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Assessment Genetic Variability among Three Parents and Six Progenies of Tomato using Multivariate Analysis

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Abstract: Six tomato hybrids developed through diallel mating design and the three parents were obtained from the plant breeding section of Adekunle Ajasin University Akungba-Akoko and used to assess the genetic variability among them. The breeding materials were raised in the nursery for three weeks before transplanting. The hybrids and parents were laid out in a randomized complete block design (RCBD) replicated three times Seedlings were transplanted at a spacing of 60 x 30 cm between and within row. Variability estimates were highly significant (p< 5%) in all the 10 measured quantitative traits. The average fruit mean yield of 21.42 g was recorded for all the materials evaluated. Phenotypic variances were higher in magnitude than its corresponding genotypic variances apart from pericarp thickness which had the same value of 0.002 and 100% heritability. Factor scores and communality of the 10 traits of tomato obtained from the factor analysis showed that the first factor were positively loaded with eigen vectors for number of branches (0.818), number of fruits per cluster (0.803), plant height (0.776), fruit yield (0.748) and number of clusters per plant (0.731). The second factor was positively loaded with pericarp thickness (0.723) and number of clusters per plant (0.460). Factor three was only positively loaded with fruit weight (0.881). The communality ranged from 0.618 for fruit yield to 0.930 for fruit weight. Conclusively, traits such as fruit yield, pericarp thickness, fruit weight, number of locules per fruit, days to flowering and days to first fruit set are important traits that should be considered in further breeding programme in tomato.
Keywords: Phenotypic variance, genotypic variance, factor score, communality

1. Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most well-liked and extensively grown vegetables globally. It belongs to the family Solanaceae cultivated widely for its edible fruits. Tomatoes are good sources of vitamin C Dhaliwal, *et al*., (2003) and the phytochemical lycopene Osekita and Ademiluyi (2014). The fruit is used for preventing cancer of the breast, bladder, cervix, colon and rectum, stomach, lung, ovaries, pancreas and prostate (Barber and Barber 2002; Shi *et al*., 2002). It also prevents diabetes, diseases of the heart and blood vessels (cardiovascular) disease Arab and Steck (2000) and Jarquin-Enriquez, *et al*., (2013) cataracts and asthma. In the ancient times, very little efforts have been taken for development of inbred lines of tomato in the course of exploiting genetic variability present in the exotic varieties. F_2 generation obtained from selfing F_1 hybrid

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provides all possible variations. Consequently, selection with particular objectives in F_2 generation is greatly effective and selfing of those selected genotypes generation after generation helps to develop inbred lines resembling the parental lines of the exotic varieties. Variability in tomato is expected to be massive as the fruits differ to a great extent in shape and size (Dixit and Dubey 1985; Bhardwaj and Sharma 2005). The nature and amount of genetic variability present in the population plays a key role in the improvement of tomato productivity Sowjanya and Sridevi (2019). Genetic variability is the essence of breeding programme from which superior genotypes can be evolved after selection. The higher the extent of variability in the population, the greater is the possibility for improvement of yield through selection. Selection based on numerous traits is always better than selection based on yield alone. Yield is a quantitative trait that is controlled by many genes, and adequate knowledge about the magnitude and degree of association of yield and its component traits is of great significance to the breeders, through which they can clearly understand the strength of correlated traits, when they have to exercise selection for immediate improvement of more than one character. However, correlation alone does not provide information on the contribution of related characters, which necessitates the study of cause and effect relationship of different characters among themselves. According to Osekita and Ademiluyi (2014) , yield is a complex character which is controlled by a large number of causative characters and their interactions. Based on this understanding multiple traits are always better than selection using yield alone. As a corollary to this, an adequate knowledge of the magnitude and degree of relationship between yield and its component traits is of great importance to plant breeders, through which concurrent selection of desirable traits is sought for enhanced improvement. The focus of the study is to estimate genetic variation among morphological and yield component traits through the use of multivariate analysis for sustained tomato production in the study area.

2. Materials and Methods

Three parents and six hybrids of tomato developed through full diallel mating design obtained from the Plant Breeding Unit of the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko, were used for this study.

Table 1. List of Tomato germplasm

S/N	Germplasm	Remark
1	NG/AA/SEP/09/042	Parent
2	Akungba I	Parent
3	Akungba II	Parent
4	NG/AA/SEP/09/042 x Akungba I	Hybrid
5	Akungba II x NG/AA/SEP/09/042	Hybrid
6	Akungba II x Akungba I	Hybrid
7	Akungba I x Akungba II	Hybrid
8	Akungba I x NG/AA/SEP/09/042	Hybrid
9	NG/AA/SEP/09/042 x Akungba II	Hybrid

The experiment was carried out at the breeding plot beside the screen house of Adekunle Ajasin University, Akungba-Akoko, Ondo State. The nine accessions of tomatoes were raised in the nursery for three weeks before they were transplanted. A randomized complete block design (RCBD) replicated three times was used to lay out

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the experiment. Two seedlings were transplanted using a spacing of 60 cm x 30 cm between rows and within a row and later thinned to one per stand. The plot size is 10 m x 8 m. Cultural practices such as weeding, disease control were carried out as at when necessary.

2.2 Data collection

Data were collection on plot basis on the following quantitative traits; number of days to 50%flowering, plant height, number of branches per plant, number of clusters per plant, number of fruits per plant, number of fruits per cluster, fruit weight, pericarp thickness, number of locules per fruit, and fruit yield. IBGPR Descriptors for tomato was used in assessing the above listed traits.

2.3 Statistical analysis

SPSS version 20 software were employed to carry out the analysis of data generated from the listed parameters above; among which are analysis of variance (ANOVA), component of variance and heritability in broad sense, coefficient of variability, correlation coefficient and Factor analysis.

3. Results and Discussion

3.1 Results

Mean squares each of the 10 measured traits were significant ($p < 0.05$) for parents and hybrids (Table 2). This is an indication that the parents and their hybrids showed wide phenotypic differences which is a product of the interaction of genotype and environment. The coefficient of variation ranged from 0.00% to 1.44% in pericarp thickness to plant height respectively. The average fruit yield of 21.42 g was recorded for all the materials evaluated. NG/AA/SEP/09/042 had a mean weight of 72.32 g followed by Akungba I (39.41 g), NG/AA/SEP/09/042 x Akungba II (26.40g). Akungba I x NG/AA/SEP/09/042 hybrid had the lowest mean weight of 4.54 g (Table 3).

Table 2: Mean squares and coefficient of variation for measured quantitative traits.

SV	DF	PLTHT (cm)	NB	NCPP	NFPC	DFFS	NDF	FW (g)	PT (mm)	NLPF	FY (g)
Treatment	8	419.20*	22.78*	78.75*	9.35*	26.27*	33.45*	89.75*	0.005*	0.46*	1494.88*
Rep	2	58.34*	3.74^{ns}	4.83*	0.50^{ns}	5.72*	0.23^{ns}	1.96*	0.000*	0.04^{ns}	7.35*
Error	16	93.03	7.16	2.51	1.48	4.81	8.05	2.99	0.000	0.07	9.66
$\bar{x}$		64.42	15.68	6.09	5.23	43.10	36.96	15.26	0.21	2.56	21.42
CV		1.44	0.46	0.41	0.28	0.11	0.22	0.20	0.00	0.03	0.45

*, ** significant at P=5% and 1% level respectively, ns is not significant.

Note: **SV**: Source of variation; **DF**: Degree of freedom; **PLTH**: Plant height (cm); **NB**: Number of branches; **NCPP**: Number of clusters per plant; **NFPC**: Number of fruit per cluster; **DFFS**: Days to first fruit set; **NDF**: Number of days to flowering; **FW**: Fruit weight (g); **PT**: Pericarp thickness (mm); **NLPF**: Number of locules per fruit and **FY**: Fruit yield (g)

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Table 3: Mean values and standard error for ten quantitative traits of Tomato.

Treatments	PLTHT (cm)	NB	NCPP	NFPC	DFFS	NDF	FW (g)	PT (mm)	NLPF	FY (g)
NG/AA/SEP/09/042	73.66±8.72^{cd}	21.33±2.05^{c}	8.87±1.92^{b}	6.92±0.71^{b}	39.83±1.70^{a}	31.00±1.53^{a}	13.40±1.70^{a}	0.18±0.01^{b}	2.36±0.20^{a}	72.32±4.37^{e}
Akungba I	68.43±6.12^{bc}	16.40±0.72^{ab}	5.33±0.47^{a}	7.22±1.30^{b}	43.49±0.81^{abc}	36.33±2.19^{bc}	13.27±0.46^{a}	0.21±0.01^{c}	3.21±0.21^{c}	39.41±2.40^{d}
Akungba II	57.21±2.05^{abc}	15.33±1.24^{ab}	2.58±0.10^{a}	3.17±0.51^{a}	47.33±1.34^{cd}	38.67±0.33^{cd}	14.19±0.10^{a}	0.15±0.01^{a}	2.89±0.27^{bc}	16.47±1.40^{b}
NG/AA/SEP/09/042 x Akungba I	59.46±4.29^{abc}	13.87±1.74^{ab}	4.87±0.38^{a}	4.87±0.37^{a}	44.95±0.23^{bcd}	38.33±0.33^{cd}	11.94±0.41^{a}	0.20±0.00^{bc}	2.46±0.14^{ab}	6.86±0.74^{a}
Akungba II x NG/AA/SEP/09/042	69.30±5.92^{bc}	13.05±1.66^{a}	3.13±0.18^{a}	4.20±0.42^{a}	42.67±0.88^{ab}	36.33±0.88^{bc}	11.20±0.15^{a}	0.20±0.01^{bc}	2.47±0.09^{ab}	6.39±0.10^{a}
Akungba II x Akungba I	62.15±6.86^{abc}	14.40±1.01^{ab}	4.03±0.49^{a}	3.33±0.60^{a}	49.09±0.96^{d}	39.33±1.33^{cd}	11.41±1.20^{a}	0.28±0.01^{e}	2.20±0.12^{a}	5.28±0.36^{a}
Akungba I x Akungba II	55.35±6.39^{ab}	12.87±1.91^{a}	3.38±0.32^{a}	4.43±0.58^{a}	48.17±0.73^{d}	41.67±1.33^{d}	27.87±1.80^{c}	0.25±0.01^{d}	2.13±0.07^{a}	15.14±0.27^{b}
Akungba I x NG/AA/SEP/09/042	46.95±2.28^{a}	15.10±1.46^{ab}	3.80±0.42^{a}	4.80±0.31^{a}	44.97±2.04^{bcd}	38.33±2.60^{cd}	20.43±0.07^{b}	0.19±0.01^{bc}	3.03±0.03^{c}	4.54±0.02^{a}
NG/AA/SEP/09/042 x Akungba II	87.30±1.78^{d}	18.53±1.25^{bc}	18.83±1.9^{b}	8.10±0.76^{b}	43.10±1.72^{ab}	32.67±1.76^{ab}	13.60±1.05^{a}	0.20±0.01^{bc}	2.27±0.07^{a}	26.40±0.80^{c}

Note: Means with the same alphabet in the same column are not significantly different ($p < 0.05$)

PLTH: Plant height (cm); **NB**: Number of branches; **NCPP**: Number of clusters per plant; **NFPC**: Number of fruit per cluster; **DFFS**: Days to first fruit set; **NDF**: Number of days to flowering; **FW**: Fruit weight (g); **PT**: Pericarp thickness (mm); **NLPF**: Number of locules per fruit and **FY**: Fruit yield (g)
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Estimates of variances, genotypic and phenotypic coefficient of variation, heritability and genetic advance for the quantitative traits of hybids and parentsof tomato as presented in Table 4 showed that observed phenotypic variances was higher in magnitude than its corresponding genotypic variances except for pericarp thickness which had the same value of 0.002, similar trend was noticed in genotypic and phenotypic coefficient of variation. Also 100% heritability is an indication that selection for pericarp thickness would be effective in considering further improvement programme in tomato breeding. All the traits had moderate to very high heritability implying that selection for yield improvement could be directed towards these traits.

Table 4: Estimate of genetic parameters on measured quantitative traits.

Traits	Vg	Vp	GCV	PCV	h^2	GA
Plant height (cm)	108.72	201.75	16.20	22.04	53.89	14.20
Number of Branches	5.21	12.37	14.56	22.43	42.12	3.52
No of clusters per plant	25.41	27.92	82.77	86.77	91.01	5.28
No of fruits per cluster	2.62	4.10	30.95	38.73	63.90	2.03
Days to first fruit set	7.15	11.96	6.20	8.03	59.78	3.46
Days to flowering	8.47	16.52	7.87	10.99	51.27	4.07
Fruit weight(g)	28.92	31.91	35.24	37.02	90.63	5.65
Pericarp thickness(mm)	0.002	0.002	95.24	95.24	100.00	0.05
No of locules per fruit	0.13	0.20	14.08	17.47	65.00	0.45
Fruit yield(g)	495.41	505.07	103.91	104.92	98.09	22.47

Note: **Vg** genotypic variance, **Vp** phenotypic variance, **GCV** genotypic coefficient of variation, **PCV** phenotypic coefficient of variation, $\mathbf{h^2}$ heritability and **GA** genetic advance

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As presented in Table 5, highly significant and positive correlation was observed between fruit yield and plant height (0.434, p< 0.01), number of branches per plant (0.669), number of clusters per plant (0.380), number of fruits per cluster (0.572) but only negative and highly significantly correlated with number of days to flowering (-0.639).

Table 5: Genotypic correlation coefficient on ten quantitative traits of tomato

Traits	NB	NCPP	NFPC	DFFS	NDF	FW	PT	NLPF	FY
PLTH	0.598**	0.726**	0.607**	-0.523**	-0.657	-0.283**	-0.006**	-0.067**	0.434**
NB	-	0.537**	0.545**	-0.582**	-0.743**	-0.138	-0.282**	0.081**	0.669**
NCPP		-	0.677**	-0.427*	-0.602**	-0.130**	-0.084	-0.215**	0.380**
NFPC			-	-0.602**	-0.683**	-0.087**	-0.150**	0.121	0.572**
DFFS				-	0.838**	0.268**	0.416*	-0.192**	-0.594
NDF					-	0.388**	0.377**	-0.086**	-0.639**
FW						-	0.230	-0.039	-0.125
PT							-	-0.375	-0.281
NLPF								-	0.053

Note: *, **, ns significant at P=5%, 1% and not significant

PLTH: Plant height; **NB**: Number of branches; **NCPP**: Number of clusters per plant; **NFPC**: Number of fruit per cluster; **DFFS**: Days to first fruit set;

NDF: Number of days to flowering; **FW**: Fruit weight; **PT**: Pericarp thickness; **NLPF**: Number of locules per fruit and **FY**: Fruit yield

Traits that showed strong and highly significant association could be used as basis for further selection in determining yield improvement in tomato.

The eigen value calculated from factor analysis (Table 6) used to explain the amount of factors which would account for total variation in the genetic analysis of the studied tomato genotypes. Ten factors were recognized, only three were considered important. These three factors accounted for 74.14% of the total variation. The first factor with eigen value of 4.823 explained 48.23% of the variance, the second factor with eigen value of 1.577 explained 15.77% of the variance and the third factor with eigen value of 1.014 explained 10.14% of the variance.

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Table 6: Eigen value, percentage variance accounted for and cumulative percentage of factor analysis for ten factors of Tomato.

Traits	Eigen value	Proportion of variance accounted for (%)	Cumulative of variance accounted for (%)
Plant height (cm)	4.823	48.23	48.23
No of Branches	1.577	15.77	64.00
No of clusters per plant	1.014	10.14	74.14
No of fruits per cluster	0.707	7.07	81.20
Days to first fruit set	0.570	5.70	86.90
Days to flowering	0.444	4.44	91.34
Fruit weight(g)	0.378	3.78	95.12
Pericarp thickness(mm)	0.242	2.42	97.54
No of locules per fruit	0.153	1.53	99.07
Fruit yield(g)	0.093	0.93	100.00

Table 7: Factor scores and communality of ten traits of Tomato from the factor analysis.

Traits	Factors			Communality
	1	2	3	
Plant height (cm)	**0.776**	0.361	-0.138	0.751
No of Branches	**0.818**	0.008	0.163	0.696
No of cluster per plant	**0.731**	**0.460**	-0.012	0.747
No of fruit per cluster	**0.803**	0.142	0.241	0.724
Days to first fruit set	**-0.828**	0.234	-0.003	0.741

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No of days to flowering	**-0.930**	0.077	0.110	0.884
Fruit weight (g)	-0.331	0.211	**0.881**	0.930
Pericarp thickness (mm)	-0.376	**0.723**	0.053	0.666
No of locules per fruit	0.101	**-0.763**	0.256	0.658
Fruit yield (g)	**0.748**	-0.071	0.232	0.618

Factor scores and communality of ten traits of tomato from the result of factor analysis is presented in Table 7 with the first factor positively loaded with eigen vectors for number of branches (0.818), number of fruits per cluster (0.803), plant height (0.776), fruit yield (0.748) and number of clusters per plant (0.731). The second factor was positively loaded with pericarp thickness (0.723) and number of clusters per plant (0.460). Factor three was loaded positively with fruit weight (0.881). The communality ranged from 0.618 for fruit yield to 0.930 in fruit weight which is the proportion of variation explained by each trait in the factor analysis.

3.2 Discussion

Genetic variability is a prominent ingredient that is important to a plant breeder. The success of any crop improvement programme is dependent on the extent of genetic variability and the degree to which the choice trait is heritable [15]**.** Hence, estimates of variability of yield causal attributes and their heritable components are more important in any crop breeding programmes. The present study uses nine F_2 generations of tomato to elucidate nature and extent of variation, character association for different quantitative traits in a bid to select genotypes with higher yielding tendencies for the environment. Analysis of variance involving three parents and six hybrids showed significant differences in the ten traits used in evaluating yield and its stability in the study area, most especially pericarp thickness as a trait of interest in ensuring that it enhances or increases the shelve life of the tomato genotypes in storage. The hybrids from observations made during harvest stays for more than ten days in storage. The coefficient of variation was the lowest among the traits measured indicating good precision with little error which invariably appropriate for further selection. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) except in pericarp thickness which had the same values, this result is similar to the findings of Osekita and Ademiluyi, (2014). In most cases, PCV is higher than GCV but where GCV is higher than PCV, it suggests that the trait is controlled more by genetic factors than environment Sunilkumar *et al*., (2016). High heritability value was observed for pericarp thickness, fruit yield, number of clusters and fruit weight, as a result of the high heritability estimates noticed in most traits, selection could be effected on these traits for improvement of crops (Akinwale *et al*., 2011; Osekita and Ajayi 2013). The genetic advance was low for pericarp thickness to a more high value in fruit yield an indication that there is genetic improvement in the measured traits. The positive and significant correlation among yield, plant height, number of branches, number of clusters per plant, number of fruits per cluster, days

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to first fruit set and number of days to flowering would be useful in effective selection of desirable genotypes in tomato improvement and further breeding programme. Similar observations had been reported by (Mohanty 2002; Tiwari 2002; Joshi *et. al*., 2004 and Indurani *et. al*., 2008). Negative association of number of days to first fruit set with most of the traits is an indication that the genotypes flower early leading to higher yielding potentials as can be seen with its significant correlation with fruit yield. This finding is in line with the reports of (Dudi and Kallo 1982; Anilkumar et. al., 2003 and Osekita and Ademiluyi 2014). The methods of multivariate techniques (Eigen value and Factor analysis) used in this study revealed that plant height, number of branches and number of clusters per plant are the most important traits in unraveling the nine genotypes of tomato. The first factor with the highest eigen value is the most variable and was positively loaded with yield component traits, as a result the first three factors contributed to the final yield of tomato based on the final yield of factor analysis. The communality for measuring the proportion of explained variation ranged from 61.8% for fruit yield to 93.0% in fruit weight in the factor analysis is also a further confirmation of sufficiency of improvement sort after in the tomato breeding. Similar results were reported by Ariyo (1993) in okra, Rice by Nassir and Ariyo (2007), Groundnut (Makinde and Ariyo (2010) and in rice by Nwafor and Osekita (2021).

4. Conclusion

From the results obtained from the multivariate techniques it can be concluded that traits which correlates significantly with fruit yield such as plant height, number of branches number of clusters per plant and number of fruits per cluster should be considered in further breeding programme in tomato. Genotype NG/AA/SEP/09/042 and its hybrid NG/AA/SEP/09/042 x Akungba II are the most superior in terms of yield and performance in Akungba Akoko area of Ondo State, Nigeria.

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