African Scientist Vol. 23, No. 3 September 30, 2022
Printed in Nigeria

1595-6881/2022 $10.00 + 0.00
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http://www.niseb.org/afs

AFS2022020/23302

Correlation of Fruit Yield with Lycopene Production in Tomato Genotypes from Igbodo, Nigeria

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(Received June 26, 2022; Accepted in revised form June 30, 2022)

ABSTRACT: Tomato as vegetable and regarded as protective food is a very significant food crop globally. In this study, lycopene present in tomato and known for its anti-oxidative ability was correlated with fruit yield. Three varieties of tomato were selected and their growth rates were compared by measuring the length (cm) of stem from the day of transplanting till maturity (at flowering), on weekly basis. The three tomato varieties identified as Igb1/9/21, Igb2/9/21 and Igb3/9/21 were not significantly different in their growth. However there were significant differences in their fruit yield (fruit weight in gram) and lycopene content. When the two traits (fruit yield and lycopene content) were correlated, interestingly, they were negatively correlated. This shows that as fruit yield of tomato increased the lycopene content decreased. This result was highlighted to be useful in breeding programme and implication discussed.

Keywords: Tomato, Lycopene, Traits, Fruit yield, Correlation

Introduction

Tomato (*Solanum lycopersicum* Mill.) belonging to the family of Solanaceae is a vegetable that is consumed worldwide and has a multipurpose uses in fresh as well as in processed food industries. It is rich in Vitamin A and C, carotenoids (β-carotene, lycopene) and as well as other essential minerals (Mahapatra *et al.*, 2013). Tomato is one of the world major traded vegetables. It is considered a protective food as it possesses several special nutritive traits, particularly antioxidant compounds which are being used in several commercial therapeutic formulations (Ratnam *et al*., 2006). The major fruit quality of interest of both market and industrial tomato includes yield, organoleptic and nutritional qualities. According to Rao and Agarwal, (1998), regular consumption of fresh tomato or tomato products can reduce the widespread of human diseases when taken daily in adequate amount. Besides carotenoids (β-carotene and lycopene), other antioxidants present in tomato that play important role in preventing diseases are phenolic compounds and ascorbic acids.

Over the years, crop improvement programs in tomato have concentrated on the agronomic and organoleptic traits. However, the nutritional importance of tomato has stimulated a lot of interest in formulating breeding programs for developing tomato cultivar rich in nutritional processing with high yielding and quality fruits. Generally, the breeding programs in tomato have gone through the following phases; breeding for yield in the 1970s, for shelf life in the 1980s, for taste in the 1990s and currently for nutritional quality (Bia and Lindhout, 2007).

Bioactive compounds play important role in inhibiting reactive oxygen species responsible for many diseases (Clinton, 1998). The protective effect of such bioactive compounds has been mainly attributed to the carotenoid constituents of the fruit particularly lycopene and β-carotene (Sies and Stahl, 1998). Hence, any program that could aid increase in the content of lycopene and β-carotenoid in tomato would be highly rewarding. Maximizing the level of these bioactive compounds in tomato fruits therefore, is now one of the major goals of tomato breeders. (Atanassova *et al*., 2007; Dorais *et al*., 2008). The starting point in this breeding program

involves the correlation of these bioactive substances with the various components of yield (Anjum *et a*l., 2020; Bali *et al*., 2021).

In some of the researches that have been carried out in line with this objective, reports show that the lycopene content in tomato have positive correlation with the following agronomic traits that fall within yield index; plant height, number of leaves, number of fruits per bunch, fruit length and fruit diameter (Muh *et al*., 2020). However, following the work according to Anuradha *et al*., (2018), fruit yield per plant exhibited high significant positive correlations with average fruit weight, beta carotene and lycopene. Since yield is a complex character, the question here is; if fruit weight as a part of yield component correlates with lycopene.

However, it has been reported that the selection for higher lycopene content in tomato may at the same time reduce the level of other antioxidants such as β-carotene (Sacks and Francis, 2001), resulted to low fruit size and productivity (Atanassova *et al*., 2007). In order to verify this claim, here in this work we decided to correlate the fruit weight (as yield component) of tomato with lycopene content in tomato from Igbodo region, Delta State Nigeria.

Materials and methods

The experimental materials for this work were based on three varieties of tomato obtained from Igbodo farm settlement in Delta State, Nigeria. The tomato varieties were seeded out on nursery beds and thereafter (four weeks), the seedlings were transplanted in three replicates for their evaluation. Ten plants per variety were transplanted in three replicates (30 tomato stands per variety) into pots containing same soil that have been previously labeled. The normal cultural practices were fully observed all through the period of cultivation (Bali *et al.,* 2021).

Evaluation of fruit yield per plant: Fruit yield per plant were measured as the weight of fruit per plant in three replicates. All the fruits were collected separately and weighed. The fruit yield was expressed in g/plant. The replicated data on yield per plant was subjected to statistical analysis (GenStat, 2003).

Comparative growth rate of tomato varieties: The comparative growth rate between the three varieties of tomato used was recorded each week from the time of transplant. The growth of the tomato varieties were measured in centimeter (cm) for 8weeks. The growth measurement was stopped at the time of first flowering (Heuvelink, 1995).

Estimation of lycopene content per plant: The lycopene content per fruit of tomato was analyzed spectrophotometrically at a wavelength of 503 nm. The lycopene contents of the tomato fruits were extracted using a mixed solvent of hexane, ethanol and acetone in 2:1:1 ratio as described by Ibitoye *et al.* (2009). Readings were taken for each variety representing fruits of different harvests. The lycopene values were expressed in mg/g of tomato fruit (Eboigbe and Edemevughe, 2018)

Statistical analysis: Correlation analysis was carried out using GenStat analytical package 12th Edition. The correlation value was measured between -1.0 and +1. Student t-test was used to confirm the significance of the correlation coefficient at $P>0.05$.

Results and Discussion

After the preliminary evaluation of the three tomato varieties from Igbodo, the decision to check the correlation of the lycopene content produced with the fruit yield in each variety was highlighted. The growth rate of the three varieties did not show any significant difference (Fig. 1). This made them the right candidates for the correlation of the fruit yield with the lycopene content produced from the three tomato varieties. The objective of the correlation was to check if lycopene trait has relationship with the yield of the fruit in tomato (Anuradha *et al*., 2018). Lycopene is one of the major characters controlling the fruit color (Bali *et al*., 2021). Since this affect the quality of the tomato fruit, we thus hypothesized; lycopene may be linked with the fruit yield. The range of lycopene content observed in this work was 0.001 to 3.09 mg/g fruit weight among the three varieties.

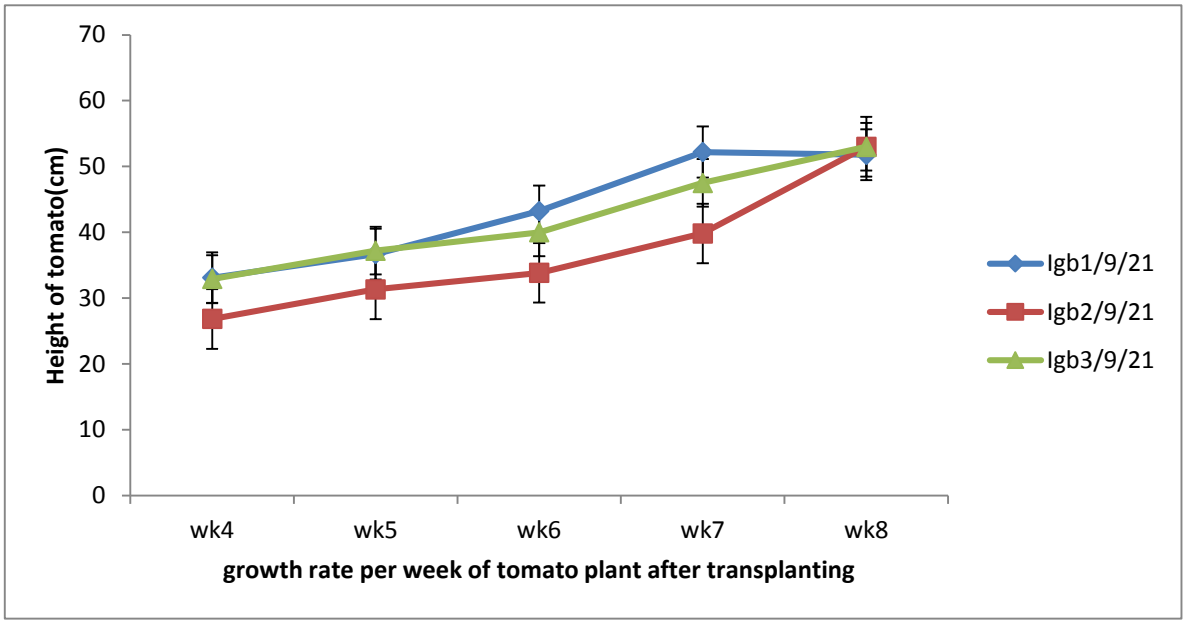

Fig. 1: The growth rate of three tomato genotypes from Igbodo, Delta State, Nigeria. Igb3/9/21 and Igb2/9/21 appeared to have continuous growth (indeterminate). However there is no significant difference in their growth rate

The highest value was observed in Igb3/9/21, while the lowest was observed in Igb1/9/21 genotype (Table1-3). Among the tomato varieties there were significant differences for lycopene content. When the lycopene content in the Igbodo tomato was compared with that previously reported from a breeding program, Igbodo tomato appears to have low lycopene content (Muh *et al*., 2020).

Table1: Lycocopene content of tomato genotypes and fruit weight (FW). Genotype: Igb1/09/21

Fruit weight(g)	Lycopene Content (mg/g)
37.59±0.30	0.001±0.0008
28.4 ±0.13	0.78±0.01
19.45±0.13	0.21±0.01
16.67±0.26	0.41±0.01
15.21±0.24	0.96±0.01
12.64±0.20	1.15±0.01
11.3±0.14	0.17±0.01
10.2±0.10	2.11±0.01
6.89±0.28	0.01±0.01
6.84±0.29	2.52±0.01

Table2: Lycocopene content of tomato genotypes and fruit weight (FW). Genotype: Igb2/09/21

Fruit weight(g)	Lycopene Content (mg/g)
28.00±0.14	0.6±0.01
25.4±0.12	0.74±0.01
24.07±0.03	0.48±0.01
23.92±0.29	0.41±0.01
15.06±0.02	0.41±0.01
14.84±0.27	0.34±0.01
14.32±0.11	0.24±0.11
13.51±0.16	1.16±0.01
11.06±0.05	0.21±0.01
10.87±0.22	1.59±0.01

Here it is clear that, crop breeding that enhances higher lycopene has not been practiced in this Igbodo farm settlement. Moreover, the peasant farmers in this settlement may not be aware of this fact. However, the tomato varieties collected from Igbodo have good prospect as breeding materials and they contain determinate and indeterminate growth habit (Sharma *et al*., 2019). Cultivar for processing purposes is determinate growing while the fresh market cultivars are indeterminate (Fentik, 2017).

Table3: Lycocopene content of tomato genotypes and fruit weight (FW). Genotype: Igb3/09/21

Fruit weight(g)	Lycopene Content (mg/g)
23.1±0.03	0.16±0.01
22.33±0.13	0.25±0.01
22.33±0.11	0.31±0.01
19.65±0.19	0.42±0.01
18.38±0.13	0.5±0.01
16.23±0.07	0.74±0.01
15.26±0.14	0.85±0.01
8.45±0.14	2.12±0.01
5.53±0.14	3.09±0.01
5.32±0.14	1.18±0.01

Our interest in lycopene content of tomato is borne out of its role in human health as an anti-oxidant and anti-cancer agent (Wu *et al*., 2011; Santini *et al*., 2014). Thus, tomato is considered a protective food because of its particular nutritive value, as it provides lycopene, beta-carotene, flavonoids, vitamin C and hydroxycinnamic acid derivatives (Fentik, 2017). Here in this work, lycopene content was correlated with the fruit yield. Interestingly, using the GenStat statistical package, the correlation of lycopene with fruit yield indicated a negative correlation coefficient (-0.4). The correlation coefficient was found to be significant at P>0.05 when it was further subjected to student t-test.

From the above test, the relationship showed that as the lycopene content increases, the fruit yield decreases. In another word as the fruit yield increases, lycopene content decreases. This suggests that introgression of the lycopene gene from one tomato genotype to another may not be favorable (Atanassova *et al*., 2007). Also, breeding for a higher yield in tomato may lead to loss of lycopene content as shown in Table 1, in which the lycopene content was 0.001mg with fruit weight 37.59g. This phenomenon is what breeders guide against when selection is carried out. This is a situation that normally leads to narrowing down of genetic stock resulting from repeated inbreeding for vigor (Yao *et al*., 2020). The lycopene content appears specific for tomato ascension (Anuradha *et al*., 2018). This suggestion was based on the minor variations observed on the data shown in the three tables in which some appeared to be positively correlated and some other no correlation. This is in accordance with Anuradha *et al*. (2018), who suggested that lycopene content recorded negligible positive direct effect at both the genotypic and phenotypic level respectively on fruit yield per plant.

In conclusion, this work has revealed that lycopene content and fruit yield (fruit weight) in tomato run against each other. This occurrence should alert plant breeders who are interested in increasing fruit yield to the detriment of other valuable qualities of the crop. As breeders evaluate and carryout selection in crops for breeding programs, all other nutritional qualities must be considered before taking the decision for increasing the yield of the crop. This will invariably prevent genetic erosion in that crop.

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