CORRELATION AND PATH COEFFICIENT ANALYSIS OF TOMATO (*Lycopersicon lycopersicum L. Karst*) UNDER FRUIT WORM (*Heliothis Zea Buddie*) INFESTATION IN A LINE × TESTER

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ABSTRACT

Field experiments were conducted under irrigation during the dry seasons of 2010 and 2011 at Lake Allau near Maiduguri, Borno State and at Hong, in Adamawa State, Nigeria to evaluate F_1 hybrids in tomato for high yield and resistant to fruit worm insect (Helicovarpa zea Buddie) developed from eight parents (2 lines and 6 testers) through line x tester. The purpose of this study among others was to estimate the association existing between fruit yield and other yield components and to also determine the path analysis. The correlation studies revealed that number of flower clusters/plant, number of leaves/plant and plant height exhibited significant positive genotypic correlations with number of fruits/plant. The results also revealed a strong positive phenotypic correlations between number of fruits/plant with trichome count, number of flower clusters, number of leaves/plant and plant height. However, there were insignificant genotypic and phenotypic correlation coefficients between percentage fruit damage and trichome count. Trichome count, flower clusters/plant, number of leaves/plant and plant height are traits therefore to be considered when selecting tomato plant for fruit yield improvement.

Keywords: *Irrigation, trichome, Helicovarpa zea Buddie, fruit, Lycopersicon lycopersicum L. Karst*

INTRODUCTION

Tomato (*Lycopersicon lycopersicum L. Karst*) is one of the most economically important vegetable crops in many parts of the world. World annual production is put at approximately 153 million tonnes (FAO, 2009). Among the top 15 countries that produce tomato in the world, Nigeria is in the 13th position, producing over 1.7 million tonnes (FAO, 2009). In the production of tomato, the fruit yield is the main objective to a plant breeder and indeed to the farmer. It is therefore important to know the relationship between the various agronomic traits. It is also very important to have knowledge of the relationship between the traits that have direct and indirect effects on fruit yield. These degrees of relationship or association between these traits with fruit yield in tomato can be ascertained by correlation and path analysis. Correlation study measures the natural relationship between various traits and helps in determining the component traits on which selection can be based for yield improvement. Correlation coefficient measures the degree of association either in positive or negative direction. However, correlation coefficient alone when considered as a criterion for selection for high yield could be misleading; as such a character may not be directly correlated with yield but may further depend on other characters. As a result, the direct contribution of each of the component traits to the yield and the indirect effect it has through its association with other components cannot be differentiated from correlation studies. The technique of path coefficient analysis was developed by Wright (1921) and demonstrated by Dewey and Lu (1959) as a means of separating direct and indirect contribution of various traits. It is a standardized partial regression coefficient analysis. It measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects. The use of this technique has been reported to require cause and effect situation among the variables according to Singh and Chaudhary (1977). The degree of association between yield and yield components of tomatoes and the degree of interrelationship between the direct and the indirect effects to fruit yield have not been studied in this environment and as a result there is paucity of information. The aim of the study was therefore to determine the correlation coefficients between various quantitative traits of tomato and to estimate their path coefficients.

MATERIALS AND METHOD

Irrigation experiments were conducted during the dry season of 2010 and 2011 on eight parental lines of tomato and their 12 hybrids derived through line × tester breeding design. The experiments were conducted at two locations, viz: Lake Allau near Maiduguri, Borno State (11` 6` N; 13` 17`E) with characteristically sandy loam soil and Hong in Adamawa State (10`15`N; 13`20` E) with characteristically clay loam soils. All the two locations are situated in north eastern Nigeria. The land for the experiments was prepared manually using hand hoe and 2m x 2m sunken beds were made and watered to field capacity. The plant materials were transplanted from the nursery into the sunken beds on 15th November, 2010 at Lake Allau and on 19th December, 2010 at Hong. The plants were spaced at 75cm on row to row and 50cm on stand to stand distance, making a total of 10 plants in each entry per replication in both locations. The treatments were laid out in Randomized Complete Block Design (RCBD) and replicated three times.

Irrigation water was applied into the beds at 2 to 4 days intervals as required from transplanting to final harvest. NPK (15:15:15) fertilizer at the rate of 80kg/ha was applied into the field 15 days after transplanting. Weeding was done as at when required according to the Nigerian crop production guide (ICS, 2011). The field was artificially infested by tomatoes fruit worm in order to see the reactions of the parental lines and hybrids to this insect. Data were collected on five randomly selected plants per plot in respect of the following yield and yield components trichome count, number of flower clusters/plant, number of leaves/plant, plant height and number of fruits/plant. Other traits on which data were recorded include weight of fruits/plant, percentage damaged fruits and days to final harvest. Data collected were subjected to correlation and path coefficient analysis as described below.

Estimation of Correlations: The correlation coefficient analysis among all possible characters combination at phenotypic (rp) and genotypic (rp) level were estimated employing the formulae (Al-Jibourie, Miller and Robinson, 1958).

Phenotypic correlation $V_{xy\,(p)} = \dfrac{COV_{xy(p)}}{\sqrt{[V_{x(p)} \times V_{y(p)}]}}$

Genotypic correlation $V_{xy}(g) = \dfrac{COV_{xy(g)}}{\sqrt{[V_{x(g)} \times V_{y(g)}]}}$

Where:

$COV_{xy\,(p)}$ = Phenotypic co-variance between variables x and y
$COV_{xy\,(g)}$ = Genotypic co-variance between variables x and y
$V_{x\,(p)}$ = Phenotypic variance for the variable x
$V_{x\,(g)}$ = Genotypic variance for the variable x
$V_{y(p)}$ = Phenotypic variance for the variable y
$V_{y(g)}$ = Genotypic variance for the variable y

Significance of correlation coefficient at both phenotypic and genotypic levels was tested by comparing table 'r' value with obtained value.

Path Coefficient Analysis: The estimates of direct and indirect effect of component characters on fruit yield were computed using appropriate correlation coefficient of different component characters as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Thus, the correlation coefficient of any character with fruit yield was split into direct and indirect effects adopting the standard formula.

$r_{iy} = r_{1i}P_1 + r_{2i}P_2 + r_{3i}P_3 + \ldots\ldots + r_{ni}P_n + \ldots\ldots r_{ii}P_1$

Where:

r_{iy} = Correlation of the *ith* character with fruit yield
r_{ni} = Correlation between nth character with ith character
n = Number of independent variables (component characters)
P_i = Direct effect of ith character on fruit yield

Direct effects of different component character on fruit yield were obtained by solving the following equations.

$r_{iy} = [P_I]\,[r_{ij}]$ which can also be rearranged as $[P_I] = [r_{iy}]^{-1}\,[r_{ij}]$

Where: $[P_I]$ = Matrix of direct effect
$[r_{ij}]$ = Matrix of correlation coefficients among all the n components characters
$[r_{iy}]$ = Matrix of correlation of all component characters with fruit yield
r_{il} = Indirect effect of ith character on fruit yield through first characters

The residual effect was obtained by the following formula.

Residual effect = PR = $\sqrt{1} - P_{iriy}$

Where: P_i and r_{iy} are as given above.

RESULTS AND DISCUSSION

Genotypic and Phenotypic Correlations: The estimates of genotypic and phenotypic correlation between eight traits of tomatoes evaluated at Lake Allau near Maiduguri and Hong during the 2010 and 2011 dry season are presented on table 1. The results indicate that genotypic correlation was positive and highly significant between numbers of fruits/plant with number of flower clusters, number of leaves per plant and plant height. The results also indicate that number of fruits/plant was phenotypically and positively correlated with number of flower clusters/plant, number of leaves/plant and plant height as well as number of trichomes. The phenotypic correlation between weight of fruits and days to final harvest were negative and not significant. There was insignificant genotypic correlation between weight of fruit and number of flower clusters, and number of leaves/plant, suggesting that selection for such traits will invariably lead to lower fruit weight/plant. Positive and significant genotypic correlation existed between weight of fruits/plant and number of fruits/plant.

The results indicate that trichome count was highly and positively genotypically correlated with number of flower clusters/plant, number of leaves/plant and percentage damaged fruits. The phenotypic correlation result on the other hand indicates that the trichome count was positively and significantly correlated with number of flower clusters, leaves/plant, plant height, fruits/plant and days to final harvest. However, the phenotypic correlation between trichome count and percentage fruit damage was significant and negative. The phenotypic correlation between percentage damaged fruits with, number of flower clusters and number of leaves/plant were also significantly negative. The phenotypic relationship between percentage damaged fruit with number of fruits per plant, number of leaves per plant and number of flower clusters were negative and significant.

Yield is a complex entity associated with number of component traits. It is the prime concern of the plant breeder and is the ultimate factor on which selection programmes are to be envisaged. All changes in crop yield must be accompanied by a shift in one or more traits (Graffius, 1964). All the shift in the traits need not, however, be expressed by changes in yield. This could be due to varying levels of positive or negative correlations between yield and its component traits and among the components themselves. The study of association between traits helps in the selection of genotypes and also proffers a way forward for a simultaneous selection scheme in more than one trait. This could explain the fact that improvement in a particular trait could result into the improvement of all the positively related traits (Indu Rani *et al.* 2008). In the breeding of tomato for resistance to fruit worm, knowledge of the interrelationships between yield and its component traits are of utmost importance. The high significant and positive genotypic correlations between number of fruits/plant with number of flower clusters, number of leaves/plant, plant height and days to final harvest implies that these traits could be improved simultaneously. Similar findings were reported by Kumar *et al.* (1979). It also means that a high level of heritability exists between these traits. Hannan *et al* (2007) and Hayder *et al* (2007) also report high and significant positive association between fruit yield and number of flower clusters/plant, number of leaves/plant and plant height in tomato. Hayder *et al* (2007) reaffirm that these traits are synonymous to yield increase in tomato. The high and significant positive correlation with trichome count actually signifies the importance of trichome as a resistance strategy in the control of fruit worm of tomato. Kennedy and Sorenson (1985) had reported a direct relationship between the preponderant levels of trichome with resistance to insects on tomato plant.

Path Coefficient for Weight of Fruits of Tomato: Path coefficient analysis provides an effective means of partitioning direct or indirect causes of relationships. Since crop yield is affected by many factors, selection based on correlation alone may be misleading because it measures only the mutual association between two variables. Path coefficient analysis however, specifically measures the relative importance of different yield components. In order to find out the direct and indirect effects and to measure the relative importance of causal factors, path coefficient analysis is useful and it permits critical examination of the specific forces acting to produce a given correlation (Bhatt, 1973)

The estimates of direct and indirect effects of yield components of tomato on weight of fruits per plant based on path coefficient analysis evaluated at Lake Alau and Hong during the 2010 and 2011 dry season are presented on table 2. The analysis revealed that the highest direct contribution towards weight of fruits per plant was evident through percentage damaged fruits followed by number of flower clusters days to final harvest and number of leaves/plant. Improving these traits that bears direct effects on fruits/plant would therefore mean increasing the fruit yield in tomato. High positive indirect effect towards weight fruits per plant through percentage damaged fruits via trichome count and days to final harvest were observed. Number of flower clusters indirect effect towards weight of fruits per plant via trichome count, number of leaves/plant, plant height and number of fruits per plant were relatively high and positive. Number of flower clusters, number of leaves at 60 days, plant height at 60 days (- number of fruit had high negative indirect effects of weight of fruits via percentage damage fruit.

The path coefficient actually partitions the correlation coefficient into direct and indirect effects through alternate pathway towards realization of yield. Highest direct contribution towards weight of fruits (yield) was evident through percentage damaged fruits followed by number of flower clusters and days to final harvest. It signified that yield in this study had direct bearing on the percentage of damaged fruits per plant, the number of flower clusters and days to final harvest of tomato. The indirect effect of percentage damaged fruits to yield via trichome count and days to final harvest were high. That of flower clusters via trichome count, number of leaves, plant height, and number of fruits was also high. This also applied to days to final harvest via number of flower clusters, plant height, number of fruits and percentage damaged fruits. It therefore means that percentage damaged fruits, number of flower clusters and days to final harvest contributed very much to fruit yield. Hayder, et al (2007); Bhardwaj and Sharma (2005) report similar results and found a significant contributions to yield through plant height, number of flower clusters, number of leaves/plant and number of fruits/plant in tomato. The important yield contributing traits could therefore be circumvented for fruit yield in tomato. This result is in agreement with that of Golani *et al.* (2007) and Indu Rani *et al.* (2008), who confirm the reliability of these traits in selecting a superior tomato type for yield/plant.

Table 1: Genotypic and phenotypic correlation coefficients between yield and yield traits in tomato

Traits	TC	NFC	NL/P	PH	NF/P	WF/P	% DF	DFH
TC	1.00	0.90**	0.90**	0.69	0.04	0.16	0.92**	0.02
NFC	0.90**	1.00	0.92**	0.91**	0.99**	-0.91**	-0.92**	0.92**
NL/P	0.90**	0.90**	1.00	0.91**	0.99**	-0.91**	-0.92**	-0.91**
PH	0.71**	0.81**	0.99**	1.00	0.95**	0.56	0.91**	0.91**
NF/P	0.91**	0.91**	0.91**	0.90**	1.00	0.92**	0.97**	0.99**
WF/P	0.22	0.22	0.29	-0.10	0.91**	1.00	-0.91**	-0.90**
% DF	-0.90**	-0.90**	-0.90**	0.66	0.92**	-0.32	1.00	-0.92**
DFH	0.90**	-0.81**	-0.91**	0.57	0.92**	-0.07	-0.77**	1.00

Source: Experimentation 2010. *** Significant at 1 % level of probability. Genotypic correlation values: upper right diagonal. Phenotypic correlation values: lower left diagonal.*

Table 2: Path coefficients of component traits on fruit yield of tomato

Traits	TC	NFC	NL/P	PH	NF/P	WF/P	% DF	DFH
TC	0.092	0.631	0.239	-0.001	0.047	0.991	0.010	0.22
NFC	0.087	0.651	0.315	-0.030	0.267	-0.991	0.440	0.22
NL/P	0.087	0.586	0.346	-0.027	-0.290	-0.991	-0.435	0.29
PH	0.069	0.527	-0.030	-0.030	-0.279	-0.980	0.435	-0.10
NF/P	0.088	0.592	0.315	0.027	-0.293	-0.945	0.473	0.91**
% DF	-0.087	-0.586	-0.311	0.020	0.270	0.977	0.440	-0.32
DFH	0.087	-0.527	-0.315	-0.017	0.270	0.829	0.478	-0.07

Source: Experimentation 2010. ** Significant at 1 % level of probability

Key: TC = Trichome count; NFC = Number of flower clusters; NL/P = Number of leaves/plant; PH = Plant height; NF/P = Number of fruits/plant WF/P = Weight of fruits/plant; %DF = % damaged; DFH= Days to final harvest

CONCLUSION

The yield contributing traits such as number of flower clusters/plant, number of leaves/plant and plant height were found to have positive and significant genotypic and phenotypic correlation levels with number of fruits/plant. The resistance trait, that is, trichome count was genotypically correlated with number of flower clusters/plant, number of leaves/plant and percentage damaged fruits. However, number of fruits/plant were phenotypically positively correlated with number of flower clusters/plant, number of leaves/plant, plant height and days to final harvest. However, trichome count was significantly and negatively phenotypically correlated with number of fruits/plant. The percentage damaged fruit exhibited the highest positive direct effect on fruit yield. The direct effects of number of flower clusters/plant, days to final harvest, and number of leaves/plant were also positive upon fruit yield. These traits could be exploited when selecting for high yielding genotypes in tomato.

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