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Characterization of eggplant (*Solanum* species) seedlings using quantitative trait analysis

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Abstract: Quantitative trait analysis of eggplant seedlings (*Solanum* species) was undertaken in the North Central zone of Nigeria with a view to revealing the level of diversity and taxonomic relationships of the collected species. 60 seeds of the various eggplant accessions were randomly collected and planted in a controlled screen house environment. A total of 52 accessions were characterized using sixteen (16) quantitative characters betweenday 4 to31 of planting. In each accession, five (5) seedlings were phenotypically investigated and the mean value of the variables was noted. Data of quantitative characters were analyzed using the SPSS (Statistical Package for the Social Scientists) software programme (20.0 versions). Cluster analysis was performed using the Average Linkage (between group) method based on Euclidean distance which generated a dendrogram for the accessions. Histograms and normal distribution curves were generated which revealed the mean values and deviations of the characters. Degree of relationships amongst the variables was determined through the Pearson's Product Moment Correlation. The results revealed substantial variations in most of the quantitative traits. Emergence of first seed leaf varied between day 4 to day 9 of planting while the percentage of germinated seeds ranged from 3.3% to 98.3% amongst the accessions. Clustering patterns which revealed a high level of intraspecific and interspecific variability were of two types: Location dependent and location independent. Interspecific similarity was also observed which indicates a common ancestral relationship of the species. Plant height was positively correlated with petiole length (0.754), plant total weight (0.903) and number of leaves (0.738). This quantitative approach of combining morphological and embryological taxonomic evidence has made available detailedtaxonomic relationships information of eggplant seedlings in Nigeria due to the dearth of such information.The implication of the findings is to ease breeding efforts where some accessions of known qualities could be selected for commercial farming. Therefore, the valuable information provided may be useful in the development of breeding, crop improvementand conservation programme of the namedgermplasm.
Keywords: quantitative traits, seedlings, germination, variability, breeding, germplasm

INTRODUCTION

Eggplants (Solanum species) belong to the family *Solanaceae* and consist of about 1500 morphologically diverse species[1-2]. According to many authors[3-6] taxonomic confusion and complications exist within this genus due to the varied morphology, wide ecogeographical distribution and presence of different hybrids in eggplants. Basically, among the commonly reported species include: *S. melongena*, *S. macrocarpon*, *S. aethiopicum*, *S. incanum*, *S. scabrum*, *S. dasyphyllum*, *S. erianthum* [2, 3, 7-9] while many species are yet to be identified, named and classified systematically[3] *S. aethiopicum*is further grouped into different ecotypes which are; Aculeatum, Gilo, Kumba and Shum group as revealed by similarities in genotypic characterization though varied phenotypes exist[1].

Though no statistics is officially available or reportedly published on the volume of eggplant produced in Nigeria, the crop is intensively cultivated in the country for its benefits. The production of eggplant is highly concentrated, with 90% of world output coming from five countries. China is the top producer (58% of world output) and India is second (25%), followed by Iran, Egypt and Turkey. More than 4,000,000 acres (1,600,000 ha) are devoted to the cultivation of eggplant in the world [10]. The crop is commonly cultivated all over the world and it is known for its nutritive values, therapeutic benefits among other uses. Hence, it has dual status of being a vegetable crop on one hand and a fruit crop on the other hand.

Assessment of the diversity and relationships of the cultivated species facilitates the establishment of conservation strategies, the use of genetic resources in breeding programmes, and the study of the crop

evolution [11]. The evaluation of genetic resources is therefore crucial for breeders to produce new cultivars or to further improve the existing ones according to changing consumer demands or overcoming challenges during plant growth such as pest and disease resistance[4,7] morphologically characterized African eggplants using twenty-eight accessions from three species of *Solanumaethiopicum* (16), *Solanummacrocarpon* (9) and *Solanumanguivi* (3). Their results indicated distinct and wide variations between the three *Solanum* species with a lot of similarities between the *S. aethiopicum* and *S. anguivi* lines. Morphological and agronomical characterization of eggplant genetic resources was carried out [12]. In their report, some genotypes were more productive and produced fruit faster than others. In Spain, conventional descriptors and the high-throughput phenomics tool of Tomato Analyzer for characterizing 63 accessions of eggplant complexes with substantial level of variations reported[9]. Different molecular markers have also been employed by authors to study the diversity of the cropand other crops across the world[2, 13-15].

However, there is dearth of information on its diversity using seedlings as embryonic evidence as most studies have confirmed the fact that taxonomic relationship is difficult to establish in the crop due its varied characters. On this note, this study was carried out on the growing seedlings by employing quantitative trait approach to reveal information on its germination and diversity.. The overall aim was to investigate the level of diversity and taxonomic relationships or otherwise among the species.

MATERIALS AND METHODS

This study was carried out across 52 north central locations in Nigeria, tropical West Africa. 60 seeds each of the various eggplant accessions were randomly collected and planted in green rounded plastic pots of equal sizes (23cm in diameter, 8.5cm in height) arranged under a controlled screen house system. All pots contained the same quantity of fertile soil and maintenance was equally apportioned. Equal depth was used in planting. A total of 52 accessions were characterized using sixteen (16) quantitative characters between day 4 to 31 of planting. In each accession, five (5) seedlings were phenotypically investigated and the mean value of the variables was noted. Meter rule was used in measurement of length, breadth, and height while electronic weighing balance with tarring function was employed in weight measurements. Number of seeds planted in relation to the proportion that germinated was physically counted. Data of quantitative characters were analyzed using the SPSS (Statistical Package for the Social Scientists) software programme (20.0 versions) following the method of Oboh *et al*.,[16]. Cluster analysis was performed using the Average Linkage (between group) method based on Euclidean distance which generated a dendrogram for the accessions. Histograms and normal distribution curves were generated to reveal the mean values and deviations of the characters. Degree of relationships amongst the variables was determined through the Pearson's Product Moment Correlation.

RESULTS AND DISCUSSION

The diversity, taxonomic relationship and information on eggplant germination have been revealed in this study. Dendrogram(figure 1) has revealed 2 main clusters. Cluster 1 consists of 2 sub clusters where four accessions from Nasarawa state were grouped on the basis of location indicating a strong relationship between them. Other accessions in these two sub clusters were grouped together but not strongly tied to their location and this indicates similarities on one hand as well variations on the other hand. They include but not limited to: *S. aethiopicum* Gilo (PL3), *S. anguivi*medium (NG2A), *S. aethiopicum*gilo (NG2B), *S. aethiopicum Shum* (PL1B) and *S. aethiopicum*Shum (KG2B). However, *S. anguivi*tiny (BN7) was semi divergent within the groups therefore reflecting a variation from the *S. aethiopicum* line. The fruit and seeds of BN7 were noted for their small size and high germination rate respectively.Cluster 2 consists of three sub clusters whose accessions display much interspecific and intraspecific similarity. For instance, BN2B and BN1B are both *S. aethiopicum*gilo while PL1A and PL4B are *S. aethiopicum* gilo and *S. aethiopicum* Kumba respectively. FCT2 and FCT3 are also *S. aethiopicum* Kumba. This shows similar characteristics among the *S. aethiopicum* groups but differ intraspecifically from *S. aethiopicum*gilo of NG2A and *S. aethiopicum* Shum of KG1B in cluster 1. Attention is particularly drawn to accession BN6 (*S. macrocarpon*) noted for its large fruit sizes which diverged from the rest *S. aethiopicum* group. In spite of this difference, it is suggested that *S. macrocarpon* and other groups of *S. aethiopicum* in this group are related. This finding is in agreement with reports from several authors[2, 14, 17, 18] that these species have a common progenitor in their phylogenetic history, hence their relationship. This notion of commom ancestral linkage is further established by BN2B (*S. aethiopicum* Gilo and KG6 (*S. macrocarpon)* forming a tied cluster together.

However, there is a strong relationship between BN1D (*S.aethiopicum* Gilo and FCT 2 (*S. aethiopicum* Kumba). Also BN1F (*S.aethiopicum* Gilo) and NS7 (*S.aethiopicum* Kumba) are also strongly tied together. This may be due to their specific relationship in most of the characters. The fruits of both sub groups of S. aethiopicum are similar except that the Kumba group has grooves longitudinally along its surfaces. The result obtained from morphological characterization in this study also aligns with the work of Osei *et al*. [7] who morphologically characterized African eggplants using twenty-eight accessions from three species of *Solanumaethiopicum* (16), *Solanummacrocarpon* (9) and *Solanumanguivi* (3) Their results indicated distinct

and wide variations between the three *Solanum* species with a lot of similarities between the *S. aethiopicum* and *S. anguivi* lines.It has further been confirmed that Statistical Correlation is a true measure of relationship. The high positive correlation between KG1A and BN1F (+0.999) indicates that they are both *S.aethiopicum* Gilo showing high affinity in their quantitative characters. PL2A (*S. aethiopicum* Kumba) and BNIE (Kumba complex) also shows high proximity by +0.997. Correlation how eve however contrasts the view of Nunome *et al*., [15] and Mariola *et al*., [9] who suggested that the sub groups in *S. aethiopicum* be treated as different species since they all display varied phenotypes and genotypes using a combination of molecular markers As illustrated in figure 2a-d,the accessions that are very fast in producing their first cotyledon within four days of planting include: NSID, NS5, NS7, KG2B, BN1A, BNIE, BN1F, BN2A, BN5, BN6, FCT2, NG2A, PL1B and PL1C among others with an overall mean value of 6.12 days. Plant height was symmetrically distributed with a mean value of 7cm.Ripe fruit weight ranged from 5.32g in BN7 (*S. anguivi* tiny) to 139.34g in BN6 (*S. macrocarpon*). Table 1 indicated that FCT5 (*S. aethiopicum*gilo) yielded the least number of germinated seeds after 30 days of planting (2 seedlings) while high number of germination was recorded in BN1A (Striped Gilo Kumba complex) yielding 59 seedlings. KG2A (*S. aethiopicum* Kumba) and BN7 (*S. anguivi* tiny) also recorded high number of seedlings, 58 each. However, there was no relationship between fruit weigh and germination (0.339). Since environmental effects are excluded in these differences by using a controlled system, the variation observed in seed germination might reflect the genetic constitutions of the species[3, 16] (irrespective of their fruit sizes.

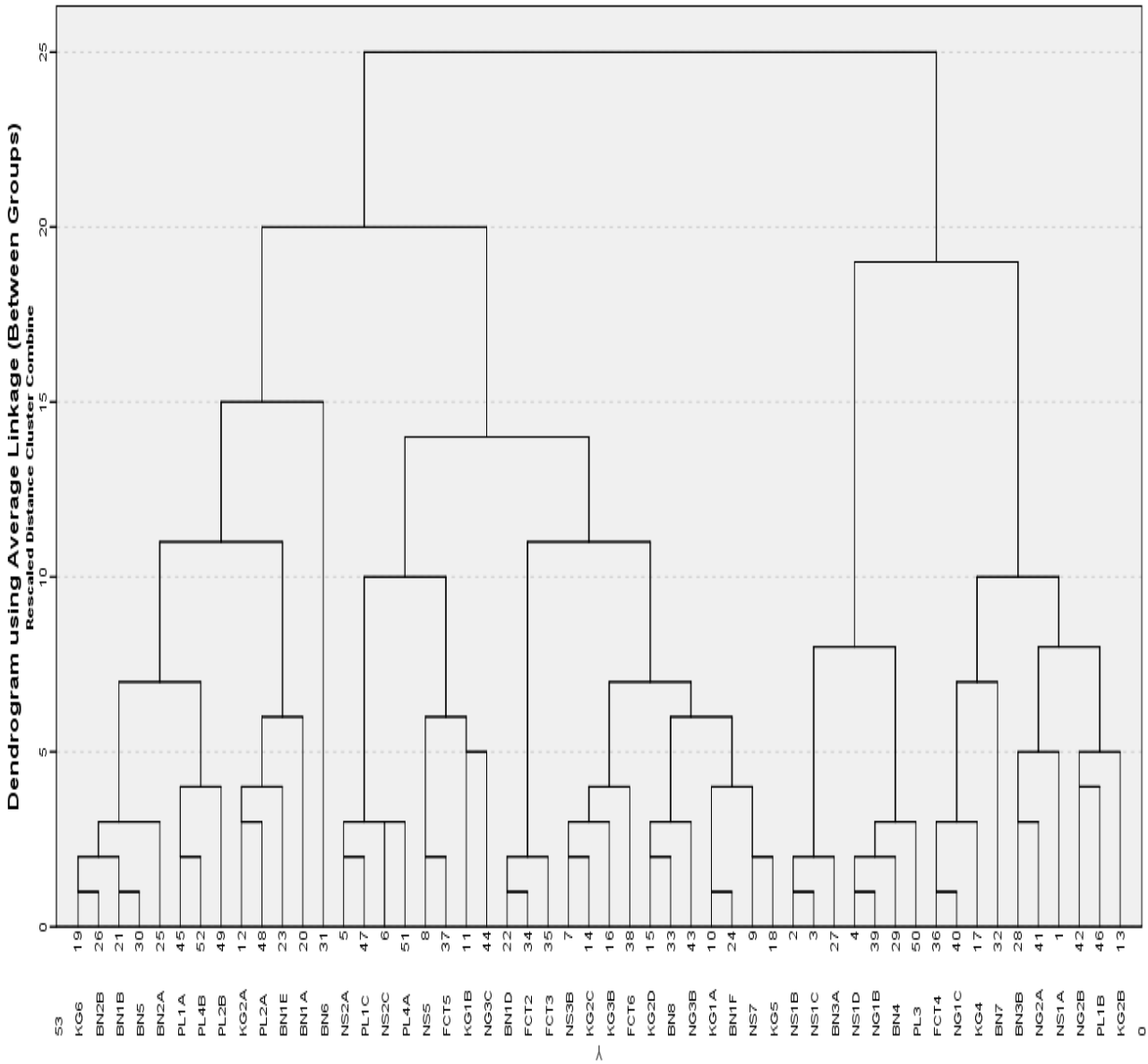

Fig-1: Dendrogram of the phenotypic quantitative characters in 52 accessions of eggplant

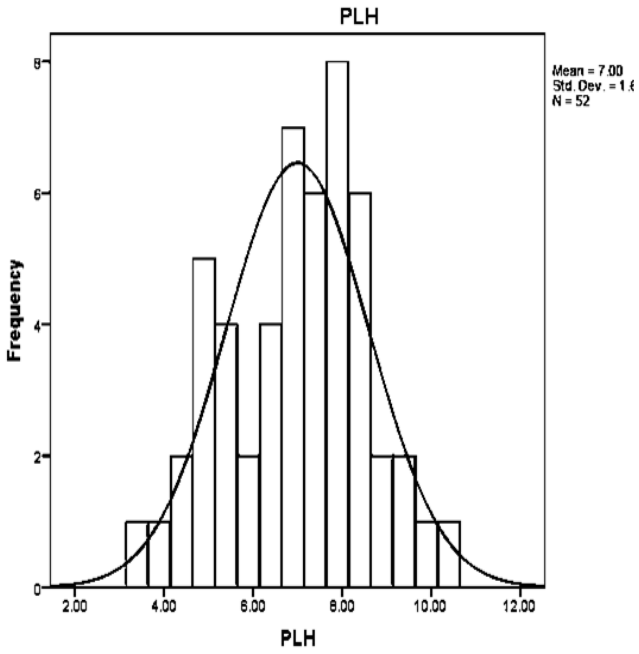

Fig- 2a: Distribution curve of plant height (PLH)

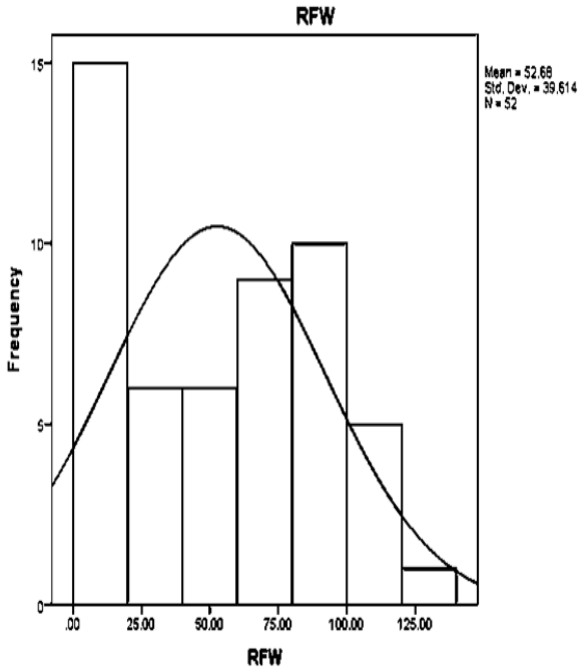

Fig-2c: Distribution curve of ripe fruit weight

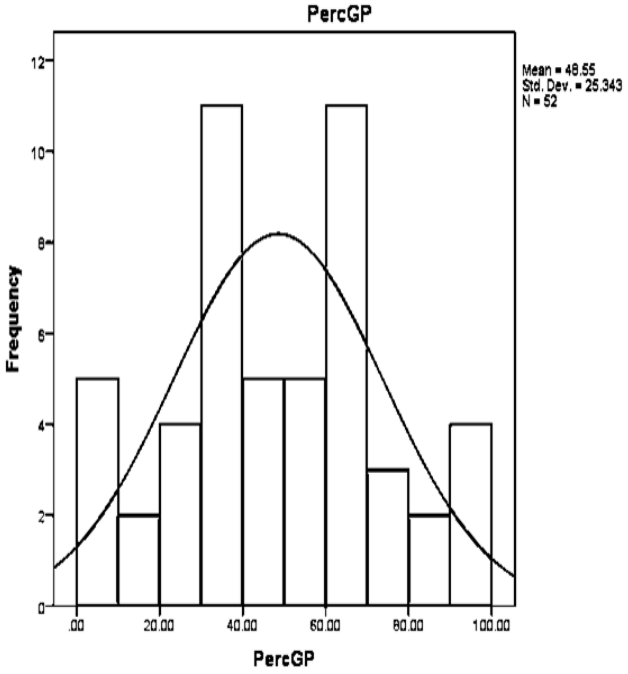

Fig-2b: Distribution curve of percentage of plants that germinated in day 30 (%GP)

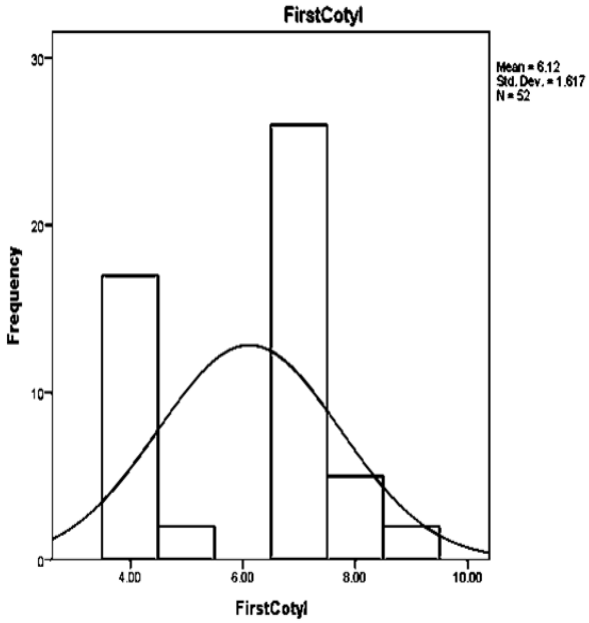

Fig-2d:Distribution curve of number of days for the emergence of first cotyledon

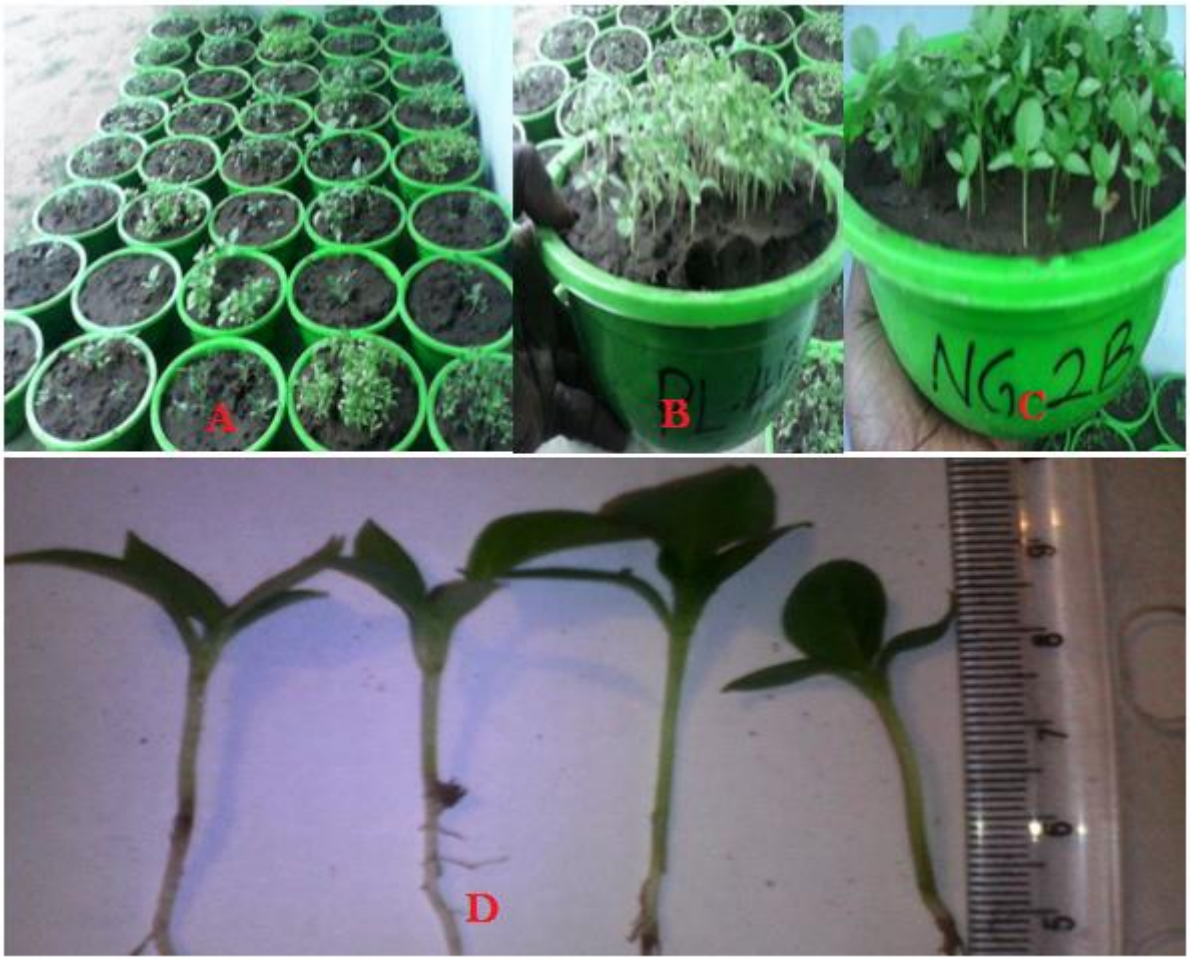

Fig-3a-d: Young eggplants and measurements

Table 1: Quantitative characters

ACCESSIONS	RFW(g)	NSP	DSW(g)/seed	GP@30days	%GP	PLH(cm)	STD(cm)	STH(cm)	PTL(cm)	LFL(cm)	LFB(cm)	FLW(g)/4lvs	PTW(g)	SHW(g)	NoL	1st cotyl (days)
NS1A	0	60	0.0028	37	61.7	4.8	0.1	1.4	0.2	1.1	0.7	0.16	0.48	0.32	3	7
NS1B	0	60	0.0026	17	28.3	7.4	0.1	2.7	0.5	2.4	1.8	0.29	1.1	0.81	4	7
NS1C	0	60	0.0026	20	33.3	7	0.1	2	0.4	1.7	1.2	0.15	0.87	0.72	4	7
NS1D	0	60	0.003	3	5	8.3	0.1	2.1	0.5	2.6	1.2	0.29	0.91	0.62	6	4
NS2A	28.2	60	0.0028	21	35	4	0.1	1.1	0.2	1.2	0.8	0.19	0.45	0.26	3	7
NS2C	39.6	60	0.0026	18	30	5.5	0.1	1.1	0.3	1.7	1	0.15	0.53	0.38	4	7
NS3B	52.8	60	0.0036	28	46.7	6.9	0.1	1.6	0.5	2.6	2.4	0.29	0.8	0.51	4	7
NS5	50.3	60	0.0034	5	8.3	9.8	0.2	3.1	0.5	3	0.9	0.32	1.31	0.99	6	4
NS7	84.9	60	0.003	33	55	10.6	0.2	4	0.4	3.2	2.1	0.37	1.91	1.54	6	4
KG1A	70.2	60	0.0034	29	48.3	8	0.2	2	0.6	2.8	2.1	0.33	0.85	0.52	4	5
KG1B	65.3	60	0.0036	11	18.3	6	0.1	2	0.4	1.8	0.9	0.2	0.52	0.32	4	7
KG2A	88.04	60	0.0034	58	96.7	6.3	0.2	2	0.4	1.7	1.2	0.18	0.6	0.42	4	7
KG2B	36.32	60	0.0028	41	68.3	8	0.1	2	0.5	2.4	2	0.3	0.91	0.61	4	4
KG2C	48.7	60	0.0032	31	51.7	4.6	0.1	1.2	0.2	1.1	0.9	0.17	0.47	0.3	4	9
KG2D	74.5	60	0.003	19	31.67	8.2	0.1	2.2	0.5	2	1.7	0.25	0.88	0.63	4	7
KG3B	60.22	60	0.0032	29	48.3	9.5	0.15	2.5	0.6	2.4	1.4	0.22	1.21	0.99	6	4

KG4	0	60	0.003	49	81.7	6.9	0.25	1.2	0.4	2.4	1.5	0.24	0.8	0.64	4	7
KG5	82.7	60	0.0026	30	50	5.9	0.1	1	0.3	2	1.5	0.26	0.52	0.26	4	7
KG6	101.8	60	0.0028	42	70	6.8	0.1	1.9	0.4	2.2	1.8	0.29	0.87	0.58	4	8
BN1A	111.42	60	0.0036	59	98.3	9	0.15	2.3	0.5	2	1.1	0.34	1.16	0.82	6	4
BN1B	94.68	60	0.0028	38	63.3	8.2	0.1	2	0.5	2.2	1.5	0.35	1.14	0.79	6	4
BN1D	98.72	60	0.003	20	33.3	6.4	0.1	1.8	0.5	1.8	1.4	0.26	0.82	0.56	4	7
BN1E	100.41	60	0.0036	51	85	8.1	0.1	2.1	0.6	2	1.2	0.32	1	0.68	4	4
BN1F	74.28	60	0.038	28	46.67	8.5	0.1	2.5	0.6	2.1	0.8	0.27	0.92	0.65	6	4
BN2A	108.43	60	0.026	39	65	8	0.2	1.9	0.6	2.5	1.7	0.28	0.94	0.66	6	4
BN2B	98.91	60	0.0022	41	68.3	6.4	0.1	1.8	0.5	1.5	1	0.18	0.54	0.36	4	7
BN3A	0	60	0.0036	14	23.3	5.2	0.1	2.2	0.3	1.6	1	0.18	0.5	0.32	4	8
BN3B	0	60	0.0036	28	46.67	7	0.1	2.5	0.3	1.6	1.1	0.15	0.71	0.56	6	7
BN4	0	60	0.0028	6	10	6.9	0.1	1.7	0.4	1.6	1.2	0.2	0.66	0.46	4	7
BN5	94.8	60	0.003	41	68.3	9.1	0.1	2.2	0.7	3.4	2	0.4	1.2	0.8	6	4
BN6	139.34	60	0.0036	40	66.7	9.5	0.2	2.7	0.6	3.9	2.3	0.43	1.43	1	6	4
BN7	5.32	60	0.0034	58	96.7	7.6	0.1	1.9	0.5	1.5	1.7	0.2	0.98	0.78	4	7
BN8	72.4	60	0.003	23	38.3	7.5	0.15	2.5	0.4	2	1.1	0.25	1	0.75	4	7
FCT2	100.83	60	0.0036	19	31.7	7.5	0.2	1.5	0.3	1.3	1.1	0.19	1	0.81	4	4
FCT3	94.3	60	0.003	21	35	8	0.25	2	0.5	2.5	1.5	0.21	0.82	0.61	6	7
FCT4	0	60	0.0034	45	75	4.8	0.2	2	0.4	1.3	0.6	0.18	0.39	0.21	3	9
FCT5	52.8	60	0.0028	2	3.3	5.5	0.2	1	0.2	1.5	1.2	0.18	0.52	0.34	4	7
FCT6	50.4	60	0.0036	23	38.3	5	0.1	1.3	0.3	1.2	1	0.15	0.53	0.38	4	7
NG1B	0	60	0.0038	2	3.3	7.4	0.1	2.4	0.2	1.9	0.9	0.21	0.89	0.68	4	8
NG1C	0	60	0.0032	43	71.67	6.9	0.1	3	0.3	1.7	1.2	0.17	0.78	0.61	4	7
NG2A	9.66	60	0.0036	32	53.3	8.1	0.1	2.3	0.4	2	1.1	0.22	0.88	0.66	6	4
NG2B	17.58	60	0.0028	37	61.7	5.4	0.1	1.8	0.2	1.5	0.8	0.19	0.55	0.36	4	7
NG3B	64.18	60	0.0033	22	36.7	7.3	0.2	2.6	0.3	1.2	1.1	0.33	0.8	0.47	4	8
NG3C	50.1	60	0.0032	14	23.3	5	0.1	1.2	0.2	1.5	1.3	0.18	0.5	0.32	3	8
PL1A	79.8	60	0.003	38	63.3	5	0.1	1.5	0.3	1.5	1	0.17	0.62	0.45	4	7
PL1B	29.2	60	0.0034	34	56.7	8.2	0.1	2	0.6	3.1	2.3	0.36	0.9	0.54	6	4
PL1C	24.8	60	0.003	21	35	7.8	0.1	1.5	0.6	2.8	2.2	0.31	0.88	0.57	6	4
PL2A	97.3	60	0.0021	56	93.3	4.4	0.25	1	0.2	1.5	1.5	0.19	0.6	0.41	4	5
PL2B	65.6	60	0.003	38	63.3	3.4	0.05	1.3	0.2	1	0.6	0.16	0.39	0.23	4	7
PL3	9.67	60	0.0034	4	6.7	6.2	0.1	1.9	0.4	2.5	2	0.28	0.59	0.31	4	7
PL4A	30.4	60	0.0036	16	26.7	7.7	0.1	1.8	0.4	1.9	1.1	0.21	0.85	0.64	4	7
PL4B	80.2	60	0.0036	41	68.3	8.5	0.2	2	0.5	1.9	1.4	0.2	0.91	0.71	6	4

RFW(g)= ripe fruit weight
0g of RFW= only dry seed collected (not ripe fruit)
NSP=number of seed planted
DSW=dry seed weight= x/50 seeds
DSW=dry seed weight= x/50 seeds
GP@30days=germinated seeds in day 30
%GP= percentage of germination
PLH= plant height
STD= stem diameter
STH= stem height
PTL= petiole length
LFL=leaf length
LFB=leaf breadth
FLW(g)/4lvs=total fresh leaf weight/plant
PTW(g)=plant total weight
SHW(g)= Shoot weight (PTW-FLW)
NoL= number of leaves per plant/accession
1st cotyl (days)= number of days for the emergence of first cotyledon

CONCLUSION

In conclusion, the establishment of continuous variations among the accessions may be due to the fact that quantitative traits are determined by the interaction between the polygenes coding for these characters or interactions between polygene and the environment

which cannot be totally excluded in phenotypic differences[19-20]. Since variability is a template for breeding programmes and crop improvement[21], accessions that display quality characters in their germination may be selected and exploited for commercial horticulture. However, further studies are recommended using larger sample size a combination of many types of molecular markers to fully substantiate these findings.

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