RESPONSE OF GROWTH AND YIELD CHARACTERS OF TOMATO (*Solanum lycopersicum* L.) VARIETIES TO NITROGEN RATES DURING THE RAINY SEASON

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Abstract
Field experiments were conducted at Bayero University, Kano (BUK) and the National Institute for Horticultural Research (NIHORT) sub-station, Bagauda, Kano, during 2014 rainy season to investigate the performance of tomato (*Solanum lycopersicum* L.) varieties during rainy season under different Nitrogen regimes. The treatment consisted of three varieties (Icrixina, RomaVF and UC82B) and four Nitrogen rates (0, 50, 100 and 150 kg ha^{-1}) factorially combinedand they were arranged in a randomized complete block design (RCBD), replicated three times. Application of nitrogen fertilizer significantly ($P \leq 0.05$) affected number of fruits plant^{-1}, average fruit weight, marketable fruit yield and fruit yield hectare^{-1} at both locations but did not significantly affect chlorophyll content (µg), leaf area, number of cracked fruits, blossom end rot and non-marketable fruit yield. Varietal differences were significant on leaf area and chlorophyll content at Bagauda. Number of fruit plant^{-1}, average fruit weight, number of cracked fruits, marketable fruit yield and yield hectare^{-1} were significant ($P \leq 0.05$) at BUK. No significant differences ($P \leq 0.05$) were observed among the varieties for leaf area, blossom end rot and non-marketable fruit yield at Bagauda. Application of 150 kg N ha^{-1} resulted in significantly ($P \leq 0.05$) higher fruit yield. The varieties Icrixina and RomaVF had more fruit yield compared to UC82B. Therefore, 150 kg N ha^{-1} is suggested for Icrixina and RomaVF varieties, respectively.

Keywords: Heat tolerant, Susceptible, *Solanum lycopersicum*, Nitrogen and Rainy Season.

Introduction
Tomato (*Solanum lycopersicum* L.) belongs to the family *Solanaceae* where pepper, potato, tobacco, eggplant and tomartillo belong (Taylor, 1986). It is one of the major commercial vegetable crops widely grown in Nigeria. Tomato can be produced successfully in Nigeria during the rainy and dry seasons. Rainy season tomato is a quite remunerative enterprise to the Nigerian farmers, but the supply is constrained by high temperature, low fruit set, low flowering, bacterial wilt etc. During the rainy season (June-September), fruit set is often poor probably due to high night temperatures. Shortage of tomato during off-season is mainly due to lack of water, especially rainfall for resource-poor farmers. However, high temperature and excessive humidity cause tomatoes to die off and stop setting fruit. Low tomato fruit supply due to a combination of many constraints often makes tomato become very expensive and scarce at such scarce periods,considering that on the average, the consumption of tomato in Nigeria is 10 grams per person per day (Olorunfemi and Ajibefun, 2007). FAO (2012) estimated the demand for fresh tomato fruit at 1,785 tons per day or 651,525 tons per annum for 178.5 million Nigerian people (World Population Review, 2014).Nigeria is also ranked second largest producer of tomato in Africa and thirtieth largest in the world, producing 1.701 million tonnes of tomato annually at an average of 25-30 tonnes ha^{-1} (FAO 2010).Tomatoes grow very well in the northern states of the country especially, Kano, Katsina, Jigawa, Zamfara, Bauchi,

Sokoto, Taraba states etc. However, Kano state is the largest producer; it has the comparative advantage for the production of Tomatoes on a commercial scale. Nitrogen (N) is one of the major elements for plant growth and development that has an important role in plant nutrition. Therefore, it is one of the yield-limiting factors for plant growth in many crops, especially in soils with low organic matter. Nitrogen deficiency generally stems from inadequate fertilizer application, denitrification by soil microbes, or leaching loss due to excessive rainfall. Although tomato is an important crop in Nigeria, little is known of its specific nitrogen fertilizer requirement during the rainy season. Current recommendation of N fertilizer for tomatoes in Nigeria was developed more than 10 years ago (Federal Ministry of Agriculture, 2012). Since then, many new tomato cultivars have been bred which have higher fruit yield potentials under high input system. A better understanding of N fertilizer requirement for tomato is necessary to develop more sustainable production practices. The specific objective of the study was to assess the response of growth characteristics and fruit yield of tomato varieties under varying nitrogen rates during rainy season.

Materials and Methods

Experimental Sites

The experiment was conducted during 2014 rainy season at the Research Farm of Bayero University, Kano (Latitude 11^0 58'N and Longitude $8^0$25'E) and the National Institute for Horticultural Research, Bagauda sub-station Kano, (Latitude 11°33´N and Longitude 8°23´E). Soils of the experimental fields were collected at 0-15cm and 15-30 cm depths prior to planting, for physico-chemical properties analyses as described by Sparks (1996), Bauder (1986), Sommers (1996) and Miller (1996).

Treatments and Experimental Design

The treatments consisted of three tomato varieties; Icrixina (heat tolerant), Roma VF (heat sensitive) and UC82B (heat susceptible) and four levels of N fertilizer (0, 50, 100, and 150 kg ha^{-1}) factorially combined and laid out in a randomized complete block design (RCBD) with three replications. The gross plot was 4.5 m x 4.0 m (18.0 m^2), i.e. each plot had six ridges of 4.0 m long and 48 plant stands per plot, while the net plot size for data collection was 1.5 m x 4.0 m (6.0 m^2) made up of 2 inner rows, giving 16 plant stands per net plot. Seedlings raised in nurseries were transplanted to the field when the rainfall was fully established at five weeks after sowing (WAS), at a spacing of 75 cm x 50 cm. Missing stands were supplied within a week of transplanting.

Fertilizer Application

NPK 15:15:15 fertilizer was applied at two weeks after transplanting(WAT) to supply 30kg each of N P and K, while the balance of nitrogen (20, 70 and 120 kg N) was applied in form of Urea (46% N) at three weeks after the first application.

Data Collection

Data were collected at three, six and nine weeks after transplanting on the following variables: leaf area (cm); measured using portable leaf area meter(YMJ-A/B model, Japan), chlorophyll content (µg); using leaf chlorophyll meter (Minolta SPAD 502). Number of fruit $plant^{-1}$ (counting the number of fruits per net plot/number of plant stand per net plot), number of cracked fruits, number of fruits with blossom end rot; (counting the affected fruits when they were approximately half their size). Marketable fruits (kg), non-marketable fruits (kg), and yield perhectare (ton); were measured using digital weighing scale (model: Soehnle-plateau, Capacity: 10kg/22 Ib).

Data Analysis

The data collected were factorially combined in RCBD and subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967). Duncan Multiple Range Test (DMRT) was used to compare the treatment means (Duncan, 1955) using Statistix 10 software.

Results and Discussion

Effect of Variety and Nitrogen Regimes on Leaf Area of Tomato

From the result obtained, (Table 1) shows that there were significant differences ($P \leq 0.05$) among the varieties in leaf area measured at BUK at 3 and 9 WAT. Icrixina was observed to have the lowest mean value (34.30b and 51.64b) respectively, while RomaVF and UC82B were statistically similar with mean LA of (68.44a and 88.51a)and (62.03a and 88.51a)respectively. However at 6 WAT no significant differences were observed. At Bagauda there were no significant differences at 6WAT among the varieties, while at 3 WAT; RomaVF had the highest mean value than the other two varieties which were statistically similar. At 9WAT RomaVF (88.51a) and UC82B (93.80) were similar but significantly ($P \leq 0.05$) higher than Icrixina. Nitrogen regimes had no significant effect on leaf area of tomato at both locations at each sampling period, though there was increase in leaf area as the nitrogen increased from 0 to 100 kg N ha^{-1}which generally decreased at 150 kg N ha^{-1}. Same trends as observed at BUK for variety and nitrogen regimes were observed at Bagauda. Severe N stress reduced tomato leaf area, biomass and fruit yield by 60 to 70% (Scholberg *et al.*, 2000). Leaf area was found to influence tomato yield. Radiation is one of the most important factors that contribute to crop yield, as it supplies the energy for photosynthesis and favor dry matter partitioning to fruits and other plant parts. Our result shows that, application of nitrogen contributed significantly to increase in leaf area which leads to increase in yield of tomato to certain level.

Effect of Variety and Nitrogen Regimes on Chlorophyll Content (µg)

From the results in Table 2, no significant differences were observed among the varieties and nitorigen levels throughout the sampling periods. However, chlorophyll contents appeared to be highest across all varieties at 6 WAT at BUK and Bagauda. Under stress chlorophyll content may drop sharply, resulting to bleaching and withering though it depend on the plant type and growth condition as reported by Chen, *et al.*, (2012). Anjum, *et al.*, (2011) also observed that Chlorophyll is one of the major components of chloroplasts with role in photosynthesis, and chlorophyll content is positively correlated with the rate of photosynthesis. Chlorophyll is an important pigment for photosynthesis of plants and its content and composition directly affects the photosynthetic capacity, nutrient level, growth and development of plants. The contents of chlorophyll as well as it proportion directly affects the selective light absorption and utilization in plants. The changes in temperature, light, water, fertilizer, plant type and other environmental conditions directly affect the synthesis of chlorophyll (Chu, *et al*. 1999). Addition of N was found to increase the content of chlorophyll in all the tomato varieties at both locations in all the periods under observation. It was observed to be high at six weeks after transplanting because that was the time when tomato plants are more active photosynthetically and more chlorophyll is an indication of more accumulation of assimilates that may lead to more productivity.

Effect of Variety and Nitrogen Regimes on Number of Cracked Fruit of Tomato

Table 3 presents the effect of variety and nitrogen regimes on number of cracked tomato fruits. From the results, there were significant differences among the varieties at BUK, where RomaVF (2.05) had higher number of cracked fruits which was significantly higher than Icrixina (0.75) but was the same with UC82B (1.00). However, no significant differences were observed at Bagauda among the varieties. Sunlight plays a role in the expression of this defect. Field-grown tomato fruits exposed to sunlight were more than twice as likely to develop cracks as shaded tomato fruits (Whaley-Emmons and Scott, 1997). From our study, application of nitrogen had no effect on number of cracked fruits. This was contrary to the finding of Ohta *et al*. (1993) who reported that an increase in the concentration of nutrients had cause cracking on cherry tomato fruit grown in hydroponics.

Effect of Variety and Nitrogen Regimes on Blossom End Rot of Tomato

Tomato varieties differed in their responses to blossom end rot disease (Table 3). At BUK, Icrixina and RomaVF had statistically similar blossom end rot but UC82B was significantly less resistant than Icrixina. Both Icrixina and RomaVF were resistant to blossom end rot of tomato with a disease severity score of 0.75b and 1.19ab, respectively. There were no significant differences observed among the varieties at Bagauda as all the varieties appeared resistant. Susceptibility to blossom-end rot varies among tomato varieties. Fast growing cultivars with extensive foliage and determinate cultivars which set all their fruit in a short period, are frequently affected. Tomato varieties with large amounts of foliage tend to be more susceptible to blossom end rot (Laurie, 2007). Also Cindy (2010) had reported differences among tomato varieties in their reactions to blossom end rot disease. Table 3 also shows that nitrogen rates had no significant effect on blossom end rot at BUK and Bagauda. Blossom end rot of tomato is usually most severe following drought stress or wide fluctuations in soil moisture (Laurie, 2007).

Effect of Variety and Nitrogen Regimes on Number of fruits per plant of Tomato

Icrixina variety statistically recorded the highest Number of fruits per plant (22.48a and 26.57a) than Roma VF (15.54b and 19.50) and UC82B (1.65c and 1.88c) in both the two locations respectively. This is in contrast to the findings of Enujeke and Emuh (2015) in which they evaluated five varieties of tomato and found UC82B recording the highest number of fruits. Olaniyi *et al.*, (2010) also observed UC82B to perform better and recorded the highest number of fruits per plant. Application of Nitrogen also had effect in both BUK and Bagauda. Based on our findings application of N up to 150 resulted in more number of fruits. This was in agreement with the findings of Masome (2013), where he observed in most traits, the use of nitrogen fertilizer (urea), 100 and 150 are the best. As such farmers could be encouraged to apply more N up to 100 kg N ha^{-1} or a little above that but, they should not exceed 150 kg N ha^{-1} for better yield.

Effect of Variety and Nitrogen Regimes on Marketable Fruit Yield

Marketable fruit yield is the major variable considered for selecting a particular variety for its commercialization and income generation capability. The difference among the varieties on marketable fruit yield was highly significant (Table 4). Icrixina produced the highest marketable fruit yield (1054.8) kg ha^{-1} at BUK and (1554.0) kg ha^{-1} at Bagauda with combined yield of 2608.80 kg ha^{-1}.

Table 1: Effect of Variety and Nitrogen Regimes on Leaf Area (cm^2) plant^{-1} of Tomato at BUK and Bagauda in 2014 Rainy Season

	BUK			BAGAUDA		
Treatments	**3WAT**	**6WAT**	**9WAT**	**3WAT**	**6WAT**	**9WAT**
Varieties						
Icrixina	34.30^b	93.20^c	51.64^b	28.47^b	71.22^c	34.54^b
RomaVF	68.44^a	132.70^a	94.30^a	62.03^a	101.83^b	88.51^a
UC82B	62.03^a	101.83^b	88.51^a	37.01^b	115.72^a	93.80^a
SE±	10.564	21.884	14.027	10.149	21.696	15.705
Nitrogen (kg ha^{-1})						
0	44.58	114.31	90.73	38.17	92.76	85.36
50	43.82	119.99	76.68	36.50	92.32	67.83
100	55.92	94.33	79.95	48.41	114.53	67.83
150	52.62	123.43	63.74	46.93	85.42	51.81
SE±	12.19	25.269	16.197	11.719	25.053	18.135
Interactions						
V*N	NS	NS	NS	NS	NS	NS

Means followed by different letter (s) differ significantly at P≤ 0.05 using DMRT and WAT= weeks after transplanting.

Table 2: Effect of Variety and Nitrogen Regimes on Chlorophyll Content (µg) of Tomato at BUK and Bagauda in 2014 Rainy Season

	BUK			BAGAUDA		
Treatments	**3WAT**	**6WAT**	**9WAT**	**3WAT**	**6WAT**	**9WAT**
Varieties						
Icrixina	50.56	72.08	48.19	27.02b	62.54	48.30
RomaVF	52.47	74.87	48.02	38.99a	59.88	48.47
UC82B	54.61	74.50	47.33	34.51a	59.88	48.10
SE±	5.759	4.2033	1.944	3.1578	2.2727	6.715
Nitrogen (kg ha^{-1})						
0	48.37	74.11	46.99	33.64	60.33	52.29
50	57.48	70.23	48.72	32.42	61.28	44.97
100	54.43	74.85	47.34	36.77	60.49	46.51
150	49.90	76.07	48.34	31.20	60.52	49.39
SE±	6.650	4.853	2.244	3.646	2.624	3.877
Interactions						
V*N	NS	NS	NS	NS	NS	*

Means followed by different letter (s) differ significantly at P≤ 0.05 using DMRT and WAT= weeks after transplanting.*= significant at 5%

Table 3: Effect of Variety and Nitrogen Regimes on Number of Cracked Fruits, Blossom End Rot and Number of Fruit plant^{-1} of Tomato at BUK and Bagauda in 2014 Rainy Season

	BUK			BAGAUDA		
Treatments	**CF**	**BER**	**NFPP**	**CF**	**BER**	**NFPP**
Varieties						
Icrixina	0.75^{b}	0.75^{b}	22.48^{a}	0.08	0.58	26.57^{a}
RomaVF	2.05^{a}	1.19^{ab}	15.54^{b}	2.08	0.25	19.50^{b}
UC82B	1.00^{ab}	2.50^{a}	1.65^{c}	0.33	1.16	1.88^{c}
SE±	0.596	0.706	1.521	1.119	0.553	1.375
Nitrogen (kg ha^{-1})						
0	1.22	1.44	6.84b	0.11	0.00	7.53d
50	2.07	1.59	10.34b	0.22	0.77	13.84c
100	1.11	2.11	17.62a	2.00	1.00	18.60b
150	1.11	0.77	18.10a	1.00	0.88	23.96a
SE±	0.689	0.815	1.756	1.119	0.639	1.587
Interaction						
V*N	NS	NS	**	*	NS	**

Means followed by different letter(s) in a column differ significantly at P≤ 0.05, CF=Cracked Fruits, BER=Blossom End Rot, NFPP= number of fruits per plant, ****=** significant at 1% and *= significant at 5%

Similarly, RomaVF produced 735.3 kg ha^{-1} at BUK and 938.60 kg ha^{-1} at Bagauda with combined yield of 1673.90 kg ha^{-1}. The lowest yield of 300.2 kg ha^{-1} at BUK and 160.60 kg ha^{-1} at Bagauda with combined yield of 460.80 kg ha^{-1} was produced by UC82B variety. In a varietal experiment conducted by Bhattarai and Subedi (1996) they reported that the marketable fruit yield of open pollinated tomato varieties grown in open field condition ranged from 0.1 to 12 t ha^{-1}. Many fold increase in fruit yield might be due to differences in variety and growing conditions during rainy season. Nitrogen was observed to have significant effect on weight of marketable fruit. Application of 50, 100 and 150 kg N ha^{-1} gave high yield than the control in both locations. In BUK 100 kg N ha^{-1}recorded the highest weight while 150kg N ha^{-1}produced heavier fruits in Bagauda. The fruits in Bagauda were observed to be heavier than those in BUK, This may be attributed to better soil and climatic condition in Bagauda.

Effect of Variety and Nitrogen Regimes on Non-marketable Fruit Yield

Non-marketable fruit yield is one of the major variables for selecting a particular tomato variety for fruit production. Surprisingly, 100 kg N ha^{-1}produced higher yield of non-marketable fruit, though it is statistically similar with 150 kg N ha^{-1}but significantly different from 0 and 50 kg N ha^{-1}at both locations. This result shows the negative impact of excessive nitrogen application as it was reported by Chen *et al.*, 1994, he observed that too much nitrogen causes excessive vegetative growth, delays maturity, increases lodging, fosters disease, and poses an environmental threat to surface. The difference among the varieties on non-marketable fruit yield was highly significant (Table 4). Icrixina yielded the highest non-marketable fruit yield of 120.02 kg ha^{-1} at BUK. Similarly, RomaVF produced 120.02 kg ha^{-1} non-marketable fruit yield at Bagauda. The lowest yields (61.23 and 57.71 kg ha^{-1}) were produced by RomaVF and Icrixina at BUK and Bagauda respectively. The results of the experiment revealed that the variety that produced higher marketable fruit yield also produced higher non-marketable fruit yield. In their work, Bhattarai and Subedi (1996) reported that the non-marketable fruit yield of open pollinated tomato varieties grown in open field condition ranged from 0 to 2.3 t ha^{-1}.

Effect of Variety and Nitrogen Regimes on Yield of Tomato

The overall fruit yield of the tomato varieties and nitrogen regimes are presented in Table 4. There were significant differences among varieties for fresh fruits: Icrixina produce significantly higher yield per hectare (4.02 and 3.73 ton/ha) than RomaVF (2.47 and 2.98 ton/ha) which was in turn higher than UC82B (0.56 and 0.57 ton/ha), at BUK and Bagauda. Wider variation was found on total yield ha^{-1} among the varieties and it varied from 0.56 to 4.02 t ha^{-1} at BUK Icrixina (being a heat tolerant variety) had the highest (4.02 t ha^{-1}) yield at BUK while UC82B (which was a heat susceptible) had the lowest (0.03 t ha^{-1}). RomaVF also produced remarkably high yield (2.47 and 2.98 t ha-^{1}) under BUK and Bagauda's conditions. Ruiz and Romero (1998) studied tomato cultivars and found that cultivar differences had significant effect on yield. The variation in yield may also be due to genetic differences among the varieties since they were grown under the same environmental conditions (Olaniyi and Fagbayide, 1999). Application of nitrogen (N) rates significantly affected total fruit yield/hectare of tomato.

Table 4: Effect of Variety and Nitrogen Levels on Weight of Marketable Fruits (kg), Non-Marketable Fruit (kg) and Yield hectare^{-1} (ton) of Tomato at BUK and Bagauda in 2014 Rainy Season

	BUK			BAGAUDA		
Treatments	**WOMF (kg)**	**WONMF (kg)**	**YPH (ton/ha)**	**WOMF (kg)**	**WONMF (kg)**	**YPH(ton/ha)**
Nitrogen (kg ha^{-1})						
0	222.22^{b}	66.44^{b}	0.54^{b}	105.60^{c}	66.44^{b}	0.23^{c}
50	879.33^{a}	74.70^{b}	2.74^{a}	886.50^{b}	74.89^{b}	1.63^{b}
100	951.50^{a}	108.31^{a}	3.00^{a}	1138.60^{ab}	110.29^{a}	3.69^{a}
150	734.11^{a}	98.46^{ab}	3.12^{a}	1407.10^{a}	93.37^{ab}	4.16^{a}
SE±	200.450	55.392	0.049	173.970	55.068	0.028
Varieties						
Icrixina	1054.8a	120.05	4.02a	1554.00a	57.71	3.73a
RomaVF	735.3a	61.23	2.47b	938.60b	123.95	2.98b
UC82B	300.2b	79.67	0.56c	160.60c	77.08	0.57c
SE±	173.59	47.971	0.034	150.660	47.690	0.024
Interaction						
V*N	*	NS	**	NS	*	**

Means followed by different letter (s) differ significantly at P≤ 0.05 using DMRT, WOMF= weight of marketable fruit, WONMF= weight of non-marketable fruit, YPH= yield per hectare. ****=** significant at 1% and *= significant at 5%.

At BUK, control (0 kg ha^{-1}) gave significantly lower fruit yield in comparison to other N rates. 50, 100, and 150 kg N ha^{-1} were not significant statistically, although higher N rate gave higher yield per hectare, while at Bagauda, increasing N from 0 to 150 kg N ha^{-1} increased yield, though the fruit yields between 100 and 150 N were not statistically different ($P \leq 0.05$). This study was in agreement with the findings of Biswas (2015), where he observed 150 kg/ha nitrogen to be the best compared to other nitrogen levels used in his experiment for growth and yield of BARI tomato-9. Also, Ahmad (1999) observed application of urea delayed flowering and fruit setting in both the varieties he used, but demonstrated positive influence on all the yield components. Differential performance of these varieties could be attributed to genetic variability, adaptability, morphological features, and physiological factors during the crop growth period. Haydar *et al*. (2007), Hidayatullah *et al*. (2008), Mehta and Asati (2008) and Ghosh *et al*. (2010) reported a wide range of variation for yield and fruit yield related traits in different tomato varieties in relation to nutrient supply .

Conclusion

Based on results obtained from this study, it could be concluded that the genotype 'Icrixna' which is heat tolerant proved to perform better under rainy condition in comparison to other investigated Varieties and the significant increases in yield components of tomato due to N application relative to the control confirm the deficiency of N in the soils of the study areas as indicated from the result of soil analysis. Application of 150 kg N ha^{-1} resulted in higher fruit yield. The varieties Icrixina and RomaVF as well as application of 150 kg N ha^{-1} is suggested for tomato production during rainy season in the study area.

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