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GROWTH , YIELD AND QUALITY OF THREE VARIETIES OF TOMATO *(Lycopersicon esculentum* Mill) AS INFLUENCED BY PLANTING DATES UNDER RAIN FED CONDITIONS IN EDO STATE, NIGERIA

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Abstract The objective of this study was to determine the most appropriate planting date for the growth, yield and quality of tomato varieties under rain fed conditions. Field experiments were conducted in the Teaching and Research Farm of Department of Crop Science, Faculty of Agriculture, University of Benin, Nigeria. The design for this experiment was a 3 x 4 factorial arrangement fitted into a randomised complete block design (RCBD) replicated three times. The treatments consisted of four planting dates, D1(14th of April), D2 (28th of April), D3 (12th of May) and D4 (26th of May) 2016 and three tomato varieties (Roma VF, UC 82, and Roma savannah). Planting dates significantly affected growth, yield, and quality of tomatoes. The earliest planting date D1, performed better than other planting dates in all the vegetative parameters measured. The highest fruit yield (9.79 t ha^{-1}), number of flowers per plant (17.94) and earliest days to fruit maturity (63.00) was produced at D1. Roma Savanna produced the highest number of flowers (11.69) per plant and vitamin C content (21.10 mg). The moisture content (94.02 %) was lowest in Roma VF while the crude protein, crude fibre and ash content (19.31%), (0.57%) and (7.46%) respectively were higher. UC82 had the highest percentage moisture content (94.32%) and ether extract (0.59 %). The study showed that any of the three varieties (Roma VF, UC 82, and Roma savana) could be used at either D1 or D2 as a rain fed crop in this locality

Keywords: planting dates, proximate composition, tomato, varieties, vitamins

Introduction

Tomato *(Lycopersicon esculentum*) is a popular fruit vegetable in Nigeria, because of its taste, colour and high nutritive value. Its fruit contains about 94% water, 2.5% total sugars, 2% total fiber, 1% proteins and other nutritional compounds like acids, lipids, amino acids and carotenoids (Koh *et al.*, 2012). Tomato fruit is rich in vitamins A, B1, B6, ascorbic acid and significant quantities of mineral matters (phosphorous, magnesium and iron). It is also rich in potassium which is helpful in controlling the rate of heart beat, heart diseases and stroke (Enujeke, 2013). It is also a source of income to farmers as the fruits are extensively cultivated for its commercial purposes, enormous quantities of tomato are industrially and home- processed (juice, puree, concentrate, extract, peeled and dried). This crop has become widely grown around the world because of its importance and value (Adepoju, 2014), and is widely used due to its great importance in Nigeria. The total estimated annual global production of tomato is over 120 million metric tons (FAO 2016). The numerous uses of tomato notwithstanding, production in Nigeria is not enough for local demand. Its production in Nigeria is low compared with those of the temperate zones due to differences in crop environmental conditions, problem of declining soil fertility, lack of high yielding varieties and other cultural practices applied to the crop on the field. In Nigeria, tomatoes are conventionally grown during the dry season with irrigation (Ayoola, 2014) while its production is scarce during the rainy season because of high disease incidence, indiscriminate use of unimproved local varieties (Denton et al., 1999; Idowu-Agida et al., 2010), and poor crop husbandry (Parker et al., 2001). The result is that fresh tomato supply during the rainy period become scarce and therefore expensive. Rainy season tomato fruits are quite remunerative business as the supply is low and price is high. Utilization of improved horticultural husbandry such as appropriate planting date and selection of improved tomato varieties for fruit production are essential factors for increasing productivity and yield quality. Souri and Dehnavard, (2018) observed that agronomic practices have been recognized as a critical factor in determining the nutritional quality of crops. Planting dates have tremendous effect on the tomato fruit quality and seed yield because of widely varying agro climatic conditions and intricate crop-weather relationships. Turner and Wien (1994) reported that during high temperature certain physiological changes occur within the plant system which decrease the sugar

content and lower enzymatic activities which encourage abnormal pollen and anther development resulting in decrease in pollen viability, pollen tube growth and abortion of buds, flowers and young fruits hence affecting yield. Photosynthetic rate, number of fruits, individual fruit weight and fruit yield per plant significantly decreased with the high temperature (32^0C) at pre-flowering and flowering stages. Islam, (2011) reported that the effects of temperature were more pronounced at flowering stage compared to pre-flowering stage (Barrett *et al*., 2007). Delayed planting and wrong selection of varieties have resulted to inconsistent yield and poor quality of tomato cultivation. Sajjan *et al.* (2002) reported that growth characters of crops such as plant height, leaf area, number of leaves or branches and fruit yields were influenced by genetic factors of different varieties. Appropriate planting dates may not only lead to greater yield, but also may contribute to better vegetable quality (Kleinhenz and Wszelaki, 2003). The need to identify suitable varieties and optimum planting date of tomato has become eminent. However, information regarding the optimum planting date as well as the interaction effect in combination with varieties on growth, yield and quality of tomato is scanty under the humid region of Nigeria. Keeping in view the tremendous potential of tomato, the present study was designed to determine the response of tomato varieties to planting dates.

Materials and Methods

Experimental site

The study was carried out during the rainy season of April to September of 2016 and 2017, at the Research Farm and Laboratory of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The location lies between latitude 6° 14' N and 7° 34' N and longitude 5° 40' E and 6° 43' E on elevation of 162 m above sea level, in the rainforest ecological zone of Nigeria which is characterized by two distinct seasons: wet (April–October) and dry (November–March). The mean annual rainfall is 1900 mm and average temperature of 27 ^{0}C. The dominant soil type is ultisols developed from coastal plain sand (Brinkhoff, 2013). The vegetation of the study area includes guinea grass (*Panicum maximum* Jacq.), sensitive plant *(Mimosa pudica L.), goose grass (Eleusine indica L.*), and common wire weed *(Sida acuta* Burm F.*).*

Soil samples and analysis

Prior to planting, composite soil samples were collected from a depth of 0 – 30 cm using soil auger, air-dried and were crushed to pass through a 2 mm sieve and packaged for routine soil physical and chemical analysis according to standard laboratory procedures. Soil pH was determined using a pH meter. Organic carbon was determined by (Walkley and Black, 1962) wet oxidation method as modified by Jackson (1969). Total nitrogen was obtained by macro Kjeldahl method as modified by Jackson (1969). Available P was extracted by Bray I method (Bray and Kurtz, 1945) and P was estimated by the blue colour method of Murphy and Riley (1962). Exchangeable K and Na were determined using flame photometer, and Ca and Mg using the Atomic Absorption Spectrophotometer.

Treatments and experimental design

The experiment was a factorial combination of 3 × 4 in randomized complete block design (RCBD) with twelve treatments in three replications. The treatments used for the trial were three varieties of tomato (Roma savanna, UC 82 and Roma VF) and four planting dates [April 14 (D1), April 28 (D2), May 12 (D3) and May 26 (D4)]. Each replicate had 12 plots for a total of 36 plots in this experiment.

Land preparation, Seed source and Transplanting

The land was cleared of the existing vegetation and the debris worked into the soil. A basal application of 20 t ha^{-1} poultry manure was applied and mixed thoroughly with the soil. Tomato seeds of three varieties, Roma Savanna, UC 82 and Roma VF which were obtained from National Institute for Horticulture and Research (NIHORT), Nigeria, were sown into prepared nursery beds well manured and watered. The seedlings were raised in the nursery and transplanted to the field three (3) weeks after sowing at two (2) weeks interval in order to achieve the different planting dates and were maintained till harvest. Weeding, insect pest and disease control were carried out when necessary.

Sampling and measurements

Data collection commenced four weeks after transplanting. Four plants were randomly selected from each plot and tagged for the purpose of collecting data. Vegetative growth, and yield components of tomato were evaluated. Vegetative growth parameters measured included plant height (cm), number of leaves, stem diameter (cm), leaf area $(cm)^2$ and number of branches while the yield components measured number of days to 50% flowering, number of flowers, number of fruits, fruit weight per plant (g) and fruit yield (t/ha).

Statistical analysis

The data obtained were subjected to statistical Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) version 1998, following the model for factorial experiment in a randomized complete block design and differences among treatments means were separated using the Least Significant Difference (LSD) at ($p \leq 0.05$).

Results and Discussion

Experimental soil

The soil texture was sandy loam consists of sand 89.80 (%), silt 5.00 (%) and clay 5.20(%). The soil pH (H_2O) was acidic (5.60) and the major plant nutrients (N, P and exchangeable K) were below recommended critical concentration levels of 0.15% N, 10 – 16 mg kg^{-1} and 0.34 c mol kg^{-1} K respectively required for optimum crop production (Table 1), hence the need for basal application of 20 t^{-1} poultry manure.

Table 1: Physico-chemical analysis of the soil sample used for the experiment

Soil properties	Values
Sand (%)	89.80
Silt (%)	5.00
Clay (%)	5.20
Textural class	Sandy loam
pH (H_2O)	5.60
Organic matter (g kg^{-1})	21.75
Total N (g kg^{-1})	0.08
Available P (mg kg^{-1})	8.92
Exchangeable K (cmol kg^{-1})	0.28
Exchangeable Ca (c mol kg^{-1})	0.62
Exchangeable Mg (c mol kg^{-1})	0.37

Vegetative and reproductive characters

Planting dates significantly ($P \leq 0.05$) influenced plant height. The highest plant height (51.85cm), number of leaves (95.11), branches (19.14) and leaf area (106.85cm ^{2}) were produced at D1 and these were closely followed by D2 (36.67cm), (74.95), (12.56) and (102.39cm^2) before D4 which produced (33.31cm), (45.33), (8.11) and (95.01cm ^{2}) for plant height number of leaves, number of branches and leaf area respectively. D3 significantly produced the lowest plant height (6.90cm), number of leaves (14.67), branches (3.97) and leaf area (89.83cm^2) however, variety had no significant ($P \geq 0.05$) effect on any of the vegetative characters measured. (Table 2).

Table 2: Vegetative growth of tomato varieties as influenced by planting dates

Varieties	Plant height (cm)	Number of Leaves	Leaf area (cm^2)	Number of Branches
Roma Vf	35.62a	58.00a	99.15[a]	10.79a
Roma Savanna	29.09a	53.10a	99.25[a]	10.39a
UC 82	31.84a	61.44a	97.17[a]	11.65a
LSD (5%)	NS	NS	NS	NS
Planting dates				
D1	51.85[a]	95.11[a]	106.85[a]	19.14[a]
D2	36.67[b]	74.95[b]	102.39[b]	12.56[b]
D3	6.90[c]	14.67[d]	89.83[d]	3.97[d]
D4	33.31[b]	45.33[c]	95.01[c]	8.11[c]
LSD (5%)	12.06	14.78	3.26	2.63

D1=14th April, D2=28 April, D3= 12th May, D4=26 May.
Means followed by the same letter in a column are not significantly different at 5% level of probability using LSD.

Similarly, there was no significant varietal difference on days to maturity studied. The three varieties produced statistically similar results on 50% days to maturity (Table 3). The effect of planting dates on days to maturity was found significant in this order D3 (87.00 days) > D2 (76.00 days) > D4 (73.00 days) > D1 (63.00 days). The earliest days to 50% maturity was found at D1 while D3 had the highest days to 50% maturity

Table 3: Yield and yield components of tomato varieties as influenced by planting dates.

Varieties	Days to maturity	Number of flower/plant	Number of fruit/plant
Roma Vf	74.45[a]	7.43[b]	5.49[a]
Roma Savanna	74.51[a]	11.69[a]	5.82[a]
UC 82	74.35[a]	7.04[b]	5.43[a]
LSD (5%)	NS	3.37	NS
Planting dates			
D1	63.00[d]	17.94[a]	10.41[a]
D2	76.00[b]	13.06[b]	8.67[a]
D3	87.00[a]	1.31[c]	0.42[b]
D4	73.00[c]	3.58[c]	2.82[b]
LSD (5%)	1.04	3.89	2.76

D1=14th April , D2=28 April, D3= 12th May, D4= 26 May.
Means followed by the same letter in a column are not significantly different at 5% level of probability using LSD.

Varieties significantly affected the number of flowers per plant, Roma Savanna increased the number of flowers (11.69) above Roma VF (7.43) and UC 82 (7.04). The earliest planting date of D1 significantly produced more numbers of flowers (17.94) compared with D3 (1.31) and D4 (3.58) which significantly produced the lowest number of flowers.

Table 4, showed that the number of fruits per plant and fruit weight per plant followed the same trend and was higher at D1 (10.41 and 342g) and D2 (8.67 and 289g) respectively while D3 and D4 significantly) ($P \leq 0.05$) produced lower values for the number of leaves and number fruits per plant. Although the fruit length and fruit diameter did not follow a particular order but significant differences were observed as influenced by planting dates. D2, planting date was similar to D1 and both increased fruit diameter and length above D3 and D4. Fruit yield (t ha $^{-1}$) was not significantly affected by varieties however, it was influenced by planting dates, D1 and D2 were significantly at par and produced higher fruit yield (9.79 t ha $^{-1}$ and 8.02 t ha $^{-1}$) respectively above D4 (3.49 t ha $^{-1}$). The lowest fruit yield (0.49 t ha $^{-}$1) was produced at D3 sowing date (Table 4).

Table 4: Yield and yield components of tomato varieties as influenced by planting dates.

Varieties	Fruit weight/plant (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield (t ha^{-1})
Roma Vf	183.0^{a}	2.74^{a}	1.43^{a}	4.80^{a}
Roma Savanna	189.0^{a}	2.97^{a}	1.74^{a}	6.83^{a}
UC 82	181.0^{a}	1.98^{a}	1.24^{a}	3.96^{a}
LSD (5%)	NS	NS	NS	NS
Planting dates				
D1	342.0^{a}	2.68^{ab}	1.48^{ab}	9.79^{a}
D2	289.0^{a}	3.58^{a}	2.14^{a}	8.02^{a}
D3	14.00^{b}	1.83^{b}	1.03^{b}	0.49^{c}
D4	94.00^{b}	2.15^{ab}	1.23^{b}	3.49^{b}
LSD (5%)	93.00	1.46	0.90	4.34

D1=14th April, D2=28 April, D3= 12th May, D4=26 May.
Means followed by the same letter in a column are not significantly different at 5% level of probability using LSD.

Proximate composition

The effect of varieties on proximate analysis of tomatoes was significant as shown in Table 5. Roma VF produced the highest ash (7.46 %), crude fibre (0.57%) and crude protein content (19.31%) and the least moisture content (94.02%), which were significantly different from other varieties. Roma savanna produced the highest vitamin C content (21.10 mg) followed by UC 82 (20.38 mg) and then RomaVF had the lowest Vitamin C content (19.49 mg), UC 82 produced the highest moisture content (94.33 %), ether extract (0.59 %) and nitrogen free extract (73.47%) (Tables 5 and 6). Similarly, the planting dates significantly affected the proximate analysis of the tomato. D2 and D4 produced the highest significantly values in moisture content (94.39% and 94.06%) respectively and Vitamin C content (0.46 mg) was higher in D1 compared with other sowing dates.

Ash content was also significant among the planting dates with the highest ash content obtained in D1 (8.82 %) and lowest ash content value obtained in D4 (2.37%). D3 produced the lowest value (2.74%) for ash content but increased the moisture content (94.16%) and vitamin C content (19.88 mg) above D1 (94.13 %, 18.00 mg) and D4 (94.06 %, 16.21 mg). The ether extract (0.54%) was at par with that of D1 (0.53%) and were significantly higher than values obtained from D2 (0.52%) and D4 (0.51%) and the Nitrogen free extract (74.57%) was highest at D4 planting date.

Table 5: Proximate composition of tomato varieties as influenced by planting dates.

Varieties	Moisture content (%)	Ash (%)	Vitamin C (mg)
Roma Vf	94.02^{c}	7.46^{a}	19.49^{c}
Roma Savanna	94.22^{b}	2.66^{b}	21.10^{a}
UC 82	94.32^{a}	2.46^{c}	20.38^{b}
LSD (5%)	0.008	0.008	0.008
planting date			
D1	94.16^{c}	8.82^{a}	18.00^{c}
D2	94.39^{a}	2.84^{b}	20.42^{a}
D3	94.13^{b}	2.74^{c}	19.88^{b}
D4	94.06^{a}	2.37^{d}	16.21^{d}
LSD (5%)	0.009	0.009	0.009

D1=14th April, D2=28 April, D3= 12th May, D4=26 May.
Means followed by the same letter in a column are not significantly different at 5% level of probability using LSD.

Table: 6 Proximate composition of tomato varieties as influenced by planting dates.

Varieties	Crude fibre (%)	Crude protein (%)	Ether extract (%)	Nitrogen free extract (%)
Roma Vf	0.57^{a}	19.31^{a}	0.52^{b}	71.30^{c}
Roma Savanna	0.46^{b}	19.05^{b}	0.46^{c}	71.62^{b}
UC 82	0.31^{c}	17.58^{c}	0.59^{a}	73.47^{a}
LSD (5%)	0.008	0.008	0.008	0.008
planting date				
D1	0.46^{a}	19.40^{c}	0.53^{a}	73.01^{b}
D2	0.44^{b}	18.75^{d}	0.52^{b}	70.35^{d}
D3	0.44^{b}	20.23^{b}	0.54^{a}	70.57^{c}
D4	0.44^{b}	22.91^{a}	0.51^{b}	74.57^{a}
LSD (5%)	0.009	0.009	0.009	0.009

D1=14th April, D2=28 April, D3= 12th May, D4=26 May.
Means followed by the same letter in a column are not significantly different at 5% level of probability using LSD.

Discussion

The insignificant differences observed in the varieties with respect to some of the vegetative growth and yield components could be due to similarity in genetic makeup of the determinate varieties studied.

The earlier planting dates did better while delayed planting gradually decreased the vegetative growth. The D3 planting had the lowest vegetative growth and this could be as a result of the time of transplanting where the rainfall was at its peak and solar radiation was low hence affecting the photosynthetic and metabolic processes thereby reducing their growth and yield performance The higher yield obtained from D1and D2 could probably be due to a more favourable climatic condition experienced by the plants. Plants under D1 and D2 experienced lesser rains and favourable temperatures and longer hours of sunshine especially in their flowering and fruiting stages compared to D3 and D4, earlier planting seemed to obtain favorable climate for maximizing fruit yield. This result is also in agreement with the findings of Bauer, (2009) who reported that the tomato plant needs at least seven hours of sunlight per day
in order to generate enough energy to produce fruit,

The results of the proximate analysis revealed that in all the varieties, moisture content was higher than other elements analysed and this agrees with the findings of Agbemafle *et al.* (2015) and Idah *et al.*

(2010). Tomato fruits in addition to the nutrients contained could serves as a thermo- regulator and help to maintain the human body fluid balance (Popkin *et al.* 2010). The higher moisture content of UC 82 when compared with Roma VF and Roma Savannah suggests that UC 82 has lesser shelf life. The ash content of a food substance depicts the total crude minerals. Roma VF and D1 planting date had the highest ash content (7.46% and 8.82%) respectively and the values are higher than the range of 0.47% - 0.98% as reported by Agbemafle *et al.* (2015).

The highest ash content in Roma VF and at D1, may be as a result of the favourable environment condition occasioned by early planting and this may have enhanced the plant's ability to absorb minerals from the soil (Agbemafle *et al.* 2015). The range of protein content of all the varieties used was 17.58 % – 22.91 % higher than 8.8 % - 9.5 % reported by USDA (2018). The differences may be as a result of varietal influence, environmental conditions and other agronomical practices during production. UC82 had highest percentage ether extract (0.59%), significantly higher than 0.22% as estimated by Idah *et al.* (2010). Ether extract is very essential in physiological functions of human as they participate primarily to produce hormone-like substances which control blood pressure, blood clotting, the immune response, blood lipid levels and the inflammatory response (Vincent *et al.* 2009). All varieties irrespective of the planting dates contain a considerable amount of crude fiber in varying quantities, comparatively higher than 2.50% as estimated by Onifade *et al.* (2013). Dietary fibre is an indigestible component of food that enhance peristaltic movement of bowels. It prevents constipation as well as colon cancer (Terry *et al.* 2001). It modulates the function of the intestinal tract and it is characterized by low calories (Marlett *et al.* 2002). Nitrogen free extract (NFE), consist of carbohydrates, sugars, starches and a major portion of hemicellulose which is the major energy source in the body. The amount of NFE is second to percentage content moisture in all the varieties and planting dates and this supports the finding of Garuba *et al.* (2018).

Conclusion and Recommendation

The study showed that any of the three varieties (Roma VF, UC 82, and Roma savana) can be used as there were no significant differences amongst them in terms of growth and yield. Planting at either D1 or D2 promoted growth and development of tomato plant as these planting dates coincides with more favourable environmental conditions compared with planting at D3 and D4. The proximate composition of the crop was appreciably influenced by planting dates. This study recommends planting any of the three varieties at the onset of the rains in April (D1or D2).

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