Performance of African eggplant (*Solanum aethiopicum*) entries across environments, and hints for selection environment in northern Tanzania

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Abstract

African eggplant (*Solanum* spp.) is a widely used fruit and leafy vegetable in Africa. The crop grows in various agro-ecological zones, and most farmers grow unimproved local cultivars. In general, African eggplant breeding is in early stages although farmer interest in improved cultivars is growing. Information on Genotype (G) x Environment (E) interaction would help guide breeders in cultivar development strategies, and whether the emphasis should be placed on specific and/or wide adaptation. The objective of this study was to determine the extent of G, E, and G x E interaction (GEI), and identify major production environments for breeding programs. A total of 21 African eggplant entries were evaluated for fruit yield and horticultural traits in two locations in 2017, and five locations in 2018 targeting two agro-ecologies in northern Tanzania. Trial locations ranged in altitude from 765 masl in the Kilimanjaro region to 1520 masl in Arusha region. Location and year were considered as independent environments so entries were evaluated in seven environments. Entries were arranged in a randomized block design with three replications. Highly significant differences among entries were found for fruit yield and other traits in each environment. G, E, and GEI effects were highly significant in an Additive Main Effect and Multiplicative Interaction (AMMI) analysis. Environment explained about 34% of the sum of squares of treatments (G+E+GEI) while G and GEI accounted for 14 and 52%, respectively. The AMMI analysis partitioned the GEI sum of squares into three significant Interaction Principal Component Axis (IPCA). The G and GEI (GGE) biplot analysis clustered the seven environments into two mega-environments. The results of the study and its implication on African eggplant selection strategy has been discussed. Interestingly, some entries identified high yielding were also found highly resistant to fusarium/bacterial wilt disease and received high farmers selection scores.

Keywords: AMMI analysis, genotype x environment interaction, GGE biplot, mega-environment, stability

INTRODUCTION

African eggplant belongs to the solanaceae family and the genus *Solanum*. Important species of African eggplant are *Solanum aethiopicum* (a dominant species that encompasses four groups (Gilo, Shum, Kamba and aculantum groups), *S. macrocarpon and S. anguvi*). African eggplant, grown throughout different regions in sub-Saharan Africa, is one of the major African traditional vegetables grown both for its fruit and leaf (Dinssa et al., 2016; Chadha and Mndiga, 2007; Ellis-Jones et al., 2008). In East African countries mainly the fruit is consumed although leaves are also consumed in Uganda. Both leaves and fruits are consumed in West Africa (Chen et al., 2001). *Solanum* *aethiopicum*, Gilo group, is the major species produced for its fruit. Uganda is a best example country growing the Shum group of *S. aethiopicum* for leaf production. The *S. macropcarpon* is mainly grown for its leaf in West African countries such as Benin (Chen et al., 2001).

Demand for African eggplant is increasing (personal observation). The fruit is abundantly available in open markets and appearing in some small supermarkets. Like other African traditional vegetables, African eggplant, however, received less R&D focus from both the public and private research and development organizations until very recently. Farmers grow local landraces with few improved varieties released so far in East Africa and West Africa from WorldVeg lines (Dinssa et al., 2016). Two popular *S. aethiopicum* open-pollinated varieties, 'Mshumaa' ('DB3') and 'Tengeru White', initially released in Tanzania, have become widely used in both eastern and southern Africa. 'DB3' was released in Cameroon in West Africa in 2020. 'Tengeru White' was not officially released but was picked up by farmers from farmers' participatory on-farm variety trials in Tanzania. Multinational breeding companies, whose major interest is hybrid varieties, are slowly giving more attention to African traditional vegetables research and development. For instance, Rijk Zwaan and East-West Seeds, both multinational breeding companies (companies operating in more than one continent), each has released at least two African eggplant hybrids. Local seed companies (companies operating in one country), and regional seed companies (those working in more than one country in a continent) are marketing seeds of varieties released by the public research institutes and are freely available for seed production and marketing.

Selection criteria for African eggplant varieties include not only yield but also market and consumer quality requirements and tolerance to biotic and abiotic stresses. Fruit shape, size, and color at the marketable stage and fruit taste are major quality factors that figure prominently in product profiles (Adeniji and Aloyce, 2012). Farmers prefer cultivars with early maturity to first harvest, but with long periods of repeat fruit harvest. Fruit quality (taste, processing/cooking, and physical characteristics) affect the perception of buyers and the marketability of the product. Taste preferences vary from sweet, medium-bitter to bitter (Keller, 2004; Weinberger and Msuya, 2004; Adeniji and Aloyce, 2012).

Knowledge of genotype, environment, and genotype x environment interaction is essential in determining the adaptation ranges of varieties and the number and type of selection environments required in a breeding program. Gaining this knowledge requires multilocation trials of a target crop genotypes. The current study evaluated the performances of African eggplant entries obtained from World Vegetable Center breeding program across environments in two administrative regions of Tanzania that vary in soil, altitude, and weather conditions. The study determined the contribution of genotype, environment, and their interaction on fruit yield of the crop.

MATERIALS AND METHODS

Plant materials

A total of 21 African eggplant (*S. aethiopicum*) entries were included in the evaluation. The entries encompassed breeding lines and commercial varieties. The breeding lines were developed by single plant selection from germplasm collections obtained from WorldVeg-ESA genebank followed by three cycles of selfing. The accessions from which single plant selections were conducted originated from eight African countries (Table 1).

Test locations and seasons

The entries were evaluated in two locations (World Vegetable Center Eastern and Southern Africa (WorldVeg-ESA) and Ngaramtoni) in 2017, and in five locations (WorldVeg-ESA, Horti-Tengeru, Ngaramtoni, Chekereni and Kilemapofu) in 2018. Considering each location and year as an independent environment there were seven environments under which the entries were evaluated. Three locations – WorldVeg-ESA (lat. 3.4° S, long. 36.8° E, elevation 1235 m), Horti-Tengeru (lat. 3.4° S, long. 36.8° E, elevation 1213 m) and Ngaramtoni (lat. 3.2° S, long. 36.4° E, elevation 1520 m) – were selected from Arusha administrative region, while the remaining two locations – Chekereni (lat. 3.4° S, long. 37.5° E, elevation 765 m) and Kilemapofu (lat. 3.4° S, long. 37.5° E, elevation 849 m) – were selected from lower Moshi area in Kilimanjaro administrative region. Arusha and Kilimanjaro regions differ in agroecology (Environment Division, 2007).

Experimental design, sowing and transplanting

The experiment was conducted in a randomized complete block design with three replications in each location. Entries were randomly assigned to plots in each location and year. Each entry in each plot was grown in two rows that were spaced 60 cm apart. Twelve plants were transplanted per row at 60 cm spacing between plants within row.

Seedlings for planting all locations were raised in seedling trays of 66 cells. In 2017 trials, sowing was conducted on 4 April for both WorldVeg-ESA and Ngaramtoni locations. The materials were transplanted on 4 and 8 May 2017 at WorldVeg-ESA and Ngaramtoni, respectively. In 2018, sowing was conducted on 9 February for WorldVeg-ESA, Chekereni and Kilemapofu trials, and on 12 February for Horti-Tengeru and Ngaramtoni trials. Transplanting was conducted on 13 March at both WorldVeg-ESA and Chekereni, and on 14, 18 and 19 March 2018 at Kilemapofu, Ngaramtoni and Horti-Tengeru, respectively.

Field management

NPK fertilizer (20N:10P:10K) was applied at the rate of 200 $kg.ha^{-1}$ one week(s) after transplanting at each location. Urea (46N:0P:0K) was applied at the rate of 120 $kg.ha^{-1}$ as side-dressing three weeks after transplanting. Weed was controlled manually by using handheld hoe. Folicur (a.i. Tebuconazole 430 g/l) at the rate of 1 ml/l of water or Ridomil (a.i. Metalaxyl-M) at 3 g/l of water were sprayed two days after transplanting to control dumping-off.

Data collection

Data collected included marketable fruit yield that was harvested 3 or 4 time during the growing period each year depending on location. Number of days to flowering was determined at WorldVeg-ESA as it was not possible to travel to each of the other locations frequently. Other data collected included plant height at final harvest, number of branches per plant, and number of fruits per plant on three plant basis. Fusarium and/or bacterial wilt damage (number of plants wilted per plot) was counted on weekly basis at WorldVeg-ESA in 2018, and later converted to percent.

Data analysis

Statistical analyses were carried out using GenStat (release 19.1; VSN International, Hemel Hempstead, UK). Both individual, and combined (entry x environment) analyses of variances were conducted on marketable vegetable yield using the Generalized Linear Mixed Model procedure of GenStat (release 19.1) in a randomized complete block design; each of the location and year was considered an independent environment. The proportions of the main effects of genotype (= entry here) and environment, and their interaction effects were estimated through the conventional genotype by environment interaction (GEI) analysis in GenStat.

The Additive Main Effects and Multiplicative Interactions (AMMI) analysis was carried out across the seven environments following the model used by Zobel et al. (1988). Interaction principal component axes (IPCAs) that significantly explained the partitioned GEI sum of squares (SS) were considered in the AMMI analysis. The AMMI model used was as follows: $Y_{ijr} = \mu + g_i + e_j + \Sigma\lambda_x\alpha_{ix}\sigma_{jx} + R_{ij} + K_{r(j)} + \varepsilon_{ijr}$, where Y_{ijr} is the value of i^{th} entry in j^{th} location for replicate r, μ is grand mean, g_i is mean of the i^{th} entry, e_j is mean of the j^{th} location, λ_x is singular value for principal component (PC) axis x, α_{ix} is PC scores for axis x of the i^{th} entry, σ_{jx} is PC scores for axis x of the j^{th} location, R_{ij} is residual that remains after fitting some of PC axes (R_{ij} value becomes zero when full model is fitted), $K_{r(j)}$ is block effect for replication r for an RCB design within location j, and ε_{ijr} is error term.

The genotype and genotype by environment (GGE) biplot analysis (Yan and Kang, 2002) was used to identify megaenvironments (MEs) and winner entries at different locations. The GGE biplot analysis focuses on genotype (G) and genotype (G) x environment (E) interaction to evaluate genotypes and test environments by analyzing and graphically displaying them simultaneously (Yan and Tinker, 2006).

Farmer-participatory selection

Farmer-participatory selection was conducted in each location in 2018. The number of farmers participated were 14 female and 18 male farmers at Chekereni, 21 female and 12 male farmers at Kilemapofu and 15 female and 10 male farmers at Ngaramtoni. The selections at WorldVeg-ESA and Horti-Tengeru were conducted by the same 15 female and 18 male farmers. A total of 123 farmers participated in the selection.

RESULTS AND DISCUSSION

Individual analyses of variance on marketable fruit yield indicated highly significant differences (P<0.001) among the entries in six of the seven environments

(Table 2). Entries RW-AE-6-ES13-4, MM10086-ES13-5, RW-AE-6-ES13-2 and MM1619-ES13-1 gave the highest yields at WorldVeg-ESA in 2017, Ngaramtoni 2017, Ngaramtoni 2018 and Kilemapofu 2018, respectively. BORYBORY-ES13-2 gave the highest yield at WorldVeg-ESA and Horti-Tengeru in 2018.

Combined analysis of variance involving 21 entries and seven environments indicated highly significant differences (P < 0.001) among entries and among environments, and in G x E interaction (Table 3). G x E interaction sum of square explained the highest proportion of treatment sum of squares (51.7%) followed by environment sum of square that explained 34.0% (Table 3). Entry yields across environments ranged from 17.2 $t.ha^{-1}$ (LAVALAVA-ES13-3) to 32.7 $t.ha^{-1}$ (RW-AE-6-ES13-Lastplant) (Table 2). In the amaranth multilocation study conducted in Tanzania, season explained the highest sum of squares of treatments followed by location (Dinssa et al., 2019); three of the current test locations were in the amaranth multilocation study. The top-yielding African eggplant line across the seven environments was also one of the most tolerant entries to fusarium and/or bacterial wilt (Table 2). Both fusarium and bacteria were identified in wilted plants pending the identification of the causative agent of the wilt disease; bacteria causing wilt may confuse with beneficiary ones. Tolerance to wilt disease is one of African eggplant breeding objectives. The wilt data collected at WorldVeg-ESA in 2018 was used to evaluate entries because consistent wilt disease data was collected at this location in 2018.

The AMMI analysis partitioned the G x E interaction some of squares into three highly significant (P<0.000) IPCAs effects (Table 4). The three significant IPCAs explained 93% of the sum of squares of G x E interaction, with the first axis described 75% of the sums of squares, and the remaining two axes 18% of the sums of squares. Possible environmental factors underlying the G x E interaction were not yet investigated in the current study and will need to be investigated in the future. Dinssa et al. (2019) reported that differences in soil sand particle size, pH and soil nitrogen content among locations were major factors that contributed to significant G x E interactions in amaranth. The AMMI analysis identified four best performing entries in each of the current seven environments (Table 5). Every entry identified among the best four entries in one environment was also among the best four entries in at least one another environment.

The GGE biplot analysis classified the seven environments into two major clusters of environments (Fig 1). One of the two clusters comprised five of the seven environments – WorldVeg-ESA 2017 (E1 in Fig 1), Ngaramtoni 2017 (E2), Ngaramtoni 2018 (E5), Chekereni (E6), and Kilemapofou (E7). WorldVeg-ESA 2018 (E3) and Horti-Tengeru (E4) formed a separate group of environments. The two locations of the Kilimanjaro region tightly grouped together within the five environments' cluster (Fig 1). The study results suggest presence of two major target environments: low altitude areas represented by the Kilimanjaro locations and the relatively high altitude areas represented by Arusha locations; further data/study may be required before drawing conclusions. The WorldVeg-ESA 2017 and WorldVeg-ESA 2018 environments were grouped in different cluster groups indicating differences between years within location. In a similar multilocation study conducted in amaranth Kilimanjaro location (Moshi) was clustered separate from Arusha region locations and with the coastal region of Tanzania (Dinssa et al., 2019).

Following the ''which-won-where'' view of the GGE biplot (Yan et al., 2007), entries G3, G19, G7, G13, G17, G18, and G14 mapped on the vertices of the polygon made large contributions to the G x E interaction, and their performances were the best or the poorest in one or more of the environments. This result is in agreement with the mean yield performances of the entries in which, for example, G3 performed well in many of the environments and had the highest mean yield across environments, while G17 gave the poorest yield in three of the seven environments (Table 2). Entries G8 (MM10086-ES13-6) and G21 (MM1619-ES13-1S1) were among the best performers at least at one of the two Kilimanjaro locations, Chekereni 2018 (E6) and Kilemapofou 2018 (E7), while entry G7 (AB2-ES13-8) was among the best lines at Ngaramtoni 2018 (E5). Entries G1, G4 and G8 located close to the origin of the polygon were stable in their yield performances across the seven environments. Horti-Tengeru 2018 (E4) followed by Ngaramtoni 2018 (E5) was located far from the origin of the polygon. Yan et al. (2007) defined environments that map far from the origin of the polygon as discriminative environments for selection of genotypes under evaluation. Accordingly, Horti-Tengeru 2018 (E4) and Ngaramtoni 2018 (E5) were the most discriminative environments for selection of the entries in the current study. Three lines (G3, G11 and G19) developed from an accession obtained from Rwanda were found resistant to unidentified but probably fusarium caused wilt disease. It is interesting that G3 and G19 are high yielding and wilt resistant lines from Rwanda. Root rots of common beans mainly caused by fusarium wilt were serious in Rwanda (P. Hanson, Pers. Comm., 2020) and if fusarium disease pressure is also high on African eggplant in the country there may have been selection pressure for wilt resistance.

Farmer participatory selection

Farmer selection criteria for African eggplant was similar among all farmers in the current trial locations. Important traits for farmers included wilt tolerance, insect tolerance, early fruiting but with a long fruit harvest period per season, oblong fruit shape and milky-yellow fruit color at marketable fruit stage, and high fruit yield. Both bitter and sweet fruit tastes were acceptable. The line G3 (RW-AE-6-ES13-Lastplant) that gave the highest yield (32.7 $t.ha^{-1}$) across environments was among the highly preferred entries by farmers, and was among three highly wilt tolerant lines identified under severe wilt conditions at the WorldVeg-ESA in 2018 (Table 2). The selection score for each gender group (Table 2) was the average of the five locations at which the entries were evaluated in 2018. Both mean female farmers' selection scores and mean male farmers' selection scores were positively correlated ($P < 0.001$) with mean fruit yield. The correlation coefficient between fruit yield and female farmers' selection score was $r = 0.68^{**}$, while the coefficient between yield and male farmers' selection score was $r = 0.85^{**}$. The selection scores of female and male farmers were highly correlated ($r = 0.88^{**}$), although female and male farmers conducted their selection independently.

CONCLUSION

In the current study, entries stable across environments were identified. It was interesting that the top four high yielding lines across environments were also highly tolerant to wilt disease. Two of these entries were ranked high in farmers selection scores. Female farmers and male farmers selection scores were positively correlated to each other and to fruit yield. G x E interaction explained the highest sum of squares of treatment, followed by environment indicating the significant role of environment and G x E interaction in determining the performances of African eggplant genotypes. The G x E interaction sum of squares was partitioned into three significant IPCAs but environmental factors responsible for the interactions need to be identified in future studies. Seed of the promising lines is available for use in breeding programs and/or for characterization and possible release as commercial varieties. The GGE biplot analysis suggested two different target environments for selection but further study may be required in which coastal region environments included.

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Table 1. African eggplant (*Solanum aethiopicum L.*) entries evaluated in Tanzania in seven environments from 2017 to 2018.

Entry code	Entry name	Accession origin
G1	MM 10260-ES13-1	Ghana
G2	LAVALAVA-ES13-3	Madagascar
G3	RW-AE-6-ES13-LAST PLANT	Rwanda
G4	Manyire	Tanzania

G5	MM 1619-ES13-1	Cote D’ivoire
G6	MM 10181-ES13-1	Ghana
G7	AB 2-ES13-8	Ghana
G8	MM 10086-ES13-6	Tanzania
G9	Tengeru White	Tanzania
G10	MM 1107-ES13-1	Burkna Faso
G11	RW-AE-6-ES13-4	Rwanda
G12	MM 1131-ES13-2	Togo
G13	DB3	Ghana
G14	BORYBORY-ES13-2	Madagascar
G15	TZSMN 57-5-ES13-2	Tanzania
G16	EX-IVORY COAST-ES13-4	Ivory Coast
G17	MM 10181-ES13-3	Ghana
G18	AB 2-ES13-2	Ghana
G19	RW-AE-6-ES13-2	Rwanda
G20	MM 10086-ES13-5	Tanzania
G21	MM 1619-ES13-1S1	Cote D’ivoire

Table 2. Marketable fruit yield (t/ha) by environment, and number of plants wilted from 24 plants and mean female and male farmers selection score (0-4 scale, 0 = very poor and 4 = excellent) across the environments in 2018; each location and year were considered independent environment[1].

Entry code	Entry Name	Environment								% Wilt ESA 2018	Female farmer scores	Male farmer scores
		ESA 2017	NGT 2017	ESA 2018	HOR 2018	NGT 2018	CHK 2018	KMP 2018	Mean			
G1	MM10260-ES13-1	15.9	11.4	31.3	46.6	41.1	23.2	28.4	26.2	29.2	2.1	2.1
G2	LAVALAVA-ES13-3	19.0	14.2	18.0	10.2	27.1	18.1	22.2	17.2	48.6	1.7	1.4
G3	RW-AE-6-ES13-Lastplant	24.1	16.4	37.3	65.2	49.2	31.6	26.4	**32.7**	**5.6**	2.5	2.5
G4	Manyire	18.7	16.3	29.2	36.5	44.9	15.0	20.3	24.2	41.7	1.7	2.0
G5	MM1619-ES13-1	19.3	14.6	26.3	28.2	51.8	26.7	37.7	27.9	56.9	2.5	2.5
G6	MM10181-ES13-1	19.0	13.5	33.4	53.0	32.3	21.1	19.4	25.1	18.1	2.1	2.2
G7	AB2-ES13-8	20.9	14.6	24.7	13.6	50.5	37.8	33.3	26.0	62.5	2.1	2.1
G8	MM10086-ES13-6	19.2	14.7	27.4	25.6	41.9	26.5	35.2	26.1	44.4	2.2	2.2
G9	Tengeru White	22.3	15.1	21.9	21.0	35.3	25.0	27.7	22.7	41.7	1.8	1.8
G10	MM1107-ES13-1	19.0	13.8	13.8	26.6	31.7	23.1	26.8	21.5	73.6	1.6	1.4
G11	RW-AE-6-ES13-4	26.6	12.0	34.5	58.6	32.6	23.4	16.9	**28.4**	**2.8**	2.2	2.2
G12	MM1131-ES13-2	26.1	13.6	18.9	10.3	40.0	35.2	31.0	23.1	72.2	1.1	1.4
G13	DB3	18.7	21.3	14.4	13.6	50.1	30.9	33.6	25.4	81.9	2.5	2.1
G14	BORYBORY-ES13-2	22.0	10.6	38.9	74.1	20.5	26.4	33.1	**29.3**	**8.3**	2.0	2.2
G15	TZSMN57-5-ES13-2	15.8	9.0	24.4	18.4	27.6	31.1	29.9	20.9	65.3	2.0	2.0
G16	EX-IVORY COAST-ES13-4	17.7	7.6	26.5	28.4	31.5	26.0	33.8	22.5	29.2	1.8	1.7
G17	MM10181-ES13-3	8.9	15.1	9.1	4.0	39.5	25.9	23.3	17.7	88.9	1.7	1.6
G18	AB2-ES13-2	18.5	15.1	15.4	16.0	20.8	22.2	16.5	17.3	51.4	1.7	1.6
G19	RW-AE-6-ES13-2	22.3	17.4	30.7	62.4	54.0	25.2	18.3	**30.6**	**0.0**	2.4	2.5
G20	MM10086-ES13-5	15.5	27.3	12.9	14.9	39.7	33.3	28.9	22.8	84.7	1.9	1.8
G21	MM1619-ES13-1S1	20.4	11.9	18.4	20.9	39.6	39.5	35.4	25.4	66.7	1.9	1.8
	Mean	19.5	14.5	24.2	30.9	38.2	27.0	27.5	24.4	46.4	1.9	1.9
	F-test (P)	<0.001	<0.001	<0.001	<0.001	<0.001	NS	<0.001	<0.001	<0.001	<0.001	<0.001
	LSD (5%)	6.1	5.2	9.9	11.7	15.8	13.3	7.4	11.2	16.609	0.9	0.7

[1]ESA – World Vegetable Center Eastern and Southern Africa (WorldVeg-ESA), NGT-Ngaramtoni, HORT-Horti-Tengeru and CHK-Chekereni and KMP-Kilemapofu; farmers selection score of each farmer group is average of five environments in the 2018, see in the text for the number of farmers in each gender group; No.Wilt – Number of plants wilted per 24 plants per plot.

Table 3. Combined analysis of variance of marketable fruit yield of 21 African eggplant entries evaluated in seven environments in Tanzania, 2017-2018.

Source of variation	Df	Sum of square	Mean square	*F*-test	Prob.	Proportion of treatment sum of square (%)[z]
Genotype (G)	20	9294.2	464.71	8.78	<0.001	14.3
Environment (E)	6	22161.84	3693.64	69.81	<0.001	34.0
Replication within E	2	1175.2	587.6	11.11		
G x E	120	33681.07	280.68	5.3	<0.001	51.7
Residual	292	15450.48	52.91			
Total	440	81762.79				

Table 4. Additive main effect and multiplicative interaction (AMMI) analysis of variance for three significant interaction principal component axes (IPCAs) on fruit yield of 21 African eggplant entries evaluated across six locations from 2017-2018.

Source	Df	Sum of square	Mean square	*F*-test	Probability	Proportion of treatment sum of square (%)[1]
Treatment	146	65137	446.1	10.87	<0.001	
Genotype (G)	20	9294	464.7	11.32	<0.001	14.3
Environment (E)	6	22162	3693.6	10.08	<0.001	34.0
Replication within E.	14	5131	366.5	8.93	<0.001	
G x E	120	33681	280.7	6.84	<0.001	51.7
IPCA 1	25	25228	1009.1	24.58	<0.001	74.9
IPCA 2	23	4085	177.6	4.33	<0.001	12.1
IPCA 3	21	2020	96.2	2.34	<0.001	6.0
Residuals	51	2348	46.0	1.12	0.278	7.0
Error	280	11495	41.1			
Total	440	81763	185.8			

[1]The proportions of the sum of squares (SS) of genotype, location and G · L interaction were calculated from treatment SS; the proportion of the SS of IPCAs and residuals were calculated from G · L interaction SS.

Table 5. Four best African eggplant entries for fruit yield by environment selected by the additive main effect and multiplicative interaction (AMMI) analysis based on three significant interaction principal component axes (IPCAs) on 21 entries in Tanzania in 2017 and 2018[1].

Number	Environment	Envt mean	1	2	3	4
1	CHK18	27.01	AB 2-ES13-8	MM 1619-ES13-1S1	MM 1131-ES13-2	MM 1619-ES13-1
5	KMP18	27.53	MM 1619-ES13-1S1	AB 2-ES13-8	MM 1619-ES13-1	MM 1131-ES13-2
7	NGT18	38.17	RW-AE-6-ES13-2	MM 1619-ES13-1	DB3	AB 2-ES13-8
6	NGT17	14.54	MM 10086-ES13-5	DB3	RW-AE-6-ES13-2	MM 1131-ES13-2
2	ESA17	19.51	BORYBORY-ES13-2	RW-AE-6-ES13-LAST PLANT	RW-AE-6-ES13-4	MM 10086-ES13-5
3	ESA18	24.16	BORYBORY-ES13-2	RW-AE-6-ES13-LAST PLANT	RW-AE-6-ES13-2	RW-AE-6-ES13-4
4	HOR18	30.86	BORYBORY-ES13-2	RW-AE-6-ES13-LAST PLANT	RW-AE-6-ES13-2	RW-AE-6-ES13-4

[1],CHK18 -Chekereni 2018, KMP18-Kilimopofu 2018, NGT18-Ngaramtoni 2017, ESA17-WorrldVeg Arusha 2017, ESA18-WorldVeg Arusha 2018, HOR18-Horti-Tengeru 2018; Envt mean-Environment mean.

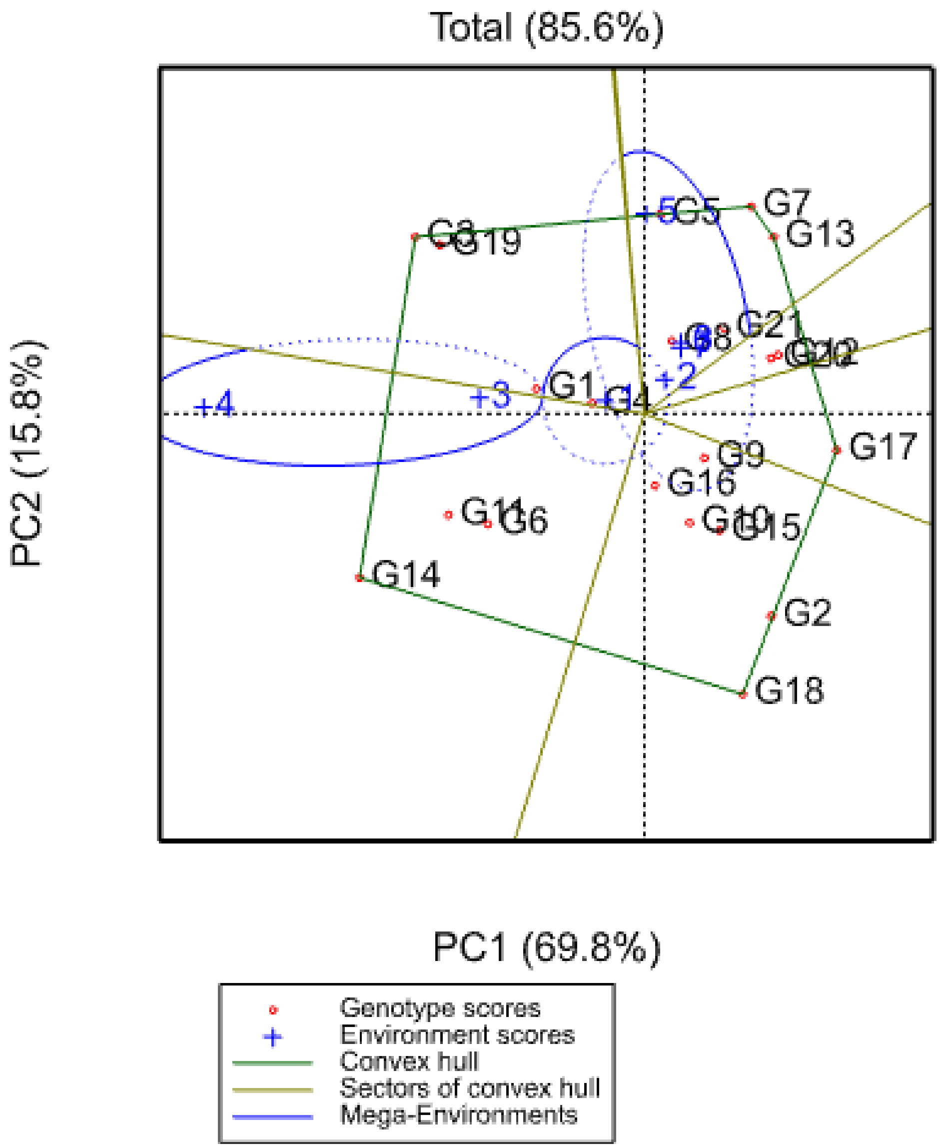

Fig 1. Genotype and genotype by environment interaction (GGE) biplot of 21 African eggplant entries evaluated in seven environments in northern Tanzania, 2017-2018. Numbers in black font stand for entries (see Table 1 for entry names). Numbers in blue font stands for environments (1 - WorldVeg-ESA 2017, 2 - Ngaramtoni 2017, 3 - WorldVeg-ESA 2018, 4 – Horti-Tengeru 2018, 5 - Ngaramtoni 2018, 6 - Chekereni 2018 and 7 - Kilemapofu 2018).