							13.32	0.13	-0.03
G2004/ 27	4.25	3.98*	0.23							13.49	4.40*	0.23
G84/47	3.82	1.27	-0.69							12.64	1.29	-0.69

+ α values significantly different from α= 0 at the probability level.
* λ values greater than Fa values derived from F table with n1 =4, n2= 48 and a = 0.05

were insignificant. However, the deviation from a linear response (λ) was significant for all the promising varieties except GT 54/9 variety (**Table 5**) indicating that GT 54/9 variety was the only variety among the test varieties which was stable for stalk height and recorded tall canes. The distribution of stability statistics of stalk height (**Fig. 1**) indicated that GT 54/9 variety was located in an area of average stability. Abu-Ellail *et al*. (2020) reported that the trait stalk height of all studied varieties was unstable in overall environments.

Concerning stalk diameter, the linear response of all tested promising varieties to the environmental effect (α) was insignificant. However, the deviation from a linear response (λ) was significant for G2003/49 and G84/47 promising varieties indicating that these two promising

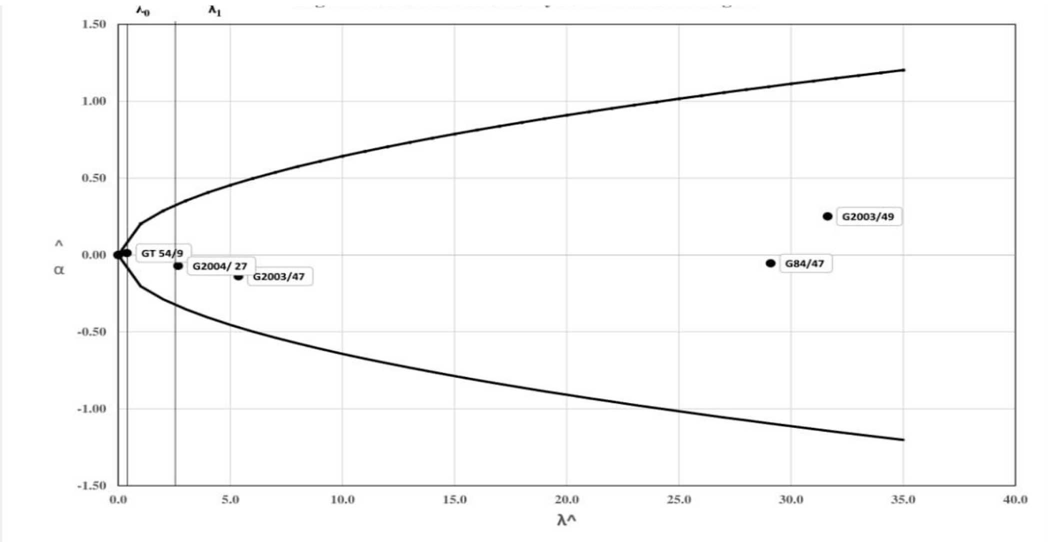

Fig. 1. Destribution of stability statictic of stalk height

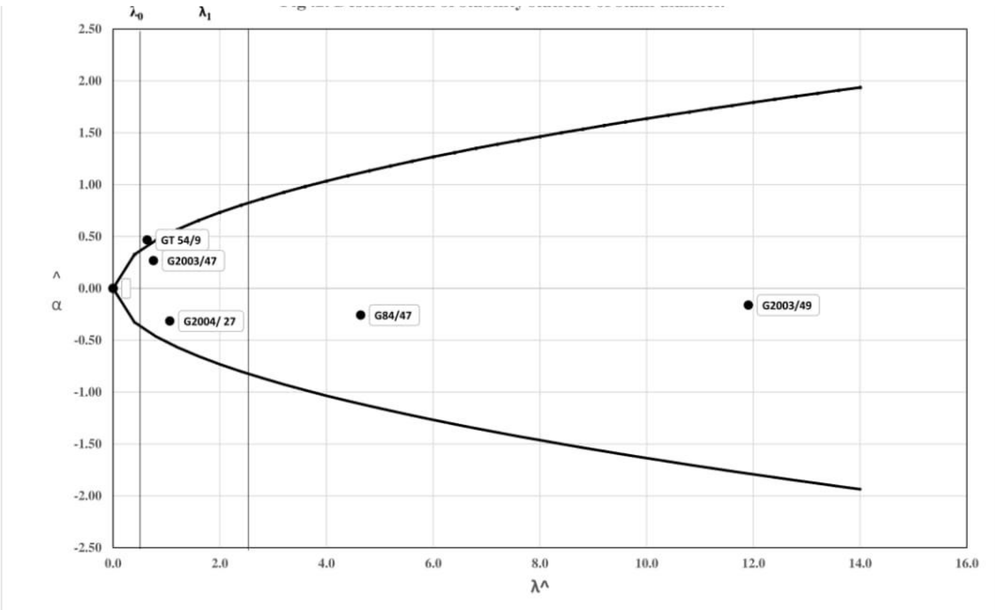

Fig.2. Destribution of stability statictic of stalk diameter

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varieties were unstable while the deviation from a linear response (λ) was insignificant for promising varieties GT 54/9, G2003/47 and G2004/29 indicating that these three varieties were stable. It is obvious that GT 54/9 was the best stable variety for stalk diameter because it recorded the maximum value of stalk diameter in all three ages. The distribution of stability statistics of stalk diameter (**Fig.2**) showed that GT 54/9, G2003/47 and G2004/27 promising varieties were located of average stability. Dubey (2017) in their study **r**evealed that two varieties; CoH 05265 and CoH 5262 were stable for the trait cane thickness.

The linear responses of all the promising varieties to the environmental effect (α) for cane yield were non-significant (**Table 5**). However, the deviation from linear responses (λ) were significant for GT 54/9 variety and variety G2003/47 indicating that these two promising varieties were unstable, while the deviation from linear responses (λ) were insignificant for G2003/49, G2004/27 and G84/47 promising varieties implying that these varieties were stable in cane yield. The distribution of the stability statistics of cane yield (**Fig. 3**) showed that G2003/49 and G2004/27 promising varieties were located in the area of average stability while G84/47 variety proved to be a perfect stable variety because it had (α) and (λ) were not

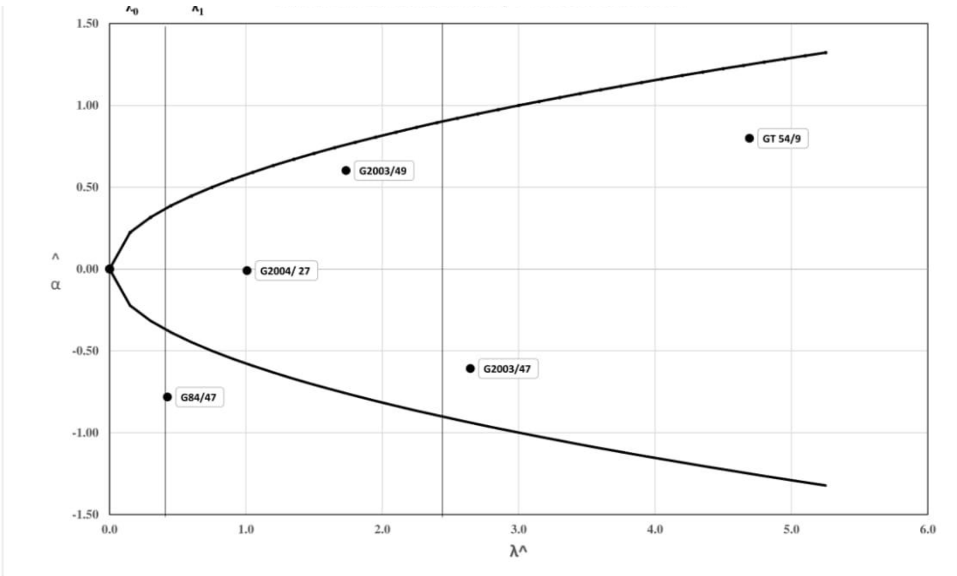

Fig.3. Destribution of stability statictic of Cane yield

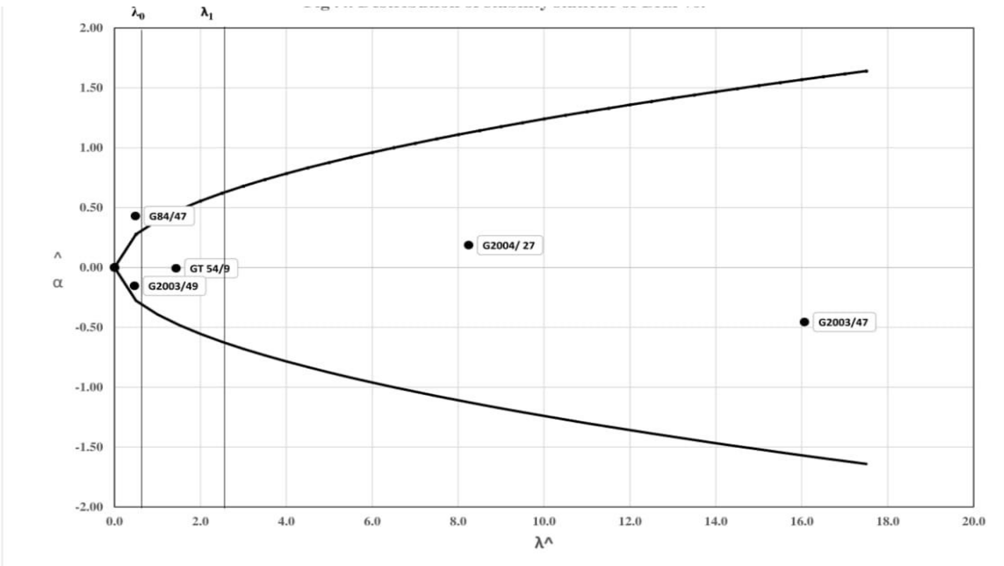

Fig.4. Destribution of stability statictic of Brix %

https://doi.org/10.37992/2021.1203.088

significantly different from (-1.1), respectively. This result was in harmony with those reported by Ali *et al*. (2020).
The linear response of brix for all test promising varieties to environmental effects (α) were non-significant. However, the deviation from linear responses (λ) was significant for G2003/47 and G2004/27 promising varieties showing that these two promising varieties were unstable, while the deviation from linear responses (λ) for GT 54/9, G2003/49 and G84/47 promising varieties was insignificant indicating that these three varieties were stable and GT 54/9 variety was the best for brix centent (19.79%) (Table 5). The distribution of the stability parameters for brix (**Fig. 4**) showed that GT 54/9, G2003/49 and G84/47 promising varieties were located in the area of average stability.
The linear responses of all test varieties to the environmental effects (α) were insignificant for sucrose content, while the deviation from linear responses (λ) was significant for GT 54/9, G2003/49 and G2004/27 promising varieties implying that these three promising varieties were unstable (Table 5). However, the deviation from linear responses (λ) for G2003/47 and G84/47 were not significant indicating that these two promising varieties were stable. The distribution of the stability statistics (**Fig. 5**) indicated that G2003/47 and G84/47 promising varieties had average stability for sucrose content. The results imply that the variety G2003/47 was considered to be superior in sucrose as it had (α) value close to (-1) and (λ) value were not significantly different from (1) and had a high sucrose percentage. These results are in accordance with those obtained by Ali *et al.*

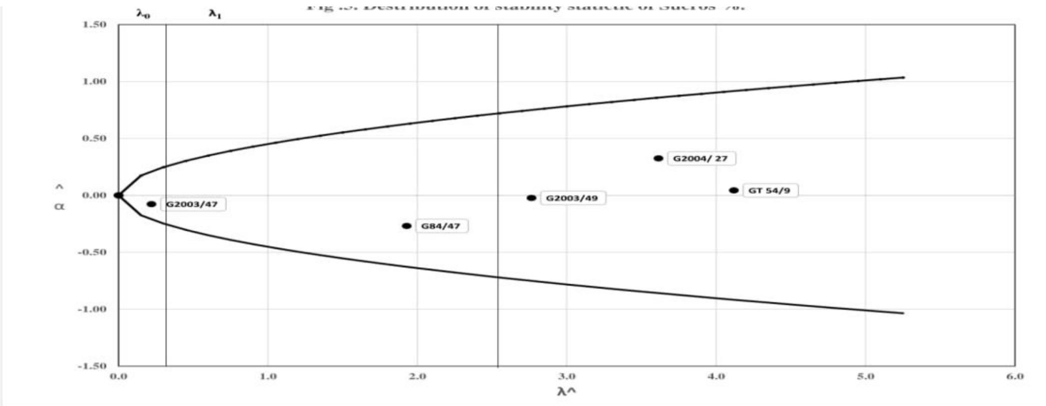

Fig.5. Destribution of stability statictic of Sucros %

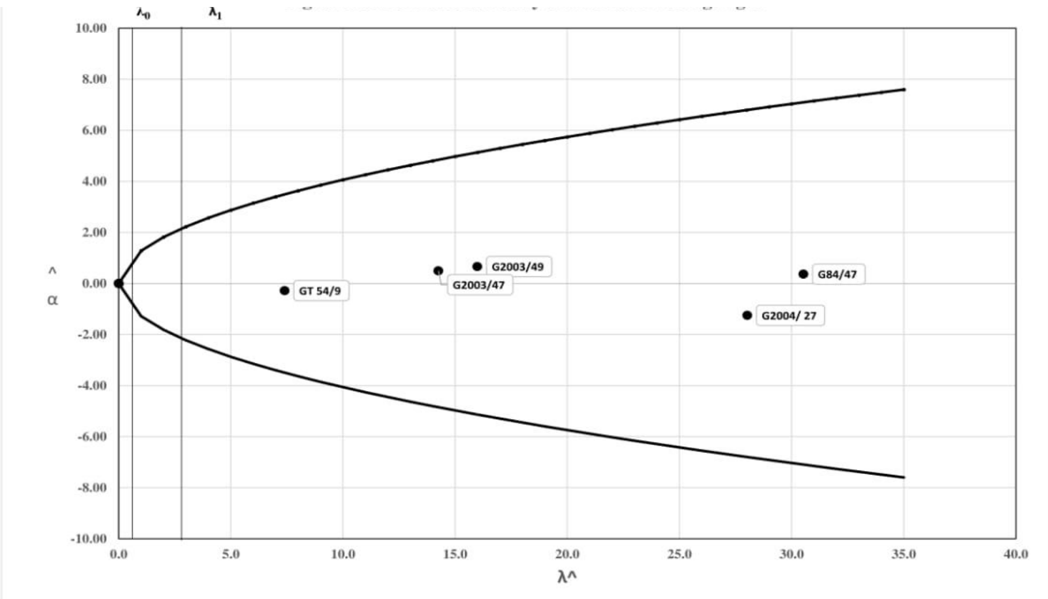

Fig.6. Destribution of stability statictic of reducing sugar

(2020). The linear responses of all test promising varieties to the environmental effects (α) were non-significant for reducing sugar and the deviation from a linear response (λ) was significant for four promising varieties except GT 54/9 variety indicating that only GT 54/9 variety was the stable for reducing sugar and located in the area of average stability (**Fig. 6**).

Data presented in **Table 5** and **Fig. 7** recorded that none of the test promising varieties was stable for purity per cent because of the significant deviation from linear responses of all these promising varieties and non-significant linear response of the varieties to the environmental effects.

Data shown in **Table 5** and **Fig. 8**, revealed that linear responses to the environmental effects (α) for pol per cent were insignificant for all test promising varieties, while the deviation from linear responses (λ) was significant for GT 54/9 variety and G2004/27 variety and was out of the stability area indicating that these two promising varieties were unstable for the trait. However, linear responses to environmental effects (α) and the deviation from linear

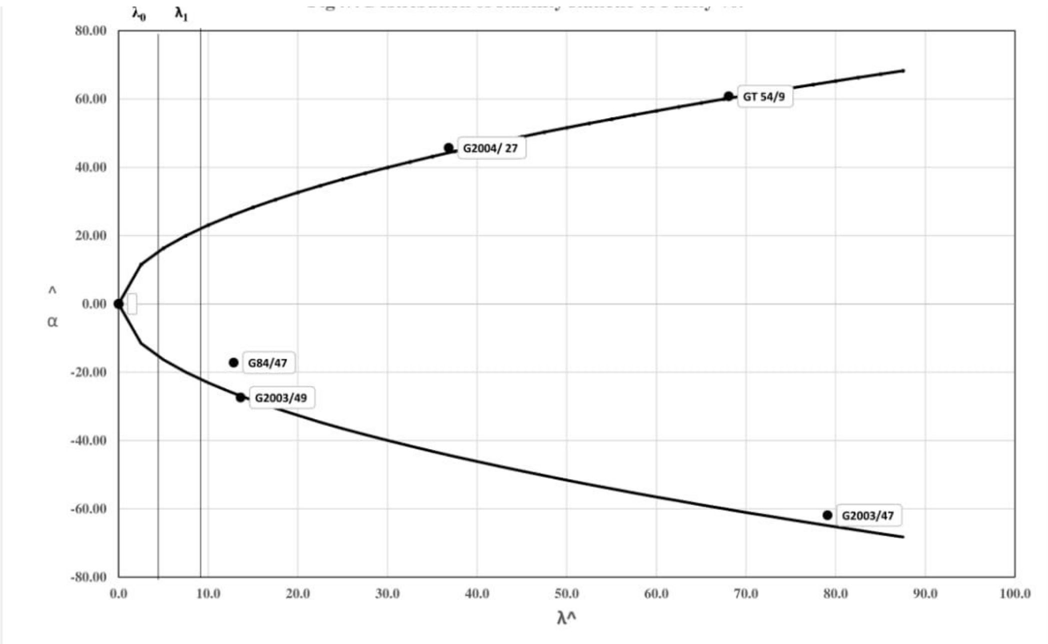

Fig.7. Destribution of stability statictic of Purity %

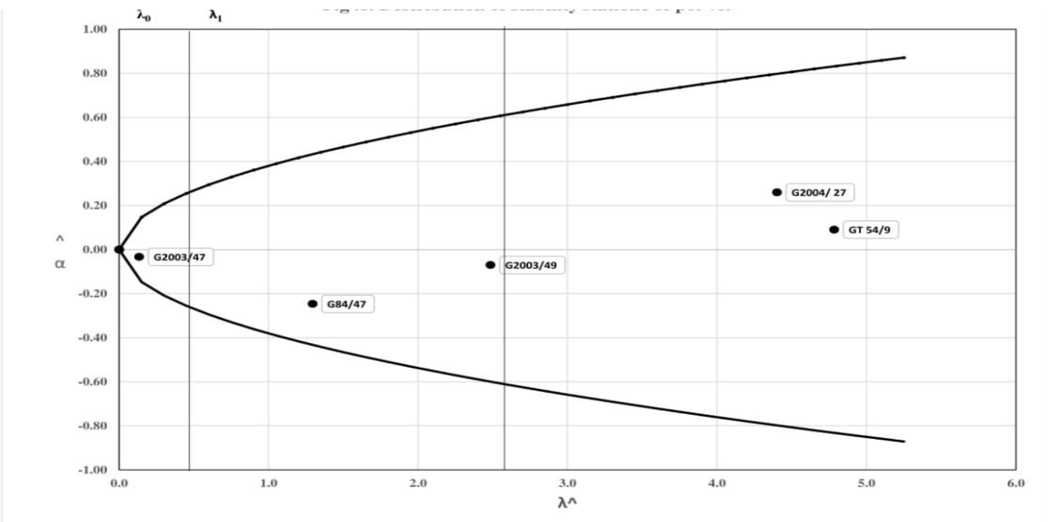

Fig.8. Destribution of stability statictic of Pol %

responses (λ) in G2003/49, G2003/47 and G84/47 were not significant and were located within the average stability area implying that these varieties were stable. These promising varieties had high pol values.

For sugar recovery, stability parameters (α) and (λ) in **Table 5** and **Fig. 9** revealed that all the studied varieties had significant linear responses to the environmental effects (α), while GT 54/9 variety, G2003/49 and G84/47 variety had non-significant deviation from linear responses (λ) indicating that these three varieties were unstable in sugar recovery. The promising varieties G2003/47 and G2004/27 recorded insignificant deviation from linear responses implying that these varieties were stable and located in the area of average stability (**Fig. 10**), in addition to achieving maximum values

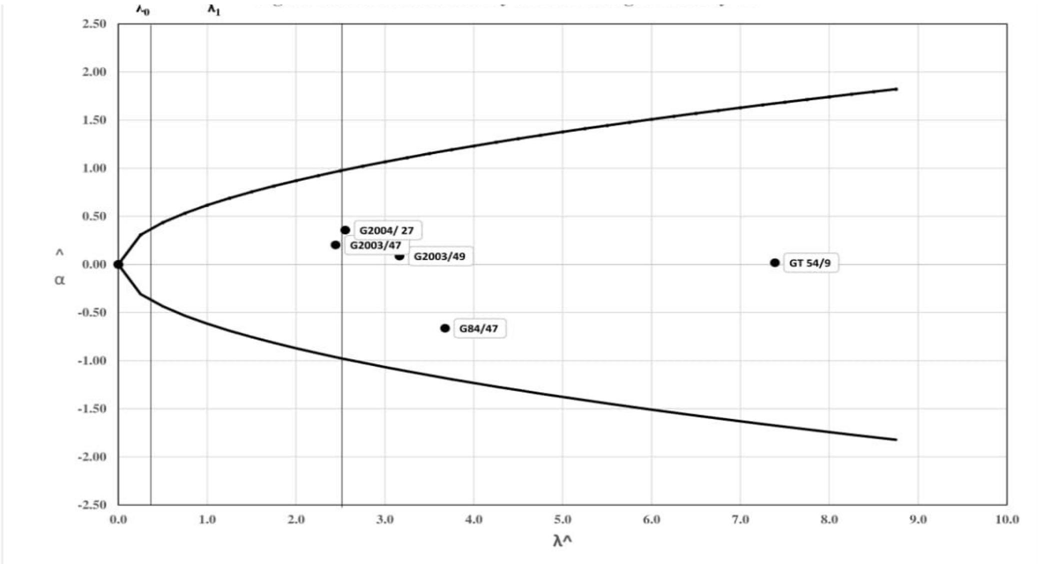

Fig.9. Destribution of stability statictic of sugar recovery %

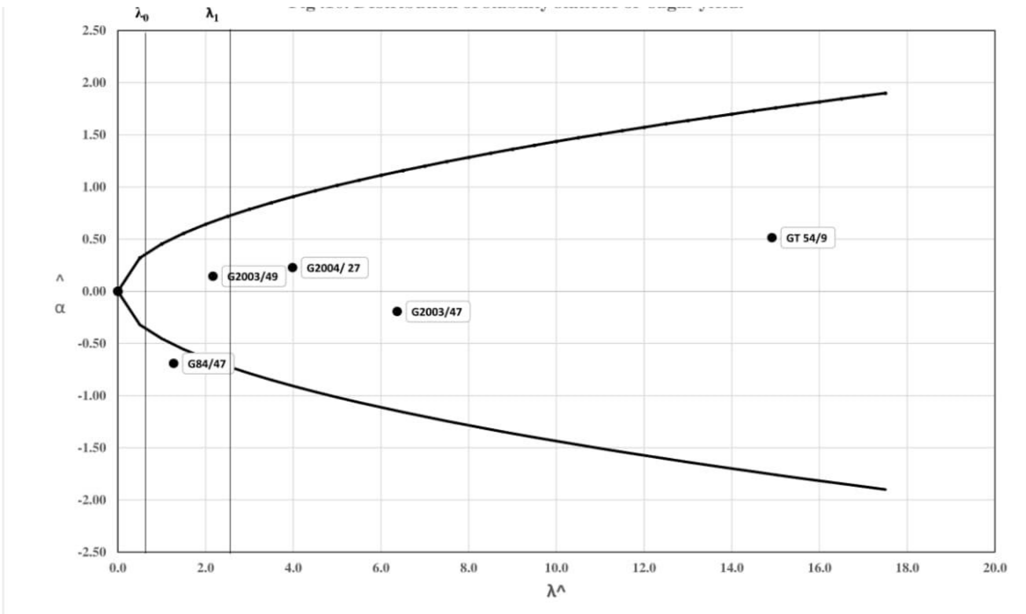

Fig.10. Destribution of stability statictic of sugar yield

of sugar recovery (10.85 and 10.36%), respectively. Muhammad *et al*. (2018) reported similar results.

For sugar yield, the stability parameters in **Table 5** and **Fig. 10** showed that G2003/49 and G84/47 promising varieties were stable in cane yield. This is due to the fact that they had linear responses to the environmental effects (α) and deviation from linear responses (λ) were not significant. G2003/47 variety recorded high sugar yield (4.49 t/fed.) and located in the area of average stability and was stable for cane yield. The variety G84/47 proved to have stability for sugar yield because it had (α and λ) which did not differ significantly from (-1.1). However, it recorded a moderate value of sugar yield (3.82 t/fed.) but it was stable in cane yield. GT 54/9, G2003/47 and G2004/27 varieties had linear insignificant responses to environment effect (α) and significant deviation from linear responses implying that these three promising varieties were unstable in sugar yield. Imtiaz *et al*. (2013) reported that one clone only was stable and recorded the maximum sugar yield compared to that of the commercial varieties.

Stability analysis concluded that GT 54/9 variety was stable for most traits followed by G2003/49 ranked third in cane yield and the second sugar yield. The commercial variety (GT54/9) was superior to the tested varieties for cane and sugar yield implying the necessity of widening the genetic base to produce improved promising varieties.

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