Journal of Agricultural Economics, Environment and Social Sciences 1(1):40–45 September,2015

Department of Agricultural Economics, University of Maiduguri, Nigeria
Available on line: http://www.unimaid.edu.ng/jaeess
ISSN: 2476 – 8423

Combining Ability Estimates for Tomato (*Lycopersicon lycopersicum* (L.) H. Karst) Resistance to Nematode (*Meloidogyne* spp.) in the Sudan Savannah of Nigeria

[1*]Aminu, D. and [2]Mala, K. K.

[1]Department of Crop Production, Faculty of Agriculture, University of Maiduguri. PMB 1069, Maiduguri, Borno State, Nigeria
[2]Department of Cereal Research, Lake Chad Research Institute, PMB 1293, Km 5 Gamboru/Ngala Road Maiduguri, Borno State, Nigeria.

ABSTRACT
Nineteen entries consisting of seven parental lines plus twelve F_1 hybrids derived from a line x tester mating design were evaluated under irrigation in a randomized complete block design (RCBD) with three replications in two locations (Gashu'a and Maiduguri) during the dry season of 2013/2014. Evaluations were done to estimates the combining ability variance, general combining ability (GCA) effect of parents and specific combining ability (SCA) effect of hybrids. The estimates of variance components in all the combining ability analyses exhibited that the ratio of GCA to SCA variance indicated greater importance of non-additive genes action for the characters except plant height (cm) and number of flower drops per plant. The proportional contribution to total variance indicated that line x tester (SCA) interaction were higher than the line and tester in almost all the analyses. It is then apparent that the non-additive genetic effect was more important than the additive gene effect as most of the GCA: SCA ratios were less than unity. The study revealed the significant differences of general combining ability (GCA) effects of parents and that of specific combining ability (SCA) effects of the hybrids. The parent's Nematex, Atkinson,Rossol, Danbaga and Dansyria were identified as the best general combiners in terms of GCA for plant height per, number of leaves per plant, number of fruits drops per plant, weight of fruits per plant (g) and weight of fruits per plot (kg/ha). The hybrids Nematex x Ex-Gashu'a, Nematex x Roma VF, Atkinson x Ex-Gashu'a, Atkinson x Dansyria, Rossol x Dansyria and Rossol xRoma VF recorded the highest SCA effects for number of flower clusters per plant, number of fruits per plant, number of fruit drops per plant, weight of fruits per plant (g) and weight of fruits per plot (kg/ha). Therefore, Nematex x Ex-Gashu'a, Nematex x Roma VF, Rossol x Dansyria and Rossol x Roma VF were identified as the highest specific combiners for further improvement in breeding for nematode resistance tomato.

Key Words: Characters, Combining Ability, Nematode, Resistance, Tomato

INTRODUCTION

Tomato (*Lycopersicon lycopersicum* (L.) H. Karst) is one of the most popularly consumed vegetables globally. The popularity of the crop stems from its acceptable flavour, nutritive value, the short life cycle and high productivity (Adil *et al*., 2003). In Nigeria the major producing areas lie between latitudes 7.5^{o} 11$^{''}$ and 25 to 30^{o}c (Umeh *et al*., 2002). Global production estimate is put at approximately 130 million metric tonnes annually on 118.71 million hectares of land (FAO, 2010). In Nigeria, it is mostly cultivated in the semi-arid region during the cool dry season under irrigation. High temperature limits the production of tomato to the cooler period of the year (Rodriguez, 2007). The fruit is highly nutritious and contains high levels of lycopene a powerful antioxidant associated with lower risk of cancers, heart and age related diseases(Hanson, 2003).Tomato is mainly constrained by biotic and a biotic pests which limits its production. However, nematode (*Meloidogyne* spp.) pest causes high economic losses if not properly checked and treated at appropriate time through soil treatment and breeding for resistant varieties. Soil treatment using chemical control and soil amendments for the control of *Meloidogyne* have been found to be costly and ineffective due to its high mobility, wide host range and boring activities (Izge and Garba, 2012). The use of resistant

*Corresponding e-mail: dattiaminu@yahoo.com

varieties adapted to the environment is the most promising method of controlling the spread and damage causes by nematode. Nematodes have been recognized as one of the major pest of tomato throughout the world, particularly in the tropical and subtropical regions including Nigeria (Fawole, 1992; Sikora *et al*., 2003). Many different species of nematodes are known to cause damage on tomato, but the most destructive species are root-knot nematode belonging to the genus *Meloidogyne*. According to Amosu *et al*. (1993) infestation of tomato by *Meloidogyne* species accounts for about 40 – 60 percent in yield reduction in Western Nigeria. Despite effective and sustainable nematode management techniques through the use of nematicides, cultural practices, biological and physical techniques, high losses are still recorded from nematode pest. When available the use of nematode resistant germplasm is the best nematode management option for resource poor farmers (Usman, 2012). Thus, there is the need for developing nematode resistant and high yield tomato varieties to minimize yield loss due to nematodes pest.

Therefore, the study of combining ability in resistant varieties that have yield potential combined with adaptable farmer varieties cannot be over-emphasized. It is a guide for identifying the best combiners which may be hybridized to exploit heterosis. The objective of the research is to estimate the general combining ability effects of parents and specific combining ability effects of hybrids.

MATERIALS AND METHODS

Two sets of tomatoes were chosen for the experiment. The first set consisted of three improved varieties (resistant to *Meloidogyne* spp.) obtained from certified seed marketers in Maiduguri. The second sets consisted of four farmers cultivars that are susceptible to nematode (*Meloidogyne* spp.). The materials were predominantly grown by the farmers in Sudano Sahelian Zone of tomato producing areas.

Line x Tester mating design was used for the formation of the hybrids. Three tomato resistant's varieties were used as lines while four susceptible varieties were used as testers. The material comprised of seven parental lines and 12 hybrids which were evaluated in two locations (highly infested fields abandoned by tomato farmers), Gashu'a and Maiduguri during 2013/2014 dry season. The treatments were laid out in a randomized complete block design (RCBD), replicated three times in both locations. Each plot size was 2.5 x 2.5m with three rows 2.5m length of sunken beds of soil spaced 75 x 50cm intra-row spacing. There were 18 plants per plot in each replication. Cultural practices such as irrigation water was applied at every two days until harvest. All emerged weeds were removed as and when necessary using hand hoe. Fertilizer NPK (15:15:15 :) at the rate of 80kg/h was applied at two weeks after transplanting. Both locations were highly infested with nematodes and abandoned by tomato farmers. The evaluations were done in those fields to see the reactions of the genotypes. Data were collected on five randomly selected plants in respect to the following characters; plant height per plant, number of leaves per plant, number of flower cluster per plant, number of flower clusters drops per plant, number of fruits per plant, number of drop fruits per plant, weight of fruits per plant (g) and weight of fruits per plot (kg/ha).All data collected were subjected to analysis of variance (ANOVA) at 5% levels of significance and the differences among the means were separated using Duncan Multiple Range Test (DMRT) (Duncan (1955). The analysis was done according to the model suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of combining ability variance

Analysis of combining ability variances and variance components across a locations for eight agronomic traits in tomatoes are presented in Table 1. The results indicated that there was significant difference among the lines in their variances for number of fruits per plant (g) and weight of fruits per plot. Similarly, combining ability variance was found to be highly significant for most of the trait among testers and line x tester. The result showed that additive and non-additive gene action played an important role in the inheritance of these characters. The results are in line with the findings of Shahabuddin *et al*. (2009); Izge and Garba (2012). The results for the variance components estimates expressed highest value among the lines and testers for number of flowers dropped, number of fruits per plant, and number of fruits dropped, weight of fruits per plant and weight of fruits per plot. The estimate of variance components in all the combining ability analysis exhibited that the ratio of GCA to SCA variance indicated greater importance of non-additive gene action for such character mentioned.

Table 1: Analysis of combining ability variance and variances for eight characters in combined locations

Source of v Variation	DF	PHT	NLV	NFC	NFLD	NFP	NFD	WFPL(g)	WFP (kg/ha)
Line	2	27.12	16.73	14.13	0.98	4599.93**	9993.33**	6893.33**	3703.12**
Tester	3	0.87	8.61	13.89	1.64	1499.75**	99752.87**	2468.98**	6984.39**
Line xTester	6	32.91	23.72*	32.51*	1.46	8041.5**	4510.00**	2261.11	8860.24**
Error	28	22.52	7.88	6.90	0.76	1001.24	914.67	711.52	211.42
Variance Component Estimates									
Line		-0.76	0.57	1.32	6.60	2861.79	679.72	-476.84	429.70
Tester		-30.01	0.23	1.02	-1.52	463.37	473.15	418.52	74.94
δ^2 gca		-0.26	0.11	0.17	0.38	109.91	89.63	55.87	123.32
δ^2sca		-3.69	1.84	2.53	16.01	637.98	678.31	-805.15	799.04
δ^2gca/sca		0.071	0.06	0.067	0.024	0.11	0.132	0.067	0.15
Proportional contribution to total variance									
Line		22.40	17.27	11.81	14.84	11.51	9.21	10.21	9.10
Tester		20.00	-6.68	9.39	17.50	20.41	21.76	22.59	20.06
Line x Tester		57.60	76.05	78.80	67.66	68.08	69.03	67.20	70.84
GCA(Line + Tester)		42.40	23.95	21.20	32.34	31.92	30.97	32.80	29.16
GCA:SCA ratios		0.536	0.315	0.478	1.02	0.660	0.59	0.391	0.50

PHT: Plant height (cm), NLV: Number of leaves, NFC: Number of flowers clusters, NFLD: Number of flowers drops, NFP: Number of fruits/plant (g), NFD: Number of fruits drops, WFPL: Weight of fruits/plant (g), WFP: Weight of fruits/plot (kg/ha).

These results are in agreement with Singh *et al.* (2005) and Aminu *et al.* (2014). The proportional contribution to total variance indicated that line x tester (SCA) interaction were higher than the line and tester in all the analysis. It is then apparent that the non-additive genetic effect was more important than the additive gene effect as most of the GCA: SCA ratios were less than unity. These results showed that parental lines would be utilised in the development of tomato hybrids. This result is in line with that of Izge and Garba (2012) and Shahabuddin *et al.* (2009).

Estimates of general combining ability effects of parents

The estimates of general combining ability effects of parents for eight characters in combined locations are presented in Table 2. General combining ability implies capacity of a parent to produce superior progeny or otherwise when crossed with another parent (Izge *et al.,* 2007; Alabi *et al.,* 1987). The results indicated that Nematex expressed significant GCA effects for all the characters. Thus, it is the highest general combiner. Similarly, Atkinson exhibited positive GCA effects for most of the characters except number of flower clusters per plant, number of flower dropped per plant, weight of fruits per plant and weight of fruit per plot. These parents exhibited high significant nematode (*Meloidogyne* spp.) resistant traits. However, Rossol expressed negative significant GCA effects for number of flower dropped per plant and weight of fruits per plant.

Table 2: Estimate of general combining ability for parents for eight characters in tomato in combined locations

Parents	PHT	NLV	NFC	NFLD	NFP	NFD	WFPL(g)	WFP (kg/ha)
Nematex	-8.22**	-8.65**	8.17**	4.17*	-20.67**	-863.72**	1032.17**	910.18*
Atkinson	4.87*	5.87*	-2.75	0.33	14.33*	794.33**	298.23	-484.20
Rossol	3.35	2.76	-5.35	-4.50*	6.34	69.39	-1330.40**	-416.00
SE±	2.01	1.96	2.12	1.91	5.32	297.13	376.40	325.17
Ex-Gashua	9.33	-2.52	-1.45	4.98	5.12	943.37*	627.55*	887.36*
Dansyria	-9.07**	4.72**	3.73	2.48	-7.23	-797.86*	-572.55*	-833.68*
Danbaga	7.67*	2.62*	-4.13**	3.45	9.48*	-383.14	712.75*	621.51
Roma VF	7.63*	4.32**	1.83	-4.01	-7.40	237..63	-727.68*	-675.19
SE±	2.22	1.21	1.51	1.87	3.51	321.17	250.17	302.17

PHT: Plant height (cm), NLV: Number of leaves, NFC: Number of flowers clusters, NFLD: Number of flowers drops, NFP: Number of fruits/plant (g), NFD: Number of fruits drops, WFPL: Weight of fruits/plant (g), WFP: Weight of fruits/plot (kg/ha)

Therefore, Atkinson is the second highest general combiner line. Premalakshmi *et al.* (2006) and Izge and Garba 2012 reported similar results in their researches. The results among the testers also indicated that Danbaga expressed significant GCA effects for almost all the characters except number of flower dropped, number of fruits dropped and weight of fruits per plot (kg/ha). It is therefore the highest general combiner tester. Similarly, Dansyria expressed significant GCA effects for plant height, number of leaves, and number of fruit dropped per plant and weight of fruits per plot. It is the second highest general combiner tester. These parents could possibly possess a tolerant trait to nematode (Meloidogyne spp.) due continues used by the farmers in the infested areas. Similarly findings were reported by (Shahabuddin *et al.* 2009; Izge and Garba, 2012). The positive significant effect of GCA effects of parents for weight of fruits per plot was observed in Nematex and Ex-Gashua.

Estimates of specific combining ability effects of parents

The estimates of specific combining ability for eight characters in tomato in combined locations are presented in Table 3. The specific combining ability (SCA) effects were significant or highly significant in the twelve hybrids studied for different characters. The study revealed that hybrids with high SCA effects involved at least one or two of the several higher general combiners as parent namely Nematex, Atkinson, Rossol, Dansyria and Danbaga. The SCA effects revealed the role of non-additive gene action in the expression of a character. Furthermore, high SCA effects may arise not only in crosses involving high combiners but also in those involving low combiners (Izge and Garba, 2012).

Table 3: Estimate of specific combining ability (SCA) effect for the hybrids for eight characters in combined locations

Hybrids	PHT	NLV	NFC	NFD	NFP	NFD	WFPL(g)	WFP (kg/ha)
Nematex x Ex-Gashua	-0.50	2.03*	12.28**	-3.08	326.33*	183.83	215.88	826.18**
NematexxDansyria	-2.30	-1.30	15.15**	-10.22	214.00	-251.17	126.79	884.00**
Nematex x Danbaga	2.03*	0.70	-6.68	0.32	485.33*	-214.50	-140.97	-425.21*
Nematex x Roma VF	0.77	2.63*	-24.58**	12.98*	-436.00*	-649.50*	-101.20	-5.33
Atkinson x Ex-Gashua	1.75	2.80*	1.33	18.92*	644.17**	458.83*	136.49	321.94
Atkinson x Dansyria	1.62	-1.47	6.27	-5.55	608.168	-756.17**	388.61*	890.71**
Atkinson x Danbaga	-0.05	-0.47	-13.40	-7.35	82.83	46.17	162.36	516.78*
Atkinson x Roma VF	-3.32*	-0.87	20.00**	-6.02	-134.17	126.17	-697.46**	-796.32**
RoaaolxEx-Gashua	-0.17	0.05	7.33	-14.50	-245.33	-225.17	-225.33	2891.00**
Rossol x Dansyria	-0.97	1.78	11.60*	-26.70*	967.00**	180.17	1253.21**	1911.67**
Rossol x Danbaga	2.77*	2.55*	5.00	-18.23*	912.33**	-848.83**	1100.24**	783.33*
Rossol x Roma VF	1.00	0.72	-15.25**	1.00	-26.67	168.83	378.30*	466.67*
SE±	3.42	1.84	3.39	3.90	168.68	164.70	162.71	201.71

PHT: Plant height (cm), NLV: Number of leaves, NFC: Number of flowers clusters, NFD: Number of flowers drops, NFP: Number of fruits/plant (g), NFD: Number of fruits drops, WFPL: Weight of fruits/plant (g), WFP: Weight of fruits/plot (kg/ha)

The study also identified a number of desirable hybrids for some important characters such as number of flowers cluster per plant, number of flower dropped per plant, number of fruits per plant, weight of fruits per plant and weight of fruits per plot. Nematex x Ex-Gashua, Nematex x Dansyria, Atkinson x Dansyria, Rossol xDansyria and Rossol x Danbaga are higher specific combiners for those characters in combined locations. These are good hybrids when breeding for nematode resistance and fruits yield. However, Nematex x Dansyria, Atkinson x Danbaga and Rossol x Ex-Gashua performed very low especially in fruits yield even though their parent performed extremely well as GCA. Srivastava *et al.* (1978) and Kadams (2000) suggested that when parents with high and low GCA effects are crossed, the poor parents could throw up desirable trangressive segregants giving rise to a new population. Hybrid that expressed negative SCA values for plant height indicating that these hybrids matured early. Hybrid exhibiting positive SCA values for number of flower clusters per plant indicating that these hybrids could produce higher number of fruits and incidentally could have considerable levels of heterosis. Similar results were reported by Yashavaritakumar (2008) and Izge and Garba (2012). In the SCA results, three out of twelve hybrids showed negative significant SCA value for number of fruit dropped per plant. These indicate that the hybrids are resistant to nematode infestation. Hybrids Nematex x Ex-Gashua, Rossol x Danbaga and Rossol xDansyria were the best specific combiners for expressing negative significant value for number of flower dropped per plant and number of fruit dropped per plant. They also expressed positive significant value for number of fruit per plant, weight of fruit per plant and weight of fruit per plot. These hybrids could be further exploited in furthering tomato breeding resistant to nematode for high yield.

Conclusion

Both the additive and non-additive genes in the control of most of the characters in combined locations are very important. The parental lines: Nematex, Atkinson, Rossol, Danbaga and Dansyria were the highest general combiners for exhibiting significant GCA effects for almost all the characters. Thus, these parents could be used for the development of nematode resistant varieties since they were able give high yield in highly infested nematodes fields. The following hybrids were the highest specific combiners (SCA) for number of flower clusters, number of fruits per plant, weight of fruits per plant and weight of fruit per plot in combined locations. Nematex x Ex-Gashua, Atkinson x Dansyria, Rossol x Dansyria and Rossol x Danbaga, may be selected for further evaluation to ascertain their improvement for yield and resistance to nematodes in infested multi-locations.

REFERENCES

Adil, H. A., Gruda, N. and Geyer, B. (2003). Effect of high temperature and heat shock on tomato (*Lycopersiconesculentum* Mill) genotypes under controlled condition. Deutscher Tropentag 2003. Gootingen, October 2003. *Conference for International Agricultural ResearchforDevelopment*. 8-10.

Alabi, S. O., Obilana, A. B. and Nwasike, C. C. (1987). Gene action and combining ability for quantitative characters in upland cotton. *Samaru Journal ofAgriculturalResearch*.5:(1-2): 59-64.

Aminu, D., Garba, Y. M. and Muhammad, A. S. (2014). Combining andHeterosis for Phonologic and Agronomic traits in Maize (*Zea mays* L.), Under Drought Conditions in Northern Guinea Savanna of Borno State, Nigeria. *African Journal of Biotechnology*.3(24):2400 – 2406. http://www.academicjournals.org.AJB

Amosu, J. O., Babalola, J. O., Onwueme, F. (1993). Infection of Root-Knot Nematodes in Western Nigeria. *Journal of Science*. 3: 20-30.

Duncan, O. B. (1955). Multiple Ranges and Multiple F-Test. *Biometrics*, 11: 1-42.

F.A.O. (2010). Statistical Division, *http//faostat. Fao.org*. pp16-21.

Fawole, B. (1992). An Overview of Nematode Problems in Africa. *Proceeding of the regional Symposium on the biology and Control of Nematode Pest of Food Crops in Africa.*University of Ibadan, Ibadan Nigeria. 26-29 July, 1992, 3-8.

Hanson, P. (2003). Heat Tolerant Tomato Lines. AVRDC *Annual Report*. Pp65-70.

Izge, A.U., Kadams,A.M. and Gungula, D.T.(2007). Heterosis and Inheritance of Quantitative Characters in diallelCross of Pearl Millet (*Pennisetumglaucam* L.). *JournalofAgronomy*. 6 2: 278-285.

Izge, A.U. and Garba, Y. M. (2012). Combining Ability for Fruit Worm Resistance in some commercially grown tomatoes in parts of North Eastern Nigeria. *International Journal of Agricultural Sciences.* 2(8): 240-244.

Kempthorne, O. (1957). *An introduction to genetic statistics*. John Wiley. Esonsiinc. New York. pp. 232.

Kadams, A. M. (2000). Combining Ability Analysis and Heterosis in Hexaploid Line of *Triticale* (*Triticoscalewittmock). Journal of Arid Agriculture*.10**:**1-8.

Premalakshmi, V. Thyagaraj, T. Veeraragavathatham, D. and Arumugam, T. (2006). Heterosis and combining ability analysis in tomato (*Solanumlycopersicom*(Mill.) Wettsd.) Foryield and yield contributing traits. Publishers, New Delhi, India. 303pp.

Rodriguez, G. R. (2007). Efffect of rice bran mulching on growth and yield of cherry tomato. *Science Innovation of Agriculture*.www.rcia. Puc.cl. 34(3): 181-186.

Shahabuddin, A. Quamruzzaman, A. K. M. and Nazim, U. M. (2009). Combining ability estimate of tomato (*Solanumlycopersicum*) in late summer SAARC *Journal of Agriculture*. 7(1): 43-56.

Sikora, A. R. Niere, B. and Kimenju, J. (2003). Endophytic Microbial Biodiversity and Plant Nematodes Management in African Agriculture In: CAB *International Biological Controlin Intergrated Pest Management (IPM) System in Africa*. 179-192.

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

Srivastava, R. L., Ahmad, Z., Singh, H. G. and Saxena, J. K. (1978). Combining ability for yield and related attributes in soyabean. *Indian Journal of Agricultural Sciences.48:148-155.*

Usman, A. (2012). Effect of Neem Fruit Powder on Plant Parasitic Nematodes found in Irrigated Tomato (*Lycopersiconlycopersicum*(L) Karst) in Alau, Borno State Nigeria. Unpublished M.Sc. Thesis. Department of Crop Science, Faculty of Agriculture, University of Maiduguri. Pp2.

Umeh, V. C., Kuku, F. O., Nwangguma, E. I., Adebayo, O. S. And Manga, A. A. (2002). A survey of the insect pests and farmers practices in the cropping of tomato in Nigeria. *Tropiculture*, (2002), 20:181-186.

Yashavantakumar, K. H. (2008). Heterosis and combining ability for resistance against topovirus in tomato (*Solanumlycopersicom*(Mill.) Wettsd.). *M.Sc. (Agriculture) Thesis*, University of Agricultural Science, Dharward.123pp.