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EVALUATION OF GROWTH AND POLLEN VIABILITY IN RELATION TO FRUIT SET AMONG FIVE VARIETIES OF TOMATO GROWN IN NIGERIA

OCJENA RASTA I VIJABILNOSTI POLENA U ODNOSU NA ZAMETANJE PLODA U PET KULTIVARA RAJČICE UZGAJANE U NIGERIJI

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ABSTRACT

The present study considered morphological traits, pollens viability and fruit set among five tomato varieties (Roma, Tropimech, Tima, Tedino and UC-82-B) grown in Nigeria. The seeds were grown in the screen house facility at the Botanical garden, University of Ilorin Nigeria. Growth and fruiting morphological data were collected and analyzed while pollen viability in relation to fruit set was determined. The results showed significant vegetative growth variations and correlations between plant height and leaf characters. However, vegetative growth was not directly related to percentage of flower formation and fruit set, but pollen viability was directly proportional to fruit set in the tomato varieties studied. Reduction in pollen viability was accompanied by lower number of fruit set. Fruit number and size may be affected by biotic or abiotic factors, nonetheless, the percentage of viable pollens in Pollen Mother Cell was found to affect fruit set. Although pollen grains in the field may be subjected to multiple stresses simultaneously; viability of pollens in a controlled setup may differ to the pollen viability in the open field environment. However, pollen viability is directly associated with fruit set in tomato and could be screened as a vital trait for improved tomato in breeding programme.

Keywords: fruit set, germination percentage, pollen viability, crop improvement

SAŽETAK

U ovom se radu razmatraju morfološke značajke, vijabilnost polena i zametanje ploda u pet kultivara rajčice (Roma, Tropimech, Tima, Tedino i UC-82-B) uzgajane u Nigeriji. Sjeme je uzgojeno u Botaničkom vrtu Sveučilišta Ilorin u Nigeriji. Sakupljeni su i analizirani podaci o morfologiji rasta i stvaranju ploda te utvrđena vijabilnost polena u odnosu na zametanje ploda. Rezultati pokazuju značajne varijacije i korelacije između visine biljke i karakterikstike listova. Međutim, vegetativni rast nije bio u izravnoj vezi s postotkom stvaranja cvjetova i zametanja plodova, ali vijabilnost polena bila je izravno proporcionalna sa zametanjem plodova kod istraživanih kultivara rajčice. Smanjenje vijabilnosti polena pratio je manji broj zametenih plodova. Na broj plodova i veličinu mogu djelovati biotički i abiotički čimbenici, iako se otkrilo da je postotak vijabilnog polena u majčinskoj stanici polena djelovao na zametanje ploda. Dok zrna polena na terenu mogu podlijegati mnogobrojnom stresu, vijabilnost polena u kontroliranom okruženju može se razlikovati od vijabilnosti polena na otvorenom. Međutim, vijabilnost polena u izravnoj je vezi sa zametanjem ploda u rajčice i može se promatrati kao vitalna značajka za poboljšanje rajčice u uzgojnom programu.

Ključne riječi: zametanje ploda, postotak klijanja, vijabilnost polena, poboljšanje uroda

INTRODUCTION

Tomato (*Lycopersicon esculentum*) a member of the family Solanaceae is one of the most important vegetable crops in the world. Solanaceae is the most variable of all crop species in terms of agricultural utility and the third economically most important crop family ranking after grasses and legumes but the most valuable in terms of vegetable crops (Van et al., 2002). According to a report (IHD, 2011), tomato production ranked second after potato in global vegetable production with estimated 458.2 million ha of cultivation cultivon globally and yield of about 32.8 tons/ha. Tomato fruits vary in size from tom-berries about 5 mm in diameter through cherry tomatoes about 1-2 cm, up to beefsteak tomatoes, 10 cm or more in diameter. The most widely grown commercial tomatoes tend to be 5-6 cm in diameter (Cong et al., 2002; ASPB, 2008).

In sub-Saharan Africa, especially Nigeria, tomato is considered as an important vegetable accounting roughly for 18% of daily consumption of vegetables with an average about 50.6g per person (Olayide et al, 1972).

In Nigeria tomato is mainly grown by rural small farm-holders and import of tomato products supplement the local production. Nigeria is the 14th largest producer of tomatoes in the world and 3rd in Africa at 1.51 million metric tons valued at N87 billion ($556.1 million) with a cultivated area of 264,430 ha (FAOSTAT, 2012). However, the country imports processed tomato products to the tune of several tons valued at several millions of dollar annually (Oladejo and oladiran, 2014). The reason for such massive import are due to low yield and lack of storage facilities. Not less than 50% of the tomato produced in the country is lost to lack of preservation (Chidi, 2012).

Although efforts have been made towards revitalizing the agricultural sector by prioritizing some crops for accelerated production and preservation in Nigeria, tomato is not on the list of priority crops (RIU, 2011), hence, importation of tomato puree has continued. Poor fruit set resulting from blossom drop and post pollination disorders is an important limitation to tomato production in the tropics. Flowering and fruit set in tomato influences yield and has effects on number and size of fruits (Bertin, 1995).

Ozores-Hampton et al. (2012) reported that temperature greatly affects blossom drop and fruit set of tomato, but hormones are claimed to be regulators of fruit-set in crops (Gillaspy et al., 1993). Influence of abiotic factors such as temperature and humidity on fruit abortion was elucidated by Stephenson (1981). Sink ratio, pollen viability, light variations, planting density, leaf pruning and genetic background have been reported to affect tomato fruiting (Marcellis et al., 2004; Valentin-Morrison et al., 2006; Wubs et al., 2009). However, reduction in fruit abortion was observed when flower number per truss reduced (Bertin, 1995).

Blossom drop and poor fruit set are important limitations to commercial tomato production in Nigeria. Janse and Verhaegh (1993) discovered that pollen density affected fruit set, seeding and seedling vigor in an apple cross. Also, Suzuki et al., 2001 reported that decrease in pollen stainability correlates with decrease in fruit formation in green bean. Pollen fertility and pollen germinations were noted to be adversely affected by high temperatures (Dane et al., 1991) and consequently affecting fruit set (Sato et al., 2000) Most reports on pollen viability merely consider the effect of a single factor, often under controlled experimental regimes using a single cultivar. The present study therefore compares growth and pollen viability in relation to fruit set among five varieties of tomato grown in Nigeria with the view of understanding the correlation between flowering, fruit set and yield characteristics of the varieties.

MATERIALS AND METHODS

Seeds of five tomato varieties usually grown for commercial purpose; Roma, Tropimech, Tima, Teddino and UC-82-B evaluated in this study were obtained from Ministry of Agriculture, Ilorin, Kwara State, Nigeria. The pot experiment was conducted in the screen house facility, Botanical garden, University of Ilorin Nigeria (N 08^0 28' 53.3'', E 04^0 40' 28.9") within the climatic region of the tropical savannah in the sub-Sahel Africa between February and June, 2013. The rainfall (of about 1200mm) is bimodal with peaks in June and early September, usually separated by a period of lower precipitation in August. Temperature varies between 24°C and 33°C and November to April constitutes the major dry season (Olaniran 1982; NIMET, 2014).

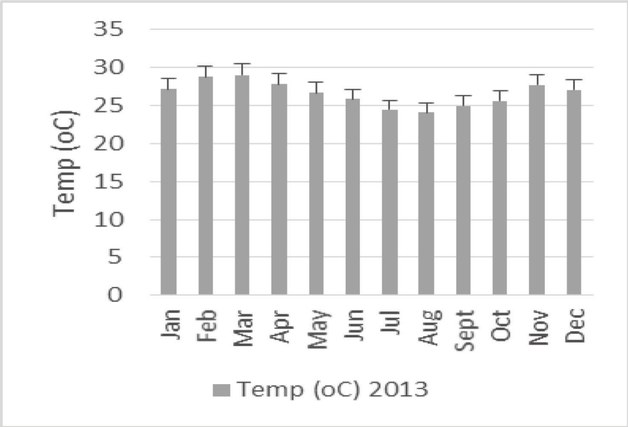
Tomato seeds were sown in nursery beds of 0.5 m x 0.5 m, rich in loam provided with shade and regular irrigation for seed germination. Two weeks after germination, two seedlings from each of the five varieties of tomato were transplanted into a planting bag filled with garden soil. Three replicates were provided in Randomized Block Design (RBD). Data were obtained on germination and the germination percentage was estimated. Quantitative growth, floral and fruit characteristics of tested varieties were measured. Stem girth was measured by using electronic venier caliper (Titan-23175 model). Young flower buds collected from the varieties maintained in the screen house were fixed in Carnoy's solution (1:3 mixture of acetic acid-ethanol) for 24 hours at room temperature. Then, the anthers of the flower buds were dissected in the middle and the Pollen Mother Cells (PMCs) spread on the slide. Drop of 2% acetone-carmine was swiftly added and carefully mixed with the PMCs.

The slide was covered with cover slip pressed gently with the thumb. The slides were observed under low and high power magnification of Olympus binocular microscope. About 100 pollen grains from each flower bud were observed and percentage pollen viability determined. The flower fruit set ratio was determined using the method described by Suzuki et al. (2001) and the percentage fruit set was also determined.

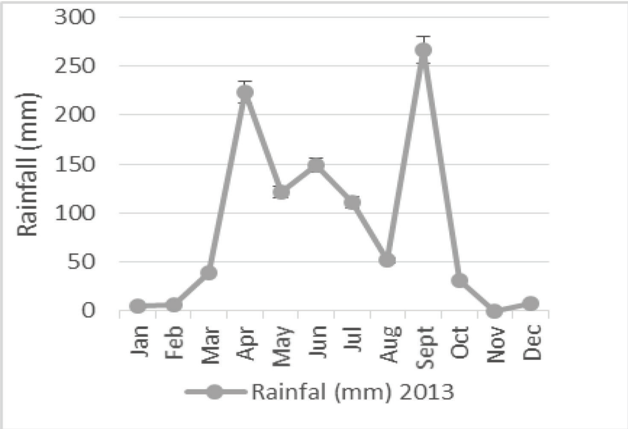
The data obtained for various parameters evaluated were subjected to Analysis of Variance (ANOVA) using SPSS 16.0. The means were separated with Duncan Multiple Range Test (DMRT) at level of significance $P < 0.05$.

RESULTS AND DISCUSSION

The mean monthly temperatures and average rainfall for Ilorin in 2013 is shown in Figures 1(a, b).



(a)



(b)

Figure 1: (a) Showing mean monthly temperature of Ilorin in 2013
(b) Average monthly rainfall for 2013 (Nigerian Metrological Agency, 2013)
Slika 1: (a) Prikaz srednje mjesečne temperature u Ilorinu 2013.,
(b) Prosječne mjesećne padaline za 2013.
(Nigerijska meteorološka agencija,2013.)

The warmest month of the year was March (31.45 °C) while September was the coolest (23.41 °C). The month of April had highest rainfall for the period of the experiment. However, average monthly rainfall was highest in September, at that time the study was already completed.

Among the five tested varieties, germination occurred between 4-7 days. The percentage of germination ranged from 56 to 96%. Germination percentage and seedlings survival after transplantation for the varieties are presented in Figure 2.

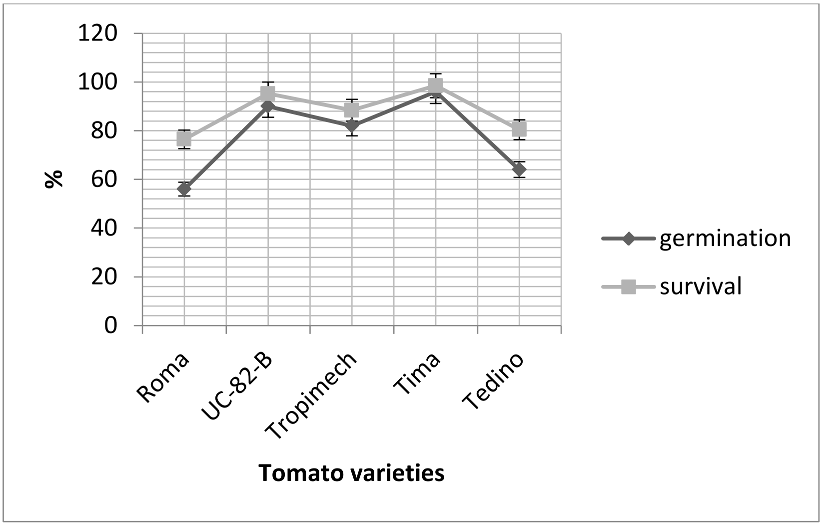


Figure 2: Percentage of germination and seedling survival of five tomato varieties
Slika 2: Postotak klijanja i preživljavanja presadnica pet kultivara rajčice

Low germination percentage and seedlings survival of variety Tima may be caused by presence of endogeneous cyanide or pysiologically imature embryo which could have reusulted in dormancy and poor germination. The reduction in seedling survival after transplanting was due to shock and stress that affect rooting and nutrient uptake from which the young plants could not recover.

At maturity, analysis of quantitative morphological parameters evaluated revealed significant variations in agreement with results reported by Akindele et al. (2011). However, some varieties did not differ significantly in some characters (Table 1). Variety Tedino achieved the highest plant (55.96 cm) and the shortest plants were obtained among Tima variety (35.08 cm).

Similar trend was obtained in number of leaves per plant. For all the quantitative vegetative characters considered, Tedino significantly maintained the lead except in stem girth and number of branches per plant. Number of branches varied from 2.20 to 7.80 among the studied varieties (Table 1).

Table 1: Quantitative vegetative characters of five varieties of tomato

Tablica 1: Kvantitativne i vegetativne karakteristike pet kultivara rajčice

VARIETY	Plant height (cm)	Number of			Stem girth (cm)
		Leaves	Leaflets	Branches	
ROMA	54.50[a]	16.40[b]	79.20[b]	2.20[b]	1.27[c]
UC-82-B	46.98[ab]	16.60[b]	84.20[b]	7.80[a]	1.41[b]
TROPIMECH	49.16[ab]	18.20[b]	89.60[b]	5.80[ab]	1.38[b]
TIMA	35.08[b]	13.40[b]	71.60[b]	6.00[ab]	1.34[b]
TEDINO	55.96[a]	24.40[a]	126.40[a]	8.20[ab]	1.67[a]

Values bearing the same letter (s) along the same column are not significantly different at $p \leq 0.05$.

Tedino significantly and consistently had best performance in vegetative characters; this suggests higher production of growth factors which enhance the vegetative growth. The positive correlations between leaf traits and plant height explain the trend in growth patterns of the varieties (Table 2).

In addition, analysis of quantitative characters reveals significant correlations between some vegetative growth traits of the varieties. A similar result was reported by Nwosu et al. (2014), that significant correlations existed in the vegetative parameters of the tomato varieties studied

Table 2: Correlation coefficient of quantitative growth characters among five varieties of tomato

Tablica 2: Koeficijent korelacije značajki rasta pet kultivara rajčice

	Plant height (cm)	Stem girth (cm)	Number of		
			Leaves	Leaflets	Branches
Plant height (cm)	1				
Stem girth (cm)	0.396*	1			
Number of leaves	0.460*	0.221	1		
Number of leaflets	0.490*	0.268	0.919**	1	
Number of branches	-0.139	0.197	0.462*	0.451*	1

* Correlation is significant at 0.05 level (2 tailed)

** Correlation is significant at 0.05 level (2 tailed)

Table 3 shows that flowering commenced earlier in Tripimech at 39.14 days after sowing (DAS), while Tedino started fruiting late (51.42 DAS). Variety Tima produced highest number of flowers (19.23) and fruits (11.40) representing 59.28% of fruit set with average fruit weight of 44.79 g. Variety Roma produced 17.20 flowers and 9.82 fruits (57.09% fruit set) were recorded (Table 3). Although variety Tedino had the best vegetative growth, the least number of flowers and fruits were obtained among Tedino variety, nonetheless, average fruit weight of 43.19 g was obtained in Tedino, which is higher than others verieties axcept Tima (Table 3). This finding is in agreement with earlier reports that different factors are responsible for plant vegetative growth and fruiting in plants (Bertin, 1995; Marcellis et al., 2004). Generally, fruit set differs from plant to plant, and fruit set percentage or probability can better reflect the variations compared with the number of set fruit. Furthermore, fruit-set is a dynamic process that varies according to crop growth stage: cyclical abortions have been observed in sweet pepper (Wubs et al., 2009).

To facilitate selection of high-fruit yielding variety with the view of commercial production therfore, early fruiting, high number of fruits, and marketable fruit size characters should be screened and selection should not be based on the vegetative growth alone as considered by Bernousi et al. (2011).

Table 3: Mean values for the floral and fruit characters of five varieties of tomato

Tablica 3: Srednje vrijednosti značajki cvijeta i ploda pet kultivara rajčice

Varieties	Number of			Peduncle length (cm)	Fruit				Seed/ Fruit
	Days to flower	Flowers	Fruits		Weight (g)	Diameter (cm)	Length (cm)	Locules	
ROMA	47.20	17.20	9.82	0.36	37.59	3.92	3.75	2.00	52.62
UC-82-B	45.30	14.61	7.89	0.34	39.02	3.08	5.38	2.41	61.20
TROPIMECH	39.14	14.04	7.94	0.44	39.83	3.48	3.94	3.08	82.84
TIMA	48.20	19.23	11.40	1.04	44.79	4.09	4.49	2.09	47.81
TEDINO	51.42	13.40	6.02	0.26	43.19	3. 88	4.21	2.25	58.87

The total number of pollen was observed the percentage of pollen viability and the percentage of fruit set for the varieties (Figure 3).

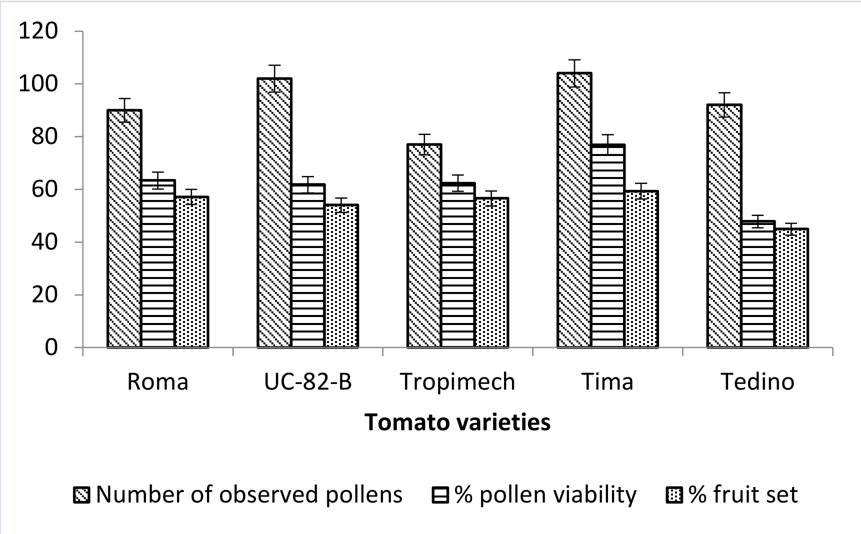


Figure 3: Total number of pollens and pollen viability percentage of five tomato varieties
Slika 3: ukupan broj polena i postotak vijabilnosti polena pet kultivara rajčice

Figures 4 (a-e) shows fruit locules of the tomato varieties while figures 5 and 6 show pollen stainability and viability.

(a) Roma

(b) UC-82-B

(c) Tropimech

(d) Tima

(e) Tedino

Figure 4 a-e: Fruit locular cavities of five tomato varieties
Slika 4 a-e: Lokularne šupljine plodova pet kultivara rajčice

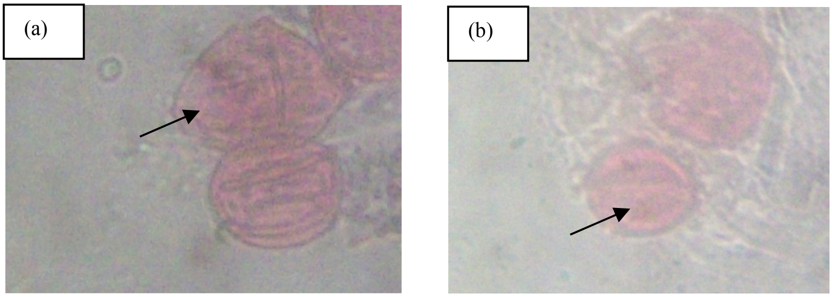


Figure 5 a-b: Typical viable pollen grains of tomato
Slika 5 a-b: Tipična vijabilna zrna polena rajčice

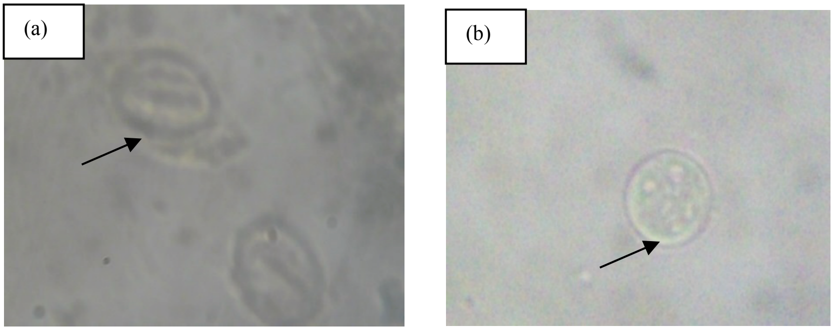


Figure 6 a-b: Typical non-viable pollen grains of tomato
Slika 6 a-b: Tipična nevijabilna zrna polena rajčice

Pollen viability was directly proportional to fruit set among the varieties studied, a number of factors have been described to influence pollen viability and subsequent fruit set in crop plants (Dane et al*.*, 1991; Abdul-Baki, 1992; Suzuki et al, 2001). The variety with the highest number of fertile pollens produced the highest number of fruits. Blossom drop and post-pollination disorder have been indicated to reduce flower-fruit set ratio in tomato (Ozores-Hampton et al*.*, 2012). This study agrees with the finding because there was great difference in the number of flowers ratio to the number of fruit produced.

Lack of direct relationship correlation between numbers of flowers and fruit set percentage suggests that different mechanisms and a number of factors contribute to fruiting in tomato. Insufficient pollination and failure of embryo growth is likely the major cause of reduced fruit set.

Dane et al*.,* (1991) had noted a decline in percentage of tomato genotypes fruit set under high-temperature stress which caused significant decrease in pollen viability and favors blossom drop. Similarly, others factors that affect fruit set have been elucidated by Sato et al., (2000) and Stepheson (1981). They include pollen production, viability, pollen dehiscence, ovule viability, stigma and stylar exertions. Any of these factors or their combination could result in reduced fruit set and production of tomato. Therefore, it is important to note that utilization of the knowledge of pollen viability as a selection criterion for high yield tomato production could provide vital information for effective breeding programme.

CONCLUSION

The present study considered morphological characters, pollen viabilty and fruit set among five tomato varieties. It was determined that significant vegetative growth may not necessarily transmit to significant fruit set and pollen viability was directly proportional to the fruit set percentage. Hence, reduced fruit set was a result of little or poor pollen viability of tested tomato varieties. Although hormone and environmental factors have been reported to affect fruit set in crop plants, the amount of viable pollens in a flower to a greater extent determines fruit set in plants. The percentage of viable pollens in tomato could be affeted by abiotic factors such as temperature and humidity among others. However, pollen grains in the field may be subjected to multiple stresses simultaneously; therefore, viability of pollens in a controlled setup may not necessarily correlate to the pollen viability in the open field environment.

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