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# EVALUATION OF GERMINATION, GROWTH AND FLOWERING CHARACTERISTICS OF SELECTED TOMATO GENOTYPES IN A HIGH RAINFALL REGION

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## ABSTRACT

This research was conducted to evaluate germination, seedling growth, vegetative and flowering characteristics of five tomato genotypes - NHTO 0201, NHTO 0294, B52, Thorgal $F_1$ hybrid and Cameroun. Seedlings from the nursery were transplanted into bags filled with 10 kg soil, replicated 6 times and laid out using the completely randomised design (CRD) in the field. Data collected from seedlings were percentage germination, days to first and last seedling emergence, height, number of leaves and seedling vigour index (SVI). At 50% flowering, plant height, number of leaves/plant, primary branches/plant, days to 50% flowering, flower clusters/plant and flowers/plant were gathered. Data were analysed using the analysis of variance (ANOVA) test. Means were compared using the least significance difference (LSD) at p = 0.05. Germination percentage and seedling characteristics did not differ significantly amongst genotypes. Significant correlations were observed between germination and SVI (r = 0.939*) and between days to the first and last seedling emergence (r = 0.895*). There were significant differences in leaves/plant and primary branches/plant but not flowering characteristics. Plant height and days to 50% flowering correlated significantly (r = 0.889*). Plant height, primary branches/plant (r = 0.978**) and flower clusters/plant and flowers/plant (r = 0.975**) were highly and significantly correlated. Selection pressure could be directed to characteristics with positive correlations.

**Keywords**: Tomato genotypes; seedling emergence; seedling vigour index; vegetative and flowering characteristics; high rainfall region
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## INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is cultivated worldwide, extensively utilised globally, providing nutritional benefits and significant income (Amurtiya and Adewuyi, 2020; Mauro *et al*., 2020; Ali *et al*., 2021). However, its productivity and yield under field cultivation are seriously impacted by biotic (diseases and pests) and abiotic pressures (salinity, drought, high rainfall, relative humidity, high and low temperatures) which critically impact germination, seedling establishment, vegetative and early reproductive growth, making field cultivation really challenging (Goddek *et al*., 2023; Abbas *et al.*, 2024), especially in a hot and humid region with high rainfall typical of Port Harcourt, Rivers State, Nigeria. Prolonged heat affects vegetative and reproductive traits of tomato negatively causing critical decline in the functions of almost all reproductive traits such as pollen viability, number of pollen grains, female fertility, amount of flowers/ inflorescence and seed fruit set (Ayankojo and Morgan, 2020).

Short-term heat stress negatively affects vegetative traits and seedling survival. High rainfall intensity and extreme humidity leads to increased disease incidence (Maxim *et al*., 2023), although the effects of rain, humidity and temperature depend mainly on the growth stage of tomato and especially on the nature of the genotype (Hoshikawa *et al*., 2021). The inability to identify tomato genotypes combining adaptation to the humid high rainfall of Rivers State with high-yielding potential, has been an impediment to large-scale tomato production in the area. Systematic breeding to improve tomato production in adverse climatic conditions require information on conditions affecting vegetative growth and flowering leading to fruiting, fruit quality and yield (Ayankojo and Morgan, 2020; Bhandari *et al*., 2021). Germination, seedling vigour and establishment, vegetative growth and flowering are crucial physiological stages of tomato growth and development; therefore, quick and even germination and establishment of seedlings are vital to increase the quality and yield of tomato (Javed and Afzal, 2020). Two of the foremost tests performed to ascertain the quality of good, healthy seeds are the germination and seedling vigour tests (Silva *et al*., 2019) because germination and growth of seedlings are important stages in successful plant establishment and good vigour in the field (Zhou *et al*., 2019). Farmers need every available seed to produce a vigorous and healthy seedling that grows into a well-formed mature tomato plant. High percentage germination and seedling vigour index are indicative of competitive ability of crops over weeds because they influence yield by enhancing crop population density in the field (Wilson, 2022). Agronomic traits are good indicators to assess adaptation of crops to specific growing conditions (Nkansah *et al*., 2019). The objective of this research was to evaluate five tomato genotypes for germination, growth and flowering dynamics in a humid high rainfall region.

## MATERIALS AND METHODS

This research was carried out in the Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt, a high rainfall and humid rainforest region of Nigeria between September 2021 and February 2022. Port Harcourt (Latitude 4.847$^o$N & Longitude 6.975$^o$E) has high rainfall all-year-round ranging from 2,369 mm - 2,500 mm per annum; annual temperatures range from 25$^0$C to 28$^0$C; relative humidity of 80 - 85% and minimum daily solar radiation of 4 hours.

### Experimental Materials

Five genotypes of tomato were used in this experiment; three improved local genotypes - NHTO 0201, B52, NHTO 0294 from the National Institute for Horticultural Research and Training (Genetic Resource Unit), Ibadan, south-western

Nigeria; and one exotic variety - Thorgal $F_1$ hybrid from Agriseed Ltd. (Technisem, France) while Cameroun is grown locally.

**Seedling Establishment**

In September, seedlings of the five tomato genotypes were raised in soil inside perforated plastic dishes of 16 cm by 10 cm by 5 cm at five seeds per container and watered as needed in the open field. The five treatments were replicated 6 times and seedlings were grown for 5 weeks before transplanting.

**Transplanting of Seedlings**

Five weeks after sowing, seedlings were transplanted at the rate of one seedling per bag, into bags filled with 10 kg of sandy-loam soil. The five treatments were replicated 6 times and arranged in a Completely Randomised Design in the field. No chemicals, insecticides, fertilizers or manures were applied.

**Data Collection and Statistical Analysis**

The data collected included daily seed germination (emergence of hypocotyls from the soil). Percentage germination was calculated using the formula: Percentage Germination = (n/N) x 100, with n as the number of seeds germinated and N as the total number of seeds sown in each experimental unit. The days to first and last seedling emergence and final germination percentage were also determined. Also measured at transplanting of seedlings, five weeks after sowing, were the number of leaves per seedling and seedling height. The seedling vigour index (SVI) was calculated as follows: SVI = (Seedling height x percentage germination)/100 (Wilson, 2022). The remaining data collected at 50% flowering of tomato included number of leaves/plant, primary branches/plant, plant height, days to 50% flowering, flower clusters/plant and flowers/plant. Data were suggested to ANOVA test in a CRD with Statistical Analysis Software (SAS, 2010). The means were compared using the LSD at p= 0.05. Linear correlation at p= 0.05 and p= 0.01 was used to test the relationships between the parameters.

## RESULTS AND DISCUSSIONS

**Germination and Seedling Characteristics of Tomato Genotypes**

The Cameroun genotype had the highest percent germination of 80% while B52 genotype had the lowest percentage of 68.8% (Table 1). Percent germination of genotypes did not differ significantly (p> 0.05). The B52, NHTO 0294 and Thorgal $F_1$ hybrid emerged 4 days after sowing (DAS) whereas others emerged 6 DAS (Table 1). The last seedling of B52 emerged 5 DAS- the fastest to emerge and complete germination. The last seedling of NHTO 0201 emerged 8.7 DAS –the last and slowest (Table 1). However, days to first and last seedling emergence did not differ significantly (p> 0.05) between genotypes. The B52 had the tallest seedlings (8.2 cm) while NHTO 0201 had the shortest 5.9 cm (Table 2). The B52 and NHTO 0294 had the highest number of leaves (5.2) and NHTO 0201 the lowest (3.4) (Table 2). The B52 had the highest seedling vigour index (SVI) value of 5.64 while NHTO 0201 had the lowest value of 4.11 (Table 2). There were no significant differences p> *0.05*) between the genotypes in height of seedlings, number of leaves and SVI, as also reported by Waiba and Sharma (2020). Farmers need healthy and vigorous seedlings to mature into healthy plants from every seed sown. Low percentage germination and low SVI are the first negative performance indicators that point to imminent and possible crop or yield loss from the farmer's investments in seed, land, labour and other inputs (Singh *et al.*, 2016). Average germination percentage was 88.46%. Waiba and Sharma (2020) reported 82% average percentage germination and concluded that tomato seeds had 50% germination within 5 days. In this study, all genotypes germinated within this period averaging 4.8 days. Crop failure and economic loss begin with poor stand establishment and inadequate plant population in the field. Therefore, quick, uniform and optimal seedling establishment in the field is a most crucial stage of any crop production system. Greenhouse tomato production can also be affected by poor quality of seedlings as it leads to waste of space, inputs and materials.

**Correlation Analyses of Percentage Germination and Seedling Characteristics**

The simple linear correlation coefficient matrix of seed germination and seedling characteristics is presented in Table 3. There were positive and significant correlations between days to first seedling emergence and days to last seedling emergence ($r = 0.895^*$) and between percentage germination and seedling vigour index ($r = 0.939^*$). Other parameters showed no significant correlations as reported by Diel *et al*. (2022). The positive and significant correlations indicate that a positive relationship exists between these two characters with a correlation coefficient of 89.5% and 93.9%, respectively.

**Vegetative and Flowering Characteristics of Tomato Genotypes at 50% Flowering**

At the vegetative and flowering stages of growth and development, the tomato genotypes began to show distinct and significant variations in their characters. Nkansah *et al*. (2019) noted that agronomic traits are suitable and reliable indicators useful for assessing variability in crops and can, therefore, be utilised in identifying desirable parents in crop breeding. The plant height of mature tomato genotypes at 50% flowering is presented in Table 4. The B52 was the tallest at 55.1cm, and the Cameroun the shortest at 43.4 cm. No significant difference ($p > 0.05$) was observed in heights of genotypes as reported by Goodlife *et al*. (2023). Cameroun had the lowest number of leaves with 7 leaves (Table 4) and NHTO 0294 had the highest number of 30 leaves. The NHTO 0294 could be described as having dense foliage, the NHTO 0201 and B52 as having intermediate / medium foliage whereas Cameroun and Thorgal $F_1$ hybrid could be described as having sparse foliage. Significant differences ($p<0.05$) were observed in the number of leaves of mature genotypes. (Nkansah *et al*. (2019) also reported significant differences in the number of leafs amongst tomato genotypes.

Table 4 shows that NHTO 0294 had 10 primary branches, the highest, whereas Thorgal $F_1$ hybrid and Cameroun had 3 primary branches each, the lowest. Generally, the tomato genotypes had similar number of primary branches as their foliage density. Significant differences ($p< 0.05$) were observed in the number of primary branches of tomato genotypes at maturity, as has been reported in previous studies (Nkansah *et al*., 2019; Goodlife *et al*., 2023). The Thorgal $F_1$ hybrid achieved 50% flowering in 63 DAS, for Cameroun it was 76 DAS (Table 4).

Despite these numerical differences, there were no significant differences ($p>0.05$) in days to 50% flowering between genotypes as has been reported by Goodlife *et al*. (2023). This character is economically important because it shows a change from the physiological vegetative phase to the reproductive flowering phase in the life cycle of tomato and could provide a clue for earliness to maturity of tomato plants. In addition, for tomato improvement, genotypes that have shorter reproductive cycles, phenological cycles combined with high yield of fruits are preferred for commercial tomato production because of their early maturity. The B52 genotype had the highest number of flower clusters (5) whereas NHTO 0201 and NHTO 0294 had the lowest number of 2 flower clusters each (Table 4). Although Benti *et al*. (2017) reported significant differences in flower clusters/plant under supplemental irrigation, in this study, there were no significant differences ($p>0.05$) in flower clusters/plant among the genotypes. The highest number of 12 flowers was observed in B52, whereas NHTO 0201 and NHTO 0294 had the lowest number of 8 flowers each (Table 4). The differences among genotypes were, however, not significant ($p>0.05$). Differences reported in different studies on vegetative and flowering characteristics of tomato could be the result of variations in their genetic make-up, effect of location (greenhouse, field or high tunnel), the environmental conditions or growing season under which the studies were conducted. Results from this study indicate that whereas some vegetative characteristics showed significant differences among the tomato genotypes at maturity, flowering characteristics did not show significant differences.

**Correlation Analyses of Vegetative and Flowering Characteristics of Tomato at 50% Flowering**

Table 5 shows the simple linear correlation coefficient matrix of the vegetative and flowering characteristics of tomato genotypes. There were highly positive and significant ($p< 0.01$) correlations between plant height and primary branches/plant ($r = 0.978$**) and between flower clusters/plant and the number of flowers (0.975**). There was a positive association between height of tomato plants and primary branches/ plant; and between flower clusters/plant and flowers/plant. Also, a significant positive correlation ($p< 0.05$) was observed between height of tomato plants and days to 50% flowering ($r = 0.889$*). These positive correlations have also been reported by Goodlife *et al*. (2023).

## CONCLUSION

In this study, the Cameroun genotype had the highest percent germination while the B52 had the highest seedling vigour index, the tallest seedlings and the highest number of seedling leaves. However, no significant differences were found in the percentage seed germination and seedling growth characteristics evaluated in the five tomato genotypes. At 50% flowering, NHTO 0294 had the highest number of leaves and primary branches and these were significantly more than in other genotypes, but plant height and flowering characteristics of tomato genotypes were not significantly different.

Table 1. Germination characteristics of tomato genotypes in a high rainfall region, Port Harcourt, Rivers State

| Tomato Genotypes | Days to first seedling emergence | Days to last seedling emergence | Percentage germination |
|---|---|---|---|
| NHTO 0201 | 6.0±1.65$^{ns}$ | 8.7±0.94$^{ns}$ | 69.7±0.44$^{ns}$ |
| NHTO 0294 | 4.0±0.41$^{ns}$ | 8.3±1.70$^{ns}$ | 78.3±0.80$^{ns}$ |
| B52 | 4.0±0.00$^{ns}$ | 5.0±0.71$^{ns}$ | 68.8±1.21$^{ns}$ |
| Thorgal $F_1$ hybrid | 4.0±0.41$^{ns}$ | 5.7±0.62$^{ns}$ | 75.8±0.66$^{ns}$ |
| Cameroun | 6.0±1.22$^{ns}$ | 7.3±1.43$^{ns}$ | 80.0±0.67$^{ns}$ |

ns = not significantly different at p = 0.05

Table 2. Seedling establishment characteristics of tomato genotypes at transplanting in Port Harcourt, Nigeria

| Tomato Genotypes | Height of seedlings | Number of seedling leaves | Seedling Vigour Index |
|---|---|---|---|
| NHTO 0201 | 5.9±0.77$^{ns}$ | 3.4±0.41$^{ns}$ | 4.11$^{ns}$ |
| NHTO 0294 | 6.4±0.55$^{ns}$ | 5.2±0.12$^{ns}$ | 5.01$^{ns}$ |
| B52 | 8.2±0.98$^{ns}$ | 5.2±0.42$^{ns}$ | 5.64$^{ns}$ |
| Thorgal F1 hybrid | 7.0±0.48$^{ns}$ | 4.4±0.26$^{ns}$ | 5.31$^{ns}$ |
| Cameroun | 6.5±0.60$^{ns}$ | 3.6±0.35$^{ns}$ | 5.2$^{ns}$ |

ns = not significantly different at p= 0.05

Table 3. Simple linear correlation coefficient matrix of germination and seedling parameters of tomato genotypes at five weeks after sowing in a high rainfall region

| | Germination (%) | Days to first seedling emergence | Days to last seedling emergence | Seedling height | Number of seedling leaves/ plant |
|---|---|---|---|---|---|
| Days to first seedling emergence | -0.173 | | | | |
| Days to last seedling emergence | -0.051 | 0.895* | | | |
| Seedling height | -0.456 | -0.660 | -0.830 | | |
| Number of seedling leaves/ plant | -0.186 | -0.826 | -0.613 | 0.650 | |
| Seedling vigour index | 0.939* | -0.410 | -0.370 | -0.130 | -0.019 |

* = significant at p= 0.05

Table 4. Vegetative and flowering characteristics of tomato genotypes at 50% flowering in Port Harcourt, Nigeria

| Tomato Genotypes | Plant height (cm) | No. of leaves/ plant | Primary branches/ plant | Days to 50% flowering | Flower clusters/ plant | No. of flowers/ plant |
|---|---|---|---|---|---|---|
| NHTO 0201 | $46.3^{ns}$ | 19 | 6 | $71^{ns}$ | $2^{ns}$ | $8^{ns}$ |
| NHTO 0294 | $51.6^{ns}$ | 32 | 10 | $68^{ns}$ | $2^{ns}$ | $8^{ns}$ |
| B52 | $55.1^{ns}$ | 22 | 8 | $66^{ns}$ | $5^{ns}$ | $12^{ns}$ |
| Thorgal F1 hybrid | $52.2^{ns}$ | 11 | 3 | $63^{ns}$ | $3^{ns}$ | $9^{ns}$ |
| Cameroun | $43.4^{ns}$ | 7 | 3 | $76^{ns}$ | $3^{ns}$ | $8^{ns}$ |
| LSD (0.05) | ns | 12.22 | 2.63 | ns | ns | ns |

ns = not significantly different at p =0.05

Table 5. Simple linear correlation matrix of the vegetative and flowering characteristics of tomato genotypes in Port Harcourt, Nigeria

| | Plant height (cm) | Number of leaves/ plant | Number of primary branches/ plant | Number of days to 50% flowering | Number of flower clusters/plant |
|---|---|---|---|---|---|
| Number of leaves/plant | 0.520 | | | | |
| Number of primary branches/ plant | 0.978** | 0.509 | | | |
| Number of days to 50% flowering | 0.889* | -0.302 | -0.212 | | |
| Number of flower clusters/ plant | 0.529 | -0.146 | 0 | -0.288 | |
| Number of flowers/ plant | 0.541 | -0.227 | -0.106 | -0.385 | 0.975** |

* = significant at p = 0.05
** = highly significant at p= 0.01

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