COMBINING ABILITY FOR FRUIT WORM RESISTANCE IN SOME COMMERCIALLY GROWN TOMATOES IN LAKE ALAU NEAR MAIDUGURI AND HONG IN ADAMAWA STATE, NIGERIA

Izge, A.U.
Department of Crop Production, Faculty of Agriculture,
University of Maiduguri, Maiduguri, Borno State, Nigeria
E-mail: *bamsyizge@yahoo.com*

Garba, Y. M.
Department of Agricultural Education
School of Vocational and Technical Education,
College of Education, Hong, Yola, Adamawa State, Nigeria

ABSTRACT

Combining ability studies for yield and yield components of tomato under artificial and deliberate infestation by tomato fruit worm (Helicoverpa zea Boddie) were made over two environments at Lake Alau near Maiduguri and at Hong Adamawa State, Nigeria in a set of 6 lines and 2 testers during the 2009 and 2010 dry season under irrigation. The pooled results showed that both General Combining Ability (GCA) and Specific Combining Ability (SCA) were influenced by the environment implying that the parents and hybrids must be evaluated over a wide range of environments to have unbiased estimate. The tester Cherry and the lines UC and Roma VF indicated great promise for the production of increased number of fruits per plant and incidentally the general fruit yield in tomato under infestation by fruit worm insect. Out of the 12 hybrids studied, 4 each were found to be good specific combiners for number of flower clusters and plant height, and 5 for number of fruits per plant over both the environment combined. Cherry × Hong Large and Cherry × Roma VF were the best specific combiners for number of fruits per plant and incidentally having high number of trichome count. These hybrids could be resistant to this insect. Additive gene action were preponderant for number of flower clusters, number of fruits per plant and days to final harvest, while non-additive action were preponderant for number of leaves per plant, plant heights, weight of fruits and the percentage damaged fruits.

Keywords: *Tomato, fruit worm resistance, yield components, Helicoverpa zea Boddie*

INTRODUCTION

Tomato is an important fruit vegetable and second most important vegetable crop after potato that is widely grown and consumed worldwide. World production of this important fruit vegetable crop is put at 130 million metric tonnes annually on 4.7 million hectares of land (Shahabuddin, Quamruzzaman and Uddin, 2009). In Nigeria the major producing areas lies between latitudes 7.5^{o} 11` and 13.0^{o}N and within temperature range of 25 - 30^{o} ^{C}. Tomato production level in Nigeria is put at 6 million metric tons of fruits on 126,000 hectares of land according to Idah and Aderibigbe (2007). Tomato is mostly produced during the dry season period under irrigation and provides employment to large a number of Nigerians. There is also a well established trade in fresh and dried tomato between the northern and southern part of Nigeria. Its cultivation is however, mainly constrained by temperature and relative humidity which limits its production to the short cool hamatan period in Nigeria. Unfortunately this period attracts much insect pests to the crop causing heavy damage and high economic losses. Most damage is caused by the devastating tomato fruit worm insect (*Helicoverpa zea Boddie*) which causes between 21.7 - 30.0 % damage on unsprayed tomato crop Steamwyk, (1983) and Cameron et al. (2001). This is far above the 5% commercially acceptable damage level.

Chemical control of tomato fruit worm has been found to be costly and ineffective due to its high mobility, wide host range and boring activities. The most promising method of controlling tomato fruit worm therefore could be through the use of host resistance. The use of host resistant tomato cultivars could be economically affordable to the farmer, requiring no technical know-how and environmentally friendly. In any crop improvement programme, combining ability is one of the important genetic tools which provide guidelines for an assessment of the relative breeding potential of the parents or identifying the best combiners which may be hybridized either to exploit heterosis or to accumulate fixable genes. It was for these reasons therefore, that the purpose of this study was to analyze 6 lines, 2 testers and 12 hybrids over two locations for:

1. Combining ability × environment interactions.
2. Combining ability estimates on the data of pooled or combined environments and
3. The genetic system governing the traits studied.

MATERIALS AND METHOD

The experimental materials comprised of hybrid population of 12 crosses developed by crossing 6 lines of tomato viz: UC, Roma VF, Roma VFI, Tandino, Golden Roma and Hong Large with two testers viz. Cherry and Current. The 8 parental materials used in the study are described on table 1. The 8 parental lines and their 12 hybrids were grown in a Randomized Complete Block Design (RCBD) with three replications during the dry season period of 2010 under irrigation at Lake Allau near Maiduguri (11^{o} 6`N; 13$^{o}$ 17` E) at the height of 696m above sea level in Borno State and at Hong (10^{o} 15`N; 13$^{o}$ 20` E) at the height of 246m above sea level in Adamawa State both in north eastern part of Nigeria. Each hybrids and parents were grown in a double row of 2m length of sunken beds of soil.

The plants were spaced at 75cm row to row and 50cm plant to plant distance. Thus, there were 10 plants in each entry per replication over both the environments and all the cultural practices regarding tomatoes were followed as recommended. Infestation of the experimental field by tomato fruit worm insect was done artificially by throwing infested tomato fruit into the field. The data were recorded on 5 randomly selected plants per plot for the following traits viz: trichome count, number of flower clusters, number of leaves per plant, plant height and number of fruits per plant. Other traits on which data were recorded included, weight of fruits per plant, percentage damaged fruits and days to final harvest. All the quantitative data were subjected to analysis of variance (ANOVA) and the entry means were used for statistical analysis. The analysis was done according to the model suggested by Kempthorne (1957).

Table 1: Description of the parental materials used in the experiment

Parents	Description and identifiable characters
Cherry	Much looping and indeterminate. Has a very dense trichome. The leaves are thin, small and less acuminate. It flowers late and has very small, round and regular fruits. The fruit yield is high. Resistant to fruit worm insect.
Current	Much looping and indeterminate. It has a very dense trichome. Leaves are attached on a very long stalk. The leaves are ovate with pointed tips and irregular margins. Fruits are small, round and regular. It is high yielding. Resistant to fruit worm insect.
UC	It is fast growing, looping and determinate. The trichomes are sparse. Leaves are narrow, tips pointed, irregular margins and uncurled. The flowering is indeterminate; fruits are globular, round and medium sized. Yield is average.
Roma VF	Slightly looping and determinate. It has sparse trichome. Leaves are narrow, pointed at the tips with a smooth margin. The plant flowers early. Fruit is spear shaped, cylindrical with a pointed tip. It is high yielding.
Roma VFI	Slightly looping and determinate. It has sparse trichome. Leaves are narrow, pointed at the tips with a smooth margin. The plant flowers early. Fruit is spear shaped, long, and increasingly flatter towards the bottom. It is very high yielding.
Tandino	The plant is erect and very compact and determinate. The trichome is sparse. Leaves are broad, curled and crown with a pointed tips. Fruits are large, round, grooved and low yielding.
Golden Roma	The plants are dwarfed, open, looping and determinate and have a very sparse trichome. Leaves are broad shaped, long and pointed at the tips with irregular margins. Early flowering. The fruit is round, medium sized and slightly grooved. Has an average yield.
Hong Large	The plants are dwarfed, looping and indeterminate. Has a very sparse trichome. Leaves are relatively broad shaped, pointed at the tips with irregular margins. The fruits are large sized and prominently grooved, kidney shaped and very low yielding. Susceptible to fruit worm insect. Local cultivar.

Source: *Experimentation*, 2010

RESULTS AND DISCUSSION

The analysis of variance for combining ability was found to be highly significant for almost all the traits studies (Table 2). The result indicated that additive as well as non-additive types of gene actions played an important role in the inheritance of these traits. These findings are in close agreement with those of Dod et al. (1992), Hannan et al. (2007) and Shahabuddin et al. (2009). However, the general combining ability variances were higher in magnitudes than the specific combining ability variances for number of flower clusters/ plant, number of fruits/plant and days to final harvest, indicating the predominance of the additive gene effects for the traits. Shahabuddin et al. (2009) also reported that additive gene effects appeared more important than non-additive gene effects for number of fruits/ plant and number of flower clusters. The results also indicated that there were highly significant difference among entries, parents and hybrids for trichome count. Heinz and Zalom (1995), report that trichome were associated with the observed variations in resistance patterns to insects in tomato. Cultivars with low trichome were found to be susceptible to insect attack.

General Combining Ability Effects (GCA): The GCA component is primarily a function of the additive genetic variance. GCA variances and SCA variances with each parents and hybrids respectively play a significant role in the choice of parents and hybrids. A parent with higher positive significant GCA effect is considered as good general combiner. The results of GCA effects for 8 traits of tomato are presented on table 3. The results indicated that UC which was among the parents with the highest trichome count produced the tallest plants and was also among plants that produced high number of fruits/plant. The estimates of GCA effects for number of flower clusters indicated that Cherry showed the highest significant GCA effects followed by Roma VF. The other parents showed insignificant positive or negative or significant negative values for the same trait. The parent UC was the best general combiner for plant height followed by Roma VFI, Cherry and Tandino, since these parents were the ones that showed higher and significant GCA values for the trait (table 2). These observations revealed that these traits could be improved by using these parents in a hybrid breeding programme for accumulation of fixable and favorable genes. Singh et al. (2005) and Premalakshmi et al. (2006) also report significant GCA effects for plant height in tomato. However, none of the parents was best general combiner for all the traits indicating differences in genetic variability for different characters among the parents. The other parents showed insignificant GCA values for plant height. Shahabuddin et al. (2009) report similar findings. The general combining ability effect for number of fruits/ plant showed that Cherry had the highest positive and significant value, followed by UC and Roma VF. Other parents showed insignificant positive GCA values. All the remaining traits of which some were positive and negative did not show any significant values in their GCA effects.

Specific combining ability effects: The SCA variance is due to dominance variance and epistatic variances. Hence, the SCA variances act as a diagnostic tool in selection of suitable cross combinations. The SCA effects signify the role of non - additive gene action in the expression of a trait. It shows the highly specific combining abilities leading to the higher performance of some specific cross combinations and that is why it is related to a particular cross. High SCA effects may arise not only in crosses involving high combiners but also in those involving low combiners. The SCA effects of 12 hybrids for the eight traits studied are presented on table 4. The results showed that the SCA effects among the hybrids were significant only in three traits among other traits studied viz: number of flower clusters, plant height and number of fruits/plant. In case of number of flower clusters, 50% of the hybrids exhibited positive SCA values indicating that these hybrids produced higher number of flower clusters and incidentally could have considerable levels of heterosis.

Similar results were reported by Tendulkar (1994) and Yashavantakumar (2008). Out of the 12 hybrids studied, five of them showed significant or highly significant positive SCA values for number of flower clusters. The hybrids, Current × Roma VF, Cherry × Roma VFI, Cherry × Tandino and Cherry × Golden Roma were the best specific combiners for number of flower clusters/plant. The four superior cross combinations, on the basis of per se performance showed higher SCA effects for this trait. Higher SCA effects manifested by crosses where both the parents were good general combiners might be attributed to sizeable additive× additive gene action. A similar finding was reported by Hannan et al. (2007). Further, Hannan et al. (2007) asserted that the high × low combinations on the other hand could beside expressing the favourable additive effect of the high parents might manifest some complimentary gene interaction effects with a higher SCA. In all the hybrids that exhibited higher specific combining ability values for number of flower clusters per plant, Cherry was one of the parental lines.

Only five out of the twelve hybrids showed higher and significant positive SCA values for plant height. Highest effect was obtained from Current × Tandino, followed by Cherry × Hong Large, Cherry × Roma VF, Cherry × Golden Roma and Current × Roma VFI (table 4). This therefore indicated that these cross combinations were very consistent in their specific combining abilities for the improvement of plant height. However, Cherry × Tandino and Current × Hong Large displayed in significant SCA effects for plant height, indicating that these materials could be good materials for short stature breeding when required. In case of number of fruits/plant, four out of the twelve hybrids exhibited positive SCA values, indicating the increase of number of fruits/plant over the mean of their parents.

The four cross combinations which had highly significant and positive values for number of fruits/plant were Cherry × Hong Large, Current × Roma VF, Cherry × Golden Roma and Current × UC. Mahendrakar (2004), Premalkshmin et al. (2006) and Asati *et al* (2007) also report a positive and significant SCA effects for number of fruits/plant in tomatoes. These same sets of hybrids incidentally had the highest number of trichome count and could mean that some level of resistance resulting due to the presence of the glandular trichome was at display and these resulted to high number of fruits/plant. Heinz and Zalom (1995) report similar result. These hybrids or cross combinations could be exploited for the improvement of tomato to fruit worm resistance, number of fruits/plant and yield as they have displayed some levels of consistency in their specific combining abilities.

Table 2: Analysis of combining ability in eight traits of tomato in a line × tester

SoV	DF	TC	NF	NL/PC	PH	NF/P	WF/P	%DF	DFH
Location	1	3.0	90.75	184.08	188.02	9436.02	75.80	659.94**	2.08
RL	4	1.72	25.08	220.16	776.27**	160.42	102.13	80.44	0.53
Entries	19	3.92**	348.53**	1378.27**	598.93**	16662.65**	7.49	261.16**	571.27**
Parents	7	6.68**	320.38**	1571.29**	1245.16**	24947.24**	10.90	429.31**	557.33**
Hybrids	11	3.00**	390.11**	1375.48**	221.42*	12844.26**	4.02	164.54**	533.85**
LE	19	0.02	32.32*	79.72	73.89*	319.52	19.82	44.08*	30.95**
LP	7	0.00	46.27*	117.18	63.31**	348.95*	18.71	60.08*	25.23**
LH	11	0.03	24.03*	57.34**	68.63**	329.25**	21.29*	37.65**	30.13**
PH	1	0.05	88.20**	64.80**	227.81**	672.80**	21.74*	142.93**	1080.45**
GCA	7	0.02	230.72**	-4552.56**	-5398.57**	196446.26**	-6.34*	-47.72*	45.51*
SCA	11	-0.03	2.47	-38.62*	-27.67*	-509.90**	-1.30*	-6.11*	-7.09
PE	20	0.58	36.55	214.00	194.04	-385.26	13.34	22.08	39.20

Source: Experimentation, 2010. SoV = *Source of variation; DF = Damaged of Fruits; TC = Trichome count; NF = Number of flowerl; NL/PC = Number of Leaves/Plant Clusters; PH = Plant height; NF/P = Number of Fruits/ plant; WFP = Weight of fruits/plant; %DF = % Damaged Fruits; DFH = Days to Final Harvest; RP = Replication/ Location; LE = Location/Entries; PH = Parents/Hybrids; LP = Location Parents; PE = Pooled Error*

Table 3: General combining ability effect of parents in eight traits of tomato

Parents	TC	NF of	NL/PC	PH	NF/P	WF/P	%DF	DFH
Cherry	0.24	7.00**	12.31	3.66**	40.04**	1.26	-4.81	-3.94
Current	-0.24	-7.00**	-12.31	-3.66**	-40.04**	-1.26	4.81	3.94
SE±(Testers)	0.18	1.42	3.45	3.28	10.44	0.86	1.11	1.48
UC	0.60	-0.42	7.27	5.18**	21.46*	0.61	-5.01	-6.11
Roma VF	-0.07	1.17**	4.33	-2.01**	20.63*	0.75	-4.50	8.22
Roma VFI	-0.07	-1.58**	4.83	4.32**	-2.54	-0.18	-2.40	0.70
Tandino	-0.49	0.75	-0.75	3.15**	-4.29	0.13	-0.97	-0.11
Golden Roma	-0.49	0.67	-4.58	0.40	-19.25	-0.62	4.66	2.39
Hong Large	-0.24	-0.58	-11.08	-0.68	-16.13	-0.68	8.23	-5.11
SE± (Lines)	0.31	2.47	5.97	5.69	18.08	1.49	1.92	2.56

Source: Experimentation, 2010

Table 4: Specific combining ability effects of hybrids in eight traits of tomatoes

Hybrids	TC	NF	NL/PC	PH	NF/P	WF/P	%DF	DFH
Cherry × UC	-0.15	-0.58	-7.06	-0.43	-9.88**	-0.44	3.95	-5.06
Current × UC	0.15	0.58	7.06	0.43	9.88**	0.44	-3.95	5.06
Cherry × Roma VF	-0.32	-8.17**	-2.47	2.74*	-14.38**	-0.37	3.72	2.61
Current × Roma VF	0.32	8.17**	2.47	-2.74*	14.38**	0.37	-3.72	-2.61
Cherry × Roma VFI	0.01	4.25*	-0.64	-1.10*	-0.04	0.20	3.20	-4.89
Current × Roma VFI	-0.01	-4.25*	0.64	1.10*	0.04	-0.20	-3.20	4.89
Cherry × Tandino	-0.05	2.42*	-0.06	-6.26**	-3.29*	-0.26	1.13	-3.06
Current × Tandino	0.05	-2.42*	0.06	6.26**	3.29*	0.26	-1.13	3.06
Cherry × Golden Roma	0.10	3.50*	7.78	1.32*	12.38**	0.31	-4.41	-1.56
Current × Golden Roma	-0.10	-3.50*	-7.78	-1.32*	-12.38**	-0.31	4.41	1.56
Cherry × Hong Large	0.51	-1.42*	2.44	3.74*	15.21**	0.55	-7.58	11.94
Current × Hong Large	-0.51	1.42*	-2.44	-3.74*	-15.21**	-0.55	7.58	-11.94
SE ±	**0.44**	**3.49**	**8.45**	**8.04**	**25.56**	**2.11**	**2.71**	**3.61**

Source: Experimentation, 2010

CONCLUSION

The variances for general combining ability and specific combing ability were significant in almost all the traits studied, indicating the preponderance of additive as well as non - additive gene effects. The relative magnitude of these variances, however, indicated that additive gene effects were more prominent in controlling most of the traits. This study revealed the importance of additive as well as non - additive gene action in the inheritance of the traits studied. Where non-additive gene action was preponderant, hybrid vigor could be exploited for the traits concerned. On the other hand, where additive gene action becomes preponderant, simple selection in the segregating population to develop pure lines could be exploited. The tomato genotype Cherry was the best general combiner for number of fruits per plant and number of flower clusters per plant. The genotype UC was the best general combiner for plant height.

In general, the hybrids Current × Roma VF and Cherry × Roma VFI were the best specific combiners for number of flower clusters/plant. The cross combinations, Current × Tandino and Cherry × Hong Large proved superior in terms of plant height, while Cherry × Hong Large and Current × Roma VF were leading in terms of fruit yield. Therefore, the best general combiner from the parental lines and the best specific combiners among the crosses may be selected for better parents and hybrids respectively for improvement of traits especially fruit worm resistance and fruit yield in tomato cultivation under irrigation in north eastern Nigeria.

REFERENCES

Asati, B.S., Singh, G., Rai, N. and Chaturvedi, A.K. (2007). Heterosis and combining ability studies for yield and quality traits in tomato. *Vegetable Science,* 34, 92-94.

Cameron, P. J., Walker, G.P. Herman, T. J. B and Walluce, A. R. (2001). Development of economic thresholds and monitoring systems for Heliothes armigera (Lepidoptera: Noctuidae) in tomatoes. *Journal of Economic Entomology,* 94.

Dod, V. N., Kale, P. B., Wankhade, R. V. and Jadhav, B. J. (1992). Heterosis in the inter-varietal crosses of tomato (*Lycopersicon esculentum Mill.*). *Crop Research*, 5, 134 - 139

Hannan, M. M., Ahmed, M.B., Razuy M.A., Karim, R., Khatun, M., Hayda A., Hossaine, M and Roy, U.K. (2007). Heterosis and correlation of yield components in tomato (*Lycopersicon esculentum Mill*). *American - Eurasian Journal of Scientific Research* 2, 2.

Heinz, Kevin M and Zalom Frank G. (1995). Variation in trichome - based resistance to Bemisia argentifolii (*Homoptera: Aleyrodidae*) oviposition in tomato. *Journal of Economic Entomology,* 88 (5): 1494 - 1502 (9)

Idah, A. P and Aderibigbe B. A. (2007). Quality changes in dried tomatoes stored in sealed polythene and open storage systems. *Leonardo Electronic Journal of Agricultural Practices and Technologies. http://lejpt.accidemicirect.org.*

Kempthorne, O. (1957). *An Introduction to Genetic Statistics.* New York: John Wiley and Sons Inc., 208 -223 pp.

Mahendrakar, P. (2004). Development of F1 hybrids in tomato (*Lycopersicon esculentum Mill*). M.Sc. (Agriculture) Thesis, University of Agricultural Science, Dharwad

Premalakshmi, V., Thyagaraj, T. Veeraragavathatham, D. and Arumugam, T. (2006). Heterosis and combining ability analysis in tomato [(*Lycopersicon esculentum (Mill*) Wettsd] for yield and yield contributing traits.

Shahabuddin Ahmad, Quamruzzaman A. K. M. and Nazim Uddin M. (2009). Combining ability estimates of tomato (*Solanum lycopersicum*) in late summer. *SAARC Journal of Agriculture,* 7 (1): 43 - 56

Singh, A.K., Pan, R.S. and Rai, M. (2005). Combining ability studies on yield and its contributing traits in tomato (*Lycopersicon esculentum Mill.*). *Vegetable Science,* 32: 82-83.

Steamwyk, R.N. Van. (1983). Lipidopterous pests of tomatoes in southern desert valley. *California Agriculture,* 37: 12-13

Tendulkar, S.K. (1994). Studies on line x tester analysis for development of F1 hybrids in tomato (*Lycopersicon esculentum Mill*). M.Sc. (Agriculture) Thesis, University of Agricultural Science, Dharwad.

Yashavantakumar, K.H. (2008). Heterosis and combining ability for resistance against tospovirus in tomato (*Solanum lycopersicon Mill*) Wettsd.). M.Sc. (Agriculture) Thesis, University of Agricultural Science, Dharwad.