CORRELATION AND PATH COEFFICIENT ANALYSES OF FRUITS AND SOME AGRONOMIC TRAITS IN ADVANCED GENERATIONS OF TOMATO HYBRIDS UNDER DERIVED SAVANNAH ECOLOGY OF NIGERIA

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Abstract
Due to the unavailability of tomato cultivars that are adaptable to the climatic conditions of south eastern Nigeria, four developed advanced generations of tomato hybrids, S1E (progeny of Wild and Roma vf), S2S (progeny of Roma vf and Wild), S3S (progeny of Wild and Tropica), and S4S (progeny of Tropica and Wild), were evaluated under field conditions. The treatments were laid out in a randomized complete block design (RCBD), replicated four times at Faculty of Agriculture, University of Nigeria Research Farm during 2011 and 2012 cropping seasons. The relationships between fruit yield per hectare in tons (FY ha^{-1}) and its fruit characters like fruit length (FL), fruit circumference (FC), and average fruit weight (AFW) together with agronomic traits such as days to flowering (DF), days to fruiting (DFt), days to fruit ripening (DFr), number of branches per plant (BrP), number of trusses per plant (TrP), and number of fruits per plant (FrP) were studied using correlation and path coefficient analyses. The result revealed that both the correlation and path analyses of the traits on FY ha^{-1} exhibited similarities in the two years of study. The FY ha^{-1} showed positive correlation with TrP, BrP, FrP and negative correlation with DF, DFt, DFr, FL, FC and AFC in both years of study, (2011 and 2012). The TrP, BrP and DF had positive direct effects towards increasing the FY ha^{-1} with path coefficient of 7.016, 1.815 and 2.132, respectively in 2011, while in the same year FrP (-7.399), DF (-0.017)and DFr (-1.086) had direct effect towards reducing the FY ha^{-1}. Similarly, in 2012 BrP, DF and DFr reduced the FY ha^{-1} with direct effect values of -13.215, -0.609, -1.103, respectively, while TrP (2.492) and FrP (10.206) had positive effects on the FY ha^{-1}. TrP and DFr are therefore, very important traits and should be given high weightage in any selection process aimed at improving fruit yield in tomato; since both traits gave consistent trend of direct effect values for the two years study.

Key words: Correlation, path coefficient, tomato hybrids, agronomic traits, fruit yield per hectare.

Introduction

Fruit yield is the main factor affecting economic value of tomato production. For this reason, agronomic and breeding studies on increasing fruit yield are being conducted intensively. Climatic factors like temperature and humidity fluctuations in cropping seasons are favourable conditions for pathogens to develop and these promote the development of a variety of diseases, thereby lowering the tomato fruit yield (Masinde et al., 2011). To obtain tomato cultivars that will adapt to south eastern Nigeria, environment is very important due to people's regard for the crop (Amuji et al., 2013), hence, the reason behind the hybrids tomato development. Tomato (*Lycopersicon sp*) fruit yield is a complex quantitative character highly influenced by environmental fluctuations (Bushra et al., 2012); therefore it is necessary to understand the relationships existing between the fruit yield and other associated traits of the crop.

Correlation measures the mutual association without regards to causation, while path coefficient analysis indicates the causes and measures their importance (Eleweanya et al., 2005). Path coefficient analysis also has the ability to partition the correlation coefficient into components of direct and indirect causes of association. Path analysis had been used by many researchers with the aim of determining the effects of important yield components (Dogney et al., 1998; Yagdi, 2001; Naazar et al., 2003; Ahmed et al., 2003).

This experiment was therefore, undertaken to study the association existing between the fruit yield and other traits among the developed advanced generations of tomato hybrids in an Ultisol of Nsukka, south eastern Nigeria. The relationships were investigated and interpreted through correlation and path analyses.

Materials and Methods

The study was conducted at Faculty of Agriculture Research Farm, University of Nigeria Nsukka during 2011 and 2012 cropping seasons. Nsukka is located at south eastern part of Nigeria (06^0 52^iN, 07^0 24^iE and 447.26 m above sea level). The area receives an average annual rainfall that ranges from 1155 mm to 1955 mm, average maximum and minimum temperature of 31^0 C to 29^0 C, and average maximum and minimum relative humidity of 69% and 79%, respectively (Uguru *et al*., 2011). The experimental soil was sandy clay loam (sandy 60%, silt 2% and clay 38%) with pH 3.8-4.7. Organic matter content of the soil is mostly 1.6-2.3% with its phosphorous and potassium levels as 18.0-22.4 and 0.15-0.25 respectively (Ogbonna and Obi, 2007; Onwudiwe et al., 2013).

Four developed 12th generation tomato hybrids; S1E (progeny selected from Wild and Roma vf), S2S (progeny selected from Roma vf x Wild), S4S (progeny selected from Wild x Tropica), S3S (progeny selected from Tropica x Wild), were evaluated under field conditions during the 2011 and 2012 cropping seasons. The advanced generations of tomato hybrids were laid out in a randomized complete block design (RCBD) with four replications. Fertilizers were applied at transplanting (basal) and other activities include staking, weeding, fungicide application and watering were done as the need arises according to recommendation.

Data collection and analysis
Data were recorded on the following parameters during the course of the experiment as follows:

Days to flowering: Days to first flowering was determined by counting the number of days from sowing in the nursery to when the first flower opened in each of the plots.

Days to fruiting: Days to fruiting was determined by counting the number of days from sowing in the nursery to when first fruit emerged in each plot.

Days to fruit ripening: Days to fruit ripening was determined by counting the number of days from sowing in the nursery to when the first fruit ripened in each of the plot.

Number of trusses per plant: This was determined by counting the number of trusses in four sampled plants from each plot measured at maturity and the average was calculated.

Number of branches per plant: This was determined by counting the number of branches in four sampled plants from each plot at maturity and the average was calculated.

Number of flowers per plant: This was determined by counting the number of flowers from four sampled plants and the average was calculated.

Fruit length: Fruit length was determined by measuring the fruit length of all the fruits harvested from the sampled plants and the average was calculated.

Fruit circumference: This was determined by measuring the fruit circumference at the widest point of all the selected sampled fruits harvested and the average was calculated.

Average fruit weight: Average fruit weight was measured by weighing twenty sampled fleshly harvested fruits using a digital weighing balance and the average was calculated.

Total fruit yield per hectare: Total fruit weight was obtained by weighing all the fruits harvested from the sampled plant and equated to hectare.

Path analyses were carried out on the traits considered according to Dewey and Lu (1959) and the fruit yield per hectare was taken as dependent variable in the method. Other traits were considered as independent variables. Correlation coefficients were obtained initially in order to determine the simple linear relationships between the traits. The correlation analyses were computed using SPSS for windows 2007 version, 16.0. The path coefficient measured the direct influence of one variable upon fruit yield and permits the separation of the coefficient into components of direct and indirect effects. Path diagram was also used to represent the causal system and effect relationships among various traits and the fruit yield in the four tomato hybrids averaged over the two cropping seasons. In the path diagram, the double arrowed lines indicate mutual association measured by correlation coefficient, and the single line represents direct influence as measured by path coefficient adapted from Eleweanya et al. (2005).

Results and Discussion

Correlation Coefficient: The relationship between advanced generation of tomato fruits yields and some studied traits in 2011 and 2012 are shown in tables 1 and 2. The results revealed that fruit yield had positive correlation with TrP (0.556), BrP (0.818) and FrP (0.489) in 2011, the same trend repeated in 2012 with TrP (0.440), BrP (0.452) and BrP (0.468). However, fruit yield was negatively and significantly correlated with DF, DFt, DFr, AFW and FC at harvest in both years.

The AFW had significant positive correlation with DF, DFr, FL and FC consistently in the two years of study. BrP, FrP and TrP have significant positive correlation with each other consistently in the two years study.

Path Coefficient analysis: The direct and indirect effects of some agronomic traits on fruit yield of tomato hybrids over the two cropping years are presented in Tables 3 and 4. The results of 2011 experiment indicated that TrP had the greatest direct positive effect (7.016) on fruit yield. This was followed by DFt (2.132), and BrP (1.815). The direct effects of FrP, DF and DFr where negative with -7.399, -0.017 and -1.086, respectively. The fruit characters; AFW, FL and FC had no direct effect on the fruit yield. The indirect effect of TrP through FrP was negative (-7.319) and the highest. This effect was also in negative direction for DFt (-1.690). Indirect effect of TrP through BrP (1.690), DF (0.007) and DFr (0.851) were towards increasing the fruit yield (Table 3). BrP (6.532) and FrP (6.940) had positive indirect effects through TrP, while other traits had negative indirect effects through TrP and were quit high with FC (-6.273), FL (-6.131), DFt (-5.561), AFW (-5.504), DFr (-5.50) and DF (-2.81) (Table 3)

Positive direct effects of FrP (10.206) and TrP (2.492) were determined on fruit yield in 2012, the second year of the trial (Table 4). BrP showed its high adverse effect on fruit yield with -13.215. Similarly, negative direct effect values on fruit yield were determined in traits of DFr (-1.103) and DF (-0.609). TrP and BrP had high positive indirect effect through FrP with the values of 10.159 and 10.198 respectively. The highest negative indirect effect in the second year trial was FC (-8.997) through FrP, while the highest positive indirect effect was by FL (11.010) through BrP (Table 4).

The effect of residual factor (0.001) on fruit yield per hectare was negligible, thereby, suggested that no serious other yield component was not captured. This present investigation showed that number trusses per plant had high positive and direct effect on fruit yield per hectare. Therefore, the number of trusses per plant should be considered in selection criteria for increasing fruit yield per plant. Similar results were obtained by Lakshmi and Mani (2004), Singh and Cheema (2005), Prasad and Mathur (1999), though none reported on the direct effect of number of trusses per plant with yield. This study was not in accordance with Bodende (2002) who reported that fruit diameter and fruit length were directly responsible for the determination of fruit yield in tomato.

Conclusion

It is concluded from the experiment that the traits investigated are quantitative characters and are affected by environmental conditions to a greater extent, as well. As a matter of that, the inconsistence in the result of path analyses of the some traits from year to year supports this suggestion.

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Table 1: Simple correlation coefficient between agronomic traits and fruit yield of tomato genotypes in 2012

	TrP	BrP	FrP	DF	DFt	DFr	AFW	FL	FC	FY ha^{-1}
TrP	1	.931**	.989**	-.408	-.793*	-.784*	-.784*	-.874*	-.894**	.556
BrP		1	.899**	-.694	-.901**	-.947**	-.943**	-.987**	-.979**	.818*
FrP			1	-.320	-.703	-.744	-.756*	-.838*	-.881**	.489
DF				1	.811*	.843*	.780*	.744	.667	-.957**
DFt					1	.884**	.823*	.888**	.818*	-.841*
DFr						1	.953**	.954**	.940**	-.926**
AFW							1	.980**	.975**	-.917**
FL								1	.985**	-.877**
FC									1	-.823*
FY ha^{-1}										1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

FL = fruit length, FC =fruit circumference, AFW = average fruit weight, DF = days to flowering, DFt = days to fruiting, DFr = days to fruit ripening, BrP = number of branches per plant, TrP = number of trusses per plant, FrP = number of fruits per plant, FY ha^{-1} = Yield

Table 2: 2012 Path coefficient analyses showing the direct and indirect effects of the traits on fruit yield of the tomatoes

Traits	TrP	BrP	FrP	DF	DFt	DFr	AFW	FL	FC
TrP	**2.492**	-13.144	10.159	0.095	0.00	0.837	0.00	0.00	0.00
BrP	2.479	**-13.215**	10.198	0.135	0.00	0.872	0.00	0.00	0.00
FrP	2.481	-13.205	**10.206**	0.119	0.00	0.852	0.00	0.00	0.00
DF	-0.390	2.938	-1.997	**-0.609**	0.00	-0.793	0.00	0.00	0.00
DFt	-1.302	7.470	-5.572	-0.548	**0.00**	-1.004	0.00	0.00	0.00
DFr	-1.891	10.442	-7.880	-0.438	0.00	**-1.103**	0.00	0.00	0.00
AFW	-1.873	10.558	-7.992	-0.457	0.00	-1.029	**0.00**	0.00	0.00
FL	-1.970	11.010	-8.374	-0.435	0.00	-1.037	0.00	**0.00**	0.00
FC	-2.119	11.783	-8.997	-0.369	0.00	-0.993	0.00	0.00	**0.00**

FL = fruit length, FC =fruit circumference, AFW = average fruit weight, DF = days to flowering, DFt = days to fruiting, DFr = days to fruit ripening, BrP = number of branches per plant, TrP = number of trusses per plant, FrP = number of fruits per plant, FY ha^{-1} = Yield

Table 3: Simple correlation coefficient between agronomic traits and fruit yield of tomato genotypes in 2011

	TrP	BrP	FrP	DF	DFt	DFr	AFW	FL	FC	FY ha^{-1}
TrP	1	.995**	.995**	-.157	-.523	-.759*	-.752	-.791*	-.850*	.440
BrP		1	.999**	-.222	-.565	-.790*	-.799*	-.833*	-.892**	.468
FrP			1	-.196	-.546	-.772*	-.783*	-.820*	-.882**	.452
DF				1	.900**	.719	.751	.714	.605	-.852*
DFt					1	.911**	.916**	.907**	.812*	-.957**
DFr						1	.933**	.940**	.901**	-.870*
AFW							1	.993**	.967**	-.794*
FL								1	.981**	-.805*
FC									1	-.694
FY ha^{-1}										1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

FL = fruit length, FC =fruit circumference, AFW = average fruit weight, DF = days to flowering, DFt = days to fruiting, DFr = days to fruit ripening, BrP = number of branches per plant, TrP = number of trusses per plant, FrP = number of fruits per plant, FY ha^{-1} = Yield

Table 4: 2012 Path coefficient analyses showing the direct and indirect effects of the traits on fruit yield of the tomatoes

Traits	TrP	BrP	FrP	DF	DFt	DFr	AFW	FL	FC
TrP	**7.016**	1.690	-7.319	0.007	-1.690	0.851	0.00	0.00	0.00
BrP	6.532	**1.815**	-6.648	0.012	-1.922	1.028	0.00	0.00	0.00
FrP	6.940	1.631	**-7.399**	0.005	-1.498	0.808	0.00	0.00	0.00
DF	-2.861	-1.259	2.366	**-0.017**	1.730	-0.915	0.00	0.00	0.00
DFt	-5.561	-1.636	5.197	-0.014	**2.132**	-0.960	0.00	0.00	0.00
DFr	-5.500	-1.719	5.507	-0.014	1.886	**-1.086**	0.00	0.00	0.00
AFW	-5.504	-1.712	5.593	-0.013	1.755	-1.035	**0.00**	0.00	0.00
FL	-6.131	-1.791	6.199	-0.013	1.894	-1.036	0.00	**0.00**	0.00
FC	-6.273	-1.777	6.515	-0.011	1.745	-1.021	0.00	0.00	**0.00**

FL = fruit length, FC =fruit circumference, AFW = average fruit weight, DF = days to flowering, DFt = days to fruiting, DFr = days to fruit ripening, BrP = number of branches per plant, TrP = number of trusses per plant, FrP = number of fruits per plant, FY ha^{-1} = Yield

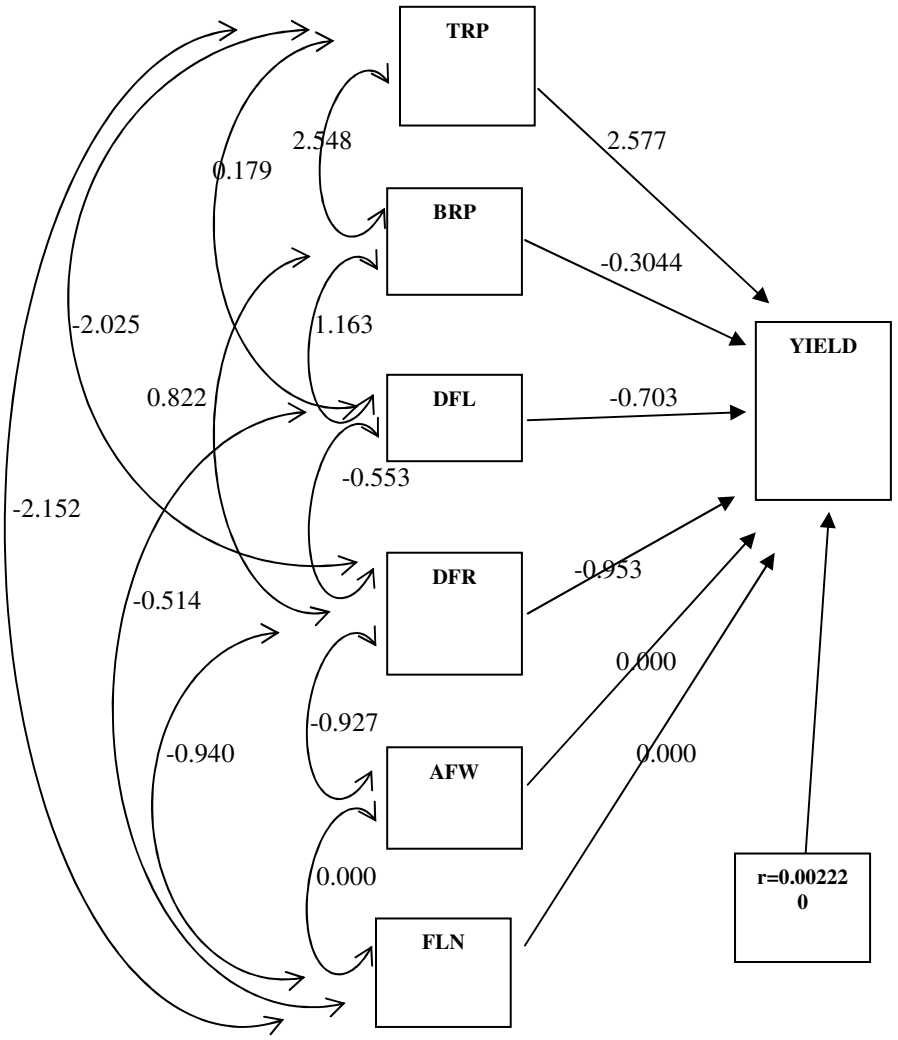

Fig.1. Diagrammatic representation of direct and indirect effects of variables on fruit yield averaged for 2011 and 2012 cropping seasons (PnY: path coefficient for each trait with yield, r: correlation coefficient, FLN = fruit length , AFW = average fruit weight , DFL = days to flowering , DFR = days to fruit ripening , BRP = number of branches per plant , TRP = number of trusses per plant).