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Adaptability and Stability of Elite Potato (*Solanum Tuberosum.* L) Genotypes in Kenya

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I. INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important food security crop and a source of income worldwide (Muthoni and Hussein 2018). In Kenya, the crop is grown by approximately 800,000 small scale farmers on more than 158,000 ha of land per season with a yield estimate of 1.2 million tons (Riungu, 2011). This harvest is worth about KES 13 billion at farm gate level and KES 40 billion when it is at the consumer level (Muthoni and Hussein 2018). The Kenyan farmers produce both Processing and Table types in the Central highlands of Kenya, Bomet, Molo, Narok and Meru where most of them have occupied approximately 25% of their land with potato production. Recently, there has been a decline in potato production in Kenya mainly due to lack of adaptive and stable cultivars, lack of clean seeds, poor pest and disease management practices and less competitive marketing strategies (Riungu., 2011; and Muthoni et al., 2015).

International Potato Center (CIP) has for a long time led the potato improvement strategies in Kenya through screening and evaluation of imported cultivars especially from Europe. To achieve higher and more stable tuber yields, selection in the target environment is necessary (Muthoni and Hussein 2018). The challenges of increased potato production in the country are compounded by decreased land hectarage and inadaptability of introduced cultivars to local growing environments (Gildemacher et al.,2009; Bai, et al.,2014). Importation of cultivars, has led to inconsistent genotypic expression in the diverse environments which in turn prolongs the selection process because of genotype by environment interactions (G x E) (Muthoni et al.,2015).

There is need therefore to ascertain the levels of G x E interactions exhibited by elite potato genotypes being developed and assess their adaptability, stability and yielding potential. In order to do this, dependable analytical methods that would identify the magnitude of G x E interactions are needed to determine the levels of genotypic main effects and environmental influence. External factors from the environments need to be estimated and measured to determine their individual contribution (Gauch and Zobel 1996).

Parametric methods have been used before to measure the effects of G x E interactions, but have proven to be less informative since they are based only on analysis of variance (ANOVA). Multivariate analytical methods such as Additive Main Multiplicative Interaction (AMMI) and Genotype, Genotype Environments (GGE) that analyze both the genotypic effect and explain the interaction using ANOVA and Principal Component Analysis (PCA) respectively, provide more robust information on the status of G x E interactions.

Using graphical bi-plots, these methods provide information that could be relied on to draw major conclusions and recommendations about the environment and the genotype (Ani et al., 2016). The bi-plots are based on the first and second principal components (PCA1 and PCA 2) that are derived from singular value decomposition (SVD) of the environment centered data. The GGE bi-plots identify such aspects as, suitability of locations for genotypes in the 'which won where' and determine the discriminating ability and representativeness of locations (Yan et al.., 2007). The bi-plots also provide information on mega environments which play a key role when pooling of information on similar environments is necessary to reduce the cost of evaluation (Affleck et al., 2008). The GGE methodology is also capable of providing details on the qualitative aspects of the yield in relation with the environment (Bach et al., 2012).

Development of superior genotypes is disadvantaged by the lack of clear description of the

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environments and adaptability aspects of the genotypes. Mega environments are important in identifying similarities and differences of test environment, provides information about the adapted genotype and ultimately establishing the yield potential of a genotype in a given region (Yan and Rajcan., 2002; Kalidasu et al., 2016). The mega environments provide important information that enables prudent resource utilization without compromising the quality of the information obtained. The potato variety breeding efforts in Kenya have developed elite genotypes whose stability and adaptability has not been established before.

II. Materials and Methods

The experiments were conducted in six locations namely, Molo, Narok, Cherengangy, Burnt Forest in Rift Valley, Timau and Kibirichia during the national performance trials in 2015 and 2016 long rainy seasons (Table 1 and Fig.1). The sites were selected from zones known for potato production in Kenya and they represent mid to high altitude agro-ecologies. These sites receive varying amounts of rainfall as well as temperatures and experience a bimodal rainfall pattern annually as shown in Table 1.

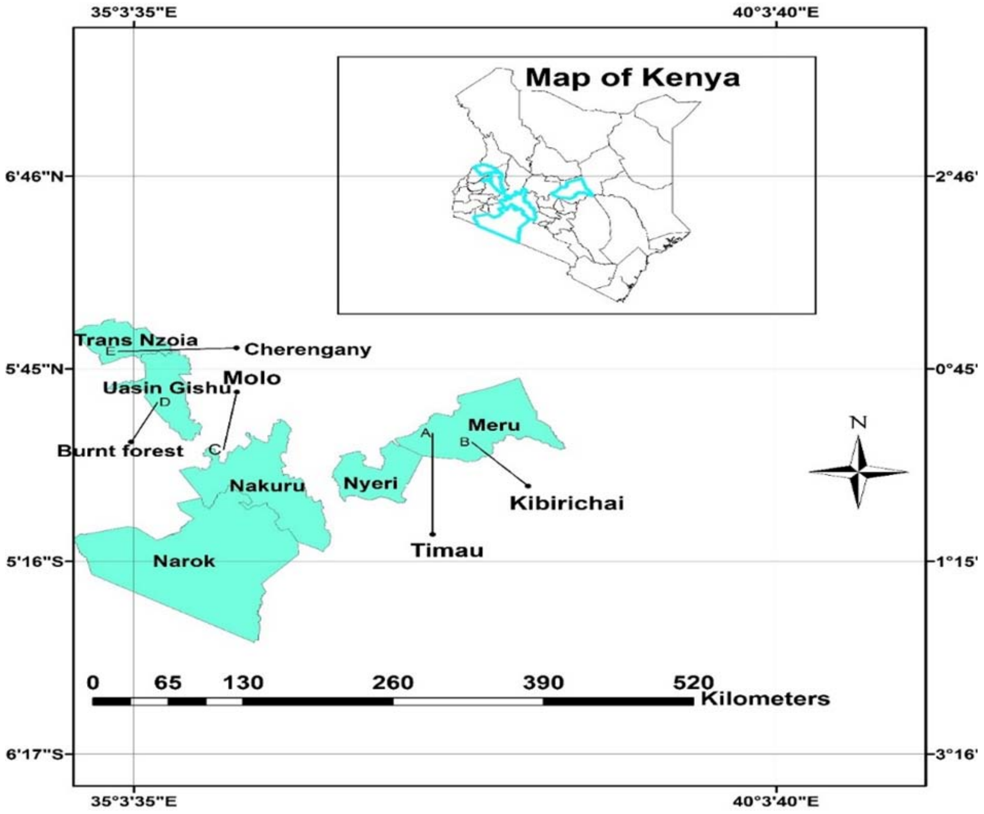

Figure 1: Map of Kenya showing the evaluation environments

Table 1: Geographical and climatic description of selected trial sites in Kenya

Location	Altitude (masl*)	Annual rainfall	Temperatures	
			Minimum	Maximum
Molo	2506	1131	16	24
Narok	1827	771	9.2	26
Cherangany	2,047	1,200	14	30
Burnt Forest	2419	1103	12	25
Timau	1767	587	6.9	23.3
Kibirichia	1827	24	16	24

**masl = Meter above sea level. Source: Kenya National Meteorological Agency, 2015*

Three Table type commercial varieties namely, G20 (Shangi), G11 (Kenya Karibu), G24 (Tigoni) and one Processing type, G8 (Dutch Robjyin) were used as checks. Among the 23 genotypes, ten were Processing types (G1, G2, G3, G10, G12, G13, G14, G17, G22 and G26) whereas thirteen were Table types (G4, G5, G6, G7, G9, G15, G16, G18, G19, G21, G23, G25, and G27). In each location, the seed was planted and managed using the farmer potato production practices. The trials were laid down in a randomized complete block design (RCBD)with plots measuring, 3 meters by 3 meters, with 0.30 meters between the plants, 0.75 meters between rows and 1meter between plots. Fifty sprouted seed potato tubers were planted per plot making a plant population of 1,350 plants per block. The seed tubers were planted at a depth of 10cm with application of Di-ammonium Phosphate fertilizer (DAP) at a rate of 500 Kg per hectare (Muthoni et al., 2016). The stems were cut off at 90 days after planting and harvested 15 days later after tuber hardening. Tuber yield was scored first in kilograms per plot but converted to tons per hectare.

III. DATA ANALYSIS

Tuber yields for each genotype and location were subjected to analysis of variance (ANOVA) using R statistical software. Treatment means were separated using Least Significant Differences (LSDs) at 5% probability level. The multiplicative effects of G x E interactions were assessed by principal component analysis (PCA1 and PCA2) using GGE bi-plot software and adopting the following formula as recommended by (Yan et al.,2000).

$$Yij = \mu + \beta j = \lambda 1\xi i1\eta ij1 + \lambda 2\xi i2\eta ij2 + \varepsilon \boldsymbol{ij}$$

Where: Yij= the performance of genotype **i** in environment **j**, $\boldsymbol{\mu}$ = the grand mean, **βj**= the main effect of environment **j**, λ_1=singular values (SV) for the first principal component, λ_2= singular values (SV) for the second principal component, ξ_{i1} = eigenvector of genotype i for (Principal Component 1) PC1, ξ_{i2}= eigenvector of genotype i for (Principal Component 2) PC2, η_{j1}= are eigenvectors of environment j for PCI, η_{j2} = are eigenvectors of environment j for PC2 and **εij**= is the residual associated with genotype i in environment.

IV. RESULTS

a) *Effect of different environments on tuber yields*

The combined analysis of variance showed that there were significant differences at ($p \leq 0.05$) among the evaluated potato genotypes. The environments were significantly different as well as the interaction between the environments and the genotypes (Table 2).

Table 2: Analysis of Variance (ANOVA) for table and Processing types for 2015 and 2016 long rainy seasons

	Table			**Processing**		
Source of variation	D.F	M.S	F pr.	D.F	M.S	F pr.
Genotype (G)	26	177.16	<.001	10	128.7	<.001
Environment (E)	5	5178.47	<.001	5	2351.47	<.001
G x E	130	99.44	<.001	50	54.22	<.001
Residual	810	33		329	27.36	
LSD Genotype	2.754			**2.417**		

Significant at level of $P \leq 0.05$

The Table type genotypes showed varied performance across the environments. The average tuber yields in the evaluation environments were significantly different except in Burnt forest and Molo where mean tuber yields were almost similar (Table 3). Genotypes, G5 (32.49 t ha-1) and G15 (32.96t ha-1) yielded higher than the check genotype G11 (24.48 t ha-1) in Burnt Forest. The highest yielding check was genotype, G20 with an overall mean yield of 23.65 t ha-1. The other two checks, G11 and G24 had mean yield of 23.65 t ha-1 and 21.11 t ha-1 respectively. Genotypes, G4 and G7 performed better than G20 and G24 the commonly grown varieties in Burnt Forest. Table type genotype G21 with a yield range of between 12.86 and 24.55 t ha-1 was the lowest yielding. The environment with the highest tuber yield was Narok with a mean tuber yield of 29.26 t ha-1 whereas Kibirichia was the lowest tuber yielding location, with 12.79 t ha-1 mean yield. The highest yielding genotype was, G25 (20.15 t ha-1) in Kbirichia whereas, genotype, G9 with 7.72 ha-1 was the lowest yielding.

Table 3: Average tuber yields (yield t ha-1) of Table genotypes among test environments during long rainy seasons of 2015 and 2016

Genotype	**Sites**						
	B.Forest	**Cherengany**	**Kibirichia**	**Molo**	**Narok**	**Timau**	**Mean**
G5	32.49	34.59	12.61	24.1	27.05	28.08	26.49
G15	32.96	26.49	15.85	19.6	25.56	23.52	24.00
G23	16.34	13.57	16.99	19.82	31.89	27.77	21.06
G25	16.84	18.26	20.15	20.47	26.04	22.52	20.71
G19	13.85	14.34	16.78	19.81	32.8	26.39	20.66
G7	20.98	11.36	11.67	16.42	36.66	26.17	20.54
G4	20.78	19.13	12.3	17.79	28.19	22.88	20.18
G6	17.22	24.33	7.83	19.32	25.67	24.35	19.79
G18	19.11	15.55	10.81	20.30	30.67	22.00	19.74
G16	26.97	12.40	9.84	16.18	25.57	25.12	19.35
G27	15.54	12.72	15.13	20.95	27.12	23.67	19.19
G9	17.95	8.99	7.72	20.69	32.34	27.22	19.15
G21	12.9	12.86	13.29	23.93	24.55	18.92	17.74
Checks							
G20	18.34	27.76	13.15	21.05	32.82	28.75	23.65
G11	24.48	22.98	9.72	16.97	33.19	28.22	22.59
G24	14.35	26.61	10.77	24.56	27.98	22.41	21.11
Mean	20.07	18.87	12.79	20.12	29.26	24.87	21.00

Among the Processing types, G2 (29.1 t ha^{-1}) and G22 (20.1 t ha^{-1}) produced the highest yields in Burnt Forest (Table 4). Genotypes, G13 (17.14 t ha^{-1}) and G8 (17.72 t ha^{-1}) in Kibirichia had almost similar tuber yields. Genotype, G8, the commonly grown check gave similar yields to that of G13 (32.62 t ha^{-1}) in Narok. In Timau, the test genotypes had lower yields compared to G8, the check, though these yields were not significantly different. All environments were significantly different from each other for tuber yield. Narok with a mean yield of 29.26 t ha^{-1} was the highest yielding location, whereas, Kibirichia with a mean yield of 13.54 t ha^{-1} had the lowest tuber yields. Cherengany and Kibirichia were the lowest yielding locations with mean yields of 13.73 t ha^{-1} and 13.54 t ha^{-1} respectively.

Table 4: Average tuber yields of Processing genotypes among test environments during the long rainy seasons of 2015 and 2016

	YIELD T HA^{-1}						
Gen	**B. forest**	**Cherengany**	**Kibirichia**	**Molo**	**Narok**	**Timau**	**Mean**
G2	29.07	15.75	11.88	19.67	30.43	24.32	21.85
G22	20.08	14.73	13.58	18.5	30.76	27.54	20.87
G13	13.91	11.93	17.14	20.52	32.62	24.31	20.07
G10	16.67	15.00	15.15	19.75	30.91	22.43	19.99
G26	16.56	17.52	12.66	22.3	24.93	24.37	19.72
G3	18.27	11.01	11.47	19.51	27.43	27.37	19.18
G17	21.38	10.76	12.78	18.51	23.23	26.4	18.84
G1	12.3	14.85	13.21	21.01	25.74	23.56	18.45
G12	15.12	14.73	11.22	15.8	25.63	20.81	17.22
G14	8.88	9.66	12.17	12.19	26.33	21.16	15.07
Check							
G8	11.54	15.14	17.72	22.07	31.61	29.04	21.19
MEAN	**16.71**	**13.73**	**13.54**	**19.08**	**28.15**	**24.66**	**19.31**

Adaptability and stability of potato Processing genotypes

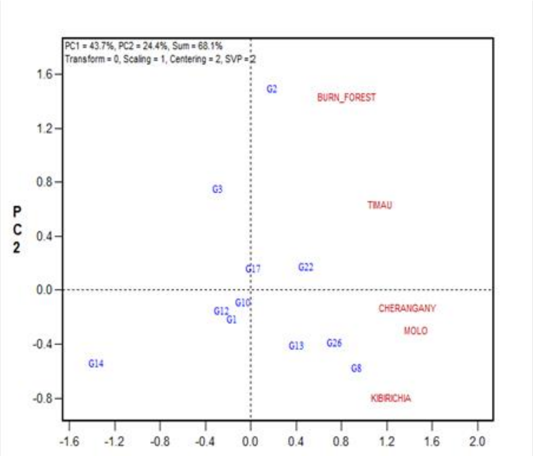

Figure 2: GGE-biplot showing the relative performance of Processing potato genotypes in Burnt forest, Timau, Cherangany, Molo and Kibirichia 2015 and 2016

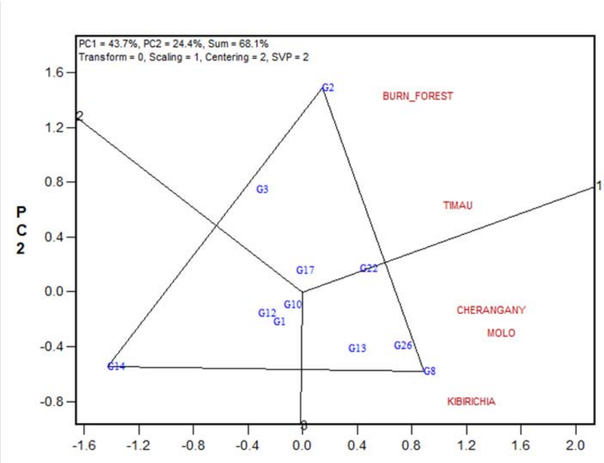

Figure 3: GGE Bi-plot analyses showing the mega-environments and the winning Processing genotypes during 2015 and 2016

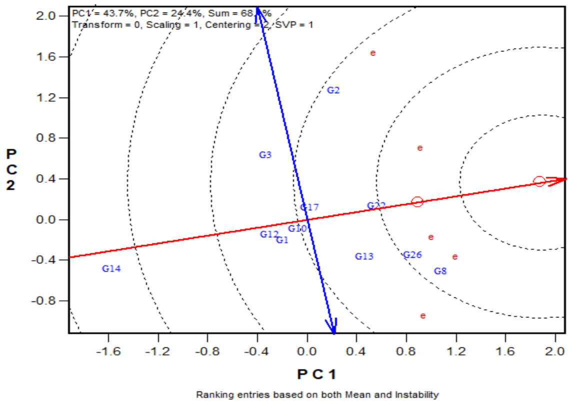

Figure 4: Positioning Processing types of genotypes relative to the ideal environment and their stability 'e' showing the distribution of environments during 2015 and 2016

The GGE bi-plot identified Burnt Forest and Timau environments as having both positive values for PC1 and PC2 (Fig 2). The Processing types, G2 and G22, gave positive values of PC1 and PC2. The two genotypes, G2 and G22, were specifically adapted to these two environments. Cherangany Molo and Kibirichia locations had large negative PC2 values which implied that they strongly interacted with the potato genotypes that had negative PC2 values. The genotypes in this region were adapted to the Cherengany, Molo and Kibirichia environments (Fig 2). Genotypes, G13, G26 and G8 were adapted to the Cherangany, Molo and Kibirichia environments. The PC1 and PC2 accounted for 43.7% and 24.4% of the variations respectively and together they accounted for 68.1% of the observed variations. In Fig 4, the double arrowed line that is perpendicular to the Average Environmental Coordinate (AEC), represents the genotypic stability and those genotypes on either side and far from it represent greater interaction with the environment and low stability whereas those closer are stable ones. The AEC points towards ideal genotype and ideal environment. The ideal genotype is one with higher mean and closer to the ideal environment represented by the small circle on the AEC. PC1 was associated with yield potential of the genotypes whereas PC2 was associated with the stability. G22 was identified as the most stable whereas G2 was the most unstable.

Two mega-environments were identified for the Processing types. The first one was Burnt Forest and Timau where, genotype, G2 was the highest yielding followed by genotypes, G3, G22 and G17 (Fig 3). The second mega-environment consisted of Cherengany, Molo and Kibirichia locations in which G8 yielded highest followed closely by G26 and G13. Genotypes G1, G10, G12 and G14 displayed low yields. The genotypes located to the right side of the polygon in Fig 4 were the high yielding ones whereas those to the left of the double arrowed line were the low yielding ones.

The midpoints of the concentric circles represent the position of an ideal genotype that is the most stable genotype with high mean tuber yield. The genotype that has the highest yield and is the most stable, shows the longest horizontal vector and shortest vertical vector (Bai et al. 2014). In Fig 4, the genotypes located closer to the ideal environment position were the highest yielding genotypes. Genotypes, G8 and G26 were closer to the ideal environment, whereas, G14 was furthest from the ideal environment and had the lowest yield. Genotypes, G8 and G2 gave high yields in specific environments but had low adaptability. Genotype, G22 was more stable than the check genotype, G8 even though the later was located closer to the ideal area. Genotype, G17 gave low yields but had higher stability compared to the check.

Adaptability and stability of potato Table genotypes

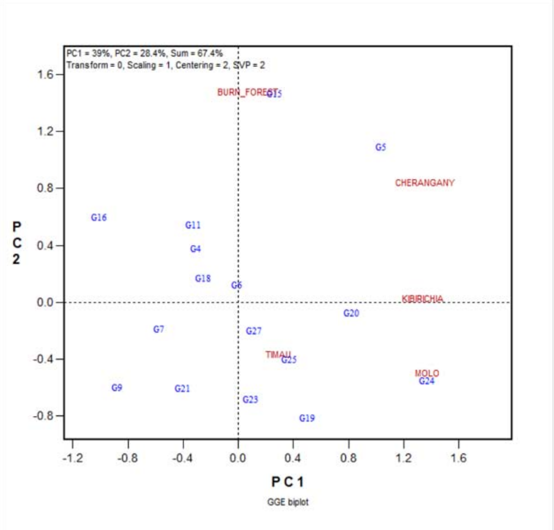

Figure 5: GGE-bi-plot showing general Table type genotypes yield performance relative to the test environments in 2015 and 2016 long rainy seasons

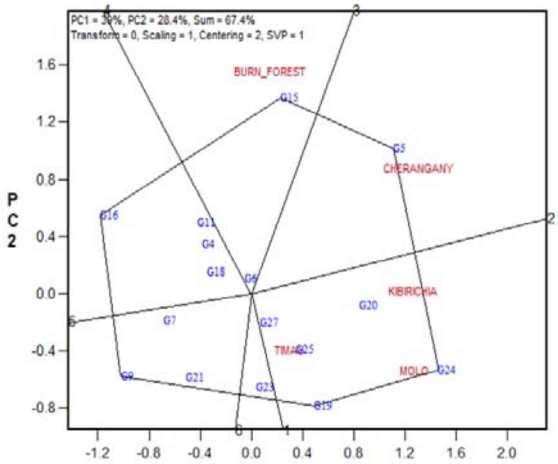

Figure 6: GGE-Biplot showing Table type yields and how they performed in different testing mega-environments during 2015 and 2016 long rainy seasons

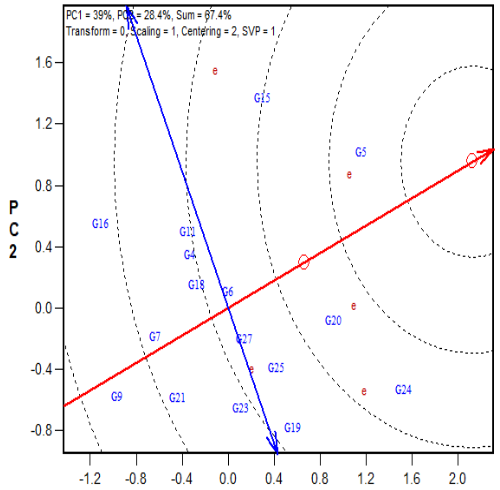

Figure 7: Stability ranking of the Table type genotypes relative to the ideal environment during 2015 and 2016 long rainy seasons

The GGE Biplot for Table types showed that PC1and PC2 explained 39% and 28.4% of the variations observed respectively and collectively explained 67.4% variation (Fig 5). Burnt Forest, Cherengany and Kibirichia locations had positive PC2 values, with G5 and G15 showing specific adaptability to Burnt Forest and Cherengany environments respectively. Timau and Molo locations had higher interactions with the genotypic effect and gave similar PC2 value to genotypes, G13, G19, G20, G23, G24, G25 and G27. Genotypes, G15 and G5 yielded highest in Cherengany whereas genotype, G9 and G21 had the poor yields. Genotypes, G27, G23, G20, G25 and G24 yielded better in Timau and Molo whereas genotypes G4, G7, G11, G9, G16, G18 and G21 were poor performers. Genotypes that had PC1 scores of >0 were high yielding and adapted to the production environment than those that had PC1 scores of <0 being poor yielders and were not adapted. The genotypes whose PC2 value was closer to zero were considered stable such as, G6 and those that had PC2 value far from zero such as G24 were considered unstable. Genotypes, G24 and G25 showed high adaptability in Molo and Timau environments respectively.

In Fig 6., the polygon graphs generated from GGE software showed the existence of three mega-environments among the evaluated locations for Table types. Burnt Forest, and Cherengany each formed one single mega-environment whereas Kibirichia, Timau and Molo formed the third mega-environment. The Table genotypes had varied levels of interaction with the environment (Fig 6. and Table 6.) with genotypes, G5, G9, G15, G16, G19 and G24 being positioned to the outermost corners of the polygon. These genotypes gave the higher yields in the mega environments whereas genotypes, G4, G7, G9, G11, G16, and G18 located in the interior of the polygon gave lower yields. On 'which won where', genotype, G15 won in Burnt Forest, whereas, G5 won in Cherengany and G24, in Timau, Molo and Kibirichia. PC1 and PC2 were accountable for 39% and 28.4% of the variation respectively.

Fig 7, shows that genotypes, G6 and G7 were more stable although they were low yielding compared to G5, G20 and G24 (Fig 7). G5, genotype gave the highest yields and was the most stable. Genotype, G15 even though was one of the high yielding ones, was unstable but had specific adaptation to Burnt Forest environment. Genotypes, G6, G19, G25 and G27 had their yields very close to the grand mean whereas, genotypes G4, G7, G9, G11, G16, G18 though low yielding were fairly stable.

Fig 8, shows the average tube yield of the Table and Processing genotypes variation among the environments. The yield between the two types ranged between 0.2 – 5.14 t ha^{-1} but for the environments, Cherengany had the highest yield difference at 5.14 t ha^{-1} and Timau had the lowest at 0.21 t ha^{-1} (Fig.8). The Processing genotypes were more sensitive to environmental factors than the Table types. This was most experienced in Cherengany and Burnt Forest environments as reflected by their yield differences.

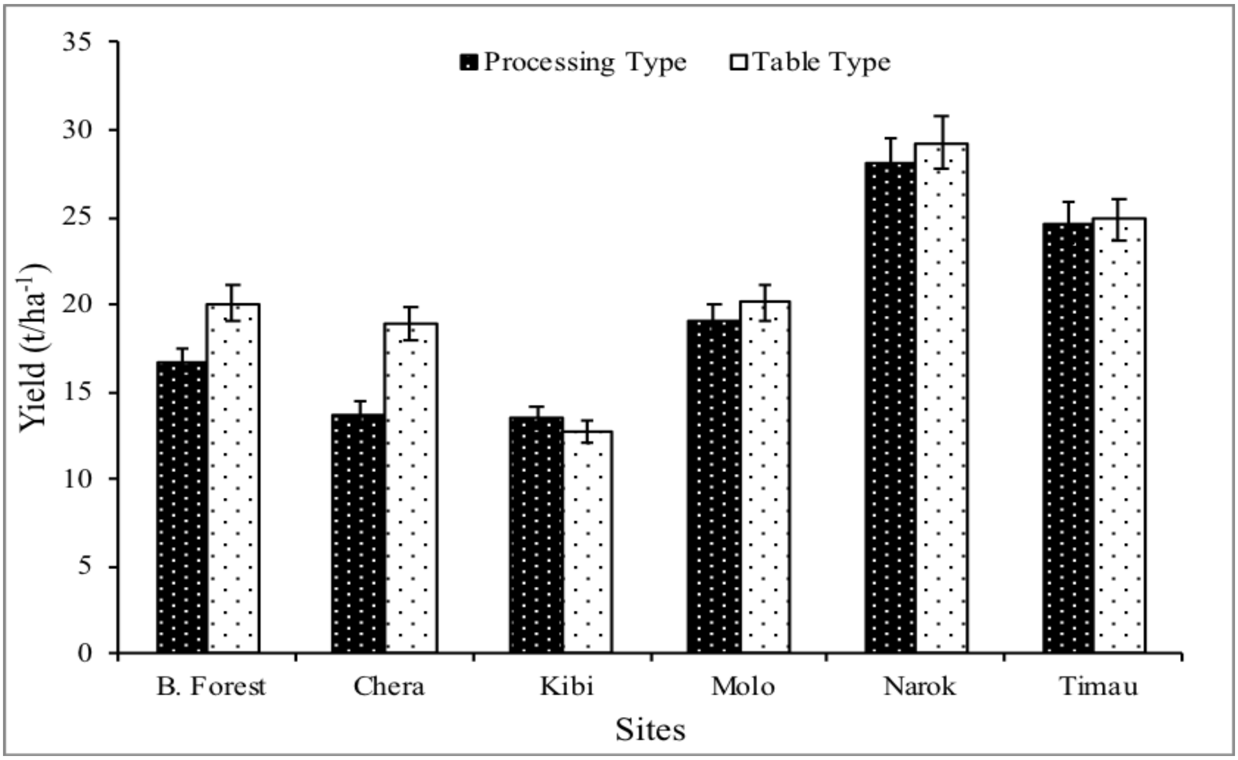

Figure 8: Comparison between Table and Processing types based on means from each environment during long rainy seasons of 2015 and 2016

V. Discussion

Analysis of variance for tuber yield revealed diverse and highly significant genotype by environment interactions (G x E). The significant G x E interaction is as a result of variations in tuber yield that was associated to the different sensitivity levels of the genotypes to environmental conditions. This was attributed to the extensive genetic variation that exists within and between the elite potato genotypes that control to tuber yield and the differences in environmental factors that influence tuber yield (Suttle, 2007; Jyotshnarani et al., 2017, Brandon et al., 2019). The significant mean sum of square of G×E interaction for tuber yield showed that the genotype response varied in different environments (Jyotshnarani et al., 2017) and the responses were due to the diverse genetic constitution. Factors within the different environments that are both predictable and un-predictable were responsible for the yield variations (Karimizadeh et al., 2012). Every genotype responded differently depending on its sensitivity levels.

The diversity in yields within and between the types also demonstrated that the potato factors controlling tuber yield responded differently to different external factors presented by the different environments (Tables 3.and 4). Some genotypes maintained stable yields while others had major yield fluctuations. For example, G22 and G6 for Table and Processing respectively were stable, whereas G15 and G2 were the most unstable. Genotype, G15 of the Table type had a superior mean yield across environments compared to the other test genotypes and the checks but was unstable compared to the low yielding but stable, G6 genotype (Fig.7). Similar variations were observed among the Processing genotypes with G2 having high yields but was unstable whereas G22 was stable but gave lower yields. Some stable genotypes such as G6 and G17 had low yields while some unstable genotypes such as G2 and G15 had higher yields in the two types. Therefore, stability of a genotype does not necessarily lead to a high yield performance of a genotype. This indicates that some genotypes were genetically better buffered compared to those that had varying responses to environmental conditions (Jyotshnarani et al., (2017); Haydar et al., (2009). The average tuber yields the of genotypes across environments ranged between 29.26 t ha-1 in Narok to 12.79 t ha-1 in Kibirichia for the Table types whereas for the Processing types, the yields ranged between 28.15 t ha-1in Narok to13.54 ha-1 for Kibirichia (Tables 3 and 4) indicating that Narok had the best conditions for tuber yield for both types whereas Kibirichia had the most tuber yield stressing factors.

There were no noticeable variations due to seasons meaning that genotypes were not sensitive to seasonal variations. This indicates that the seasonal changes were not determining genotypic response. The stable genotypes were not necessarily the high yielding ones within the mega environment or the micro environments. Taking this into account, genotypes such as G5 and G15 for the Table potato type and G22 for the Processing type should be selected for tuber high yield.

The two potato types had low mean yields in Kibirichia, Narok location recorded the highest yield for the two types (Tables 3,4. and Fig 7). This shows that, Narok has most of the required potato production nutrients and the cool and humid weather conditions that are conducive for potato production. The two potato types had some specific requirements that are necessary for optimum yield, as shown by the variation in yield of each type from one environment to the next (Fig 8). Where these resources are limited and or not readily accessible in optimum quantities when needed, the affected genotype performs poorly. The selection of adapted genotype faces many challenges when based on environmental means rather that genotype mean.

The micro-environments that form a mega-environment have a lot of similarities than differences and therefore genotypes are subjected to almost similar conditions in any of the microenvironment. Two mega-environments for Processing type and three mega-environments for Table type were identified by GGE biplots (Fig. 3 and 6) respectively. The formation of different number mega-environment formed is an indicator of some differences in genetic responses to environmental pressures. The mega-environments provide a guide on judicious utilization of resources without compromising on quality of the recommendations and decisions that can be derived from collected data (Affleck., 2008). Timau, Molo, Kibirichia environments had similar characteristics and therefore any two the sites could be eliminated during varietal evaluation and still provide reliable and representative information for the Table genotypes. Cherengany and Burnt Forest environments, came out as different independent mega-environments meaning that varietal evaluation could be conducted in any one of these environments. Similarly, for the Processing types, either Burnt forest or Timau environment could and still dependable data obtained.

The mega-environments that were obtained for both the Table and Processing potato genotypes, showed that some locations were similar while others were different. Tuber yield and stability of the test genotypes are important aspects to determine the suitability of a genotype for recommendation in a particular location. For the Processing types, genotype, G22 demonstrated the highest stability whereas genotype G2 was the most unstable (Fig 4). Among the Table types G5 was the highest yielding genotype that was also fairly stable and was closer to the ideal environment, whereas G19 was the most unstable (Fig 7). In both Table and Processing types, the stable genotypes had fairly consistent yields across contrasting environment compared to the unstable ones that had low yields (Table 3 and 4). The stable genotypes were those that had insignificant interaction with the environment whereas the unstable ones were those that significantly interacted with the environment (Bogdan et al., 2014).

There was expression of both general and specific adaptability among the genotypes used in the study. For example, among the Table type genotypes, G5 and G15 expressed general adaptability by giving consistently high yield across environments whereas the other genotypes only displayed good performance in specific environments (Table 3 and Fig 7). In both potato types evaluated here, there were those that had dismal performance across all the experimental sites. For example, the Processing type had their poor performers as G1, G12 and G14 and the Table type had, G21, G9 and G27. The best performing genotypes passed as the best adapted genotypes because of their dependable tuber yield. For crop improvement reasons, the genotypes with a combination of high mean tuber yield and high stability are possibly the reliable genotypes for selection and further evaluation (Bai et al.,2014) though this situation is a rare combination.

The genotypes of the two potato types, Table and Processing, expressed both static and dynamic stability. Static stability was expressed by some genotypes that yielded in a fairly similar manner in more than one site. For example, G6 and G22 of the Table type and Processing respectively expressed static form of stability whereas dynamic stability was expressed by genotypes G20 and G26 Table and Processing respectively. In these cases, the yields of the genotypes varied significantly from one location to another but did not differ significantly from the environmental mean. The Table type genotypes, namely, G6 and G7 showed static stability, an indication that the genetic strength of these genotypes had been stretched to the maximum and no agronomic improvement with favourable climatic conditions could alter their performance significantly. The Processing genotypes, G22 and G17 expressed static stability whereas G2, G13 and G26 and the check G8 showed dynamic stability.

From the results, it was clear that the sensitivity of genotypes to environment differed among and within the Table and Processing types. Some environments produced almost similar yield and therefore could be classified as being related. Positively correlated environments have similar conditions hence similar discrimination while those that are not related present unrelated yields (Yan and Hunt 2001). This means, one of the environments could be eliminated and still reliable data obtained in the future evaluations (Bai et al., 2014). Burnt Forest, Kibirichia and Molo were the most discriminating environments. Varietal evaluation could be conducted in any one of the three environments to save the time and resources.

The Processing types were the most susceptible to the negative effects of the environment compared to the Table types. Bernie et al., (2011) associated the variation of genotype performance to differential gene expression in response to different environmental conditions. Tumwegamire et al. (2016) recommended that stability and adaptability studies be carried out on new genotypes before deployment to determine the potential of the genotypes. This study showed that there were differences in adaptability and stability within and between the potato types in the different environments. Genotypes that were less sensitive to secondary effects were the most stable compared to those that were sensitive to secondary effects (Gehan et al., 2015).

VI. CONCLUSION

Genotypes, G5 and G22 were the highest yielding among the Processing and Table types respectively. Genotypes, G2, G8, G13, G17 and G26 gave high yields with relatively low stability, whereas, genotypes G3, G10, G12 and G14 were unstable. The unstable genotypes, with low yields may qualify as being adapted to specific environments. Narok and Timau environments provided favourable conditions for both Processing and Table genotypes. Kibirichia was the least favourable environment whereas, Narok was the most favourable environment for potato production. G x E interactions significantly affected the yielding ability of all genotypes and therefore, their effects should be determined before deploying new varieties to target environments. G x E interactions for other traits need also be analyzed to establish their stability before deployment.

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