Agro-Science Journal of Tropical Agriculture Food, Environment and Extension
Volume 6 Number 1 January 2007 pp. 71 – 81

ISSN 1119-7455

ASPECTS OF TOMATO FRUIT QUALITY AS INFLUENCED BY CULTIVAR AND SCHEME OF FERTILIZER APPLICATION

Oko-Ibom, G.O. and Asiegbu, J. E.
Department of Crop Science, University of Nigeria, Nsukka

ABSTRACT

The fruit quality characteristics of eight tomato (Lycopersicon esculentum Mill.*) cultivars namely; UN-83, Nsukka Local, Roma VFN, Ronita, Ife-1, Rossol, NHle 7-7-1 and Ace VF were assessed under seven fertilizer application schemes in two field experiments at Nsukka, Southeast Nigeria. The tomato cultivars, UN-83, Roma VFN and Ronita excelled in most of the fruit quality characteristics studied, especially, resistance to cracking, low seed content, firmness, percent titratable acidity and soluble solids and, longer shelf life. On the average, fertilizer application at two weeks after transplanting either in single dose or in two splits with the second split applied at flowering, gave better fruit quality characteristics than the other application schedules except the two split application with one-half at transplanting and one- half at flowering.*

Key words: Tomato, Fruit quality, Fertilizer, ***Lycopersicon esculentum***

INTRODUCTION

The quality of tomato fruits determines its suitability for use both as fresh vegetable and for processing. Fruit quality attributes like fleshiness of tissue, pH, titratable acidity and seed content are important processing factors for canning and for use as fresh vegetable. According to FAO (2004), food quality is an increasingly important issue for consumer protection, and hence an essential marketing criterion.

Most aspects of tomato fruit quality have been reported to be under genetic control and hence do vary widely with cultivar. Large varietal differences in percent soluble solids, titratable acidity, pH, and soluble carbohydrates have been reported in tomato (Abani, 1985; Hewitt and Carvey, 1987), while significant differences in their susceptibility to fruit cracking have been demonstrated between strains and varieties of tomato (NIHORT, 1986).

Emphasis in crop research has increasingly shifted from quantity to quality of produce besides the need to step up yield of crops. Mineral fertilizers are recognized to increase yield and improve quality but published reports indicate that, though mineral fertilizers can increase the nutritional quality of vegetables, their most obvious commercial effect on quality is correction of defects caused by nutrient deficiencies (Vittum, 1963; Fritz and Habben, 1973).

Split application of fertilizers has been reported to be the most beneficial mode of nutrient supply to tomatoes for optimum growth and yield (Fawusi, 1977; Jones, 1999), but there is limited information on the effect of split NPK fertilizer application on tomato fruit quality thus informing the objective of this study, aimed at evolving the best time in the life of a tomato crop to apply fertilizers for improved fruit quality and, to assess the quality characteristics of selected tomato cultivars.

MATERIALS AND METHODS

Two field experiments were conducted during the rainy season in Southeastern Nigeria from April to September, 1992 at the Department of Crop Science teaching and research farm, University of Nigeria, Nsukka. The sites were located at latitude 06^0 25'N, longitude 07^0 24'E and altitude of 447.02m above mean sea level. The soil was a well-drained ferralitic sandy clay loam classified as ultisol.

Experiment 1 (April – June 1992)

This experiment was carried out as a 5 X 4 factorial laid out in a randomized complete block design with three replications. The treatments comprised five cultivars of tomato namely: UN-83, Nsukka local, Roma VFN, Ronita and Ife-1, and four fertilizer application schedules viz: all fertilizers applied at two weeks after transplanting; one-half of the fertilizers applied at two weeks after transplanting and one-half at flowering; one-third of the fertilizers applied at two weeks after transplanting, one-third at flowering and one-third at fruiting; and all fertilizers applied at flowering.

The experimental area was ploughed and harrowed and soil samples taken for the laboratory analysis to determine the physical and chemical characteristics of the site. Lime in the form of calcium carbonate was applied to the field at the rate of 1.5t ha^{-1}. The seedlings were raised in a nursery and transplanted after two weeks. Plant spacing was 60cm between rows and 45cm within rows.

Fertilizer N, P and K were supplied from Urea, single super phosphate and muriate of potash, respectively and applied at the rates of 100kgN ha^{-1}, 30kgP ha^{-1} and 120kgK ha^{-1} following the prearranged fertilizer application treatment schedule. Weeding was manual at two weeks and four weeks after transplanting while insect pest control was done once by spraying Rogor^R (a dimethoate) at the onset of flowering at the rate of 0.80l ha^{-1}.

At every harvest, fruits were sampled from each plot and assessed for percentage fruit cracking per plant, number of locules per fruit, number of seeds per fruit and shelf life under room temperature. The fruit pH was determined after blending, using a Pye Unicam digital pH meter while other biochemical characteristics and nutrient elements of the fruits were determined using the following methods: Soluble solids (Winsor and Massey, 1958), titratable acidity (Hobson and Kilby, 1984), soluble carbohydrates (Deriaz, 1961), and percentage Ca (Pearson 1976).

Experiment 2 (July–September 1992)

This was similar to the first experiment in design, cultural practices and parameters measured, but was however, a 5 X 5 factorial experiment with three replications. The treatments comprised five tomato cultivars namely: UN-83, Nsukka local, Rossol, NHle 7-7-1 and Ace VF, and five fertilizer application schedules namely: all fertilizers applied at transplanting; all fertilizers applied at two weeks after transplanting; one-half of the fertilizers applied at transplanting and one-half at flowering; one-half of the fertilizers applied at two weeks after transplanting and one-half at flowering; one-third of the fertilizers applied at transplanting, one-third at flowering and one-third at fruiting.

The data collected were statistically analyzed using the procedures outlined by Obi (2001) for a factorial experiment in a randomized complete block design. Separation of treatment means for significant effects was done using the least significance difference (LSD) procedure as described by Udom (2005).

RESULTS

Rainfall was high in September, low in August and moderate during the other months of the experiment (Table 1). Solar radiation and sunshine hours for the same period were considered adequate although radiation values for the months of July and August were lower than those of other months. Air and soil maximum temperatures for the study period were within the acceptable range (Asiegbu and Nwosu, 1990) but air minimum temperatures were rather high for tomato fruit induction.

The soils of the experimental sites were texturally sandy clay loam and acidic (Table 2). Soil N was low, K and Mg low to medium and P high. Lime application increased the soil pH to the recommended range of 5.5 – 7.0. Nutrient-wise, the soils of the experimental sites were poor, with low nutrient elements and organic matter (Table 2).

Interaction effects between tomato cultivars and scheme of fertilizer application were generally non-significant ($P>0.05$) in all the parameters investigated and were therefore not presented.

Table 1: Weather records of the field sites for the period of the experiments

Parameter	March	April	May	June	July	August	September
Total rainfall (mm month^{-1})	47.3	110.7	209.3	126.6	115.9	80.0	456.8
Solar radiation (cal cm^{-2} day^{-1})	640.8	706.2	644.7	522.9	463.5	416.4	510.8
Maximum air temperature (^oC)	32.74	31.5	30.23	28.23	25.94	25.1	27.1
Minimum air temperature (^oC)	20.47	21.13	21.13	20.83	20.94	20.34	20.3
Maximum soil temperature (^oC)	40.0	38.5	35.2	32.6	31.6	29.9	30.9
Minimum soil temperature (^oC)	30.1	30.3	28.3	27.2	25.8	24.9	25.5

Source: Meteorological Report 1992. University of Nigeria Meteorological Station, Nsukka, Nigeria.

Table 2: Mechanical and chemical properties of the experimental field soils

Mechanical properties	Experiment 1	Experiment 2
Coarse sand (%)	60	61.5
Fine sand (%)	12	10.5
Clay (%)	26	26
Silt (%)	2	2
Textural class	sandy clay loam	sandy clay loam
Chemical properties		
Nitrogen (%)	0.06	0.06
Organic carbon (%)	1.0	1.10
Organic matter (%)	1.72	1.90
Potassium (meq K $100g^{-1}$ soil)	0.20	0.22
Calcium (meq Ca $100g^{-1}$ soil)	0.80	1.20
Magnesium (meq Mg $100g^{-1}$ soil)	0.90	1.30
Sodium (meq Na $100g^{-1}$ soil)	0.24	0.28
Cation exchange capacity	6.5	8.0
Available phosphorus (meq kg^{-1} soil)	44	49
pH (soil:water; 1:2.5) before liming	4.6	4.8
pH (soil:0.1N KCl; 1:2.5) before liming	4.2	4.4
pH (soil:water; 1:2.5) ten weeks after liming	5.92	5.75
pH (soil:0.1N KCl; 1:2.5) ten weeks after liming	5.59	5.25

The tomato cultivars UN-83, Roma VFN and Ronita had little or no cracked fruits and fruits with significantly thicker mesocarp ($P< 0.05$) than Ife-1 and Nsukka Local, (Experiment 1) while NHle 7-7-1 and Rossol had significantly higher number of cracked fruits ($P<0.05$) than Nsukka Local (Experiment 2) (Table 3). Fruits of UN-83, Ronita and Roma VFN also had significantly lower number of locules and seeds ($P<0.05$) than Nsukka Local, Rossol, NHle 7-7-1 and Ife-1 (Experiments 1 & 2).

Whereas scheme of fertilizer application had non-significant effects ($P>0.05$) on the proportion of cracked fruits, delaying fertilizer application until two weeks after transplanting either in single dose or in split application significantly increased ($P<0.05$) the thickness of fruit mesocarp and reduced the number of locules and seeds per fruit when compared to fertilizer applications at transplanting (Experiments 1 & 2) (Table 4). On the average, single dose fertilizer application reduced the number of locules and number of seeds per fruit but had no consistent effects on percent fruit cracking and thickness of fruit mesocarp.

Table 3: Effect of tomato cultivar on percent fruit cracking, thickness of fruit mesocarp (cm), and number of locules and seeds per fruit

	Cultivar	Fruit cracking plant^{-1} (%)	Thickness of mesocarp (cm)	No of locules fruit^{-1}	No of seeds fruit^{-1}
Experiment 1	UN-83	NC*	0.35	3.4	102.8
	Nsukka local	10.0	0.24	8.9	228.6
	Roma VFN	NC	0.46	2.3	75.0
	Ronita	NC	0.47	2.3	85.3
	Ife-1	17.9	0.27	5.4	155.5
	$LSD_{0.05}$	**1.5****	**0.06**	**0.7**	**37.7**
Experiment 2	UN-83	10.8	0.49	2.9	116.1
	Nsukka local	15.4	0.31	9.3	254.1
	Rossol	27.2	0.22	8.2	228.6
	NHle 7-7-1	46.3	0.32	8.2	177.9
	Ace VF	23.2	0.33	3.3	109.8
	$LSD_{0.05}$	**8.7**	**0.05**	**0.9**	**35.4**

Legend: NC* = No fruit cracking; ** = LSD based on cultivars that produced cracked fruits.

Table 4: Effect of scheme of fertilizer application on percent fruit cracking, thickness of fruit mesocarp (cm), and numbers of locules and seeds per fruit

	Fertilizer application	Fruit cracking plant^{-1} (%)	Thickness of mesocarp (cm)	No of locules fruit^{-1}	No of seeds fruit^{-1}
Experiment 1	A-TWT	13.3	0.39	4.5	138.4
	H-TWT-FW	14.9	0.36	4.6	122.0
	T-TWT-FW-FT	13.9	0.36	4.3	135.8
	A-FW	13.8	0.37	4.4	121.6
	$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**
Experiment 2	A-TP	21.2	0.31	6.1	175.5
	H-TP-FW	24.2	0.32	6.7	194.1
	A-TWT	21.9	0.37	7.0	188.9
	H-TWT-FW	28.2	0.37	6.1	139.5
	T-TP-FW-FT	27.4	0.31	5.9	188.5
	$LSD_{0.05}$	**NS**	**0.05**	**0.9**	**35.4**

Legend: **A-TWT** = All at two weeks after transplanting; **H-TWT-FW** = Half at two weeks after transplanting and half at flowering; **T-TWT-FW-FT** = One-third at two weeks after transplanting, one-third at flowering and one-third at fruiting; **A-FW** = All at flowering; **A-TP** = All at transplanting; **H-TP-FW** = Half at transplanting and half at flowering; **T-TP-FW-FT** = One-third at transplanting, one-third at flowering and one-third at fruiting.

Fruits of the tomato cultivars, Ronita, Roma VFN, UN-83 and Ace VF had significantly longer shelf life (P<0.05) than those of Ife-1, Nsukka Local, Rossol and NHle 7-7-1 (Experiments 1& 2) (Table 5).

The fruit pH was significantly lower (P<0.05) in the cultivars Ife-1, NHle 7-7-1 and Ace VF, while Nsukka Local, Ife-1 and NHle 7-7-1 also had significantly lower titratable acidity (P<0.05)

Table 5: Effect of tomato cultivar on shelf life of fruits (days), percent fruit moisture, fruit pH and percent fruit titratable acidity

	Cultivar	Fruit shelf life (days)	% Fruit moisture	Fruit pH	% Fruit titratable acidity
Experiment 1	UN-83	18.5	96.7	4.20	0.46
	Nsukka local	12.4	96.6	4.22	0.24
	Roma VFN	21.0	96.7	4.27	0.38
	Ronita	23.4	96.5	4.22	0.33
	Ife-1	16.6	96.1	4.17	0.23
	$LSD_{0.05}$	**3.2**	**0.4**	**0.06**	**0.03**
Experiment 2	UN-83	11.8	96.6	4.20	0.25
	Nsukka local	8.5	95.7	4.23	0.23
	Rossol	8.7	95.2	4.21	0.30
	NHle 7-7-1	8.2	95.7	4.15	0.27
	Ace VF	11.0	95.7	4.15	0.29
	$LSD_{0.05}$	**1.5**	**0.3**	**0.06**	**0.01**

Although scheme of fertilizer application produced non-significant effects (P>0.05) on fruit moisture, fertilizer application at transplanting significantly reduced (P<0.05) fruit titratable acidity by approximately 7 – 10% and fruit shelf life by 19 – 23% compared with treatments where fertilizer application was delayed to two weeks after transplanting (Experiment 2) (Table 6).

Nsukka Local and NHle 7-7-1 had fruits of significantly lower soluble solids and soluble carbohydrates (P<0.05) compared with Roma VFN, UN-83 and Ronita which also had comparatively higher percent fruit calcium (Experiments 1 & 2) (Table 7). Fruits of Ife-1, Rossol and Ace VF showed good promise by their appreciable values in these biochemical attributes studied.

Fertilizer application treatments produced apparent non-consistent effects on fruit soluble solids but early application of fertilizer significantly increased (P<0.05) fruit soluble carbohydrates and significantly decreased (P<0.05) percent fruit calcium over delayed fertilizer application treatments (Table 8).

Table 6: Effects of scheme of fertilizer application on shelf life of tomato fruits (days), percent fruit moisture, fruit pH and percent fruit titratable acidity

	Fertilizer application	Fruit shelf life (days)	% fruit moisture	Fruit pH	% fruit titratable acidity
Experiment					
1	A-TWT	18.5	96.5	4.18	0.33
	H-TWT-FW	18.0	96.4	4.23	0.32
	T-TWT-FW-FT	18.3	96.6	4.25	0.33
	A-FW	18.6	96.5	4.21	0.33
	$LSD_{0.05}$	**NS**	**NS**	**0.05**	**NS**
Experiment					
2	A-TP	9.7	95.6	4.20	0.26
	H-TP-FW	10.8	95.7	4.20	0.26
	A-TWT	8.8	95.5	4.19	0.26
	H-TWT-FW	9.1	95.8	4.18	0.29
	T-TP-FW-FT	9.8	95.5	4.18	0.27
	$LSD_{0.05}$	**1.5**	**NS**	**NS**	**0.01**

Legend: A-TWT = All at two weeks after transplanting; **H-TWT-FW** = Half at two weeks after transplanting and half at flowering; **T-TWT-FW-FT** = One-third at two weeks after transplanting, one-third at flowering and one-third at fruiting; **A-FW** = All at flowering; **A-TP** = All at transplanting; **H-TP-FW** = Half at transplanting and half at flowering;: **T-TP-FW-FT** = One-third at transplanting, one-third at flowering and one-third at fruiting.

Table 7: Effect of tomato cultivar on fruit soluble solids (°brix), fruit soluble carbohydrates (%) and percent fruit calcium

	Cultivar	Fruit soluble solids (°brix)	(%) Fruit soluble carbohydrates	% Fruit calcium
Experiment				
1	UN-83	5.8	4.6	0.092
	Nsukka local	5.6	4.6	0.086
	Roma VFN	6.2	4.6	0.087
	Ronita	5.7	4.6	0.090
	Ife-1	5.7	4.9	0.089
	$LSD_{0.05}$	**0.4**	**NS**	**0.004**
Experiment				
2	UN-83	5.2	4.9	0.082
	Nsukka local	4.4	3.2	0.082
	Rossol	5.5	3.9	0.065
	NHle 7-7-1	4.3	4.1	0.061
	Ace VF	5.1	4.2	0.080
	$LSD_{0.05}$	**0.2**	**0.6**	**0.006**

Table 8: Effect of scheme of fertilizer application on tomato fruit soluble solids (^{o}brix), percent fruit soluble carbohydrates and percent fruit calcium

	Fertilizer application	Fruit soluble solids (^{o}brix)	% Fruit soluble carbohydrates	% Fruit calcium
Experiment 1				
	A-TWT	5.8	4.9	0.088
	H-TWT-FW	5.8	5.0	0.086
	T-TWT-FW-FT	5.9	4.1	0.092
	A-FW	5.7	4.6	0.089
	$LSD_{0.05}$	**NS**	**0.7**	**0.003**
Experiment 2				
	A-TP	4.8	3.9	0.062
	H-TP-FW	4.9	4.6	0.071
	A-TWT	5.0	3.1	0.075
	H-TWT-FW	4.8	4.0	0.080
	T-TP-FW-FT	4.9	4.7	0.082
	$LSD_{0.05}$	**0.2**	**0.6**	**0.006**

Legend: A-TWT = All at two weeks after transplanting; **H-TWT-FW** = Half at two weeks after transplanting and half at flowering; **T-TWT-FW-FT** = One-third at two weeks after transplanting, one-third at flowering and one-third at fruiting; **A-FW** = All at flowering; **A-TP** = All at transplanting; **H-TP-FW** = Half at transplanting and half at flowering; **T-TP-FW-FT** = One-third at transplanting, one third at flowering and one-third at fruiting.

DISCUSSION

Characters contributing to good tomato fruit quality have been reported (Villareal 1980; Fuchs *et al.* 1984; Lewis 1993; Smith 1994 and, Atherton and Rudich 1996) to include excellent red colour, high soluble solids, low pH, high titratable acidity, high soluble carbohydrates, low seed content, firm fruits (thick fruit mesocarp), crack resistance and long shelf life. These quality attributes besides being largely dependent on inherent genetic control (Gibrel, 1983; Hewitt and Carvey, 1987), have been reported to be influenced by the type, amount and time of fertilizer application (Vittum, 1963; Fritz and Habben, 1973).

Synder (2006) reported significant differences among tomato varieties in their susceptibility to fruit cracking and ascribed such differences to inherent genetic causes. However, fruit cracking is a physiological disorder arising essentially from deficiency in calcium nutrition that results in thinner fruit mesocarp (Fritz and Habben, 1973) and irregular environmental (temperature and water) regimes (Synder, 2006). As reported in this experiment, fruits of the cultivars UN-83, Roma VFN and Ronita, which showed little or no susceptibility to cracking also, had relatively higher fruit concentrations of calcium. The ability to absorb and mobilize calcium into the fruit obviously may differ among cultivars. The increased thickness of fruit mesocarp and higher fruit calcium concentration obtained with fertilizer applications at two weeks after transplanting would have resulted from an enhanced mobilization of calcium into the fruits due to a limited nutrient-N and –P availability at the fruit forming and bulking stages. Fatokun and Chheda (1983) had reported that high nutrient-N and –P availability at fruiting depressed fruit calcium concentrations.

Fruits of Roma VFN, Ronita, UN-83, and Ace VF, which had less numbers of locules and seeds, also had thicker mesocarps and higher calcium content. Asiegbu and Nwosu (1990) similarly associated lower number of locules and seeds, to fruits of thick mesocarp (firmer fruits), while Carolus (1975) and Mengel and Kirkby (1979) reported fruit calcium content as directly affecting fruit firmness. The increase in number of seeds with split fertilizer application could relate to a probably increased efficiency in P uptake, which was reported (Wilcox, 1984) to increase seed content of tomato fruits.

Davies and Hobson (1981) and Fuchs *et al*, (1984) reported that the keeping quality or shelf life of tomato fruits are determined primarily by the genetic make up of the variety. That fruits of the cultivars UN-83, Roma VFN, Ronita and Ace VF with longer shelf life also had higher fruit calcium concentrations and thicker mesocarps, corroborated the report by Brady (1987) that calcium supply limits wall hydrolysis in tomato fruits and that fruits of genotypes with less calcium concentrations softened and senesced more rapidly. The reduction in tomato fruit shelf life and percent fruit calcium by fertilizer application at transplanting agrees with the report by Fatokun and Chheda (1983) that high nutrient – N and – P availability depresses fruit calcium concentrations which according to Brady (1987) will consequently result to shortened shelf life.

The fruit pH and percent titratable acidity obtained were comparable with the values reported by NIHORT (1986) but were lower than those obtained by Asiegbu and Nwosu (1990). Fruits of the cultivars UN-83, Roma VFN and Ronita which were firmer and with thick mesocarps also had higher pH values. This was consistent with earlier reports (Villareal and Lai, 1979) that firm fruited tomato cultivars have higher pH values because of the lesser locular area, which normally contains most of the fruit acids.

It is therefore recommended that UN-83, Roma VFN and Ronita, which had good quality attributes, be adopted for rainy season tomato production in south-eastern Nigeria and similar agroecological zones. However, marginal and apparent non-consistent effects of time and mode of fertilizer application on the fruit quality characteristics studied appear to weaken the idea of splitting fertilizer application. Fertilizer application at two weeks after transplanting either in single full dose or in 2-split with the second split applied at flowering is therefore recommended since they optimized labour and enhanced quality. Finally, since a large variability existed in the fruit quality attributes studied, a breeding programme that could improve the quality of the large fruited cultivars of Rossol, Nsukka local, NHle 7-7-1 and Ife-1 will be highly advantageous to tomato production in the study area.

REFERENCES

Abani, M.S.C. (1985). The genetics of processing attributes in crosses among selected tomato lines (*Lycopersicon esculentum* Mill.) PhD Thesis, University of Nigeria, Nsukka.

Asiegbu, J.E. and Nwosu, V.C. (1990). Agronomic and quality evaluation of some tomato genotypes under late short growing season conditions of a tropical derived savanna. *Bionature* *10* (1 & 2): 7 – 11.

Atherton, J. G. and Rudich, J. (1996). *The Tomato Crop: A Scientific Basis for Improvement.* Chapman and Hall, New York.

Brady, C.J. (1987). Fruit ripening. *Annual Review of Plant Physiology* ***38***: 155 – 178.

Carolus, R. (1975). Calcium relationships in vegetable nutrition and quality. *Communications in Soil Science and Plant Analysis* ***6***(2): 285 – 298.

Davies, J.N. and Hobson, G.E. (1981). The constituents of tomato fruit – the influence of environment, nutrition and genotype. *CRC Critical Review of Food Science and Nutrition 15*: 205 – 280.

Deriaz, R.E. (1961). Routine analysis of carbohydrates and lignin in herbage. *Journal of the Science of Food and Agriculture* ***12***: 152 – 160.

FAO (2004). *Improving the Quality and Safety of Fresh Fruits and Vegetables:A Practical Approach.* FAO Sales and Marketing Group, Rome, Italy. 176p.

Fatokun, C. A. and Chheda, H. R. (!983). The effects of nitrogen and phosphorus on yield and chemical composition of okro [*Abelmoschus esculentum* (L.) Moench] *Acta Horticulturae* 123: 283 – 290.

Fawusi, M.O.A. (1977). Influence of plant density and time of fertilizer application on growth characteristics, nutrient uptake and yield of tomato. *Scientia Horticulturae 7* (4): 329 – 337.

Fritz, D. and Habben, J. (1973). Influence of fertilization on the quality of vegetables particularly for processing. ***Acta*** *Horticulturae 29*: 349 – 361.

Fuchs, Y., Barkai-Golan, R., Aharomi, N. and Rot, I. (1984). Keeping quality of tomato fruits as affected by harvest methods and transport conditions. *Acta Horticulturae 163*: 121 – 123.

Gibrel, G.F. (1983). The heritability of earliness, fruit size, yield and high processing quality in tomatoes as measured by early generation. *Dissertation Abstracts International 43*(10): 3085B – 3086B En.

Hewitt, J.D. and Carvey, T.C. (1987). Wild sources of high soluble solids in tomato. ***In***: Tomato Biotechnology vol. 4. Nevins, D.J. and R.A. Jones (Eds.), Alan R. Liss Inc., New York. Pp 45 – 54.

Hobson, G.E. and Kilby, P. (1984). Rapid assessment of tomato composition during high quality fruit production and distribution. ***Acta Horticulturae 163***: 47 – 54.

Jones, J. B. (1999). *Tomato Plant Culture*. CRC Press, LLC, Boca Raton, Florida. pp 1 – 3.

Lewis, R. G. (1993). Genetic Freshness: the Biotech Tomato Heads for the Market. ***Ceres***, Mar – Apr. 1993: Pp 10 – 12.

Mengel, K. and Kirkby, E.A. (1979). *Principles of Plant Nutrition* (2nd edition). Der Bund AG, Bern, Switzerland. 593p.

National Institute of Horticultural Research, (NIHORT) (1986). Vegetable Improvement: Tomato. *In*: Advances in Fruit and Vegetable Research at NIHORT (1976 – 1986). NIHORT, Idi– Ishin, Ibadan, Nigeria. Pp 23 – 36.

Obi, I. U. (2001). *Introduction to Factorial Experiments for Agricultural, Biological and Social Sciences Research* (2nd Edition).Optimal International Limited, Enugu, Nigeria. 92p.

Pearson, D. (1976). *Chemical Analysis of Foods* (6th edition). Churchill Livingstone, London. 575p.

Smith, A. F. (1994). *The Tomato in America*.University of Illinois Press, Urbana-Champaign, Illinois, USA. 387p.

Synder, R. G. (2006). *Greenhouse Tomato Handbook*. Publication No. P1828, Mississippi State University Press, Mississippi, USA. pp 24 – 28.

Udom, A. U. (2005). *Essentials of Statistics*. Magnet Business Enterprises, Enugu, Nigeria. 197p.

Villareal, R.L. (1980). *Tomatoes in the Tropics*. Westview Press Inc., Boulder, Colorado. 174p.

Villareal, R.L. and Lai, S.H. (1979). Development of heat-tolerant tomato varieties in the tropics. *In*: Proceedings of the 1st International Symposium on Tropical Tomato, Oct. 23 – 27, 1978 at Shanhua, Tainan, Republic of China. AVRDC Publication 78-59. Pp 188 – 200.

Vittum, M.T. (1963). Effect of fertilizers on the quality of vegetables. *Agronomy Journal* **55**(5): 425 – 429.

Wilcox, G.E. (1984). Nutrient uptake by tomatoes in nutrient film technique. *Acta Horticulturae 145*: 173 – 180.

Winsor, G.W. and Massey, D.W. (1958). Studies on the composition of tomato fruit. *In*: Annual Report, 1957, Glasshouse Crops Institute. Pp 40 – 52.