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EFFECTS OF WATER STRESS AND ORGANIC NITROGEN ON THE LEAF AND MINERAL CONTENTS OF TOMATO (*Lycopersicon esculentum* (L.)) VARIETIES

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ABSTRACT

The effects of water stress on leaf and mineral composition of tomato (*Lycopersicon esculentum*) varieties were investigated . The three varieties of tomato used were Beske, Ibadan Local and Roma VF sourced from local market at Ibadan. A 3 x 3 x 4 factorial experiment in a completely randomized design (CRD) was used for the experiment. All data collected were subjected to Analysis of Variance and the significant means were separated using the Least Significant Difference (LSD) at 5% probability level.The difference in the leaf nutrient content was not significant ($P<0.05$) within the varieties. Roma VF had the highest concentrations of nitrogen (2.61%), phosphorus (0.62%), calcium (3.18%) and potassium (2.02%). Ibadan Local had the highest manganese (134 ppm) and iron (133.55 ppm) while Beske had the highest copper (17.29 ppm) and zinc (28.17 ppm). The results showed that increase in organic nitrogen increased the concentration of calcium, sodium and copper while the concentrations of nitrogen, phosphorus, magnesium, potassium, iron and zinc decreased. The investigation also revealed that the concentrations of nitrogen (2.86%), potassium (2.16%), manganese (134.88ppm), copper (17.37ppm) and zinc (31.95ppm) were highest at 25 % field capacity while the concentration of phosphorus (0.54%), calcium (2.92%) and magnesium (0.50%) were highest at 100% field capacity but the concentration of iron (137.59 ppm) was the highest at 50% field capacity. The study showed that water is a limiting factor for proper physiological growth performance of tomato varieties.

INTRODUCTION

Tomatoes are eaten freely throughout the world, and their consumption is believed to benefit the heart among other things. They contain lycopene, one of the most powerful natural antioxidants. In some studies, lycopene, especially in cooked tomatoes, has been found to help prevent prostate cancer. Lycopene has also been shown to improve the skin's ability to protect against harmful UV rays. Natural genetic variation in tomatoes and their wild relatives has given a genetic treasure trove of genes that produce lycopene, carotene, anthocyanin and other antioxidants. Tomato varieties are available with double the normal vitamin C (Double rich), 40 times normal vitamin A (97L97), high levels of anthocyanin (P20 Blue) and two to four times the normal amount of lycopene (numerous available cultivars with the high crimson gene).

Tomato consumption has been associated with decreased risk of breast cancer, head and neck cancers and might be strongly protective against neurodegenerative diseases. Tomato is acidic; this acidity makes tomatoes especially easy to preserve in home canning as whole, in pieces, as tomato sauce or paste. Tomatoes are major food plants, so, extensive research is necessary to develop growing conditions in moderate drought to produce good vegetative growth (Ayers and Westcot, 1985).

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Inorganic nitrogen has been reported to pollute underground water, volatilize in high hence less than 30% is available to the plant. Whereas, organic sources of nutrients are ecolog and even organically produced crops attract higher premium in the market.

The main objective of this study was to determine the physiological response of tomato (L esculentum) to water stress under different rates of organic source of nitrogen.

MATERIALS AND METHODS

Collection of Seeds

The potted experiment was conducted in a water- controlled environment. Sample of top soil coll the teaching and research farm of the University of Agriculture, Abeokuta and was dried to con while the field capacity was determined and analyzed for nutrient composition.

The three varieties of tomato used were Beske, Ibadan Local and Roma VF. Clean, uninfected and fully ripe fruits of the three varieties were sourced from local market and extracted, washed and sun-dried for three days.

Nursery Establishment and Transplanting

The study was carried out from September, 2010 to December, 2010. Each variety of tomato was separate seed trays and transplanted at 4 weeks after planting (WAP). After establishment of seedl pots, they were watered every other day using varying water regimes.

Experimental Design

A 3 x 3 x 4 factorial experiment in a completely randomized design (CRD) was used for the experime

Treatments

Thirty - six (36) treatments were used including 3 varieties x 4 water stress regimes x 3 rates of requirements with 3 replicates.

Estimation of growth parameters

The plant parameters for estimating nitrogen and water stress are leaf nitrogen, leaf dry weight, leaf el and leaf area (Green, 1976). Parameters taken from each replicate were:

Plant Height: Plant height (cm) was determined using a meter rule by measuring the distance from soi the top of each of the plants.

Number of Branches: Number of branches per plant was determined by counting all the branches plant.

Leaf Length: Leaf length (cm) was determined by using a meter rule.

Leaf Width: Leaf width (cm) was also determined by using a meter rule.

Number of Flowers: The number of flowers at flowering period was counted and recorded.

Chlorophyll content: SPAD 500 chlorophyll absorbance meter was used for chlorophyll content determ y clamping over leafy tissues of leaves of each plant.

Destructive plant analysis

The harvested leaves were oven-dried (using the Selecta model 150- 900 L oven) at 80ºC to constant weight and ground into powder using Thomas Willey milling machine. Powdered samples were stored in sample bottles, kept in a dry place and assayed for concentrations of total N, P, K, Ca, Mg, Na, Mn, Fe, Cu and Zn using methods described by A.O.A.C. (1980), Novozansky *et al.*(1983) and Udo and Ojuwole (1986).

Determination of mineral composition

For the concentration of some of the mineral elements (sodium, potassium, calcium, magnesium and phosphorous), 0.2 g of each of the sieved sample was weighed into a 150 ml conical flask; 50 ml of the extraction mixture (sulphuric acid- selenium- salicylic acid) was added to the leaf sample and allowed to stand overnight. The mixture was heated initially at 30°C for 3 hours and 5 ml of perchloric acid ($HClO_4$) added. It was then heated vigorously until the digestion was completed. The solution was allowed to cool and filtered using an acid washed filter paper into a 50 ml volumetric flask and finally made to mark with distilled water.

Determination of potassium and sodium contents

The potassium and sodium contents of the leaves were determined using flame photometer. 5 ml of the digested extract was diluted to 50 ml with distilled water and the galvanometer reading taken using flame photometer by selecting the appropriate photocell (K and Na) at each time. Potassium and sodium standards were also prepared and used in the calibration of the equipment and for calculations. The standards were at concentrations of 0 ppm, 2 ppm, 4 ppm, 6 ppm, 8 ppm and 10 ppm.

Determination of calcium and magnesium content

The calcium and magnesium contents of the leaves were determined using the Versenate- Ethyl diaminate tri acetic acid method. 10 ml of the digested extract was pipetted into 150 ml conical flask, a pinch of potassium Ferro cyanide, potassium cyanide and hydroxylamine and hydrochloride added. 20 ml of ammonium buffer and a pinch of solochrome black indicator were also added and titrated with 0.02 M EDTA for both calcium and magnesium. The process was repeated, but 10% sodium hydroxide (NaOH) and solochrome dark blue indicator was used for the titration for calcium alone. The data obtained were analysed.

Determination of phosphorus content

The phosphorus content of the leaves was determined using the yellow calometric method. 5 ml of the extract was pipetted into a 50 ml volumetric flask.10 ml of vamado – molybdate yellow reagent was added and read in the spectrophotometer at 400 nm wave length. Working standards of 0 ppm, 2 ppm, 4 ppm, 6 ppm, 8 ppm and 10 ppm phosphorous standards were prepared and 10 ml of the reagent added and read in the spectrophotometer at 400 nm wave length. The standards were used to plot a curve for the calculations.

Estimation of leaf area ratio

Two types of measurement were used for leaf area ratio (i) the plant weight, that is the oven dry weight (g) and (ii) the size of the assimilating system, leaf area (cm^2). The leaf area ratio (LAR) was calculated for growth analysis.

The leaf area per plant was calculated using the traditional field method and applying:

A= [(L) (W) (0.75)] x 2.

A: Leaf Area

L: Leaf Length

W: Leaf Width
0.75: Constant

Leaf area ratio: The leaf area ratio (ratio of the assimilatory material per unit of plant material pre calculated using the following formula:

$$LAR = \frac{\text{Total leaf area}}{\text{Total dry weight}} = \frac{(cm^2)}{(g)}$$

Source of Organic Nitrogen

Poultry manure used as the source of organic nitrogen was collected from the battery cage poultry an to constant weight. The nutrient content in the manure was determined in the laboratory to get the q of manure to apply. Five kg of dry-sieved soil sample was filled into pots (108 pots in all) and manure based on recommended N (nitrogen) rate for vegetable (15 kgNha^{-1}) (Aduayi *et al.*, 2002). The mixture for two weeks in the pots for full decomposition before transplanting.

Statistical Analysis

All data collected were subjected to the Analysis of Variance and the means were separated where appro using the Least Significant Difference (LSD) at 5% probability level; the statiscal software (SAS) was

RESULTS

Effect of water stress and organic nitrogen content on Tomato

The nutrient content, organic nitrogen and water stress differed with varieties. Roma VF had the hi concentrations of nitrogen (2.61%), phosphorus (0.62%), calcium (3.18%) and potassium (2.02%). Th Local had the highest manganese (134 ppm) and iron (133.55 ppm) while Beske had the highest copper (ppm) and zinc (28.17 ppm).

The results indicated that the concentrations of nitrogen and calcium were higher than those o other nutrients. The concentrations of nitrogen (2.86%), potassium (2.16%), manganese (134.88 ppm), co (17.37 ppm) and zinc (31.95 ppm) were highest at 25 % field capacity while the concentration of phosph (0.54%), calcium (2.92%) and magnesium (0.50%) were highest at 100% field capacity; the concentratio iron (137.59 ppm) was the highest at 50% field capacity (Table 1).

The results also revealed that increase in organic nitrogen increased the concentration of calc sodium and copper while the concentrations of nitrogen, phosphorus, magnesium, potassium, iron and decreated. The highest concentrations of calcium (3.78%), sodium (9.99%) and copper (18.36 ppm) observed at 100% N while the highest concentrations of nitrogen (3.02%), phosphorus (0.65%), magnes (0.50%), potassium (2.44%), iron (158.05 ppm) and zinc (31.54 ppm) were recorded at 0% N (Table 1).

Table 1: Effects of variety, water stress and organic nitrogen on nutrient composition in tomato.

Treatments	% N	% P	% Ca	% Mg	% K	ppm Na	ppm Mn	ppm Fe	ppm Cu	ppm Zn
Variety										
Beske	2.59[a]	0.57[a]	2.87[a]	0.50[c]	1.72[b]	9.85[a]	106.42[b]	116.94[a]	17.29[a]	28.17[a]
Ibadan Local	2.60[b]	0.36[a]	2.53[b]	0.47[c]	1.91[c]	9.36[b]	134.58[b]	133.55[b]	13.21[b]	25.04[a]
Roma VF	2.61[a]	0.62[b]	3.18[c]	0.50[a]	2.02[c]	9.88[a]	104.70[a]	123.84[b]	17.11[a]	26.35[a]
Water stress										
25% field capacity	2.86[a]	0.53[b]	2.92[c]	0.48[c]	2.16[a]	9.72[a]	134.88[a]	135.01[a]	17.37[a]	31.95[c]
50% field capacity	2.68[b]	0.50[c]	2.87[a]	0.50[b]	1.88[b]	10.05[a]	119.07[b]	137.59[a]	14.86[b]	30.24[b]
75% field capacity	2.42[c]	0.51[c]	2.72[a]	0.48[c]	1.85[b]	9.38[a]	107.19[b]	104.17[a]	14.15[b]	21.70[b]
100% field capacity	2.44[a]	0.54[c]	2.92[a]	0.50[c]	1.64[b]	9.65[a]	99.79[a]	122.32[a]	17.12[b]	22.19[b]
Organic nitrogen										
0% Nitrogen	3.02[a]	0.65[c]	2.29[a]	0.50[c]	2.44[a]	9.24[a]	132.38[a]	158.05[a]	14.68[b]	31.54[a]
50% Nitrogen	2.75[a]	0.58[a]	2.81[a]	0.49[c]	2.01[a]	9.86[a]	94.40[b]	125.35[b]	14.58[b]	29.98[a]
100% Nitrogen	2.02[c]	0.32[b]	3.48[b]	0.48[c]	1.21[c]	9.99[a]	118.91[a]	90.92[c]	18.36[a]	18.05[b]

% = percentage; N = nitrogen; P = phosphorus; K = potassium; Mg = magnesium; Ca = calcium; Na= sodium; Mn= Manganese; Fe= Iron; Cu= copper and Zn= zinc.

Interactive effects of variety, water stress and organic nitrogen on leaf mineral contents of tomato

Table 2 shows that in Roma VF, nitrogen concentration was highest at 25% field capacity at 50% N (3.65%) and lowest at the same field capacity at 100% N. Phosphorus concetation was highest at 25% field capacity at 0% N (0.85%) and lowest at 100%N (4.63%); the lowest at 100% was found at 50% N (1.87%). The calcium concentration was highest at 100% N. Magnesium was highest at 75% field capacity at 50% N (3.72%) and lowest at 100% N at 50% field capacity. The highest concentration was observed at 50% N. Potassium had the highest concetration of 1.66% at 100% N at 75% field capacity and the lowest (0.30%) at 50% N at 25% field capacity. The highest concentration was at 100% N at all field capacities.

In Beske, nitrogen concentration increased with decrease in organic nitrogen in the field capacity. The highest concentration was recorded at 0% N of 25% field capacity (3.12%) and the lowest at 100% N of 100% field capacity (1.72%). Phosphorus had highest concentration of 0.88% at 0% and at 75% field capacity and the lowest of 0.27% at 100%N at 50% field capacity. The highest concentration was recorded at 0% N except at 100% field capacity where it was recorded at 50% N. Calcium concentration was highest at 100% N at all field capacities. The highest concetration was 4.50% at 100% N at 100% field capacity while the lowest of 1.54% was observed at 50% N at the same field capacity. Magnesium had the highest concentration at 50% N at 100% field capacity (3.10%) and the lowest at 100% N at 75% field capacity (0.45%). Potassium had highest concentration at 75% N at 100% field capacity (1.66%) and the lowest at 50% N at 25% field capacity (0.30%). The highest concetration was at 100 % N at all the field capacities (Table 2).

In Ibadan Local, nitrogen had the highest concetration at 25% field capacity at 0% N (3.55%) and the lowest at 100% field capacity at 100% N (1.40%). The highest was observed at 0% N at 25% and 50% field capacities; at 75% and 100% field capacity, the N concetration was 50% N. Phosphorus had the highest concetration of 0.56% at 50% field capacity at 0% N and the lowest at 75% field capacity at 100%N (0.10). The highest concetration was at 0% N at all but 25% field capacity where the highest concetration was observed at 50% N. Calcium was highest at 25% field capacity at 0% N (2.85%) and lowest at 50% N at 50% field capacity (1.80%). It was highest at 100% N at all field capacities. Magnesium had the highest concetration at 25 % field capacity at 0% (2.90%) and the lowest at 100% N at 50% and 100% field capacity (0.46%). The highest concetration was at 0% N at 100% and 25% field capacity; 50% N was observed at 50% and 75% field capacities. Potassium was highest at 25% field capacities at 100% N (1.77%) and lowest at 75% field capacity at 0% N (0.43%). The highest concetration was observed at 100% N across the field capacities (Table 2).

Table 2: Interactive effects of variety, water stress and organic nitrogen on leaf mineral contents of tomato.

Variety	Water Stress	Nitrogen	% N	% P	% Ca	% Mg	% K
	25% F. C	0% N	2.98^{c}	0.85^{c}	2.21^{b}	2.18^{a}	0.49^{c}
		50% N	3.65^{a}	0.65^{c}	2.64^{a}	3.12^{a}	0.30^{c}
		100% N	1.59^{b}	0.31^{c}	4.63^{a}	0.59^{c}	1.35^{b}
	50% F.C	0% N	3.08^{b}	0.62^{c}	2.84^{b}	2.48^{a}	0.51^{b}
		50% N	2.51^{b}	0.70^{c}	2.30^{c}	2.83^{a}	0.50^{c}
		100% N	2.10^{a}	0.36^{b}	4.55^{a}	0.48^{c}	1.19^{c}
Roma VF	75% F.C	0% N	2.58^{a}	0.74^{b}	2.55^{a}	2.38^{b}	0.52^{c}
		50% N	2.26^{b}	0.83^{b}	2.38^{c}	3.72^{a}	0.54^{c}
		100% N	2.54^{c}	0.54^{b}	3.50^{a}	0.49^{c}	1.66^{a}
	100% F.C	0% N	3.20^{a}	0.60^{b}	2.14^{a}	1.89^{b}	0.50^{c}
		50% N	2.52^{b}	0.64^{c}	1.87^{c}	3.47^{a}	0.54^{c}
		100% N	2.25^{b}	0.54^{c}	3.38^{b}	0.49^{c}	1.12^{a}
	25% F. C	0% N	3.12^{a}	0.69^{c}	2.83^{b}	1.70^{b}	0.48^{c}
		50% N	2.80^{b}	0.67^{c}	2.14^{a}	2.70^{b}	0.51^{a}
		100% N	1.93^{c}	0.47^{a}	3.57^{a}	0.52^{c}	1.30^{a}
	50% F.C	0% N	3.19^{a}	0.71^{a}	2.54^{a}	2.39^{a}	0.51^{c}
		50% N	2.55^{b}	0.64^{c}	1.65^{c}	3.02^{a}	0.53^{c}
		100% N	2.33^{b}	0.27^{b}	3.41^{a}	0.50^{c}	0.95^{c}
Beske	75% F.C	0% N	3.20^{a}	0.88^{b}	2.15^{a}	2.51^{a}	0.54^{a}
		50% N	2.77^{b}	0.40^{a}	1.67^{c}	1.91^{b}	0.47^{c}
		100% N	1.85^{c}	0.38^{c}	3.11^{a}	0.45^{c}	0.88^{a}
	100% F.C	0% N	3.05^{a}	0.63^{b}	2.30^{b}	2.53^{b}	0.51^{c}
		50% N	2.53^{a}	0.76^{c}	1.57^{c}	3.10^{a}	0.53^{a}
		100% N	1.72^{c}	0.37^{c}	4.50^{a}	0.48^{c}	0.63^{c}
	25% F.C	0% N	3.55^{a}	0.46^{a}	2.85^{b}	2.90^{b}	0.51^{b}
		50% N	2.94^{a}	0.49^{a}	2.37^{b}	2.40^{b}	0.47^{b}
		100% N	3.15^{b}	0.16^{c}	3.10^{a}	0.49^{c}	1.77^{a}
	50% F.C	0% N	3.43^{b}	0.56^{c}	2.64^{b}	1.96^{a}	0.50^{c}
		50% N	3.26^{b}	0.41^{a}	1.80^{b}	2.52^{a}	0.49^{c}
		100% N	1.64^{c}	0.21^{b}	2.70^{a}	0.46^{c}	1.05^{c}
Ibadan Local	75% F.C	0% N	2.30^{b}	0.36^{b}	2.01^{a}	2.17^{a}	0.43^{c}
		50% N	2.50^{b}	0.32^{b}	1.87^{b}	2.70^{a}	0.49^{c}
		100% N	1.74^{c}	0.10^{a}	2.46^{a}	0.39^{c}	1.47^{a}
	100% F.C	0% N	2.59^{b}	0.71^{c}	2.18^{a}	2.33^{b}	0.52^{c}
		50% N	2.74^{b}	0.43^{c}	1.86^{b}	2.23^{b}	0.48^{c}
		100% N	1.40^{c}	0.16^{c}	2.90^{a}	0.46^{c}	1.09^{a}

Interactive effects of variety, water stress and organic nitrogen on the leaf mineral contents of toma

In Roma VF, sodium concentration was highest at 25 % field capacity at 100% N (12.10 ppm) and lowest same field capacity at 0% N. Manganese had the highest concetration at 25 % field capacity at 100% N (1 ppm) and the lowest at 100% field capacity at 100%N (57.01 ppm). The iron concentration was highest a field capacity at 0% N and lowest at 100% field capacity at 100%N (13.51 ppm). Copper was highest at field capacity at 100% N (23.72 ppm) and lowest (12.38 ppm) at 100% N of 75% field capacity. Zinc had highest concetration of 41.50 at 50% N at 75% field capacity and the lowest (12.42 ppm) at 100% N at field capacity (Table 3).

In Beske, sodium concentration was highest at 50% N at 50% field capacity (13.71 ppm) and lo at 0% N of 75% field capacity (9.03 ppm). Manganese had the highest concentration of 220.58 ppm at 0% 50% field capacity and the lowest (66.07 ppm) at 50%N at 75% field capacity. Iron concentration was hig at 0% N (184.39 ppm) at 25% field capacity and lowest (58.58 ppm) at 100% N at 75% field capacity. Co had the highest concentration at 100% N at 75% field capacity (26.17 ppm) and the lowest at 50% N at field capacity (10.30ppm). Zinc had the highest concentration at 50% N at 25% field capacity (44.44 ppm) the lowest at 100% N at 75% field capacity (10.82 ppm) (Table 3).

Table 3 shows that in Ibadan Local, sodium had the highest concetration at 25% field capacity at N (9.89 ppm) and the lowest at 75% field capacity at 0% N (8.94 ppm). Manganese concetration was hig (284.58 ppm) at 25% field capacity at 100% N and lowest at 100% field capacity at 100%N (82.51 ppm). concetration was highest at 100% field capacity at 0% N (196.74 ppm) and lowest at 50% N at 50% f capacity (84.54 ppm). Copper had the highest concetration at 100% field capacity at 0%N (16.63 ppm) lowest at 0% N at 75% field capacity (9.48 ppm). Zinc was highest at 25% field capacity at 50% N (36.96 p and lowest at 75% field capacity at 100% N (10.51 ppm).

Table 3: Interactive effects of variety, water stress and organic nitrogen on the leaf mineral contents of tomato

Variety	Water Stress Regimes	Nitrogen Rate	ppm Na	ppm Mn	ppm Fe	ppm Cu	ppm Zn
Roma VF	25% F. C	0%	8.99^{b}	118.85^{a}	172.71^{a}	17.11^{c}	36.28ab
		50%	9.62^{b}	101.54^{a}	124.66^{a}	16.19^{c}	26.86b
		100%	12.10^{a}	119.02^{a}	45.28^{b}	21.65^{c}	17.77c
	50% F.C	0%	9.47^{a}	133.80^{a}	213.24^{a}	17.68^{c}	29.45c
		50%	9.29^{a}	100.72^{b}	154.61^{a}	12.38^{c}	32.81c
		100%	10.44^{a}	104.78^{b}	99.88^{a}	17.82^{c}	18.70c
	75% F.C	0%	9.32^{a}	114.82^{b}	185.58^{a}	17.54^{c}	33.77c
		50%	10.10^{b}	103.14^{a}	84.79^{a}	15.69^{c}	41.50c
		100%	9.80^{b}	103.83^{a}	105.47^{b}	12.73^{c}	16.13c
	100% F.C	0%	9.14^{b}	89.92^{a}	129.06^{a}	13.72^{b}	23.68c
		50%	10.20^{a}	108.92^{a}	157.27^{a}	19.13^{b}	26.83c
		100%	10.04^{c}	57.01^{b}	13.51^{a}	23.72^{a}	12.42b
Beske	25% F. C	0%	8.97^{a}	148.84^{a}	184.39^{a}	16.12^{c}	28.55c
		50%	9.09^{b}	116.22^{a}	96.04^{b}	15.04^{c}	44.44b
		100%	9.71^{a}	84.64^{a}	125.15^{a}	26.35^{a}	41.01c
	50% F.C	0%	9.33^{a}	220.58^{a}	154.88^{a}	15.38^{c}	58.59c
		50%	13.71^{a}	86.91^{b}	163.32^{a}	15.70^{c}	33.73c
		100%	9.85^{ab}	81.75^{c}	111.89^{a}	16.37^{a}	17.33^{c}
	75% F.C	0%	9.03^{a}	94.16^{c}	88.04^{a}	13.6^{c}	27.69^{a}
		50%	9.21^{a}	66.07^{c}	110.74^{a}	10.30^{c}	18.64^{b}
		100%	9.83^{ab}	93.53^{b}	58.58^{b}	26.17^{b}	10.82^{b}
	100% F.C	0%	9.27^{a}	140.93^{b}	138.63a	12.86^{b}	26.41^{b}
		50%	9.76^{a}	77.20^{c}	102.56^{a}	19.28^{a}	18.72^{c}
		100%	10.39^{a}	66.23^{c}	69.03^{b}	20.30^{a}	12.16^{c}
Ibadan Local	25% F.C	0%	9.89^{a}	148.19^{a}	176.44^{a}	12.43^{c}	29.15^{a}
		50%	9.40^{c}	92.02^{c}	153.90^{a}	15.58^{a}	36.96^{b}
		100%	9.68^{b}	284.58^{a}	136.53^{a}	15.89^{a}	26.58^{b}
	50% F.C	0%	9.29^{b}	133.36^{a}	146.45^{a}	13.56^{a}	34.45^{a}
		50%	9.54^{a}	84.84^{b}	84.54^{b}	12.03^{b}	28.78^{c}
		100%	9.48^{a}	124.90^{a}	109.50a	12.82^{b}	18.34^{c}
	75% F.C	0%	8.94^{b}	101.12^{a}	110.39^{c}	9.48^{c}	14.53^{c}
		50%	9.14^{c}	112.72^{b}	109.88^{a}	10.57^{a}	21.70^{a}
		100%	9.01^{b}	175.30^{a}	84.08^{a}	11.16^{c}	10.51^{c}
	100% F.C	0%	9.19^{a}	143.97^{a}	196.74^{a}	16.63^{a}	35.91^{b}
		50%	9.24^{b}	82.51^{b}	161.92^{a}	13.08^{c}	28.80^{b}
		100%	9.56^{b}	131.38^{a}	132.19^{b}	15.32^{b}	14.78^{a}

F.C=field capacity; N=nitrogen ; ppm = part per million = mg per litre

Effects of variety and water stress on leaf area ratio and chlorophyll content of tomato

The effects of water stress and variety on leaf area ratio of tomato is shown on Table 4. At100% field c and 100%N, Ibadan Local had the highest leaf area ratio of 14.53 while the lowest leaf area ratio of 4 observed at 25% field capacity and 0%N. At 100% field capacity and 100%N Beske had the highest le ratio of 25.21 while the lowest leaf area ratio of 4.20 was observed at 25% field capacity and 0%N. At 100 capacity and 100%N Roma VF had the highest leaf area ratio of 47.24 while the lowest leaf area ratio was at 25% field capacity and 0%N.

Table 4 also shows the interactive effects of variety, water stress and organic nitrogen on chlor content of tomato varieties at 10 and 12 WAP. At 100% field capacity and 100%N, Ibadan Local h highest chlorophyll contents of 43.77$\mu g\ cm^{-2}$ and 43.13$\mu g\ cm^{-2}$, respectively, while the lowest chlor contents of 34.47$\mu g\ cm^{-2}$ and 34.10$\mu g\ cm^{-2}$ were observed at 25% field capacity and 0%N. At 100% capacity and 100%N, Beske had the highest chlorophyll contents of 41.47$\mu g\ cm^{-2}$ and 39.60$\mu g\ cm^{-2}$, respec while the lowest chlorophyll contents of 32.90$\mu g\ cm^{-2}$ and 29.03$\mu g\ cm^{-2}$ were observed at 25% field ca and 0%N. At 100% field capacity and 100%N, Roma VF had the highest chlorophyll content of 43.53μg and 39.07$\mu g\ cm^{-2}$, respectively, while the lowest chlorophyll content of 32.33$\mu g\ cm^{-2}$ and 31.13$\mu g\ cm^{-2}$ observed at 25% field capacity and 0%N.

Table 4 : Interactive effect on variety and water stress on leaf area ratio and chlorophyll content of tomato (*Lycopersicon esculentum*).

Variety	Water Stress	Nitrogen Rate	Leaf Area Ratio	Chlorophyll content	
				8*	10*
ROMA VF	25% F.C	0% N	4.54 ᵃ	32.33 ᵃ	31.13 ᵃ
		50% N	7.9 ᶜ	35.57 ᶜ	33.60 ᶜ
		100% N	11.39 ᶜ	37.53 ᵇ	37.37 ᵇ
	50% F. C	0% N	6.56 ᶜ	33.10 ᵃ	31.77 ᵃ
		50% N	8.48 ᶜ	35.80 ᵇ	34.50 ᵇ
		100% N	15.94 ᵇ	37.60 ᵃ	37.57 ᵃ
	75% F. C	0% N	7.33 ᶜ	33.53 ᶜ	31.90 ᶜ
		50% N	9.07 ᶜ	36.43 ᵇ	35.50 ᵇ
		100% N	18.24 ᵇ	40.27 ᵃ	38.20 ᵃ
	100% F. C	0% N	7.34 ᶜ	35.40 ᶜ	33.03 ᶜ
		50% N	10.68 ᵃ	36.73 ᵇ	36.00 ᵇ
		100% N	47.24 ᵃ	43.53 ᵃ	39.07 ᵃ
BESKE	25% F.C	0% N	4.20 ᶜ	32.90 ᵃ	29.03 ᵃ
		50% N	7.67 ᶜ	34.30 ᶜ	33.87 ᶜ
		100% N	17.28 ᵇ	37.00 ᵇ	37.43 ᵇ
	50% F. C	0% N	6.30 ᶜ	33.03 ᵃ	30.10 ᵃ
		50% N	9.03 ᶜ	36.10 ᶜ	35.13 ᵇ
		100% N	18.59 ᵇ	38.73 ᵃ	37.43 ᵃ
	75% F. C	0% N	7.30 ᶜ	33.80 ᶜ	31.07 ᶜ
		50% N	12.10 ᵇ	36.50 ᵇ	35.37 ᵇ
		100% N	19.61 ᵇ	40.07 ᵃ	37.90 ᵃ
	100% F. C	0% N	7.43 ᶜ	34.07 ᶜ	33.63 ᶜ
		50% N	12.40 ᵇ	36.77 ᵇ	35.90 ᵇ
		100% N	25.21 ᵃ	41.47 ᵃ	39.60 ᵃ
IBADAN LOCAL	25% F.C	0% N	4.40 ᶜ	34.47 ᵇ	34.10 ᶜ
		50% N	5.60 ᶜ	38.20 ᵇ	37.20 ᵇ
		100% N	10.92 ᶜ	38.67 ᵃ	37.93 ᵃ
	50% F. C	0% N	5.34 ᶜ	35.13 ᶜ	34.10 ᶜ
		50% N	6.41 ᶜ	38.27 ᵇ	37.27 ᵃ
		100% N	13.08 ᵇ	38.87 ᵃ	38.57 ᵃ
	75% F. C	0% N	5.48 ᵈ	37.73 ᵇ	34.13 ᶜ
		50% N	6.46 ᶜ	38.63 ᵃ	37.53 ᵃ
		100% N	13.87 ᵃ	39.97 ᵃ	40.43 ᵃ
	100% F. C	0% N	5.57 ᵃ	37.97 ᵇ	35.03 ᵇ
		50% N	7.42 ᶜᵈᵉ	38.63 ᵃ	37.93 ᶜ
		100% N	14.53 ᵇᶜᵈᵉ	43.77 ᵃ	43.13 ᵃ

Means not followed by the same letter within a column are significantly different using LSD.
***=WAP: Week after Planting; F. C: field capacity; N: nitrogen.**

DISCUSSION

Effects of water stress and organic nutrient composition of the leaf of some varieties of tomato
The smaller leaf area transpires less water, effectively conserving limited water supply in the soil over a period (a mechanism called Leaf Area Adjustment) (Hopkin and Huner, 2004). The leaf area decreased increasing water stress. The water-stress treatment caused significant leaf senescence and shedding reduction in leaf initiation and expansion as the pots dried, which contributed to the reduction in leaf the water-stressed plants. This agrees with previous research by Boutraa (2010) and Human *et al.* Ibadan Local had the highest leaf area across the water-stress condition. Leaves fold at watering inte water stress increased. In terms of reduction in evaporation, plants showed an extreme reduction in leaf and width (reduction in evaporation area). Organic nitrogen rate increased the leaf area with Ibadan receiving a greater influence.

In addition to the decrease in leaf area, stomata of water-stressed plants have been reported to for longer hours of the day, contributing to decreased growth as a result of reduced carbon assimi (Costa *et al.*,2004). Leaf Area Ratio decreased as water stress increased. The highest leaf area ratio occ in Roma VF at 25% field capacity. Organic nitrogen influenced the variety Beske more than the other va

The sharp reduction in the level of DNA, RNA and protein in stressed conditions might have responsible for the arrest of various growth processes including a decrease in height, number of branches leaves and leaf area (Labidi *et al.* 2009).

Interactive effects of variety and water stress on leaf area ratio and chlorophyll content of tomato
The chlorophyll content also decreased with water stress. The Chlorophyll content of Ibadan Local was affected by water stress compared to Beske and Roma VF. Chlorophyll concentration is an index for evalua of source; therefore, a decrease of this can be considered as a non-stomata limiting factor in the dro stress conditions. There are reports about decrease of chlorophyll in the drought stress conditions (Ma *et al.*, 1981; Kuroda *et al.*, 1990; Majumdar *et al.*, 1991). In contrast, Boutraa (2010) reported that the maxim chlorophyll content was found at the severe water stress conditions in *Calotropis procera*. Organic nitro application increased the chlorophyll content of all the varieties, though; it was reported that nitrogen fertilizers generally cause reduction in proteins, alternating amino acid balance and consequently chang the quality of proteins which are the main elements in chlorophyll production (Cooper, 1974).

Honda (1971) reported that when plants were stressed to low internal water potential, uptake nutrients usually decreased due to diminishing absorbing power of roots. Bharambe and Joshi (1993) fo that the uptake of nitrogen, phosphorus, calcium and magnesium was adversely affected under the irriga treatments of decreasing soil water potential. Nahar and Gretzmacher (2002) reported that there was a tende of diminishing concentration of nitrogen, phosphorus, potassium, sulphur, sodium, calcium and magnes with increasing water stress by tomato plants. The result showed that water stress caused an increase in nitrogen, phosphorus, potassium, manganese, iron, copper and zinc but led to a reduction in the calci magnesium and sodium contents of the leaves of Beske variety. It caused an increase in the nitrogen, calci potassium, sodium and manganese but led to a reduction in the phosphorus, iron, copper and zinc cont of the leaves of Ibadan Local variety. In Roma VF variety, it caused an increase in the potassium, calci phosphorus, manganese, iron, copper and zinc but led to a reduction in the nitrogen and sodium content the leaves while there was no significant increase or decrease in magnesium. Singh and Singh (20 demonstrated that decreasing water supply resulted in an increase in nitrogen concentration, decrea potassium concentrations and variable effects of phosphorus, calcium and magnesium concentration plants. Inclan *et al.* (2005) observed that water stress led to significant increase in the phosphorus nitrogen content of plants. Xu and Zhou (2005) reported that water stress caused increased nitrogen contents of plants. Khalid (2006) reported that water stress caused reduction in the nitrogen and phosphorus contents of the leaves of plants. De Carvalho and Saraiva (2005) reported increased potassium, calcium and magnesium contents due to water stress. Paranychianakis and Angelakis (2008) reported that water stress resulted in increased level of sodium. Yu *et al*. (2007) observed that water stress caused reduction in the potassium, magnesium and sodium contents of *Robinia pseudoacacia*, which was explained to be due to decrease in the proportion of inorganic ions in osmotic adjustment and an increase in organic ions. Kaya *et al*. (2006) and Lee *et al*. (2006) reported reduction in the concentration of calcium in plant tissues especially the leaves, which was related to the reduction in root activity and leaf water potential due to water stress.

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