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# HETEROTIC EFFECT OF TOMATO (*Lycopersicon lycopersicum* (L.) H. Karst) VARIETIES SUSCEPTIBLE TO ROOT-KNOT NEMATODE (*MELOIDOGYNE* SPP) IN SUDAN SAVANNA ZONE OF NIGERIA

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## ABSTRACT

Fifteen entries consisting of six parents and eight crosses derived from a line x tester mating design were evaluated in three replications in a randomized complete block design (RCBD) in two locations (Teaching and Research Farm Faculty of Agriculture and Lake Chad Research Institute) Maiduguri, Borno State during 2016/2017 dry season under irrigation. The research was done to estimate the heterotic effect of tomato varieties susceptible to root-knot nematode (*Meloidogyne* spp). It was observed that great potential for increased production of tomato with resistance to nematode infestation exist in this population. All the crosses exhibited significant heterosis in majority of the traits. These crosses showed lowest degree of superiority over their parents in terms of heterosis. The cross Lindo x Dan-Kano and Lindo x Dan-Gombe showed highest significant negative heterosis for number of fruits per plant. There was high significant negative heterosis for the cross Lindo x Dan-Gombe for the characters of weight of fruit per plant and weight of fruit per plot, respectively despite root knot nematode infestation. For nematode initial population (Pi), the parent Dan-Kano (16.21) recorded the highest value. The lowest values were recorded for the cross Tandino x Lindo, Dan-Chadi x Cobra and Tandino x Cobra. However, for the final population (Pf), the parent Dan-Gombe (39.83) had the highest value. The parent Dan-Gombe (2.73) recorded the highest reproductive factor, where lowest reproductive factor was recorded for the parent Cobra (1.69). This desirable segregates should be used for development of acceptable tomato varieties to ascertain their improvement for yield and resistance to nematodes in infested locations. Furthermore, the segregates could also be used in developing tomato varieties that have high heterotic values with less or no galls in the root system of tomatoes.

**Key Words:** Tomato, Heterosis, Nematode, Resistance

## INTRODUCTION

Tomato (*Lycopersicon lycopersicum* (L.) H. Karst.) is originated from the tropics of Central and South America. It is now among the most important vegetables in these areas (Plant Resources of Tropical Africa, 2004). It is a tropical day neutral plant and is a self-pollinating crop but certain amount of cross pollination may take place. 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 available local variety in production has low fruit yield, with poor quality fruits, short shelf life due to very high water content of the fruits and high susceptibility to insect pests and diseases. Tomato serves as an important source of nutrient for human in many parts of the world. The edible fruits are eaten raw in salads and in juices, cooked with meat, and other vegetables, sun dried and preserved for use during off season. It is an important source of β-carotene and ascorbic acid, which is source of vitamins and antioxidants (Hanson, 2003). Tomato is also a rich source of antioxidants as well as vitamins A, and C and the minerals Ca, P and Fe in diets (Saleem *et al*., 2013). Tomato production is limited by economic, edaphic and biological factors. Tomato is largely produced by subsistence farmers in Nigeria who mostly lack the financial resources for proper management such as land development, seed procurement and pests and disease control. Apart from rainfall, tomato production is hampered by temperature and relative humidity (Lange and Bronson, 1981). These made tomato production limited to the cool harmattan period and which coincides with the dry season in Nigeria. Production in the wet season apart from the high relative humidity, also results in high incidences of pests and diseases (Lange and Bronson, 1981; Gwary and Nahunnaro, 2003). Root-knot nematode (*Meloidogyne* spp) recognized as a major pest of tomato in the world there by causing high economic losses if not properly checked and treated at appropriate time through soil treatment and breeding for resistant varieties. Chemical and cultural control strategies are the most widely adopted. Some of the cultural practices are normally carried out by farmers for several reasons. Practices such as crop rotation, fallow, soil polarization, trap cropping,

flooding, host plant resistance and tolerance, natural pesticides, and healthy propagation materials have been used especially by African farmers. However, despite all these, nematodes still pose a serious threat to crop productivity (Misari, 1992). Nematicides historically have been highly effective and reliable in controlling a wide range of nematode species and have been the favored economic management option. However, the high cost and hazards associated with their application is limiting their use. The use of resistant varieties adapted to the environment is the most promising method of controlling the spread and damage caused by root-knot nematode. Heterosis has been commercially exploited in the form of hybrid or synthetic varieties in large number of sexually propagated crops. However, utilization necessitates the production of sufficient quantity of $F_1$ progeny to be grown on a field scale. The objective of the study was to determine the heterotic effect of tomato varieties selected for nematode resistance.

## MATERIALS AND METHODS

The research involves four commercially cultivated susceptible tomato cultivars (Dan-Chadi, Dan-Kano, Dan-Gombe, Tandino) predominantly grown by the farmers in the experiment area and two resistant varieties (Lindo and Cobra).

### Design and Treatment Combinations

Line x tester mating design was used for the formation of the hybrids. Four susceptible varieties were used as lines and two resistant varieties were used as testers. Hence, the material consisted of six parental lines and eight hybrids which were evaluated in two locations; Teaching and Research Farm, Faculty of Agriculture, University of Maiduguri (latitude $11^0$ 80`N, and longitude $13^0$ 19`E) and at Lake Chad Research Institute (LCRI), Maiduguri (latitude $11^0$ 86`N, and longitude $13^0$ 22`E), during 2016/2017 dry season under irrigation. Crosses were made between the four commercially cultivated root-knot susceptible cultivars (the lines) and the two non-commercially cultivated root knot resistant cultivars (the testers) which generate eight crosses.

### Crossing Procedure

The crosses were obtained using the procedure of Comstock and Robinson mating design as described by Singh and Chaudhary (1985) where each male in a set of two was made to mate with four sets of females, thus, making a total of eight crosses. These crosses were obtained by emasculating the flowers of the females (lines) to remove the anther for each cross in the evening. Emasculation involved selecting a flower of the female that was just about to turn yellow, where subsequent flowering was detached. The anther cone was carefully removed making sure the stigma and style do not break. The pedicel, the sepals, and the pistillate parts were left intact. Tomatoes were ready for pollination one day before anthesis or flower opening. At this stage, sepals begin to separate; anthers and corona begin to change from light green to dark yellow. Pollens were collected from male flowers (testers) very early in the morning and used to pollinate the females (lines) in the evening. Mature anther cones were removed from partially opened flowers into paper envelops. Anther cones were then allowed to dry by opening the envelopes to the sun. Drying allow the pollens to be released. Envelopes were shaken vigorously to release the pollens. The stigma was ready for pollination 24 hours after the emasculation. Pollens were collected on to the stigma to ensure good seed set. Each cross was labeled appropriately using white strings tied to the petioles. Usually improperly pollinated flowers abort and fall down from the plant. Properly pollinated flowers formed fruits which grow to maturity. Ripped mature fruits were collected crushed, fermented for three days and seeds were washed out clean. Seeds were stored in marked brown envelopes.

### Nematode Sample Collection

Two sets of data were collected in two parameters for the identification and determination of nematode (initial population from soil samples and final population in the root system of tomato). Initial population levels of nematodes were determined by taking three core samples with a Core sampler (soil Auger) of 250 $cm^3$ to a depth of 20 cm in a zig-zag pattern from each experimental plot, bulked, labelled and transported to the laboratory for extraction of nematodes.

### Extraction of Nematode

Bulked soil samples for each plot were thoroughly mixed and a 250 g sub-sample was taken for extraction of nematodes using Whitehead and Hemming (1965) tray method which consists of a double ply tissue paper sandwich between two plastic sieves placed in a plastic bowl with some water in it. The sub-samples of 250 g were thinly spread on topmost sieve and additional water was added gently into the tray until the soil become just moist to enable the nematodes to swim through the tissue paper from the soil into the water within the tray. The whole set up was left for 24 hours for the nematodes to migrate into the water within the tray. After 24 hours, the nematode suspension was poured into a 500 ml beaker for 4 hours so that the nematode will settle at the bottom of the beaker. The nematode suspension was gently drained out by tilting the beaker, leaving about 20 ml of nematode suspension.

The suspension was poured into labeled sample bottles for storage, preservation and immediate determination of nematode genera.

**Identification of Nematodes**

This was done by pouring the nematode suspension into a Doncaster (1962) counting dish for counting under the stereo-microscope where nematodes were observed, identified and counted according to their genera. After nematodes were identified, they were confirmed under the compound microscope by picking them from the counting dish into slides which was placed under 10x magnification of a compound microscope. Identification of the different nematode genera was done using nematode identification keys of Dropkin (1980). The first nematode count was the Pi (initial population) and it was prior to planting or transplanting after soil sample was collected at the field of study. The second counting which was not done for this study is the Pm (mid-season population), these will be before flowering of tomatoes two months after sowing. While the third count which is called the Pf (final population) was at harvest. However, to determine the final plant population and stands with root galls, five randomly surviving plants after harvest in each plot were selected and carefully uprooted, the roots were observed and the number of galls was counted. The treatments were laid out in a randomized complete block design (RCBD), replicated three times in both locations. The net plot size for the evaluation was 25 m x 12 m and each sub plot was 4 $m^2$ of sunken beds of soil spaced at 60 cm x 60 cm for both inter and intra-row. All cultural practices in relation to tomato production were carried out.

**Data Collection**

Data were collected on five randomly selected plants in respect of the following characters: plant height, number of leaves, leaf area per plant, number of flower clusters per plant, number of aborted flowers per plant, number of fruit dropped per plant, number of fruits per plant, weight of fruits per plant and weight of fruits per plot.

**Statistical Analysis**

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's Multiple Range Test (DMRT) (Duncan, 1955). The analysis was done according to the model suggested by Kempthorne (1967).

## RESULTS AND DISCUSSION

**Heterosis**

Significant efforts have been made for exploitation of heterosis in different yield contributing traits to find the feasible cross for the production of $F_1$ hybrids. The hybrids showing high heterosis have good chances to identify desirable lines in succeeding generations as compared to hybrids having low heterotic effects. It was observed from the study that great potential for increased production of tomato with resistance to nematode infestation exist in this population. All the crosses exhibited significant heterosis in majority of the traits indicating a predominance of non-additive gene action in the genetic control of these traits. Yadav *et al*. (2013) found similar result where he observed significant positive heterosis over mid and better parent for shelf life of tomato. These crosses showed lowest degree of superiority over their parents in terms of heterosis. Choudhary *et al*., (1965) emphasized the extensive utilization of heterosis to step up tomato production. The cross Lindo x Dan-Kano and Lindo x Dan-Gombe showed highest significant negative heterosis for number of fruits per plant followed by Cobra x Tandino. There was high significant negative heterosis for the cross Lindo x Dan-Gombe for the characters of weight of fruit per plant and weight of fruit per plot, respectively despite root knot nematode infestation. This confirms the findings of Kulkarni (2003) which states that significant positive heterosis over better parent was observed where six cross combinations exhibited positive significant heterosis over mid parent. The result further states that crossing of two different strains will usually show more vigorous hybrid offspring's than either of the parent strains considered separately. Heterosis is usually expressed in the form of increased yield which in turn is dependent on the contribution of many component characters for both mid and better parents. Kumari and Sharma (2011) also stated similar result where positive significant heterosis over mid and better parent were observed in three cross combinations of their study.

**Mean Performance and Reproductive Factor of Nematode Population Count**

The mean performance and reproductive factor of parent and crosses of tomato varieties on nematode count in combined locations are presented in Table 2. For initial population (Pi), the parent Dan-Kano (16.21) recorded the highest value followed by the cross Dan-Gombe x Cobra (15.05). The lowest values were recorded for the cross Tandino x Lindo, Dan-Chadi x Cobra and Tandino x Cobra. However, for the final population (Pf), the parent Dan-

Gombe (39.83) had the highest value followed by the parent Dan-Chadi (38.44) and Dan-Kano (37.16). The parent Dan-Gombe (2.73) recorded the highest reproductive factor followed by the parent Dan-Chadi (2.58) and the cross Tandino x Cobra (2.53). The lowest reproductive factor was recorded for the parent Cobra (1.69), this is indicating their ability to resist nematode infestation with minimal reproductive factor. These are in line with the findings of El-Sherif *et al*., (2007) who stated that infestation with minimal reproductive factor was due to the reduced amount of food available per nematode at higher nematode densities and the greater competition for food and space in the roots. These also confirms with the findings of Pogrebnova (1982) who found tomato varieties to be highly resistant against *M. acrita* and *M. javanica*.

**Genotypic and Phenotypic Correlation**

The genotypic and phenotypic correlations for yield and yield components combined across locations are presented in Table 3. The results showed that the magnitude of rg > rp in all the cases. The results of the correlation showed significant positive genotypic correlation between plant height, with number of leaves, leaf area, numbers of flower clusters per plant, number of fruits per plant, weight of fruits per plant and weight of fruits per plot. Number of fruits per plant showed significant positive genotypic correlation with weight of fruits per plant and weight of fruits per plot. Similarly, weight of fruits per plant showed significant positive genotypic correlation with weight of fruits per plot. The phenotypic correlation estimates showed significant positive phenotypic correlation between leaf area with plant height. Number of fruits per plant showed significant positive phenotypic correlation with plant height, leaf area and number of flower clusters per plant. Weight of fruit per plant showed significant positive phenotypic correlation with plant height, leaf area, number of flower clusters per plant and number of fruits per plant. Similarly, weight of fruit per plot showed significant positive phenotypic correlation with plant height, leaf area, and number of flower clusters per plant, number of fruits per plant and weight of fruits per plant. In general, the magnitude of genotypic correlation coefficient was higher than the corresponding phenotypic coefficient indicating thereby a strong inherent association between various traits of the study. The phenotypic correlation coefficient for all the characters, plant height exhibited high positive correlation with number of leaves, leaf area, number of flower clusters per plant, number of fruits per plant, weight of fruits per plant and weight of fruits per plot. This suggests that fruit yield can be increased whenever there is an increase in characters that showed positive and significant association with yield per plant. The correlation of yield with most of the quality traits indicated that simultaneous improvement of yield and quality traits was not possible because of the negative correlation of yield with such quality traits. These are similar with the findings of Rani (2010) who reported that correlation coefficient among different characters indicated that yield per plant was significantly and positively associated with number of fruits per plant at the phenotypic and genotypic levels, where number of fruits per plant was significantly and positively correlated with number of fruits per cluster. All the shift in the traits need not, however, is expressed by changes in yield. This could be due to varying levels of positive or negative correlations between yield and its components themselves. Similar result was found by Indu-Rani *et at.*, (2008), this explains the fact that improvement in a particular trait could result into the improvement of all the positively related traits. There were more significant genotypic correlations for pairs of characters than the phenotypic correlation estimates observed for this study.

**CONCLUSION AND RECOMMENDATION**

Appreciable levels of heterosis were observed for most of the characters studied. All the crosses exhibited significant negative better parent heterosis in plant height, where the crosses Cobra x Tandino showed the highest positive heterosis for number of leaves. However, the crosses Lindo x Dan-Kano and Lindo x Dan-Gombe showed the highest significant negative heterosis for weight of fruits per plant and weight of fruits per plot, respectively. Correlation effect showed significant genotypic correlations for pairs of characters than phenotypic correlation estimates. Dan-Gombe observed the highest reproductive factor. Lindo and Cobra observed the lowest gall number showing its resistance to root-knot nematode However, the crosses Lindo x Dan-Chadi, Lindo x Dan-Kano, Lindo x Tandino, Cobra x Dan-Gombe and Cobra x Dan-Chadi are desirable segregates to be used for development of acceptable tomato varieties to ascertain their improvement for yield and resistance to nematodes in infested locations. Furthermore, the segregates could also be used in developing tomato varieties that have high heterotic values with less or no galls in the root system of tomatoes.

**Table 1 Estimates of Heterosis (%) over Higher Parent of Tomato Varieties Resistance to Nematode for Nine Agronomic Characters in Combined Locations**

| Hybrids | PLHT | NLVS | LAREA ($cm^2$) | NFCL | NABFL | NFPLNT | NDFPLNT | WFPLNT (g) | WFPLOT (ha) |
|---|---|---|---|---|---|---|---|---|---|
| DAN-CHADI x LINDO | -7.29* | -0.39 | -11.05** | -7.73 | 2.02 | -8.95** | -16.67 | -5.72* | -5.74* |
| DAN-KANO x LINDO | -11.64** | -0.67 | -10.68** | -10.98* | -0.70 | -14.15** | -13.33 | -9.05** | -11.79** |
| DAN-GOMBE x LINDO | -11.16** | -1.08 | -8.92** | -25.27** | -9.05* | -14.15** | -30.00* | -17.01** | -17.07** |
| TANDINO x LINDO | -3.75 | 2.21 | -12.27** | -10.33* | 2.02 | -8.58** | -13.33 | -9.55** | -12.57** |
| DAN-CHADI x COBRA | -13.73** | -0.70 | -5.99* | -13.32* | -9.81* | -8.53** | 0.00 | -13.89** | -13.90** |
| DAN-KANO x COBRA | -6.21 | -0.46 | -6.05* | -10.13** | -1.14 | -12.46** | -7.69 | -12.64** | -12.63** |
| DAN-GOMBE x COBRA | -5.35 | -1.07 | -5.34* | -17.78** | -10.17* | -7.10** | -17.85 | -3.34 | -3.36 |
| TANDINO x COBRA | -16.75** | 2.69 | -11.37** | -15.23* | -8.44* | -13.00** | -20.00 | -12.23** | -12.22** |
| **SE±** | 0.44 | 0.52 | 0.98 | 1.98 | 1.92 | 1.01 | 3.11 | 1.57 | 1.57 |

* = P≤0.05 and ** = P≤0.01 Levels of probability

**Key:** PLHT= plant height, NLVS= number of leaves, LAREA= leaf area ($cm^2$), NFCL= number of flower clusters, NABFL= number of aborted flowers, NFPLNT= number of fruits per plant, NDFPLNT= number of dropped fruits per plant, WFPLNT= weight of fruits per plant (g), WFPLOT= weight of fruits per plot (ha).

**Table 2: Mean Performance and Reproductive factor of Parent and Crosses of Tomato Varieties on Nematode Count in Combined Locations**

| Entries | Means of Pi | Means of Pf | RF (Pf/Pi) |
|---|---|---|---|
| LINDO | 14.60 | 27.42 | 1.87 |
| COBRA | 14.60 | 24.69 | 1.69 |
| DAN-CHADI | 14.88 | 38.44 | 2.58 |
| DAN-KANO | 16.21 | 37.16 | 2.29 |
| DAN-GOMBE | 14.55 | 39.83 | 2.73 |
| TANDINO | 14.94 | 31.41 | 2.10 |
| DAN-CHADI x LINDO | 14.33 | 28.24 | 1.97 |
| DAN-KANO x LINDO | 14.44 | 30.19 | 2.09 |
| DAN-GOMBE x LINDO | 14.77 | 29.82 | 2.02 |
| TANDINO x LINDO | 13.88 | 28.37 | 2.04 |
| DAN-CHADI x COBRA | 13.66 | 29.64 | 2.17 |
| DAN-KANO x COBRA | 14.94 | 33.35 | 2.23 |
| DAN-GOMBE x COBRA | 15.05 | 31.73 | 2.12 |
| TANDINO x COBRA | 13.77 | 34.81 | 2.53 |
| CHECK | 14.33 | 32.44 | 2.26 |
| **SE±** | **0.16** | **1.10** | **0.07** |

**Key:** **PI**= initial population, **PF**= final population, **Rf** = reproductive factor

**Table 3 Genotypic (above diagonal) and Phenotypic (below diagonal) Correlation Coefficient Analysis of Nine Agronomic Characters of Tomato in Combined Locations**

| Characters | PLHT | NLVS | LAREA | NFCL | NABFL | NFPLNT | NDFPLNT | WFPLNT | WFPLT |
|---|---|---|---|---|---|---|---|---|---|
| PLHT | | 0.57* | 0.82* | 1.00* | -0.20 | 0.77* | -0.54* | 0.89* | 0.91* |
| NLVS | 0.40 | | 0.75* | 1.00* | 0.54* | 0.46 | -0.81* | 0.64* | 0.70* |
| LAREA | 0.72* | 0.44 | | 1.00* | 0.36 | 0.84* | -0.00 | 0.93* | 0.88* |
| NFCL | 0.08 | 0.61* | 0.78* | | 0.09 | 0.96* | -0.17 | 1.00* | 1.00* |
| NABFL | -0.18 | 0.35 | 0.26 | 0.07 | | 0.01 | 0.61* | 0.10 | 0.11 |
| NFPLNT | 0.69* | 0.35 | 0.77* | 0.77* | -0.02 | | -0.29 | 0.90* | 0.85* |
| NDFPLNT | -0.24 | -0.26 | -0.01 | -0.10 | 0.37 | -0.16 | | -0.15 | -0.04 |
| WFPLNT | 0.81* | 0.47 | 0.81* | 0.85* | 0.11 | 0.80* | -0.05 | | 1.00* |
| WFPLOT | 0.79* | 0.45 | 0.82* | 0.84* | 0.08 | 0.83* | -0.10 | 0.98* | |

* = P<0.05 and ** = P<0.01 Level of probability

**Key:** PLHT= plant height, NLVS= number of leaves, LAREA= leaf area, NFCL= number of flower cluster, NABFL= number of aborted flowers, NFPLNT= number of fruits per plant, NDFPLNT= number of dropped fruits per plant, WFPLNT= weight of fruits per plant, WFPLT= weight of fruits per plot.

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