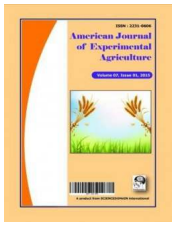

American Journal of Experimental Agriculture
11(1): 1-7, 2016, Article no.AJEA.20434
ISSN: 2231-0606

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Combining Ability of Yield Related Traits and Gene Interaction on Tomato (*Lycopersicon esculentum* Mill.) in Yola

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Authors' contributions

This work was carried out in collaboration between all authors. Author SJL designed the study, wrote the protocol and wrote the first draft of the manuscript. Author SYS reviewed the experimental design and all drafts of the manuscript. Authors EME and MIJ managed the analyses of the study. Author EME identified the plants. Authors SJL and SYS performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2016/20434
Editor(s):
(1) Anita Biesiada, Department of Horticulture, Wroclaw University of Environmental and Life Sciences, Poland.
Reviewers:
(1) A. K. M. Aminul Islam, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.
(2) Claude Ahouangninou, University of Abomey-Calavi, Benin.
Complete Peer review History: http://sciencedomain.org/review-history/12733

Original Research Article

Received 28th July 2015
Accepted 3rd November 2015
Published 18th December 2015

ABSTRACT

Field experiments were conducted to estimate the combining ability and nature of gene action governing inheritance of characters in tomato (*Lycopersicon esculentum* Mill) under high temperature stress. The experiment was conducted at the Teaching and Research Farm of Department of Crop Production and Horticulture Modibbo Adama University of Technology, Yola. (latitude 9° 18 [1] N and long 12° 15 [1] E) and the Teaching and Research Farm of Adamawa State University, Mubi (latitude 10° 03 [1] N and long. 13° 07 [1] E) all in Adamawa state of Nigeria. Fourteen entries consisting of six parents and eight croses developed by crossing two males (testers) and four females (lines) following line x tester design were evaluated in three replications in a Randomized Complete Block Design (RCBD) in two locations. Ten plants were randomly sampled for recorded observation. Data were collected from the following characters; Trichome count, plant height at 60DAT, number of leaves per plant at 60DAT, number of fruits per plant, weight of fruits

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per plant % damaged fruits and number of days to final harvest. Data were subjected to biometrical analysis. Result of the analysis of variance indicated highly significant difference for all characters among entries except weight of fruits per plant. The result suggested the presence of genetic variability among the tomato genotypes under study. Significant difference were observed in the combining ability analysis of variance in all the agronomic characters under study except for trichome count suggesting both additive and non-additive genetic effects were important in governing this characters under study with more preponderance of additive effects. The cultivars, Cherry, Currant, UC28B, and RomaVF were identified as the best general combiners and the best yielders in terms of number of fruits per plant with appreciable tolerance to heat damage.

Keywords: Combining ability; gene action; inheritance and tomato.

1. INTRODUTION

Tomato (*Lycopersicon esculentum* mill) is an important and widely grown vegetable around the world and belong to the family of Solanacae. It ranks second, only after potato. According to [1] tomato is referred as a "poor man's orange'' because of it attractive appearance and nutritive value. [2] said that tomato diversified first in peru, Mexico where it was domesticated from its ancestor *Lycopersicon cerasiforme*. According to [3] world production of tomato is about 130 million metric tones of fresh tomato from an estimated 4.7 million hectares of land. China, the largest producer accounted for about one quarter of the global output, followed by united state and turkey. India stands fourth position in tomato producing countries of the world. In Nigeria, tomato is mostly produced in the Northern parts of the country in places such as Borno, Kano, Sokoto, Bauchi, Gombe and Adamawa states. [4] reported that about 1.4 million metric tones of tomato fruits were produced from 224,000 hectares of land in Nigeria in 2009. The crop is mainly produced during the dry season, facilitated by -irrigation. The inability of most tomato (*Lycopersicosn esculentum* Mill,) cultivars to set fruit under high night and day temperatures has been a limiting factor for tomato production in the tropical and sub-tropical areas of the world. Although [5] reported that tomato plants can be grown under a wide range of climatic conditions, they are extremely sensitive to hot and wet conditions. El- Ahmadi [6] also said that fruit setting in tomato is interrupted at temperature above 26℃ and 20℃ day/night and is often completely arrested at temperature above 38/27℃ day/night. Tomato production in Nigeria is constrained by high temperature and relative humidity limiting it production to the short harmatan period. Therefore, it is difficult to advocate eradication of heat and the only way is to concentrate on the development of varieties that are tolerant to heat. Considering the spectrum of aforesaid requirements in tomato, the present investigation is done to estimate the combining ability and nature of gene action governing inheritance of characters in tomato under high temperature stress.

2. MATERIALS AND METHODS

The genetic materials used for the study consist of 6 parents and 8 crossed seeds, aggregate of 14 entries generated during 2013 cropping season. These were evaluated in a Randomized Complete Block Design (RCBD) in two locations, Yola and Mubi locations of Adamawa State. The crossing nursery was established in June to October 2013 at the teaching and research Farm of the Department of Crop Production and Horticulture Modibbo Adama University of Technology, Yola. After normal land preparation, Crosses were made between the four exotic breeding lines (Roma VF, UC28B, GoldenRoma and RioGrandei) and the two non-commercially cultivated heat tolerant cultivars as testers (Cherry and Currant) thereby generating 8 crosses, each line was crossed with the four exotic lines to generate 8 crosses. These crosses were made by emasculating the flowers of the lines by removal of the anther from the female plants in the evening. Emasculation involved selecting of flowers that was just about to show yellow color, The anther cone was carefully removed making sure the stigma and style do not break, leaving intact the sepals, pistilate and the pedicel parts. One day before maturation of the anthers, tomatoes are ready for pollination at this stage. The resultant $8F_1$s progenies along with six parental cultivars making 14 genotypes were evaluated on a 2 m x 2 m bed containing 16plants at both Yola and Mubi locations of Adamawa State during the dry season of 2013/ 2014 in a Randomized

Complete Block Design (R.C.B.D) with three replications. Each replication has 14 plots for each cross and parents.

3. RESULTS AND DISCUSSION

Results of Mean squares from the general analysis of variance for 8 characters in tomato combined across locations as presented in Table 1 indicates that, there was no significant difference among the locations for all characters measured except for percentage damaged fruits. Highly significant difference was observed for all characters among the entries except for weight of fruits per plant. Similar results were also observed for parents and for crosses. The location by entries variance was noticed to be high for plant height at 60 days after transplanting as well as percentage damaged fruits, number of flower cluster and number of days to final harvest. It is also clear that location by parents interaction was highly significant in characters such as plant height at 60 days after transplanting, percentage damaged fruit, number of flower cluster, number of fruits per plant and number of days to final harvest. With regards to location by crosses, all characters showed highly significant differences except for number of trichome. Similar results were also observed for parents by crosses. The GCA variance were highly significant in characters such as plant height at 60 days after transplanting, number of leaves at 60 days after transplanting, number of fruit per plant and number of flower cluster. However, SCA variance showed significant differences for all characters except number of flower cluster, trichome count and number of days to final harvest. The GCA / SCA variance ratios were less than unity with respect to trichome count and number of fruits per plant. While it was positive and greater or equal to unity for all the remaining characters. Highly significant difference observed in the mean squares for location among the genotypes for percentage damaged fruits is an indication that performance of the entries differ in difference locations in terms of temperature stress. Highly significant difference observed in the mean squares for parents and for crosses for all character except weight of fruit per plant indicates the existence of genetic variability between the parents and their respective crosses implying that the materials could be used for varietal improvement or could respond to selection pressure. This is in accordance with [4] that the amount of improvement that is obtained by selection among a number of cross is dependent on the level of genetic variance between the crosses and the intensity of selection applied. Highly significant mean squares for location and entries interaction noticed on most characters further, suggested that difference genotypes used in this study, behaved differently in the respective locations with respect to agronomic characters such as plant height at 60 days after transplanting, number of flower cluster percentage damaged fruits and number of days to final harvest. Highly significant differences observed in all characters except trichome count for location x crosses and parents x crosses interaction had also suggested that the genotypes used in this study performed differently in different locations. This is similar to the report of [7] on tomato, they found significant difference in genotypes by environmental interaction for number of fruits damaged by heat. They stated that genotypes and environmental effect is important for heat tolerance in tomato. This finding suggested that more than one test environment might be needed to obtain reliable information on the characters among the parents and crosses. This is also similar to the report of [8]. Significant differences observed in the general combining ability (GCA) variances in all the agronomic characters under study except trichome count indicates the importance of additive gene actions in governing characters in tomato. This is in accordance with the report of [9]. The significant different observed in the specific combining ability in most characters under study except trichome count and number of days to final harvest indicate the important of non-additive gene action in controlling this charactres in tomato. Less than unity GCA: SCA observed with respect to number of fruits per plant and trichome count suggests the preponderance of non-additive component of variances in the control of these characters, this also conformed to the findings of [10] in number of fruits per plant. Greater than unity ratio observed in most characters indicate additive gene actions while unity ratio observed in characters such as number of leaves at 60 days after transplanting and number of flower cluster indicates these characters are controlled by both gene actions.

Table 1. Mean square from the analysis of variance for 8 characters in tomato combined across locations

Source of variation	DF	Plant height at 60 DAT (cm)	Weight of fruits Per plant (kg)	Number of leaves at 60 DAT	Number of fruits per plant	Number of flower cluster	Trichome count	Percentage damaged fruits	Number of days to final harvest
Location	1	178. 06NS	73.90NS	180.07 NS	183.01 NS	92.68NS	4.10NS	668.83**	2.09 NS
Rep x location	3	875.32 **	108.21 NS	210.16	158.43	26.90	1.63 NS	78.45 NS	0.44 NS
Entries	1	684.84**	6.82 NS	1466.26**	17663.55**	352.54**	4.32**	271.16**	601.12**
Parents	5	1351.13**	9.83 NS	1562.33**	25936.31**	324.41**	6.56**	438.21**	498.23**
Crosse	7	322.34	4.08**	1455.39**	12744.25*	308.12**	3.80**	173.51**	544.64**

*NS = not significant; * = Significant at 0.05 Probability;** = Significant at 0.01 Probability; DAT=Days after Transplanting*

Table 2. Estimate of general combining ability effects of parents for 8 characters measured on tomato combined across locations

Parents	Plant height at 60 DAT (cm)	Weight of fruits Per plant (kg)	Number of leaves at 60 DAT	Number of fruits per plant	Number of flower cluster	Trichome count	Percentage damaged fruits	Number of days to final harvest
Testers								
Cherry	9.44**	0.65	11.98**	17.02*	5.50**	0.45	- 0.81	15.62**
Currant	9.55**	0.92*	11.18**	17.27*	5.03**	0.42	- 1.35	13.80*
S.E. ±	3.28	0.86	3.45	10.44	1.42	0.18	1.11	1.48
Lines								
UC28B	0.41	0.13	3.86	16.30*	1.22*	0.18	- 1.23	0.04
;gtf Roma VF	1.24*	0.02	5.69	11.61	2.25*	0.05	- 0.81	- 4.71
Golden Roma	1.30*	- 0.25	- 4.03	- 13.73	- 3.45**	- 0.16	0.22	2.71
Rio Grandei	2.06*	0.26	- 7.93	- 23.84*	- 2.53**	- 0.38	3.54	- 4.04
S.E ±	1.29	2.11	8.6	15.12	1.11	2.00	5.00	6.21

** = Significantly different at 5% level of probability*

Table 3. Estimate of specific combining ability (SCA) effects of hybrids for agronomic characters in tomato combined across locations

	Plant height at 60DAT (cm)	Weight of fruits per plant (kg)	Number of leaves at 60 DAT	Number of fruits per plant	Number of flower cluster	Trichome count	Percentage damaged fruits	Number of days to final harvest
Cherry x UC28B	- 0.62	0.06	- 0.04	0.99	1.43*	0.10	0.12	1.95
Currant x UC28B	2.99*	- 0.06	0.11	- 0.98	- 1.42	- 0.10	- 0.12	- 1.94
Cherry x 0.02*		0.07	0.22	0.90	- 0.04	0.02	0.33	178

*** = Significantly different at 1% level of probability*

The estimate of general combining ability effects of parents combined across locations for all the characters studied are presented in Table 2 above. The result revealed that currant was the highest general combiner, because it showed significant positive GCA effects with respect to all the characters except percentage damaged fruits where negative values are preferable. Cherry, the second high general combiner had significant positive GCA effects in all characters studied except weight of fruits per plant. This genotype however, recorded negative GCA effects for percentage damaged fruits. Among the lines, Romavf is the best general combiner, because it recorded positive GCA effects for plant height, number of leaves at 60 days after transplanting, number of fruits per plant, number of flower clusters and high negative GCA effect for number of days to final harvest which shows earliness. It was closely followed by UC28B as it has high positive GCA effects for number of leaves at 60 days after transplanting, number of fruits per plant and number of flower clusters, it also recorded high negative GCA effect with respect to percentage damaged fruits. The remaining lines are the least general combiners because they have low GCA effects. In the present study cherry, currant, UC28 and Romavf has been identified as the best general combiners for all agronomic characters under study. The positive general combining ability shown by these genotypes for all characters under study except for percentage damaged fruits where negative is preferable, indicated that these genotypes are good testers and lines that had shown superiority of their hybrids where they are both used as parents or one of the parent. The negative general combining ability (GCA) shown by these genotypes in case of percentage damaged fruits is an indication of tolerance to heat damage. The parent with good general combining ability (GCA) also exhibited good perse performance. This is true with respect to cherry, Currant, UC28B and Romavf for all characters under study. This suggested that combining ability of parent used in this study can be judge accurately by their perse performance. Similar results were reported by [11] in brinjal. Low gca was recorded for all characters under study except for percentage damaged fruits for the lines Golden Roma and RioGrandei indicating that their hybrids performed below average. The high positive general combining ability (GCA) for percentage damaged fruits indicated their high level of susceptibility to heat. Ajjappalavara and [12], noticed that the segregation of population to the inheritance of heat tolerance was 3 (tolerance): 1 (susceptible) ratio and suggested single gene inheritance for heat tolerance. [7,1] had also observed some tomato genotypes with good general combining ability in number of flower clusters, plant height at 60 days after transplanting and number of fruits per plant.

Specific combining ability effects for the eight hybrids, for the eight characters studied across locations are presented in Table 3 above: Four hybrids showed positive SCA effects for plant height, while others showed negative SCA effects. Among these hybrids Currant x UC28B showed the highest positive SCA effects for plant height and was followed by Currant x RioGrandei. Currant x Golden Roma recorded the highest positive SCA effects for weight of fruits per plant, while least positive SCA effect was shown by Currant x RioGrandei. In terms of number of leaves at 60 DAT, Currant x GoldenRoma recorded the highest SCA value while the lowest was shown by Currant x UC28B. Five hybrids exhibited positive SCA values for number of fruits per plant. Among these are Cherry x GoldenRoma which recorded the highest SCA value and the lowest was recorded by Currant x RioGrandei. Three hybrids exhibited significant positive SCA Values for number of flower cluster while four hybrids showed negative. Among the significant positive SCA values, Currant x GoldenRoma registered the highest values closely followed by Cherry x GoldenRoma and Cherry x UC28B, had the lowest. Four hybrids showed negative SCA values for % damage fruits. Among these, Cherry x RioGrandei recorded the highest negative value closely followed by Currant x Romavf while Currant x UC28B and Cherry x Golden Roma recorded the lowest negative SCA values for percentage damage fruits. Negative SCA values were shown by three hybrids for number of days to final harvest. Among these, Currant x Romavf exhibited the highest negative SCA values followed by Currant, UC28B and Cherry x RioGrandei had the lowest negative SCA values with respect to number of days to final harvest. Other hybrids recorded moderate positive SCA values with respect to this same character. Estimates of specific combining ability effects are usually used to identify the best hybrids. However, specific combining ability (SCA) effects are reported not to contribute much to the improvement of self-pollinated crops [7]. [7,13] stated that the crosses showing desirable specific combining ability could be utilized in breeding programs, such programs would be

more effective if one of the parents is a good combiner and the other one is poor combiner. In such a situation, they are expected to produce desirable transgressive segregates if the additive genetic system in the good combiner and complementary epistatic effect act in the same direction as to increase desirable genes of interest. The present study however revealed that the best hybrids in terms of SCA effects involved at least one of the high general combiners namely; currant, cherry, UC28B, and Romavf. However, poor general combiners such as GoldenRoma and RioGrandei gave good hybrids when they were crossed with high general combiners such as observed from cherry x GoldenRoma for number of fruit per plant, number of flower clusters and percentage damaged fruits respectively. Similar results on SCA obtaind by [14] on wheat population [8] on grain sorghum and [15] on malting sorghum showed that inter-crossing of such materials could generate a large gene pool which could break linked gene through mass selection. Crosses with good specific combining ability estimate were equally having parents with good mean performance in most cases, for one character or the other. Crosses such as currant x GoldenRoma and Cherry x GoldenRoma in terms of number of flower cluster and percentage damaged fruits

4. CONCLUSION

This study had widely evaluated and established important genetic information in tomato based on the existence of genetic variability among the tomato genotypes under consideration. Genotypes such as Cherry, Currant and Romavf and UC28B are genotypes that had registered high performance in all the characters under consideration. The testers, Cherry and Currant showed greater performance in terms of yield and heat tolerance are not commercially acceptable due to their small fruited sizes. However, lines such as UC28B and RomaVF are good commercially acceptable genotypes that farmers can depend on for commercial cultivation. Furthermore, segregates such as Cherry x UC28B, Currant x UC28B and Cherry x Romavf are identified as desirable direction for development of agronomically acceptable tomatoes through back crossing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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