CHARACTERISTIC STABILITY ANALYSIS OF EGGPLANT (*Solanum melongena* L.) GENOTYPES USING PARAMETRIC AND NONPARAMETRIC APPROACHES

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SUMMARY

Eggplant (*Solanum melongena* L.) is one of the important horticultural commodities in Indonesia that has a high productivity. Indonesia has an abundant eggplant germplasm collection in which some have a potential to become a superior variety. Stability analysis of prospective genotypes in different environments is needed to observe its general performance. This research aim to analyze eggplant genotypes performance and appearance in different locations based on altitude. Efforts to quantify the interaction between specific eggplant characteristics and environment can be done with both parametric and non-parametric approaches. A total of 25 eggplant genotypes were planted in three different locations in West Java, Indonesia during the time period of May 2014 – July 2015. This research was conducted using randomized complete block design in each location. Variables observed are fruit length, fruit diameter, fruit weight, plant height and stem diameter. Combined analysis of variance showed highly significant effect of location, genotypes and genotypes x location for all variables observed. Genotypes 2014-044, 2014-047, 2014-077a and 2014-071 were stable based on parametric analysis using Wricke (1962), Finlay & Wilkinson (1963), Eberhart & Russel (1966), Shukla (1972) and Francis & Kannenberg (1978) methods. Nonparametric analysis using Kang (1988) and Thennarasu (1955) methods showed that genotypes 2014-033, 2014-024, 2014-080, 2014-071 and THP were stable. Overall, genotype 2014-071 was the only genotype that was stable in both parametric and nonparametric analysis. This genotype performs well and has generally consistent appearance in all location.

Keywords: Interaction, GxE, environment, multilocation, fruit, vegetable, performance

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the important horticultural commodities in Indonesia that has a high productivity. This vegetable has a high economic value and can support human health, since it has high vitamin and high antioxidant content. It is widely distributed in tropical and temperate zones of China, Turkey, Syria, Iraq, Japan, Indonesia, Philippines, Thailand and Jordan (Hedges and Lister, 2007; Daunay and Janick, 2007; Sathappan *et al.*, 2012). Indonesia has an abundant eggplant germplasm collection in which some have a potential to become a superior variety.

Successful new varieties must show high performance for yield and other essential agronomic traits. Their superiority should be reliable over a wide range of environmental conditions (Becker and Leon, 1988). Thus, prospective genotypes stability analysis in different environments is needed to observe its general performance. Genotype stability is the genotype's ability to have a similar phenotypic performance in a variety of diverse environment. In other words, the characteristic of the genotype is not much changed in each of the environments.

Measures of adaptability and stability are necessary to suggest a target environment for the preferred genotypes (Kılıç, 2012) since different genotypes has different performance in different locations. A stable genotype is a genotype that has a consistent performance in different environment, while unstable genotypes only perform well in a specific location. This research aim to analyze eggplant genotypes performance and appearance in different locations based on altitude.

MATERIALS AND METHODS

The genetic materials used for this experiment were 25 eggplant genotypes that consist of 5 open pollinated commercial varieties, 2 genotypes from CTHS collection and 18 local genotypes explored from East Java. The list of genetic materials used is stated in Table 1.

Table 1. List of genetic materials used in the experiment

Code	Genotype	No	Genotype
G1	TUP^1	G14	2014-024^3
G2	THP^1	G15	2014-029^3
G3	Bruno^2	G16	2014-067^3
G4	Pulus^2	G17	2014-080^3
G5	Hijo^2	G18	2014-050^3
G6	Ronggo^2	G19	2014-044^3
G7	Sriti^2	G20	2014-034^3
G8	2013-057-1^3	G21	2014-054^3
G9	2014-040^3	G22	2014-008^3
G10	2014-033^3	G23	2014-047^3
G11	2014-013^3	G24	2014-077^3
G12	2014-052^3	G25	2014-071^3
G13	2014-032^3		

^{1} being genotypes from the CTHS collection, ^{2} being genotypes from open pollinated commercial varieties and ^{3} being genotypes from CTHS collection explored from East Java

The field experiment was conducted from May 2014 until July 2015 at three different experimental field stations of University Farm and Center for Tropical Horticulture Studies (CTHS), Bogor Agricultural University. The three experimental fields are Cikabayan (6°55'13.23"

S, 106°71'53.6" E) with an altitude of 160 m above sea level, Tajur (6°63'62.4" S, 106°82.34" E) with an altitude of 340 m above sea level and Pasir Sarongge (6°76'64.07" S, 107°04'96.09" E) with an altitude of 1105 m above sea level. All experimental fields are located in West Java, Indonesia.

The experiment was arranged in randomized complete block design with three replications in each location. Seeds are sowed in plastic sowing tray and watered regularly. Five-week old seedlings were transplanted manually in a 5 x 1 m plot for each experimental unit. Each genotype is planted at a spacing of 50 × 50 cm between and within rows in each plot. As many as 10 plants out of 20 plants in each plot were chosen and observed for the experiment. Harvesting was done manually when the fruit is firm but and before the seeds are visible in the fruit's flesh.

Variables observed in this experiment are fruit length (cm), fruit diameter (mm), fruit weight (g), plant height (cm) and stem diameter (mm). The parameters observed refer to the guideline made by the Plant Variety Protection Center, Indonesian Ministry of Agriculture (2007).

Data analysis was done by using Microsoft Excel, SAS and IRRI Statistical Tool for Agricultural Research (STAR). A combined analysis of variance across the test environments was done. Differences between genotypes and locations are tested using F-test (α=5%) and followed by Duncan Multiple Range Test (DMRT). Further data analysis was made using parametric and nonparametric approaches. As many as five parametric analyses were used in this experiment. Wricke's (1962) method used ecovalence (W_i^2) as a stability parameter while Finlay & Wilkinson's (1963) method used regression coefficient (b_i). Eberhart and Russel's (1966) method used deviation from regression parameter (δ^2) and regression coefficient (β_i), Shukla's (1972) method used stability variance (σ_i^2), and Francis and Kannenberg's (1978) method used coefficient of variability (CV_i) and genotypic variance (S_i^2) as a stability parameter.

Meanwhile, two methods are used in nonparametric analysis of the data observed. Kang's (1988) method in using rank-sum (Ysi) is a procedure where both yield and Shukla's (1972) stability variance were used as selection criteria. Thennarasu's (1955) method used non-parametric stability index according to the average corrected ranking of each genotype in the different locations (NPi1, NPi2, NPi3 and NPi4).

RESULTS

Performance of the eggplant genotypes is an important indicator to see its stability in different locations. During the course of observation we found as many as 32 distinct genotypes according to its fruit size and color even though 25 genotypes were used in the experiment. In this case, some genotypes had as many as 2 or 3 different fruit phenotypic difference. Combined analysis of variance for all the characters observed showed that environments' main effect, genotypes' main effects as well as genetic and environment interaction (GxE) for all characters were significant at $P \leq 0.01$. Coefficient of variance in each characters varied 7.04 % to 19.1 % (Table 2).

Table 2. F-value and CV of observed variable

Characters	**F-Value**			**CV (%)**
	Environment	**Genotipe**	**GxE**	
Fruit length	90.53**	107.72**	4.37**	14.16
Fruit diameter	103.03**	42.82**	4.72**	10.01
Fruit weight	242.14**	89.21**	9.67**	19.1
Plant height	619.59**	10.14**	3.91**	8.99
Stem diameter	1180.72**	6.31**	3.35**	7.04

** Significant at $P \leq 0.01$ probability level

Fruit length for genotypes ranges from the average of 29.47 cm to 2.47 cm. Fruit diameter for genotypes ranges from the average of 94.54 mm to 28.59 mm. Fruit weight for all genotypes ranges from the average of 394.36 g to 10.08 g. Plant height for the genotypes ranges from the average of 94.39 cm to 67.06 cm. Stem diameter for genotypes ranges from the average of 18.34 mm to 14.31 mm. Considering the location, Pasir Sarongge has the highest average of all the characters.

S_i^2 = genotypic variance, CV_i = coefficient of variability for Francis and Kannenberg's method; (W_i^2 = ecovalence for Wricke's method; b_i = regression coefficient for Finlay & Wilkinson's method; $'^2$ = regression parameter, $'_i$ = regression coefficient for Eberhart and Russel's method; $'_i^2$ = stability variance for Shukla's method; NPi1, NPi2, NPi3 and NPi4 = average corrected ranking of each genotype in the different locations for Thennarasu's method; Ysi = rank-sum for Kang's method

In Cikabayan, G25 has the longest fruit length (25.15 cm) but not significantly different from G2, G4 and G21a. In Tajur, G21a has the longest fruit length (29.21 cm) but not significantly different from G2, G4, G16a and G25. As for Pasir Sarongge, G21b has the longest fruit length (39.49 cm) but not significantly different from G2 and G16. In all location, G7 has the shortest fruit length (2.60 cm to 2.28 cm) out of all genotypes in all location.

G6 has the biggest fruit diameter in Cikabayan (92.20 mm) and Tajur (92.72 mm) location. G8 has the biggest fruit diameter in Pasir Sarongge (107.97 mm) but not significantly different from G6. G7 has the shortest fruit diameter of all the genotype in three locations (29.99 mm to 27.62 mm).

G6 (277.02 g) and G8 (340.05 g) have the heaviest fruit weight in Cikabayan. The same genotype G8 also has the heaviest fruit weight in Tajur (344.23 g) but not significantly different from G6 and G11. Genotype G16 has the heaviest fruit weight in Pasir Sarongge (539.19 g) but not significantly different from G8. G7 has the smallest fruit weight (11.82 g to 8.67 g) in all locations.

The character plant height showed G19b has the highest height in Cikabayan (71.94 cm), G22 has the highest height in Tajur (128.45 cm) and G9 has the highest height in Pasir Sarongge (112.33 cm). The lowest plant height for Cikabayan, Tajur and Pasir Sarongge location are G1 (45.87 cm), G6 (70.87 cm) and G25 (73.67 cm) respectively. Genotype G22 has the biggest stem diameter in Cikabayan (13.45 mm) and Tajur (21.19 mm). Genotype G8 has the biggest stem diameter in Pasir Sarongge (23.29 mm). Genotypes with the smallest stem diameter are G25 in Cikabayan (9.51 cm), G1 in Tajur (14.37 cm) and G19b in Pasir Sarongge (16.43 mm).

Table 3. Fruit length and fruit diameter of 25 eggplant genotypes grown at three environments

Genotype	**Fruit length**				**Fruit diameter**			
	Cikabayan	**Tajur**	**Pasir Sarongge**	**Average**	**Cikabayan**	**Tajur**	**Pasir Sarongge**	**Average**
G1	21.09^{abc}	$23.92^{\text{b-e}}$	29.07^{b}	24.69^{AB}	$42.66^{\text{e-j}}$	$44.72^{\text{h-k}}$	$54.02^{\text{f-i}}$	$47.13^{\text{F-K}}$
G2	24.82^{a}	26.86^{abc}	36.74^{a}	29.47^{A}	$38.79^{\text{h-k}}$	39.54^{jk}	44.45^{ijk}	40.92^{JKL}
G3	21.96^{abc}	20.43^{def}	25.59^{cd}	22.66^{BC}	$45.27^{\text{d-j}}$	$52.30^{\text{d-h}}$	$58.46^{\text{e-h}}$	$52.01^{\text{D-K}}$
G4	23.86^{a}	28.09^{ab}	29.95^{b}	27.30^{AB}	$41.19^{\text{f-k}}$	42.09^{ijk}	51.79^{ghi}	$45.02^{\text{H-K}}$
G5	$19.65^{\text{a-d}}$	$21.81^{\text{c-f}}$	26.75^{bcd}	22.74^{BC}	$49.89^{\text{c-i}}$	$50.25^{\text{e-i}}$	$63.29^{\text{d-g}}$	$54.48^{\text{D-J}}$
G6	$12.38^{\text{e-i}}$	13.96^{gh}	15.13^{i}	13.83^{DE}	**92.20^{a}**	**92.72^{a}**	98.69^{a}	94.54^{A}
G7	**2.60^{j}**	**2.28^{m}**	**2.53^{k}**	2.47^{I}	**29.99^{k}**	**27.62^{l}**	**28.16^{l}**	28.59^{L}
G8	13.05^{efg}	17.84^{fg}	18.12^{gh}	16.34^{D}	$53.14^{\text{c-f}}$	74.63^{b}	**107.97^{a}**	78.58^{B}
G9	13.69^{ef}	19.55^{def}	24.29^{de}	19.18^{CD}	$43.85^{\text{d-j}}$	$56.10^{\text{c-g}}$	67.05^{cde}	$55.67^{\text{C-I}}$
G10	$16.13^{\text{c-f}}$	18.25^{fg}	20.35^{fg}	18.24^{CD}	53.33	$51.15^{\text{e-i}}$	$59.92^{\text{d-h}}$	$54.80^{\text{D-J}}$
G11	$11.45^{\text{e-i}}$	19.05^{efg}	17.14^{hi}	15.88^{D}	$58.41^{\text{c-f}}$	$56.67^{\text{c-g}}$	77.40^{bc}	64.16^{CDE}
G12a	6.79^{hij}	9.39^{hij}	9.45^{j}	$8.54^{\text{E-H}}$	$39.66^{\text{g-k}}$	$52.37^{\text{d-h}}$	52.71^{ghi}	$48.25^{\text{F-K}}$
G12b	$7.19^{\text{g-j}}$	11.04^{hi}	10.78j	9.67^{EF}	$46.23^{\text{d-j}}$	$54.35^{\text{c-h}}$	$57.36^{\text{e-h}}$	$52.65^{\text{D-J}}$
G12c	$7.35^{\text{g-j}}$	11.04^{hi}	9.45^{j}	9.28^{EFG}	$42.04^{\text{e-j}}$	$52.37^{\text{d-h}}$	52.71^{ghi}	$49.04^{\text{F-K}}$
G13	$17.13^{\text{b-e}}$	18.85^{efg}	18.63^{fgh}	18.20^{CD}	54.11^{cde}	62.77^{c}	$62.50^{\text{d-g}}$	$59.80^{\text{C-G}}$
G14	14.74^{edf}	17.97^{fg}	19.41^{fgh}	17.37^{CD}	55.10^{cd}	59.68^{cde}	70.44^{cd}	$61.74^{\text{C-F}}$
G15	$16.07^{\text{c-f}}$	19.02^{efg}	21.62^{ef}	18.90^{CD}	$46.10^{\text{d-j}}$	$47.25^{\text{g-k}}$	$58.67^{\text{e-h}}$	$50.67^{\text{D-K}}$
G16a	$19.98^{\text{a-d}}$	$24.84^{\text{a-d}}$	36.90^{a}	27.24^{AB}	$50.59^{\text{c-h}}$	$48.33^{\text{f-k}}$	70.82^{cd}	$56.58^{\text{C-I}}$
G16b	22.15^{ab}	$23.30^{\text{b-f}}$	36.90^{a}	27.45^{AB}	$52.24^{\text{c-f}}$	$47.69^{\text{f-k}}$	70.82^{cd}	$56.92^{\text{C-I}}$
G17	$19.49^{\text{a-d}}$	$21.99^{\text{c-f}}$	26.95^{bcd}	22.81^{BC}	$43.02^{\text{d-j}}$	$47.63^{\text{f-k}}$	$57.34^{\text{e-h}}$	$49.33^{\text{F-K}}$
G18	6.91^{hij}	$7.80^{\text{i-l}}$	8.40^{j}	$7.70^{\text{F-I}}$	$43.70^{\text{d-j}}$	$46.06^{\text{h-k}}$	49.30^{hij}	$46.35^{\text{G-K}}$
G19a	6.72^{hij}	$7.80^{\text{i-l}}$	8.40^{j}	$7.64^{\text{F-I}}$	$41.68^{\text{f-j}}$	$46.06^{\text{h-k}}$	49.30^{hij}	$45.68^{\text{G-K}}$
G19b	3.18^{j}	3.46^{lm}	3.25^{k}	3.29^{HI}	34.10^{jk}	39.27^{k}	39.48^{jk}	37.62^{KL}
G20	$12.57^{\text{e-h}}$	18.19^{fg}	19.93^{fgh}	16.90^{D}	$51.55^{\text{c-g}}$	61.51^{cd}	81.66^{b}	64.91^{CD}
G21a	23.30^{a}	**29.21^{a}**	28.49^{bc}	27.00^{AB}	$45.73^{\text{d-j}}$	$46.21^{\text{h-k}}$	84.50^{b}	$58.81^{\text{C-H}}$
G21b	$20.55^{\text{a-d}}$	$23.21^{\text{b-f}}$	**39.49^{a}**	27.75^{AB}	$42.83^{\text{e-j}}$	$51.34^{\text{e-i}}$	$53.93^{\text{f-i}}$	$49.37^{\text{F-K}}$
G22	3.95^{ghi}	$4.46^{\text{j-m}}$	4.54^{k}	$4.32^{\text{F-I}}$	69.09^{b}	74.78^{b}	64.89^{def}	69.59^{BC}
G23a	$10.49^{\text{f-i}}$	$7.42^{\text{i-m}}$	8.57^{j}	$8.83^{\text{E-H}}$	$46.15^{\text{d-j}}$	$49.21^{\text{f-j}}$	$54.45^{\text{f-i}}$	$49.94^{\text{E-K}}$
G23b	6.49^{ij}	$8.97^{\text{h-k}}$	8.41^{j}	$7.96^{\text{F-I}}$	$43.30^{\text{d-j}}$	$57.19^{\text{c-f}}$	49.70^{hij}	$50.06^{\text{E-K}}$
G24a	$7.78^{\text{g-j}}$	$8.97^{\text{h-k}}$	3.17^{k}	$6.64^{\text{F-I}}$	$48.53^{\text{c-i}}$	$49.21^{\text{f-j}}$	34.29^{kl}	44.01^{IJK}
G24b	4.21^{j}	3.67^{klm}	3.17^{k}	3.68^{GHI}	38.23^{ijk}	39.66^{jk}	34.29^{kl}	37.39^{KL}
G25	**25.15^{a}**	26.79^{abc}	29.93^{b}	27.29^{AB}	$41.71^{\text{f-j}}$	$48.03^{\text{f-k}}$	44.29^{ijk}	$44.68^{\text{H-K}}$
Average	13.84^{C}	16.23^{B}	18.80^{A}		47.64^{C}	52.15^{B}	59.52^{A}	

Mean in the same column and row followed by a common letter are not significantly different at P ≤ 0.05 by DMRT. Different capital letter(s) indicate significant difference between environments and between cultivars.

Table 4. Fruit weight of 25 eggplant genotypes grown at three environments

Genotype	Fruit weight			
	Cikabayan	**Tajur**	**Pasir Sarongge**	**Average**
G1	153.92^{cde}	197.53^{b}	326.76^{cd}	226.07^{BC}
G2	139.20^{de}	168.19^{bcd}	283.22^{def}	196.87^{BCD}
G3	153.60^{cde}	192.13^{b}	319.13^{cde}	221.62^{BC}
G4	102.67^{efg}	195.80^{b}	261.29^{ef}	186.59^{B-E}
G5	194.68^{cbd}	194.57^{b}	323.18^{cd}	237.48^{BC}
G6	**377.02^{a}**	**327.67^{a}**	478.41^{b}	394.36^{A}
G7	**9.76^{h}**	**8.67^{h}**	**11.82^{j}**	10.08^{F}
G8	340.05^{a}	344.23^{a}	490.79^{ab}	391.69^{A}
G9	161.65^{cde}	211.43^{b}	308.25^{de}	227.11^{BC}
G10	129.54^{e}	182.93^{bc}	248.42^{fg}	186.96^{B-E}
G11	210.03^{bc}	**284.67^{a}**	313.52^{de}	269.41^{BC}
G12a	62.16^{gh}	107.50^{def}	81.44^{h}	83.70^{EFD}
G12b	62.16^{gh}	107.50^{def}	81.44^{h}	83.70^{EFD}
G12c	62.16^{gh}	107.50^{def}	81.44^{h}	83.70^{EFD}
G13	225.37^{b}	178.13^{bcd}	197.36^{g}	200.29^{BC}
G14	140.23^{de}	166.67^{bcd}	314.24^{de}	207.04^{BC}
G15	146.16^{de}	151.53^{bcde}	271.46^{def}	189.72^{B-E}
G16a	194.01^{cbd}	173.37^{bcd}	**539.19^{a}**	302.19^{AB}
G16b	194.01^{cbd}	173.37^{bcd}	**539.19^{a}**	302.19^{AB}
G17	126.34^{ef}	198.27^{b}	319.00^{cde}	214.53^{BC}
G18	56.50^{gh}	67.63^{fgh}	70.07^{hi}	64.73^{F}
G19a	56.50^{gh}	67.63^{fgh}	70.07^{hi}	64.73^{F}
G19b	20.57^{h}	20.23^{gh}	16.23^{ij}	19.01^{F}
G20	141.07^{de}	209.30^{b}	303.93^{def}	218.10^{BC}
G21a	201.72^{cbd}	169.77^{bcd}	373.14^{c}	248.21^{BC}
G21b	201.72^{cbd}	169.77^{bcd}	373.14^{c}	248.21^{BC}
G22	70.38^{fgh}	116.40^{c-d}	69.03^{hi}	85.27^{EFD}
G23a	69.48^{efg}	87.43^{gh}	74.11^{hi}	77.01^{EF}
G23b	69.48^{efg}	87.43^{gh}	74.11^{hi}	77.01^{EF}
G24a	15.82^{h}	23.30^{gh}	23.53^{hij}	20.88^{F}
G24b	15.82^{h}	23.30^{gh}	23.53^{hij}	20.88^{F}
G25	142.47^{de}	191.33^{b}	205.95^{g}	179.92^{CDE}
Average	132.70^{B}	153.29^{B}	233.32^{A}	

Mean in the same column and row followed by a common letter are not significantly different at P ≤ 0.05 by DMRT. Different capital letter(s) indicate significant difference between environments and between cultivars.

Table 5. Plant height and stem diameter of 25 eggplant genotypes grown at three environments

Genotype	Plant height				Stem diameter			
	Cikabayan	Tajur	Pasir Sarongge	Average	Cikabayan	Tajur	Pasir Sarongge	Average
G1	**45.87^{cd}**	71.53^{h}	84.67^{ghi}	67.36^{FG}	10.84^{b-f}	**14.37^{f}**	19.24^{b-e}	14.82^{C}
G2	54.00^{bcd}	89.27^{c-g}	89.73^{d-h}	77.67^{B-G}	10.97^{b-f}	16.19^{c-f}	18.48^{c-h}	15.22^{C}
G3	58.64^{a-d}	73.13^{gh}	87.53^{e-h}	73.10^{C-G}	10.85^{b-f}	15.08^{def}	18.59^{b-h}	14.84^{C}
G4	52.18^{bcd}	73.33^{gh}	85.33^{f-i}	70.28^{EFG}	11.74^{a-d}	16.39^{c-f}	19.60^{bcd}	15.91^{BC}
G5	59.29^{a-d}	76.27^{e-h}	93.27^{d-h}	76.28^{B-G}	11.17^{b-f}	15.75^{c-f}	19.41^{b-e}	15.44^{C}
G6	66.51^{ab}	**70.87^{h}**	87.67^{e-h}	75.02^{B-G}	11.39^{b-f}	15.39^{c-f}	20.54^{bc}	15.77^{C}
G7	58.81^{a-d}	93.60^{cd}	85.13^{f-i}	79.18^{A-G}	10.21^{c-f}	16.03^{c-f}	16.68^{hi}	14.31^{C}
G8	55.89^{bcd}	100.13^{bc}	95.67^{c-f}	83.90^{A-F}	12.46^{ab}	19.28^{ab}	**23.29^{a}**	18.34^{A}
G9	62.91^{abc}	96.47^{cd}	**112.33^{a}**	90.57^{AB}	12.13^{abc}	17.65^{bcd}	19.90^{bcd}	16.56^{ABC}
G10	57.14^{a-d}	91.40^{cde}	98.80^{bcd}	82.45^{A-G}	11.07^{b-f}	17.36^{b-e}	19.46^{b-e}	15.96^{BC}
G11	52.76^{bcd}	71.47^{h}	90.08^{d-h}	71.44^{D-G}	11.49^{b-e}	15.73^{c-f}	19.02^{b-g}	15.42^{C}
G12a	58.37^{a-d}	95.73^{cd}	108.87^{ab}	87.66^{A-D}	11.42^{b-f}	17.03^{b-e}	17.46^{e-i}	15.30^{C}
G12b	58.37^{a-d}	95.73^{cd}	108.87^{ab}	87.66^{A-D}	11.42^{b-f}	17.03^{b-e}	17.46^{e-i}	15.30^{C}
G12c	58.37^{a-d}	95.73^{cd}	108.87^{ab}	87.66^{A-D}	11.42^{b-f}	17.03^{b-e}	17.46^{e-i}	15.30^{C}
G13	65.44^{ab}	88.60^{c-g}	105.73^{abc}	86.59^{A-E}	9.57^{ef}	17.37^{b-e}	18.61^{b-h}	15.18^{C}
G14	53.41^{bcd}	81.27^{d-h}	82.47^{hij}	72.38^{C-G}	10.16^{def}	17.14^{b-e}	17.04^{ghi}	14.78^{C}
G15	53.90^{bcd}	71.53^{h}	75.73^{ij}	67.06^{G}	11.19^{b-f}	14.40^{f}	18.81^{b-g}	14.80^{C}
G16a	58.47^{a-d}	80.20^{d-h}	96.50^{cde}	78.39^{A-G}	11.47^{b-e}	14.95^{ef}	17.19^{f-i}	14.54^{C}
G16b	58.47^{a-d}	80.20^{d-h}	96.50^{cde}	78.39^{A-G}	11.47^{b-e}	17.27^{b-e}	17.19^{f-i}	15.31^{C}
G17	62.48^{abc}	90.00^{c-f}	96.93^{cde}	83.14^{A-G}	11.79^{a-d}	17.27^{b-e}	20.39^{bc}	16.49^{ABC}
G18	64.33^{ab}	114.07^{ab}	96.50^{cde}	91.63^{AB}	11.17^{b-f}	19.18^{ab}	17.87^{d-i}	16.07^{BC}
G19a	64.33^{ab}	114.07^{ab}	96.50^{cde}	91.63^{AB}	11.17^{b-f}	19.18^{ab}	17.87^{d-i}	16.07^{BC}
G19b	71.94^{a}	99.93^{bc}	93.07^{d-h}	88.31^{ABC}	11.53^{bcd}	20.78^{a}	**16.43^{hi}**	16.25^{ABC}
G20	56.57^{a-d}	74.00^{fgh}	95.50^{c-g}	75.36^{B-G}	10.64^{b-f}	16.26^{c-f}	20.56^{b}	15.82^{C}
G21a	53.13^{bcd}	82.87^{d-h}	97.27^{cde}	77.76^{A-G}	10.81^{b-f}	17.85^{bc}	19.17^{b-f}	15.94^{BC}
G21b	53.13^{bcd}	82.87^{d-h}	97.27^{cde}	77.76^{A-G}	10.81^{b-f}	17.85^{bc}	19.17^{b-f}	15.94^{BC}
G22	68.00^{ab}	**128.45^{a}**	86.73^{e-h}	94.39^{A}	**13.45^{a}**	**21.19^{a}**	19.88^{bcd}	18.17^{AB}
G23a	65.20^{ab}	96.67^{cd}	99.47^{bcd}	87.11^{A-D}	10.51^{c-f}	16.11^{c-f}	18.25^{d-i}	14.96^{C}
G23b	65.20^{ab}	96.67^{cd}	99.47^{bcd}	87.11^{A-D}	10.51^{c-f}	16.11^{c-f}	18.25^{d-i}	14.96^{C}
G24a	65.31^{ab}	102.36^{bc}	90.53^{d-h}	86.07^{A-E}	11.79^{a-d}	17.62^{bcd}	19.50^{b-e}	16.30^{ABC}
G24b	65.31^{ab}	102.36^{bc}	90.53^{d-h}	86.07^{A-E}	11.79^{a-d}	17.62^{bcd}	19.50^{b-e}	16.30^{ABC}
G25	48.49^{cd}	83.20^{d-h}	**73.67^{j}**	68.45^{FG}	**9.51^{f}**	16.92^{b-f}	16.66^{hi}	14.36^{C}
Average	59.13^{C}	89.50^{B}	93.97^{A}		11.19^{C}	17.04^{B}	18.72^{A}	

Mean in the same column and row followed by a common letter are not significantly different at $P \leq 0.05$ by DMRT. Different capital letter(s) indicate significant difference between environments and between cultivars.

Table 6. Parametric and nonparametric analysis for fruit length character

Genotype	**Parametric**							**Nonparametric**				
	S_i^2	**CV_i**	**W_i^2**	**b_i**	**δ^2**	**β_i**	**σ_i^2**	**NPi1**	**NPi2**	**NPi3**	**NPi4**	**Ysi**
G1	321.19	72.58	5.34	1.23	641.46	0.05	7.63	**6.00**	**0.20**	9.01	0.14	**28**
G2	474.98	73.95	34.05	1.87	937.39	0.75	53.57	10.00	**0.27**	13.21	0.39	**35**
G3	263.81	71.67	7.95	0.59	524.83	0.17	11.81	21.00	**0.24**	15.30	0.11	**24**
G4	382.34	71.63	**1.70**	0.92	764.58	0.01	**1.82**	13.00	**0.14**	9.48	0.15	**32**
G5	271.79	72.50	**3.44**	2.02	526.13	1.04	**4.59**	10.00	**0.23**	8.47	0.09	**25**
G6	97.48	71.41	**2.49**	0.43	189.45	0.33	**3.07**	**6.33**	**0.17**	**4.66**	**0.02**	12
G7	**3.08**	71.04	12.69	**-0.01**	**-10.90**	**1.02**	19.39	20.00	1.33	14.60	0.04	-2
G8	141.56	72.83	**3.66**	1.94	268.36	0.88	**4.94**	16.00	0.31	11.41	0.04	**16**
G9	212.03	75.93	16.17	1.45	420.59	0.21	24.97	19.67	0.40	14.43	0.09	22
G10	170.89	71.65	**0.27**	0.65	339.74	0.12	**-0.48**	**5.33**	**0.10**	**3.92**	**0.02**	**20**
G11	141.69	74.96	15.90	1.39	280.77	0.16	24.53	26.00	0.54	18.54	0.07	13
G12a	38.79	72.91	**3.87**	1.01	77.58	0.00	**5.29**	**6.67**	0.40	**5.56**	**0.02**	6
G12b	51.40	74.13	**3.98**	0.69	101.14	0.10	**5.46**	12.00	0.39	8.78	**0.03**	10
G12c	46.48	73.46	9.05	0.85	92.57	0.02	13.57	14.33	0.70	11.15	0.05	9
G13	166.57	70.90	6.71	1.27	331.94	0.07	9.82	**5.67**	0.28	**7.02**	0.04	**19**
G14	156.64	72.03	**0.69**	**0.01**	296.80	0.98	**0.19**	**6.00**	**0.13**	**4.24**	**0.02**	**18**
G15	186.38	72.22	**0.22**	2.24	346.80	1.55	**-0.56**	**3.33**	**0.14**	**3.68**	**0.02**	**21**
G16a	446.92	77.61	79.82	0.32	886.08	0.46	126.80	12.00	0.37	14.11	0.15	**22**
G16b	444.05	76.77	73.10	0.75	887.04	0.06	116.05	10.67	0.33	13.29	0.14	25
G17	274.58	72.65	4.02	0.49	544.85	0.26	5.52	**8.00**	0.27	**8.26**	0.06	**26**
G18	30.23	71.38	6.03	0.54	56.93	0.21	8.74	12.33	0.56	9.01	**0.03**	4
G19a	29.91	71.58	5.45	**0.29**	51.42	0.50	7.80	8.33	0.62	**6.39**	**0.02**	3
G19b	**0.02**	**4.50**	12.01	2.63	**-44.40**	2.65	18.30	14.00	4.00	11.27	0.04	-1
G20	14.81	22.77	5.64	4.41	**-164.87**	**11.60**	8.11	19.00	0.49	13.91	0.04	**17**
G21a	**10.39**	**11.94**	7.75	**0.23**	**10.77**	**0.60**	11.49	22.00	0.29	15.62	0.10	**29**
G21b	105.15	**36.95**	127.92	**0.25**	200.97	0.56	203.76	11.00	0.45	14.83	0.12	**26**
G22	**0.10**	**7.43**	9.60	**-0.08**	**-19.48**	1.17	14.44	13.33	2.22	10.06	**0.03**	1
G23a	**2.40**	**17.54**	26.32	4.01	**-146.98**	**9.05**	41.21	27.00	1.21	19.91	0.05	8
G23b	**1.69**	**16.36**	6.30	**-0.23**	**-21.86**	1.51	9.18	**8.00**	1.07	**7.26**	**0.03**	5
G24a	**9.38**	**46.16**	54.30	0.58	**15.88**	**0.17**	85.96	10.00	2.50	14.32	0.05	-2
G24b	**0.27**	**14.22**	18.03	-0.74	**-50.36**	**3.04**	27.94	21.33	9.33	15.62	0.04	0
G25	**5.89**	**8.90**	**0.31**	**0.00**	**-5.05**	**1.00**	**-0.41**	**8.00**	**0.14**	**5.87**	0.04	31

S_i^2 = genotypic variance, CV_i = coefficient of variability for Francis and Kannenberg's method; (W_i^2 = ecovalence for Wricke's method; b_i = regression coefficient for Finlay & Wilkinson's method; δ^2 = regression parameter, β_i = regression coefficient for Eberhart and Russel's method; σ_i^2 = stability variance for Shukla's method; NPi1, NPi2, NPi3 and NPi4 = average corrected ranking of each genotype in the different locations for Thennarasu's method; Ysi = rank-sum for Kang's method

Table 7. Parametric and nonparametric analysis for fruit diameter character

Genotype	Parametric							Nonparametric				
	S_i^2	CV_i	W_i^2	b_i	δ^2	β_i	σ_i^2	NPi1	NPi2	NPi3	NPi4	Ysi
G1	36.61	12.84	**3.34**	0.56	54.28	0.19	**-0.10**	**8.67**	**0.11**	**6.35**	**0.02**	9
G2	**9.46**	**7.51**	19.63	**0.28**	**-31.56**	**0.51**	25.97	13.67	**0.18**	9.99	**0.03**	2
G3	43.55	12.69	**3.18**	0.60	71.31	0.16	**-0.35**	**11.00**	**0.13**	**8.22**	0.04	**17**
G4	34.56	13.06	**6.71**	0.53	47.89	0.22	**5.29**	11.00	**0.12**	**8.07**	**0.02**	6
G5	58.25	14.01	17.20	1.34	105.26	0.11	22.07	14.67	**0.26**	10.87	0.08	**21**
G6	**13.01**	**3.82**	15.66	0.41	**-8.66**	**0.35**	19.62	13.00	**0.31**	9.82	0.22	**35**
G7	**1.55**	**4.35**	94.09	**-0.07**	**-108.65**	**1.14**	145.10	19.00	1.50	14.11	0.04	-2
G8	763.31	35.16	935.75	3.62	852.40	6.88	1491.76	13.67	0.61	14.78	0.27	**26**
G9	134.73	20.85	66.94	1.07	268.96	0.01	101.66	18.67	0.35	13.69	0.08	**23**
G10	**20.83**	**8.33**	24.92	0.40	**6.04**	**0.36**	34.42	21.00	0.35	14.85	0.08	**22**
G11	132.19	17.92	89.29	1.20	260.40	0.04	137.41	14.33	0.48	11.36	0.14	**30**
G12a	55.34	15.42	39.35	0.81	107.28	0.03	57.51	24.00	0.80	17.03	0.05	10
G12b	33.19	10.94	**10.89**	0.49	41.31	0.26	**11.97**	12.00	0.33	8.49	0.04	**18**
G12c	36.77	12.37	28.25	0.62	59.48	0.14	39.75	21.00	0.64	15.01	0.05	11
G13	24.26	**8.24**	29.28	1.02	48.49	0.00	41.40	13.33	0.33	9.89	0.08	**27**
G14	62.02	12.76	**7.81**	0.74	117.46	0.07	**7.05**	**7.00**	0.33	**6.94**	0.07	**28**
G15	48.30	13.71	**9.36**	0.63	83.41	0.13	**9.53**	11.33	**0.25**	**8.29**	**0.03**	**16**
G16a	153.37	21.89	114.70	1.07	306.32	0.00	178.07	15.33	0.32	12.37	0.08	**24**
G16b	150.15	21.53	125.10	2.03	195.39	1.07	194.72	18.00	0.31	13.49	0.08	**25**
G17	53.46	14.82	**3.82**	0.73	99.63	0.07	**0.66**	**5.00**	**0.17**	**5.00**	**0.02**	12
G18	**7.89**	**6.06**	20.41	**0.26**	**-37.75**	**0.55**	27.22	**10.00**	0.59	**7.76**	**0.03**	8
G19a	**14.59**	8.36	**11.79**	0.89	27.91	0.01	**13.42**	**3.00**	0.43	**4.30**	**0.02**	7
G19b	**9.28**	**8.10**	31.32	**0.16**	**-49.88**	**0.70**	44.67	**6.00**	2.67	**7.43**	**0.02**	1
G20	235.31	23.63	175.08	2.79	157.23	3.20	274.67	14.00	0.72	12.90	0.11	**31**
G21a	494.75	37.82	564.81	3.78	230.55	7.74	898.25	11.33	0.40	14.01	0.07	**18**
G21b	33.71	11.76	13.19	1.50	42.99	0.25	**15.65**	14.00	**0.20**	9.91	**0.03**	13
G22	24.64	**7.13**	185.89	2.87	**-294.53**	**3.51**	291.98	**10.00**	3.11	13.40	0.11	**32**
G23a	**17.65**	8.41	**6.47**	0.63	22.15	0.13	**4.91**	**5.67**	**0.29**	**4.14**	**0.01**	14
G23b	48.34	13.89	112.95	1.10	95.69	0.01	175.27	25.33	1.73	18.82	0.05	15
G24a	70.96	19.14	397.93	-0.43	**-57.84**	**2.04**	631.24	11.00	2.58	14.61	0.06	-5
G24b	**7.74**	**7.44**	140.72	**0.29**	**-34.34**	**0.51**	219.71	12.33	9.00	12.20	0.04	0
G25	**10.09**	**7.11**	71.04	**0.06**	**-66.40**	**0.88**	108.21	**10.33**	0.32	10.42	0.04	5

S_i^2 = genotypic variance, CV_i = coefficient of variability for Francis and Kannenberg's method; (W_i^2 = ecovalence for Wricke's method; b_i = regression coefficient for Finlay & Wilkinson's method; δ^2 = regression parameter, β_i = regression coefficient for Eberhart and Russel's method; σ_i^2 = stability variance for Shukla's method; NPi1, NPi2, NPi3 and NPi4 = average corrected ranking of each genotype in the different locations for Thennarasu's method; Ysi = rank-sum for Kang's method

Table 8. Parametric and nonparametric analysis for fruit weight character

Genotype	Parametric							Nonparametric				
	S_i^2	CV_i	W_i^2	b_i	δ^2	β_i	σ_i^2	NPi1	NPi2	NPi3	NPi4	Ysi
G1	33633.30	81.12	2721.18	1.67	63655.49	0.45	3996.84	26.00	0.29	18.71	0.17	**24**
G2	25180.46	80.60	**1059.03**	1.42	48960.57	0.17	**1337.39**	11.00	**0.11**	7.81	0.04	18
G3	32060.75	80.79	**2246.45**	1.61	61121.03	0.37	**3237.26**	**5.33**	**0.09**	**4.08**	0.04	**23**
G4	23760.59	82.61	2945.46	1.35	46557.74	0.12	4355.68	21.00	0.23	15.70	0.07	15
G5	33706.27	77.31	**1188.35**	1.36	66394.65	0.13	**1544.31**	13.33	0.28	10.72	0.13	**26**
G6	83667.74	73.35	3297.12	1.24	166862.20	0.06	4918.34	**6.33**	**0.17**	**4.72**	0.09	**35**
G7	**53.40**	72.47	5366.33	**0.03**	**-7540.36**	**0.95**	8229.08	21.67	1.39	15.85	0.04	-2
G8	84081.26	74.03	**2402.05**	1.58	165499.60	0.33	**3486.22**	**6.67**	0.35	9.03	0.21	**34**
G9	31347.44	77.96	**1082.70**	1.37	61584.41	0.14	**1375.27**	**8.00**	**0.16**	**5.88**	0.05	**25**
G10	21023.14	77.55	**540.35**	1.07	42010.89	0.00	**507.50**	11.00	**0.18**	7.81	0.03	**16**
G11	39142.30	73.44	**1849.60**	0.83	78050.46	0.03	**2602.31**	10.33	0.27	7.61	0.07	**30**
G12a	4020.63	75.76	6162.46	**0.04**	684.02	0.91	9502.88	**10.00**	0.33	**7.22**	**0.02**	7
G12b	4020.63	75.76	6162.46	**0.04**	684.02	0.91	9502.88	10.00	0.28	**7.09**	**0.02**	7
G12c	4020.63	75.76	6162.46	**0.04**	684.02	0.91	9502.88	10.67	0.36	7.82	**0.02**	7
G13	20622.23	71.70	8282.69	-0.13	30968.60	1.28	12895.25	20.00	0.37	14.80	0.07	**19**
G14	30226.63	83.97	3326.86	1.74	56016.00	0.55	4965.92	4.33	0.11	3.18	0.01	20
G15	23014.89	79.96	**810.49**	1.30	45292.61	0.09	**939.72**	**9.00**	0.23	**6.74**	0.03	**17**
G16a	87891.63	98.11	47725.41	3.71	116528.51	7.36	76003.59	18.00	**0.22**	12.88	0.07	**23**
G16b	87891.63	98.11	47725.41	3.71	116528.51	7.36	76003.59	26.00	0.31	18.61	0.10	**23**
G17	32490.76	84.02	4253.94	1.78	60090.63	0.61	6449.26	18.00	0.27	12.87	0.05	**21**
G18	**2147.32**	71.59	4563.42	0.10	**-2169.67**	**0.80**	6944.42	20.67	0.89	15.11	0.04	3
G19a	**2147.32**	71.59	4563.42	0.10	**-2169.67**	**0.80**	6944.42	11.67	0.81	8.72	**0.03**	3
G19b	**5.81**	**12.68**	6172.40	**-0.04**	**-8774.29**	**1.09**	9518.78	20.00	3.33	14.78	**0.03**	0
G20	6688.95	**37.50**	**2118.31**	2.14	3002.67	1.29	**3032.24**	21.00	0.54	15.18	0.06	**22**
G21a	11960.87	**44.06**	7661.27	1.48	22042.35	0.23	11900.98	13.00	**0.17**	9.22	0.04	**27**
G21b	11960.87	**44.06**	7661.27	1.92	17107.81	0.85	11900.98	13.00	**0.19**	9.71	0.04	**27**
G22	**727.21**	**31.62**	9092.51	**-0.04**	**-7286.98**	**1.09**	14190.96	**7.67**	1.22	**5.71**	**0.02**	10
G23a	**86.92**	**12.11**	5979.78	**-0.01**	**-8112.84**	**1.03**	9210.59	22.33	0.96	16.58	0.04	5
G23b	**86.92**	**12.11**	5979.78	**-0.01**	**-8109.08**	**1.03**	9210.59	13.33	1.60	11.10	0.04	5
G24a	**19.20**	**20.99**	5058.87	**0.06**	**-7152.92**	**0.89**	7737.13	**7.00**	0.92	**5.38**	**0.02**	1
G24b	**19.20**	**20.99**	5058.87	**0.06**	**-7152.92**	**0.89**	7737.13	21.33	7.33	15.83	**0.03**	1
G25	1105.15	**18.48**	**2152.88**	0.50	**180.73**	**0.25**	**3087.55**	**8.00**	**0.19**	**6.55**	**0.03**	14

S_i^2 = genotypic variance, CV_i = coefficient of variability for Francis and Kannenberg's method; (W_i^2 = ecovalence for Wricke's method; b_i = regression coefficient for Finlay & Wilkinson's method; δ^2 = regression parameter, β_i = regression coefficient for Eberhart and Russel's method; σ_i^2 = stability variance for Shukla's method; NPi1, NPi2, NPi3 and NPi4 = average corrected ranking of each genotype in the different locations for Thennarasu's method; Ysi = rank-sum for Kang's method

Table 9. Parametric and nonparametric analysis for plant height character

Genotype	**Parametric**							**Nonparametric**				
	S_i^2	CV_i	W_i^2	b_i	δ^2	β_i	σ_i^2	**NPi1**	**NPi2**	**NPi3**	**NPi4**	**Ysi**
G1	389.31	29.29	**37.57**	0.98	778.23	0.00	**53.19**	**7.00**	**0.12**	**5.39**	**0.02**	-1
G2	420.14	26.39	**13.63**	1.04	839.34	0.00	**14.88**	**11.00**	**0.11**	**8.22**	**0.03**	10
G3	**208.71**	**19.76**	128.60	**0.67**	**338.35**	**0.11**	198.84	25.00	0.29	17.68	0.06	1
G4	**281.76**	23.88	**48.12**	**0.83**	540.96	**0.03**	**70.06**	18.00	**0.19**	12.73	0.03	2
G5	**288.58**	**22.27**	112.31	**0.79**	544.81	**0.04**	172.77	25.00	0.32	17.81	0.07	5
G6	**124.77**	**14.89**	338.65	**0.42**	**-0.05**	**0.34**	534.92	31.00	0.74	21.93	0.08	-2
G7	**329.20**	22.91	86.54	**0.87**	645.03	**0.02**	131.54	**9.00**	0.94	**7.82**	0.04	**15**
G8	593.22	29.03	98.95	1.21	1153.45	0.04	151.39	23.00	0.45	16.41	0.07	**20**
G9	636.82	27.86	117.55	1.25	1225.55	0.06	181.16	15.00	0.43	12.75	0.15	**27**
G10	494.08	26.96	**23.42**	1.13	976.13	0.02	**30.55**	11.00	**0.18**	**8.08**	**0.03**	**18**
G11	348.19	26.12	114.05	**0.87**	683.79	0.02	175.55	22.00	0.46	16.14	0.04	-1
G12a	686.31	29.89	122.95	1.32	1297.79	0.10	189.80	19.33	0.93	14.55	0.11	**23**
G12b	686.31	29.89	122.95	1.32	1297.79	0.10	189.80	19.33	0.78	14.53	0.10	**23**
G12c	686.31	29.89	122.95	1.32	1297.79	0.10	189.80	19.33	0.85	14.52	0.09	**23**
G13	408.98	23.36	80.62	0.97	817.45	0.00	122.07	11.00	0.31	8.48	0.07	**24**
G14	**270.34**	22.72	**16.82**	**0.83**	519.87	**0.03**	**19.98**	**8.00**	0.31	**6.54**	**0.02**	4
G15	**134.16**	**17.27**	110.53	**0.59**	**141.70**	**0.17**	169.93	20.67	0.39	15.26	0.04	-6
G16a	364.04	24.34	74.85	0.92	723.04	0.01	112.84	16.00	**0.20**	11.95	0.04	13
G16b	364.04	24.34	74.85	0.92	723.04	0.01	112.84	16.00	**0.19**	11.95	0.04	13
G17	332.00	21.92	4.77	0.92	659.57	0.01	**0.71**	**4.00**	**0.06**	**2.87**	**0.01**	**19**
G18	636.11	27.52	289.37	1.14	1257.21	0.02	456.07	24.33	0.93	18.11	0.09	**24**
G19a	636.11	27.52	289.37	1.14	1257.21	0.02	456.07	24.33	1.19	18.10	0.09	**24**
G19b	**212.89**	**16.52**	107.43	**0.70**	**357.09**	**0.09**	164.97	11.67	4.17	11.45	0.08	**26**
G20	380.24	25.88	157.97	1.96	**73.51**	**0.93**	245.83	24.00	0.67	17.68	0.05	4
G21a	506.53	28.94	**61.74**	1.23	973.59	0.05	**91.87**	**6.67**	**0.21**	**7.32**	**0.03**	11
G21b	506.53	28.94	**61.74**	1.12	1002.82	0.01	**91.87**	**6.67**	**0.23**	**7.32**	**0.03**	11
G22	957.59	32.78	1099.43	1.03	1914.38	0.00	1752.16	26.33	3.44	19.29	0.09	**27**
G23a	362.03	**21.84**	**1.45**	0.97	723.19	0.00	**-4.60**	**8.00**	0.33	**5.98**	**0.03**	**25**
G23b	362.03	**21.84**	**1.45**	0.97	723.19	0.00	**-4.60**	**8.00**	0.53	**5.98**	**0.03**	**25**
G24a	358.05	**21.99**	134.25	0.87	704.10	0.02	207.88	16.00	2.17	12.57	0.07	**17**
G24b	358.05	**21.99**	134.25	0.87	704.10	0.02	207.88	16.00	8.67	12.56	0.07	**17**
G25	**321.55**	26.20	102.85	**0.84**	625.21	**0.02**	157.64	**9.67**	**0.26**	8.63	**0.03**	0

S_i^2 = genotypic variance, CV_i = coefficient of variability for Francis and Kannenberg's method; (W_i^2 = ecovalence for Wricke's method; b_i = regression coefficient for Finlay & Wilkinson's method; δ^2 = regression parameter, β_i = regression coefficient for Eberhart and Russel's method; σ_i^2 = stability variance for Shukla's method; NPi1, NPi2, NPi3 and NPi4 = average corrected ranking of each genotype in the different locations for Thennarasu's method; Ysi = rank-sum for Kang's method

Table 10. Parametric and nonparametric analysis for stem diameter character

Genotype	Parametric							Nonparametric				
	S_i^2	CV_i	W_i^2	b_i	δ^2	β_i	σ_i^2	NPi1	NPi2	NPi3	NPi4	Ysi
G1	17.81	28.47	5.46	0.95	255.18	0.00	8.60	25.33	0.31	18.63	0.07	-3
G2	**14.83**	25.30	**0.26**	0.94	261.10	0.00	**0.28**	**9.00**	**0.09**	**6.37**	**0.02**	10
G3	**15.05**	26.14	2.02	0.92	250.17	0.01	3.10	20.33	**0.24**	15.10	0.05	6
G4	15.63	24.85	1.30	0.95	284.31	0.00	1.94	13.67	**0.16**	10.08	0.07	**21**
G5	17.05	26.74	2.01	0.99	272.59	0.00	3.08	17.33	0.28	12.70	0.06	**16**
G6	21.03	29.07	6.06	1.05	290.85	0.00	9.56	20.00	0.67	14.88	0.09	11
G7	**12.70**	24.90	**0.72**	0.87	229.66	0.02	**1.02**	**6.67**	0.67	**5.56**	**0.02**	-1
G8	29.96	29.84	5.74	1.33	393.16	0.11	9.05	17.00	0.61	15.13	0.37	**27**
G9	15.97	**24.13**	**0.17**	0.98	306.13	0.00	**0.13**	**5.67**	**0.11**	**4.18**	0.05	**32**
G10	19.03	27.33	**0.36**	1.07	292.70	0.01	**0.44**	**11.33**	**0.23**	**8.30**	**0.04**	**24**
G11	**14.26**	**24.49**	1.74	0.90	265.91	0.01	2.65	20.00	0.42	14.54	0.05	**15**
G12a	**11.37**	**22.03**	1.28	**0.82**	255.93	0.03	1.92	**11.67**	0.70	9.77	0.05	11
G12b	**11.37**	**22.03**	1.28	**0.82**	255.93	0.03	1.92	**11.67**	0.58	9.76	0.05	11
G12c	**11.37**	**22.03**	1.28	**0.82**	255.93	0.03	1.92	**11.67**	0.64	**9.75**	0.05	11
G13	24.04	32.29	2.08	1.20	277.38	0.04	3.20	24.00	0.44	17.30	0.05	9
G14	15.99	27.06	1.61	0.96	250.40	0.00	2.44	15.33	0.40	11.21	**0.03**	2
G15	**14.66**	25.86	4.85	0.87	247.84	0.02	7.62	29.00	0.51	21.23	0.06	-4
G16a	**8.30**	**19.82**	3.11	**0.70**	225.20	0.09	4.83	25.00	0.31	18.04	0.05	-3
G16b	11.05	21.71	2.12	**0.80**	255.38	0.04	3.25	11.67	0.30	11.37	0.06	**14**
G17	18.95	26.41	1.13	1.06	309.58	0.00	1.67	**6.67**	**0.24**	7.43	0.07	30
G18	18.49	26.75	4.74	0.99	295.34	0.00	7.44	25.00	1.00	18.44	0.07	**17**
G19a	18.49	26.75	4.74	0.99	295.34	0.00	7.44	25.00	1.29	18.44	0.07	**17**
G19b	21.41	28.48	18.26	0.87	**42.34**	**0.02**	29.08	24.33	5.17	17.82	0.08	**19**
G20	24.74	31.44	4.21	2.09	**13.98**	**1.18**	6.60	12.33	0.69	12.28	0.06	12
G21a	20.20	28.19	**0.73**	1.02	**40.39**	**0.00**	**1.04**	19.00	0.25	13.45	0.05	**22**
G21b	20.20	28.19	**0.73**	1.11	**40.07**	**0.01**	**1.04**	19.00	0.28	13.45	**0.04**	22
G22	17.19	**22.82**	4.56	0.95	**34.32**	**0.00**	7.16	21.67	3.00	15.93	0.13	**26**
G23a	15.98	26.73	**0.11**	0.98	**31.95**	**0.00**	**0.04**	**2.67**	**0.17**	**2.01**	**0.01**	7
G23b	15.98	26.73	**0.11**	0.98	**31.95**	**0.00**	**0.04**	**2.67**	**0.27**	**2.01**	**0.01**	7
G24a	16.17	**24.66**	**0.03**	0.99	**32.33**	**0.00**	**-0.10**	**2.33**	**0.25**	**1.71**	**0.01**	**28**
G24b	16.17	**24.66**	**0.03**	0.99	**32.33**	**0.00**	**-0.10**	**2.33**	1.00	**1.71**	**0.01**	**28**
G25	17.66	29.25	2.11	1.01	**35.31**	**0.00**	3.23	19.00	0.26	14.03	**0.03**	0

Result on parametric and nonparametric analysis is determined by stability parameter. Each method has a different parameter to determine the stability level of each genotype. The stability parameter calculated for the analysis include ecovalence (Wi2), regression coefficient (bi and βi), deviation from regression parameter (δ2), stability variance (σi2), coefficient of variability (CVi), genotypic variance (Si2), non-parametric stability index (NPi1, NPi2, NPi3 and NPi4) and rank-sum (Ysi). Stability parameter calculation results are presented for each observed characters which are fruit length (Table 6), fruit diameter (Table 7), fruit weight (Table 8), plant height (Table 9) and stem diameter (Table 10).

DISCUSSION

The genotypes used were open pollinated varieties and landraces which lead to various phenotypic expressions. Frary *et al.* (2007) reported that cross pollination is caused by insect and can reach 70%. Chen (2011) wrote that the rate of natural out-crossing in eggplant may vary from 0 to 48% depending on the genotype. This is in line with Bubici dan Cirulli (2008) finding in which the cross pollination percentage depends on the genotype, location and insect activities. Qiao *et al.* (2011) stated that eggplant fruit shape is a quantitative trait and controlled by many genes. This results in the probability of different fruit shape in one genotype, specifically for G12, G16, G19, G21, G23 and G24 in this experiment.

Significant genotype main effect showed that the performance of genotype varied. Datta and Jana (2014) stated that significant environment main effect showed that the different environments condition affect the genotype performance. Highly significant G x E interaction in all observed characters indicated that the phenotypic expressions of all the genotype varied in each of the different environments. Lodhi *et al.* (2015) also said that the significant estimates of G × E interaction indicated that the characters may considerably fluctuate with change in environments.

According to Francis and Kannenberg's (1978) method, genotype with a small coefficient of variability (CVi) and small genotypic variance (Si2) value is a stable genotype. In this case, G19 is considered stable for fruit length, fruit weight, fruit diameter and plant height. G24b and G25 is considered stable for fruit length, fruit weight and fruit diameter. G22, G23 and G24a is stable for fruit length and fruit weight. G6 is stable for fruit diameter and plant height.

Ecovalence (Wi2) is a stability parameter in Wricke's (1962) method. Ecovalence is the contribution of each genotype to the genotype x environment interaction sum of square. Genotypes with a small ecovalence value have smaller fluctuation across environments and therefore are stable (Fikere *et al.,* 2014). Based on this method, G10 is stable for fruit length, fruit weight, stem diameter and plant height. G21b and G23a is stable for fruit diameter, stem diameter and plant height. Other genotypes that are stable based on fruit length are G4, G14 and G15; for fruit weight are G2 and G15; for stem diameter is G2; for fruit diameter are G4, G14 and G15; for plant height are G2, G4 and G14.

Finlay & Wilkinson's (1963) method used regression coefficient (b_i) for stability parameter. An increase to the regression coefficient ($b_{i.} > 1.0$) means that the genotype adaptability decreases to the changing environment, while a decrease ($b_{i.} < 1.0$) means that the genotype adaptability increases. This method was then improved by Eberhart and Russell (1966) (Gurung *et al.,* 2012). Eberhart and Russel's (1966) method used deviation from regression parameter (δ^2) and regression coefficient (βi). A βi value at 1.0 with a δ^2 value of zero indicates an average stability parameter in a genotype. Small δ^2 value indicates a stable genotype while a high δ^2 value indicates otherwise. Regression coefficient value below 1.0 indicate that the genotype is better adapted to a sub-optimum environment while a value higher that 1.0 indicate that the genotype is better adapted in an optimum environment.

Calculation showed there are some genotypes that are stable according to Finlay & Wilkinson's (1963) and Eberhart and Russel's (1966) methods. G7 is stable for fruit length, fruit weight and fruit diameter. G19 is stable for fruit diameter and plant height. G24 is stable or fruit weight and fruit diameter. G25 is stable for fruit length and fruit diameter. Genotypes that are stable according to Finlay & Wilkinson's method for stem diameter are G12 and G16 meanwhile G19, G20, G21, G22, G23, G24 and G25 are stable for the same character according to Eberhart and Russel's method.

Shukla's (1972) method used stability variance (σi2) in which a low value of σ_i^2 indicate a stable genotype. In this experiment, G10 is a stable for the character fuit length, fruit weight, stem diameter and plant height. G4 is stable for fruit length, fruit diameter and plant heigth. G15 is stable from fruit length, fruit weight and fruit diameter. G21b and G23a are stable for fruit diameter, stem diameter and plant height.

Nonparametric analysis is also done by using Thennarasu's (1955) and Kang's (1988) methods. A genotype is stable in Thennarasu's method if its rank position is fixed according to the average corrected ranking of each genotype in the different locations (NPi1, NPi2, NPi3 and NPi4). G10 is stable for he character fruit length, stem diameter and plant height. G25 is stable for fruit length, fruit weight and plant height. G1 and G17 are stable for fruit diameter and plant height. While G14 is stable for fruit length and height; G2 is stable for stem diameter and plant height; G15 is stable for fruit length and fruit diameter; and G23a is stable for fruit diameter and stem diameter.

Kang's (1988) method use rank-sum (Ysi) in which the genotype with a low rank-sum is considered stable. G1, G2, G4, G21a and G25 are stable for fruit length. G6, G8, G11 and G21 are stable for fruit weight. G6, G11, G14, G20 and G22 are stable for fruit diameter. G8, G9, G17 and G24 are stable for stem diameter. G9, G19, G22 and G23 are stable for plant height.

An overall recapitulation was done to find out which genotype is considered the most stable of all in both parametric and nonparametric analysis. For combined parametric analyses, some of the most stable genotypes in order are G19, G23, G24b and G25 (2014-044, 2014-047, 2014-077a and 2014-071). Meanwhile for combined nonparametric analysis, G10, G14, G17, G25 and G2 (2014-033, 2014-024, 2014-080, 2014-071 and THP) are the most stable genotypes. Combined recapitulated scores for both parametric and nonparametric analysis showed that G25, G10, G23a and G2 (2014-071, 2014-033, 2014-047a and THP) are the most stable genotype out of all the genotype observed. Overall, genotype 2014-071 was the only genotype that was stable in both parametric and nonparametric analysis. This genotype performs well and has generally consistent appearance in all location.

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