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INTERACTIVE EFFECT OF NITROGEN SUPPLY AND VARIETIES ON FRUIT YIELD OF TOMATO (*Solanum lycopersicum*) DURING RAINY SEASON

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ABSTRACT
The use of nitrogen (N) fertilizer with suitable varieties contributes significantly to the proper growth and development of tomato production, with substantial gains in fruit quality and yield. However, incorrect use of N fertilizer synchronize with poor season specific variety under field conditions can hinder tomato fruit quality and yield, making it undesirable for economic value. The aim of this work was to study the interactive effect of different N doses and varieties on tomato fruit yield during rainy season. The experiment was conducted at teaching and research farm of faculty of agriculture, Bayero University Kano, Nigeria. The experimental design was a randomized block with 4 replicates: three tomato varieties (Icrixina, RomaVF and UC82B) and four doses of N (0, 50, 100 and 150 kg ha^{-1}) in a 3×4 factorial. The result shows that increased in N doses positively influenced Plant height with Icrixina being the tallest in comparison to other varieties. The chlorophyll content increase with increase in N level but no statistical difference among the varieties. For the interaction effect between N rates and varieties on number of fruits $cluster^{-1}$ (NFC), it was observed that under all N rates Icrixina and RomaVF were significantly had higher NFC than UC82B. Pertaining to the Number of fruits $plant^{-1}$ (NFP); when Icrixina fertilized at 150 kg N ha^{-1} it was observed to be significantly higher than 50 and 100 kg N ha^{-1} having control with lowest NFP. However, RomaVF produced NFP under 100 N ha^{-1} significantly higher than control but exponentially similar with 50 kg N ha^{-1} while UC82B linearly shows no significant difference within all N doses. Visibly, the fruit yield ha^{-1} (FYH) of Icrixina under 150 kg N ha^{-1} gave significantly higher yield than 0 and 50 kg N ha^{-1} but similar with 100 kg N ha^{-1} while RomaVF under 100 kg N ha^{-1} produced significantly higher yield than control but was statistically similar to 50 and 100 kg N ha^{-1}. Surprisingly, no significant difference observed among the N doses when UC82B was cropped and no varietal difference was observed under control and 50 kg N ha^{-1} among all the varieties for FYH. Conclusively, the varieties Icrixina and RomaVF had performed excellently compared to UC82B under 100 and 150 kg N ha^{-1}, respectively, hence, suggested during rainy season for sustainable tomato production.
Keywords: Icrixina; Interaction; Nitrogen fertilizer; Tomato; Rainy season; RomaVF; UC82B

INTRODUCTION

Nitrogen (N) fertilization has a strong impact on the development of tomato fruits and optimizing yields, and so necessitates appropriate management to obtain a stability between reproductive and vegetative development (Warner *et al.,* 2004). Inappropriate application of N fertilizer, both in low and excess, may have negative effects on tomato production and fruit quality (Arah *et al.,* 2015; Albornoz, 2016), while representing a potential risk to disease incidence (Cameron *et al.,* 2013; Flores *et al.,* 2005). Most of the studies reported the effect of N.P.K fertilizer on growth and yield as influenced by external factors, however, N fertilizer and varietal involvements was neglected, which must be considered in order to optimize N nutrition and fruit quality.

One of the factors that may interact with the absorption of nutrients in general, and N in particular, is the increase of high night temperatures (Gruda, 2005; Harel *et al.,* 2014; Zakari *et al.,* 2016). The increase in night temperature during rainy season is one of the environmental factors that most affects quality of tomato fruit and yield in semi-arid climates, becoming a limiting factor during wet season in Nigeria, especially for field grown vegetables (Harel *et al.,* 2014; Zakari *et al.,* 2017). Hence, the consequent increase in night temperature may interfere with basic physiological processes, leading to vaster competition for photoassimilates, and developing a negative impact on flowering, vegetative growth, fruit development and quality and as well as its composition (Stagnari *et al.,* 2015; Fu *et al.,* 2017). The use of heat tolerant tomato varieties curtails the flower abscission (abortion) and allows proper fruit setting during rainy season under field condition in an economic and efficient way (Zakari *et al.,* 2017,). For these processes to enhance and adapt the nutritional needs of the plant, and therefore they must be accompanied by understanding the N doses of fertilization requirement, although this is rarely studied in practice. The aim of this work is to evaluates the influence of N doses and its interaction with heat tolerant, heat insensitive and susceptible tomato varieties during rainy season, on the production and quality of tomatoes, taking into consideration fruit yield characters.

MATERIALS AND METHODS

EXPERIMENTAL SITES

The experiment was conducted during 2014 rainy season, at teaching and research farm of faculty of agriculture, Bayero University, Kano (Latitude 11^0 58'N and Longitude $8^0$25'E), Nigeria.

TREATMENTS AND EXPERIMENTAL DESIGN

The treatments consisted of three tomato varieties (Icrixina, Roma VF and UC82B) and four doses of N fertilizer (0, 50, 100, and 150 kg ha^{-1}), which were laid out in randomized complete block design (RCBD) and factorially combined with three replications. The gross plot was 4 m x 4.5 m (18 m^2) and consisted of six (6) ridges while the net plot size was 4 m x 1.5 m (6.0 m^2) comprised of 2 inner rows. Seedlings raised in nurseries were transplanted to the field when the rainfall was fully established (5WAS), at a spacing of 75 cm x 50 cm, giving 48 plants per plot. missing stands were supplied within a week of transplanting.

Description and Source of the Plant Materials

Icrixina: heat tolerant, determinate with round fruit in shape, small size and matures in 60-80 days to first harvest after transplanting. It is sourced from ICRISAT, Niger Republic.

RomaVF: heat insensitive, determinate with pear shaped fruit elongated fruit 65-70 maturity days to first harvest after transplanting. Roma tomato is a *Verticillium* and *Fusarium* wilt resistant (thus the VF in the name) (Chronica Horticulture, 2010). RomaVF is heat susceptible and sourced from Seed Project Company, limited, Hadejia Road, Kano.

UC82B: heat susceptible, determinate with squared fruit elongated cylindrical fruit with 70-80 maturity days to first harvest after transplanting. It is heat susceptible and sourced from Seed Project Company, limited, Hadejia Road, Kano.

FERTILIZER APPLICATION

NPK 15:15:15 fertilizer was applied at 2WAT to supply 30 kg each of N P and K, the balance of nitrogen 20, 70 and 120 kg N ha^{-1} was applied in form of Urea (46% N) at three (3) weeks after the first application. Data was taken on five tagged plants leaving plants from the row after the border row to avoid the border effect.

Plant height (cm): Height of the plants was measured from the base to the tip of the plant using a meter rule.

Leaf chlorophyll content (µg): This was determined by using leaf chlorophyll meter (Minolta SPAD 502).

Number of Fruits Cluster^{-1}: Three fruit bunches were chosen at random in each of the five tagged plants before first picking and average recorded. Number of fruits plant, mean fruit weight, total yield per plant and fruit yield plant

Number of Fruits Plant^{-1}: Number of fruits per plant= $\frac{\text{Number of fruits per net plot}}{\text{Number of plant stand per net plot}}$

Mean Fruit Weight (g): Average fruit weight was measured using digital weighing scale (model: Soehnle-plateau, Capacity: 10kg/22 Ib) and computed by using following formula.

$$\text{Mean fruit weight} = \frac{\text{Total fruit weight from all the pickings}}{\text{Total number of fruits from all the pickings}}$$

Total yield plant^{-1} (kg): Total fruit weight of five plants was obtained from net plot using digital weighing scale (model: Soehnle-plateau, Capacity: 10kg/22 Ib) and the divided by five and the mean recorded.

Fruit yield ha^{-1}: The entire fruits from the net plots were harvested at successive intervals at maturity and weighed. Total fruit yield was determined by pooling the individual yields. These was converted into t ha^{-1} and recorded.

$$\text{Yield hectare}^{-1}\ \text{(ton/ha)} = \frac{\text{Yield per net plot (kg)} \times 10{,}000}{\text{plot area (m2)} \times 1{,}000}$$

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967) SAS (SAS Institute, 2001). Duncan Multiple Range Test (DMRT) was used to compare the treatment means (Duncan, 1955).

RESULTS

The result from figure 1A shows no significant differences among the varieties under control, even though Icrixina and UC82B were superior than RomaVF, in terms of height. But, fewer than 50 and 150 kg N ha^{-1} increases the height of UC82B and Icrixina statistically at par recovered than RomaVF. However, under 100 kg N ha^{-1} Icrixina's height was significantly greater than the other varieties, which were statistically at par. Under RomaVF there were no significant differences among N regimes but under Icrixina 100 and 150 kg N ha^{-1} were similar but significantly higher than 0 and 50 kg N ha^{-1}, under UC82B, 50 and 150 kg N ha^{-1} were similar also but significantly higher than 0 and 100 kg N ha^{-1}. For the Chl content (Fig. 1B); under 0, 50 and 100 kg N ha^{-1} there were no significant difference among varieties. Under 150 kg N ha^{-1} RomaVF produced Chl significantly higher than UC82B but statistically similar to Icrixina. Under Icrixina there were no significant differences among N rates, but under RomaVF 150 kg N ha^{-1} was significantly higher than 50 kg N ha^{-1} but was at par with other N rates, however under UC82B control treatment was significantly higher than 100 and 150 kg N ha^{-1} but was at par with 50 kg N ha^{-1}.

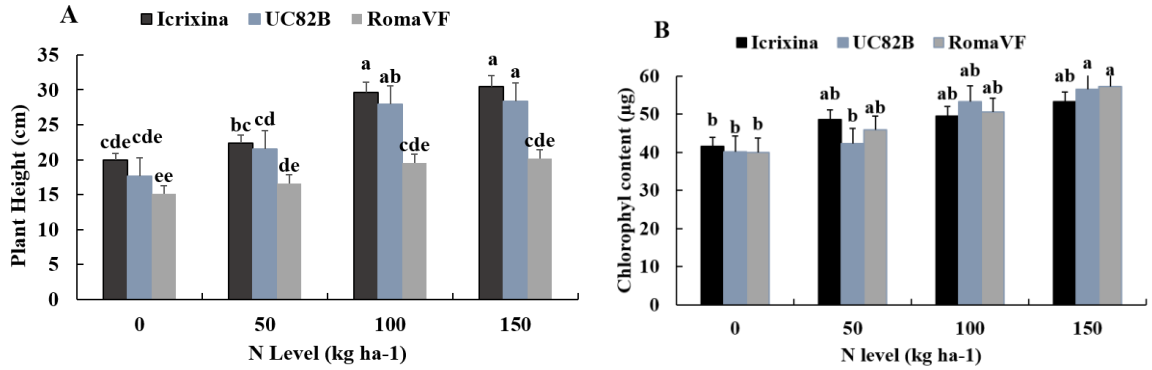

Figure 1. Variety*Nitrogen Interaction on Plant Height and Chlorophyll content of Tomato at BUK during the 2014 Rainy Season. Means followed by different letter(s) differ significantly at P≤ 0.05 using DMRT

The interaction effect between N rates and varieties on number of fruit per cluster from figure 2A; it was observed that under all nitrogen rates Icrixina and RomaVF were significantly had higher number of fruits per cluster than UC82B. Pertaining to the varieties, Icrixina had higher number of fruits per cluster under 50, 100, and 150 kg N ha-1 which was significantly higher than control, the trend was statistically similar with RomaVF and UC82B. Figure 2B shows the number of fruits per plant; when Icrixina fertilized at 150 kg N ha-1 was observed to have significantly higher fruits than 50 and 100 kg N ha-1 which were not. Control has lowest fruits. For RomaVF 100 and 150 kg N ha-1 were significantly higher than control but exponentially similar with 50 kg N ha-1 while UC82B linearly shows no significant difference within all N doses. Visibly, the various N rates shows Icrixina and RomaVF were statistically similar but significantly higher than UC82B under control, the trend was similar under 50 and 100 kg N ha-1. However, at 150 kg N ha-1 Icrixina significantly higher fruits than RomaVF and UC82B

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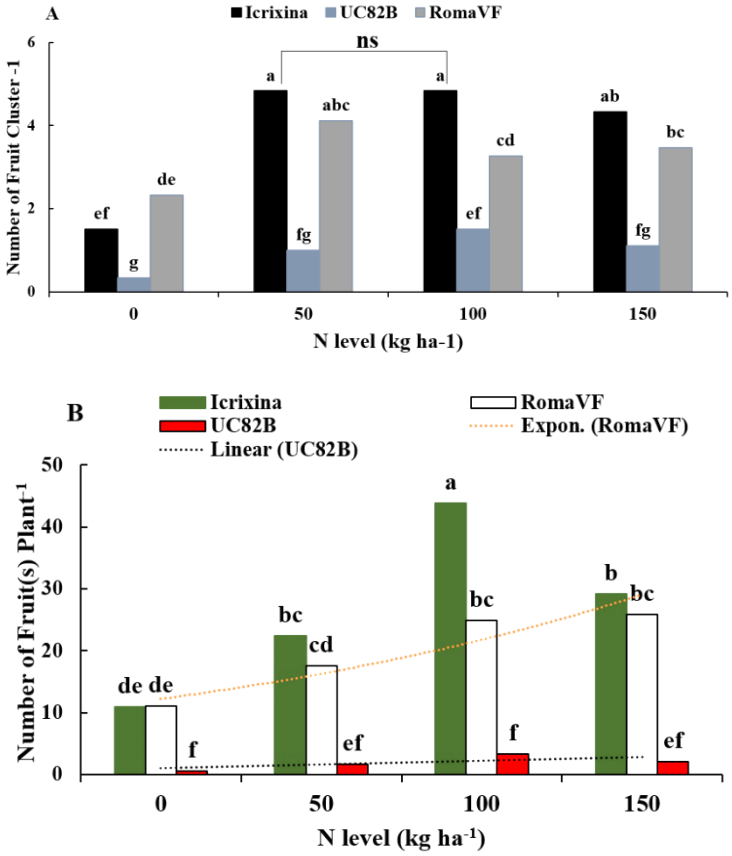

Figure 2. Interactive effect of Variety and Nitrogen on Fruit Cluster^{-1} and number of fruits plant^{-1} of Tomato at BUK during 2014 Rainy season. Means followed by different letter(s) differ significantly at P≤ 0.05

Interaction between nitrogen and variety on average fruit weight is shown in figure 3. Looking under control there were no significant differences observed among varieties, but at 50 kg N ha^{-1}, RomaVF was significantly higher than the other varieties which were at par. However, at 100 kg N ha^{-1}, UC82B and RomaVF were statistically similar but UC82B was significantly higher than Icrixina, while at 150 kg N ha^{-1} UC82B and RomaVF were similar but were significantly higher than using Icrixina. Looking at varieties Icrixina there were no significant differences among all the nitrogen rates, when RomaVF was used 50, 100, and 150 kg N ha^{-1} were statistically similar but significantly higher than 0 kg N ha^{-1}, using UC82B, 100 kg N ha^{-1} and 150 Kg N ha^{-1} were similar but 100 kg N ha^{-1} was significantly higher than 0 and 50 kg N ha^{-1}.

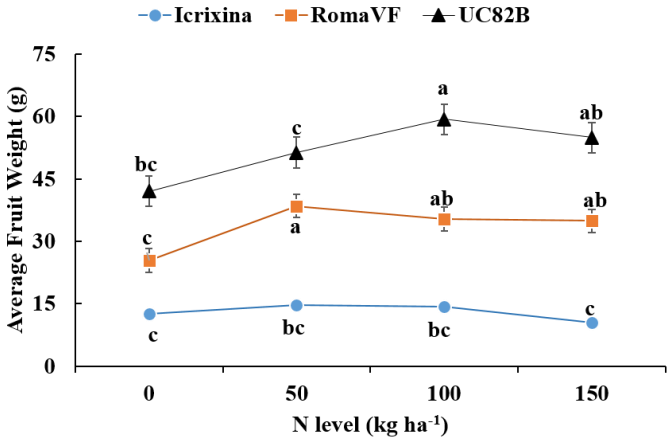

Figure 3. Variety*Nitrogen Interaction on Average Fruit Weight (g) of Tomato during the 2014 Rainy Season.

Table1 shows interaction between N and variety on total fruit yield plant^{-1}, when UC82B and Icrixina was supply with N from 0 to 100 kg N ha^{-1} it increases yield, further increase to 150 kg N ha^{-1} did not affect the yield per plant significantly. For RomaVF, the yield was highest when 150 kg N ha^{-1} applied, while 0 kg N ha^{-1} gave the lowest yield, the difference between the applications of 50 100 kg N ha^{-1} was not significant. Looking under control Icrixina and RomaVF were similar but significantly higher than UC82B. Under 50 and 150 kg N ha^{-1} no significant differences were observed among the varieties, but under 100 kg N ha^{-1} Icrixina has significantly higher yield than the other two varieties which are at par.

Table 1: Variety*Nitrogen Interaction Tomato on Total Yield Plant-1 (kg) of Tomato at BUK during 2014 Rainy Season.

	Nitrogen(Kg ha^{-1})			
	0	50	100	150
Varieties				
Icrixina	0.38d	0.74bc	1.01a	1.15a
RomaVF	0.32d	0.72bc	0.91a	0.83b
UC82B	0.03e	0.69c	0.75b	0.89ab
SE±	0.183			

Means followed by different letter(s) differ significantly at P≤ 0.05

The result in Table 2 shows the interaction of variety and nitrogen on yield hectare^{-1}, Icrixina under 150 kg N ha^{-1} gave significantly higher yield than 0 and 50 kg N ha^{-1} but similar with 100 kg N ha^{-1}. RomaVF under 100 kg N ha^{-1} produced significantly higher yield than control but was statistically similar to 50 and 100 kg N ha^{-1}. No significant difference was observed among the N doses when UC82B was cropped. Looking under control and 50 kg N ha^{-1} no significant difference was observed among all the varieties. Under 100 kg N ha^{-1} UC82B produce significantly lower yield than other doses which were statistically similar while at150 kg N ha^{-1} Icrixina produce significantly higher yield than RomaVF and UC82B which were statistically at par.

Table 2: Variety*Nitrogen Interaction Tomato on Total Yield Hectare t ha^{-1} of Tomato at BUK during 2014 Rainy Season.

	Nitrogen(Kgha^{-1})			
	0	50	100	150
Varieties				
Icrixina	0.78cd	3.58bc	4.47ab	5.72a
RomaVF	0.40d	3.74bc	3.94abc	1.79bcd
UC82B	0.44d	0.69cd	0.79cd	0.31d
SE±	0.084			

Means followed by different letter(s) differ significantly at P≤ 0.05

DISCUSSION

Relative to the vegetable size and chlorophyll content, some authors found that higher N doses of above 150 kg ha^{-1} in tomato field experiments increased plant height by 50% coherently with chlorophyll content when compared to the control (0 kg ha^{-1}) with no N applied, depending on the variety (Warner, 2004; Najafvand *et al.,* 2008; Albornoz, 2016). In the present experiment, the varieties showed trends in plant growth, with tallest variety recorded from Icrixina and UC82B varieties when treated with 150 kg N ha^{-1}. while Icrixina and RomaVF being able to recorded higher chlorophyll. This explaining that decreasing the content of chlorophyll under low N supply resulted in minimal photosynthetic activity, and the taller the variety the lower the photosynthesis, this was in line with finding of Hernández, et al. (2019). The phenomenal height and chlorophyll increment in Icrixina might be due to high N uptake that progressively enhanced the vegetative growth of the plant in tomato as reported by Nemomsa and Tesfaye 2019. Supply of major nutrients such as N resulted in enhanced fruit formation (Balemi, 2008). In the present studies, remarkably, Icrixina produced optimum number of fruit cluster^{-1} and plant^{-1} under 100 kg ha^{-1}, while those of UC82B and RomaVF increases with increase in N rates. These findings were in agreement with that of Satpal and Saimbhi (2003), Aminifard *et al*. (2010), Kumar *et al*. (2013) stated that N enhanced the reproductive growth in tomato and the fact that N is the element absorbed in larger quantity by Solanaceae family fundamentally for fruit growth (Campos *et al.,* 2008).

On the other hand, Icrixina producer higher number fruits in comparison to the other varieties under 100 kg N ha^{-1}, evidently proved that Icrixina has a lower N requirement than RomaVF and UC82B, thus, might be due to genotypic differences.

Application of N fertilizer not only influences the fruit setting but also initiates fruit biomass and the response of N varied with change in varieties (Henareh, 2015; Nemomsa and Tesfaye 2019). Presently, the heaviest average fruit weight was recorded from UC82B where the order of differences among the three varieties was UC82B > RomaVF > Icrixina under all the N doses. Correspondingly, 100 kg N ha^{-1} gave highest average fruit weight for all the three varieties. Therefore, the average fruit weight substantial increases observed in UC82B was as a consequence of the decrease in the number of fruits with decreasing N dose and could be explained by a mobilization of carbohydrate reserves stored in stems and leaves towards the remaining fruits, in addition to high water content. Similar results were obtained from Kumar *et al.* (2010) and Hernández *et al.,* (2019). On the other hand, under 100 kg N ha^{-1}, the dose of N could favour the maintenance of vegetative growth at the expense of fruit weight and the average weight reached a value similar to that obtained in the treatment 150 kg N ha^{-1} dose. The result of analysis showed that, there was significance ($P<0.05$) difference among N treatments in influencing yield of tomato varieties; the highest fruit yield $plant^{-1}$ was recorded from Icrixina (1.15 to 1.53 kg) treated with 150 kg N ha^{-1} whereas; the lowest was from the control (0.38 to 0.75 kg). However, this variety was more responsive to N since it produced the heaviest individual fruit (24.42 g) along with reasonable higher fruit yield per plant (0.31 kg). Nevertheless, for RomaVF the highest yield was obtained from 100 kg N ha^{-1} of 0.91 kg and 0.91 t ha^{-1} for yield $plant^{-1}$ and ha^{-1}, respectively. This result revealed that the gradual increase in yield of tomato with the rate of N fertilizer up to optimum level. This result was in line with the finding of Biswas *et al.,* (2015) who reported that the highest fruit yield from the plot treated with 150 kg and 108.6 kg N ha^{-1}.

CONCLUSION

Yield potentiality of the varieties Icrixina and RomaVF during rainy season clearly indicated that these varieties could be grown during rainy season with application of 100 and 150 kg N ha^{-1} since they produced more yield of fruits $plant^{-1}$.

Conflict of Interests

The authors declare that they have no conflict of interests regarding the publication of this paper.

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