Brief Report on Tomato Breeding

1.Background

Tomato (*Solanum lycopersicum* L.) is one of the most economically important vegetable crops worldwide due to its nutritional value, versatility, and wide adaptability. It is a rich source of vitamins, antioxidants and essential micronutrients, a key component of human diets globally (Bergougnoux, 2014). Plant breeding plays a central role in improving tomato productivity and its resilience. The use of hybridization between genetically diverse parents is a widely adopted strategy to combine desirable agronomic traits. In this study, the Roma, a determinate plant type is used as the female parent due to its high yield potential, firm plum-shaped fruits, and suitability for processing industries. The Red Tommy Toe, a cherry-type cultivar, is used as the male parent due to its superior flavor, high sugar content, adaptability, and vigorous growth habit. The cross between Roma and Red Tommy Toe is expected to generate genetically variable progenies with the desirable traits like disease resistance, yield stability, fruit size, flavor, and adaptability. Such inter-varietal hybridization is an important strategy for broadening the genetic base of cultivated tomato and developing improved cultivars suited for diverse agro-ecological conditions (Bai & Lindhout, 2007).

2.Objectives

1. To develop improved tomato genotypes through hybridization between Roma (female parent) and Red Tommy Toe (male parent) combining yield, fruit quality, and resistance traits.
2. Breeding between F2 generation to Roma, F2 generation to RTTO with the aim of recovering desirable parental traits, improving fruit quality and identifying promising breeding lines for further selection and evaluation.

3. Rationale

Tomato breeding in Bhutan is necessary to develop high-yielding, climate-resilient, disease-resistant, and locally adapted varieties capable of meeting the growing domestic demand for tomatoes. Through the development of improved cultivars with superior yield, fruit quality, shelf life, and resistance to biotic and abiotic stresses, tomato breeding can contribute significantly to national food security, import substitution, farmer income enhancement and sustainable agricultural development in Bhutan.

4. Methodology

The plantation was done inside the two greenhouses. The Red Tommy Toe, Roma and F2 seeds from the previous season was planted on a raised bed inside polyhouse for further multiplication. The seed sowing was done in June 25, 2026, potting on July 3, 2026 transplanting in July 22,2026. The tomato breeding for

the F2 generation progeny with the parents started from 17. 8. 2026. 15 fruits were bred for F2O with Roma and 15 F2R with RTTO.

5. Results and Discussion

1. Sample distribution

Tomato group	Number of fruits	Percentage of total (%)
F2 Round	34	22.4
F2O X Roma	15	9.9
F2Oval	21	13.8
F2R X RTTO	15	9.9
Fruit Roma	33	21.7
RTTO	34	22.4
Total	152	100.0

A total of 152 tomato fruits has been taken as a sample. Sample sizes ranged from 15 fruits in F2O X Roma and F2R X RTTO to 34 fruits in F2 Round and RTTO.

2. Descriptive statistics of fruit characteristics

Group	n	Weight mean ± SD (g)	Weight range (g)	Height mean ± SD (mm)	Height range (mm)	Girth mean ± SD (mm)	Girth range (mm)
F2 Round	34	41.62 ± 9.69	27.23–65.45	42.00 ± 5.33	34.10–54.10	41.22 ± 3.73	35.70–50.70
F2O X Roma	15	55.71 ± 11.71	37.06–74.23	62.17 ± 6.31	47.87–70.11	38.91 ± 7.04	24.45–50.03
F2Oval	21	53.41 ± 11.50	32.14–71.43	63.62 ± 4.74	55.10–73.70	40.39 ± 5.13	30.60–48.00
F2R X RTTO	15	27.70 ± 4.47	21.27–35.77	28.26 ± 2.99	23.30–33.30	32.72 ± 2.80	28.90–37.60
Fruit	33	47.24 ±	28.16–	61.51 ±	53.20–	38.09 ±	31.10–

Roma		8.97	70.42	4.81	69.00	3.87	47.50
RTTO	34	24.63 ± 2.98	19.07–30.95	30.75 ± 2.21	24.10–34.10	35.72 ± 2.97	30.30–40.70

Mean fruit weight was highest in F2O X Roma (55.71 ± 11.71 g), followed by F2Oval (53.41 ± 11.50 g) and Fruit Roma (47.24 ± 8.97 g). RTTO had the lowest mean fruit weight (24.63 ± 2.98 g), followed by F2R X RTTO (27.70 ± 4.47 g). Mean fruit height was highest in F2Oval (63.62 ± 4.74 mm), closely followed by F2O X Roma (62.17 ± 6.31 mm) and Fruit Roma (61.51 ± 4.81 mm). F2R X RTTO had the lowest mean height (28.26 ± 2.99 mm). For fruit girth, F2 Round had the highest mean (41.22 ± 3.73 mm), followed by F2Oval (40.39 ± 5.13 mm), while F2R X RTTO had the lowest mean (32.72 ± 2.80 mm).

3. Coefficient of variation

Group	n	Weight CV (%)	Height CV (%)	Girth CV (%)
F2 Round	34	23.28	12.69	9.05
F2O X Roma	15	21.02	10.14	18.10
F2Oval	21	21.52	7.45	12.69
F2R X RTTO	15	16.15	10.59	8.56
Fruit Roma	33	18.99	7.81	10.16
RTTO	34	12.09	7.19	8.33

Fruit-weight CV ranged from 12.09% in RTTO to 23.28% in F2 Round, indicating that relative variation in fruit weight was lowest in RTTO and highest in F2 Round in this sample. Fruit-height CV ranged from 7.19% in RTTO to 12.69% in F2 Round. Fruit-girth CV ranged from 8.33% in RTTO to 18.10% in F2O X Roma. Thus, RTTO showed comparatively low relative variation for all three measured traits, whereas F2O X Roma showed notably greater relative variation in girth.

4. Distribution of fruit characteristics

The histograms show the frequency distribution of individual fruit measurements within each group. The weight distribution places F2O X Roma and F2Oval toward higher weight values, while RTTO and F2R X RTTO has much lower values. Fruit Roma has most observations around the middle-to-upper weight range, with a small number of heavier fruits. The height distributions similarly show F2O X Roma, F2Oval and Fruit Roma at higher height values, while RTTO and F2R X RTTO with lower values.

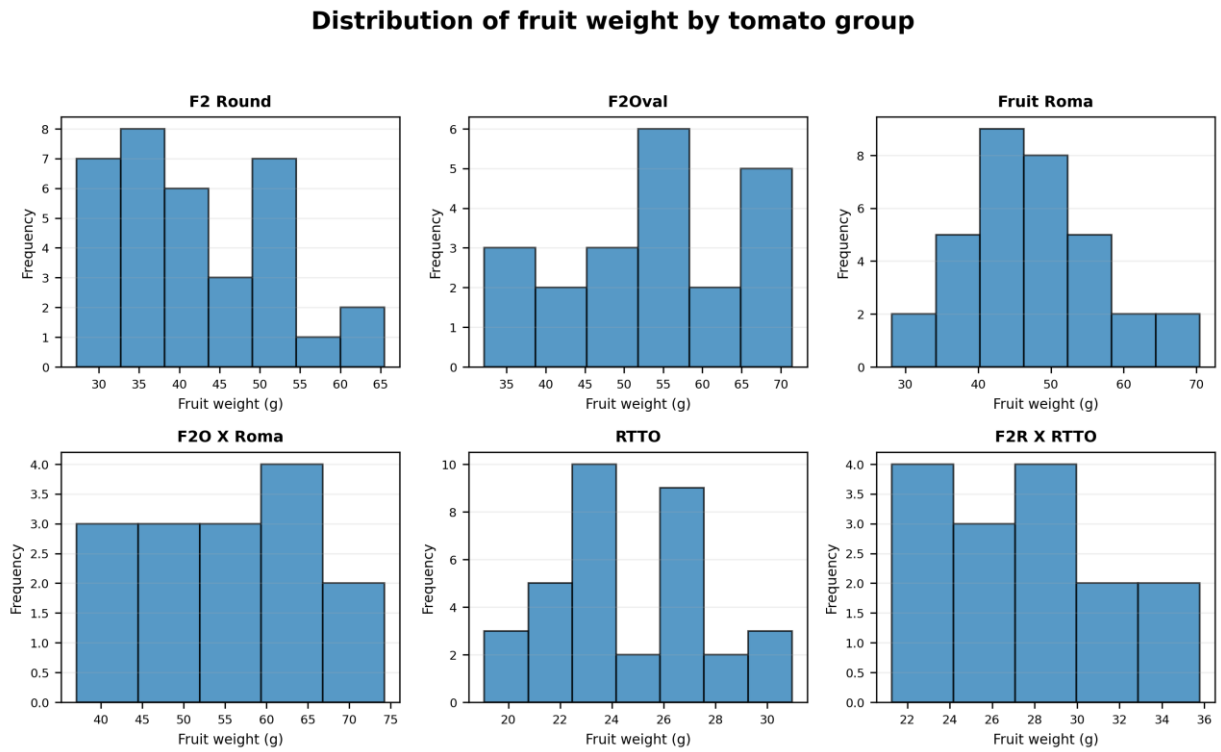


Figure 1. Distribution of fruit weight by tomato group.

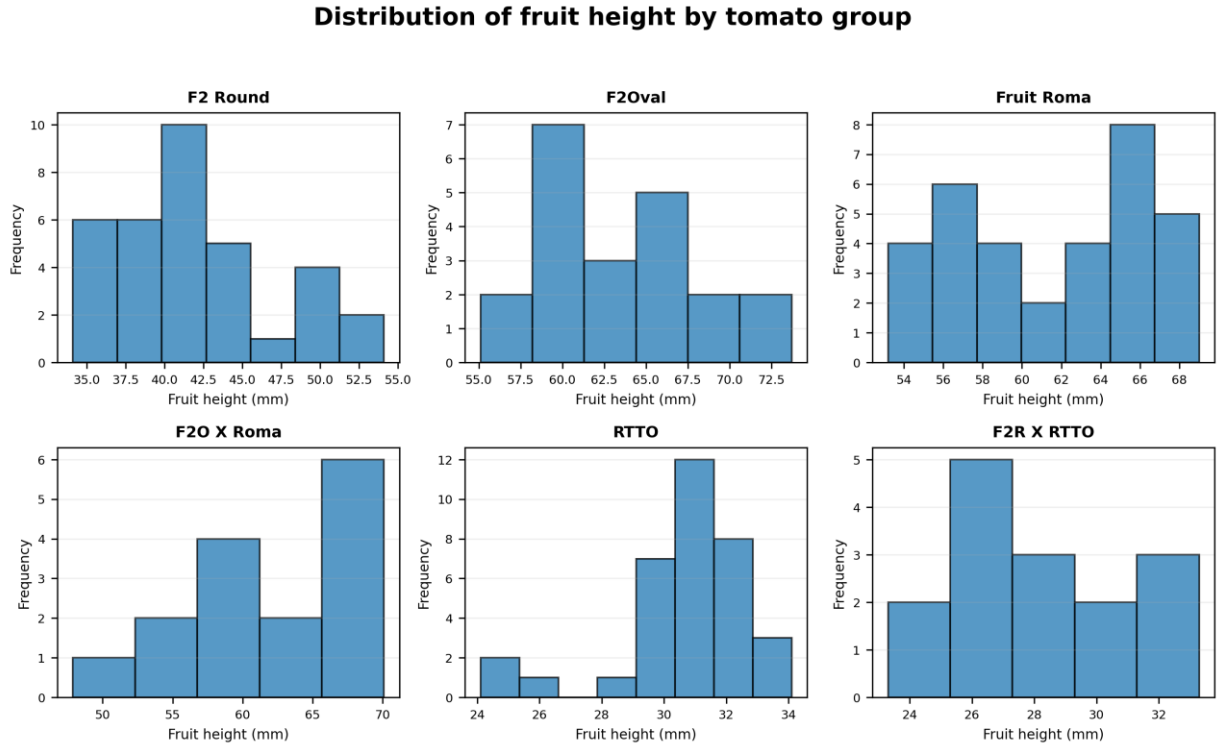


Figure 2. Distribution of fruit height by tomato group.

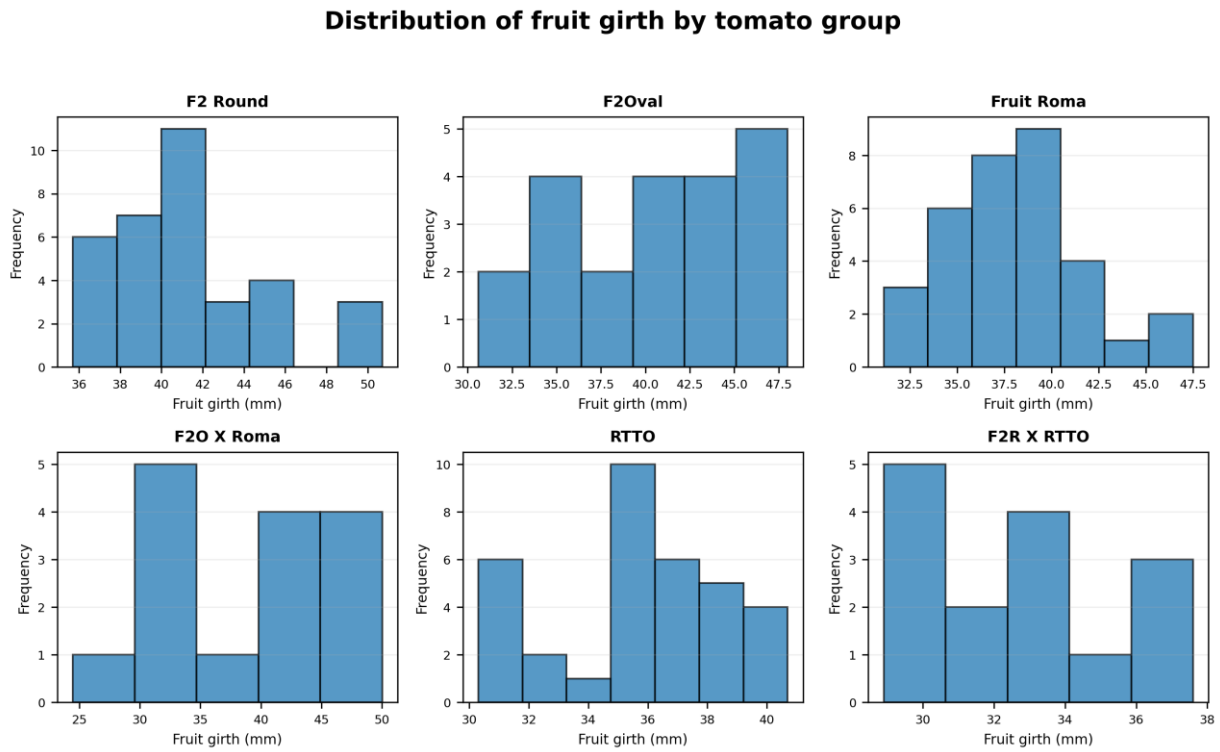


Figure 3. Distribution of fruit girth by tomato group.

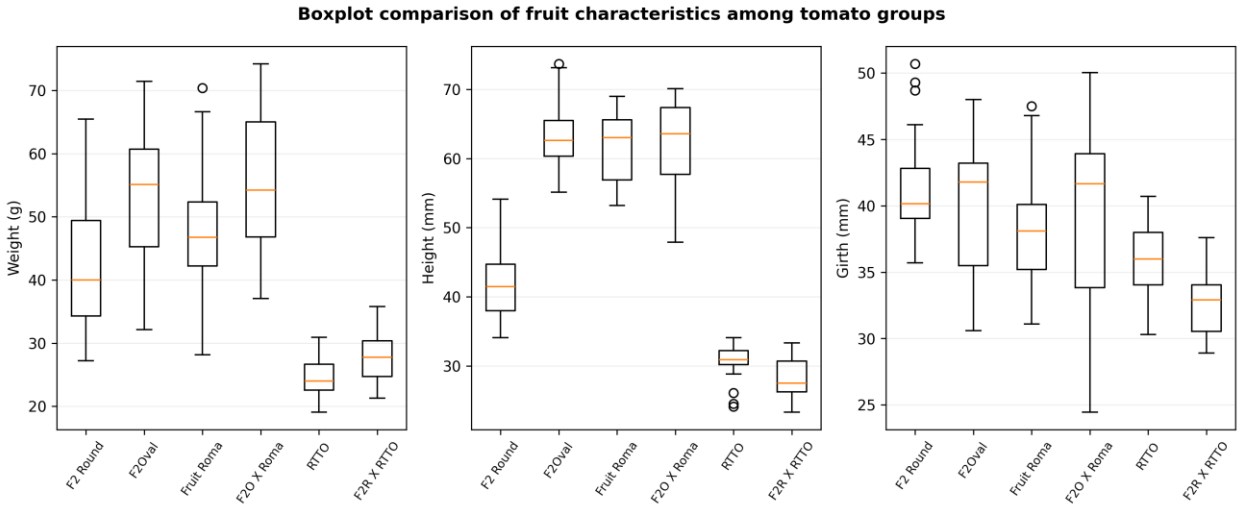


Figure 4. Boxplots of fruit weight, height and girth by tomato group.

5. Relationships among fruit characteristics

Trait pair	Spearman rho	p-value	Interpretation
Fruit height and fruit weight	0.873	$<2.2 \times 10^{-16}$	Strong positive association

Fruit girth and fruit weight	0.701	$<2.2 \times 10^{-16}$	Strong positive association
Fruit height and fruit girth	0.530	2.1×10^{-12}	Moderate positive association

The strongest overall association was between fruit height and fruit weight (rho = 0.873), indicating that taller fruits tended to be heavier. Fruit girth was also positively associated with fruit weight (rho = 0.701), suggesting that fruits with greater girth generally tended to weigh more. The association between fruit height and girth was moderate (rho = 0.530). All three overall correlation tests returned small p-values.

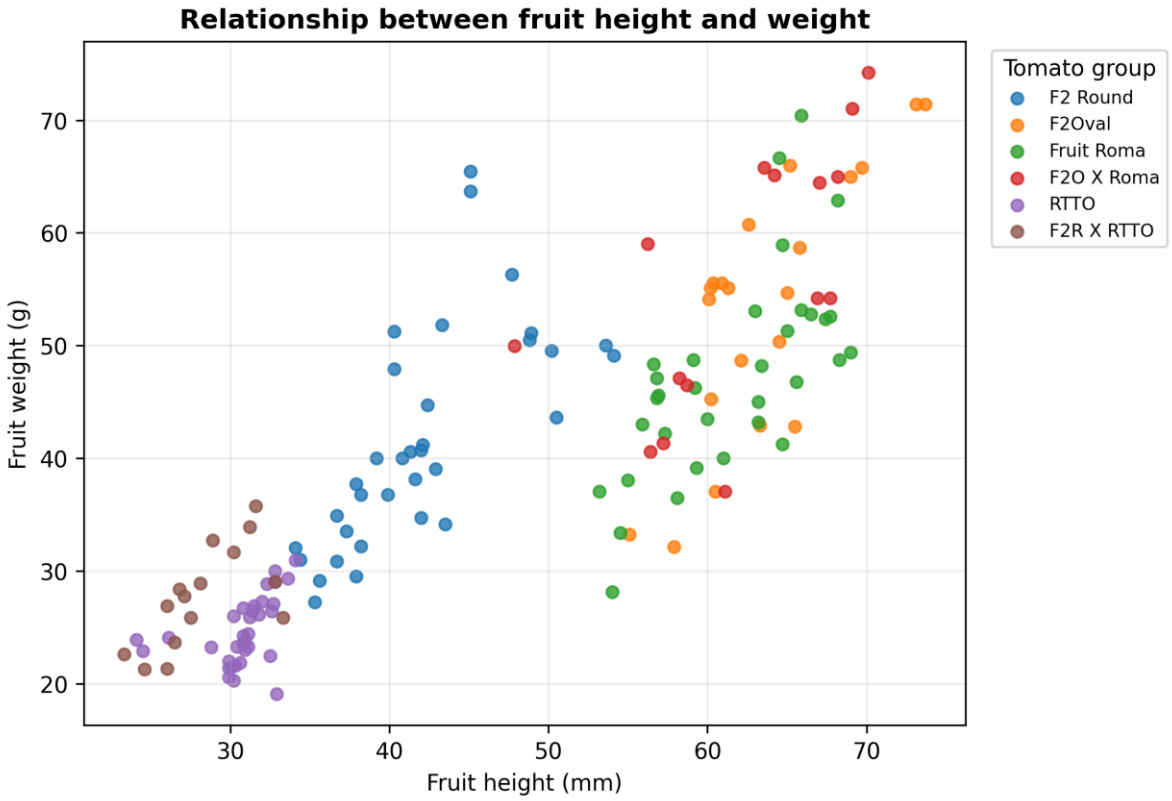


Figure 5. Relationship between fruit height and fruit weight.

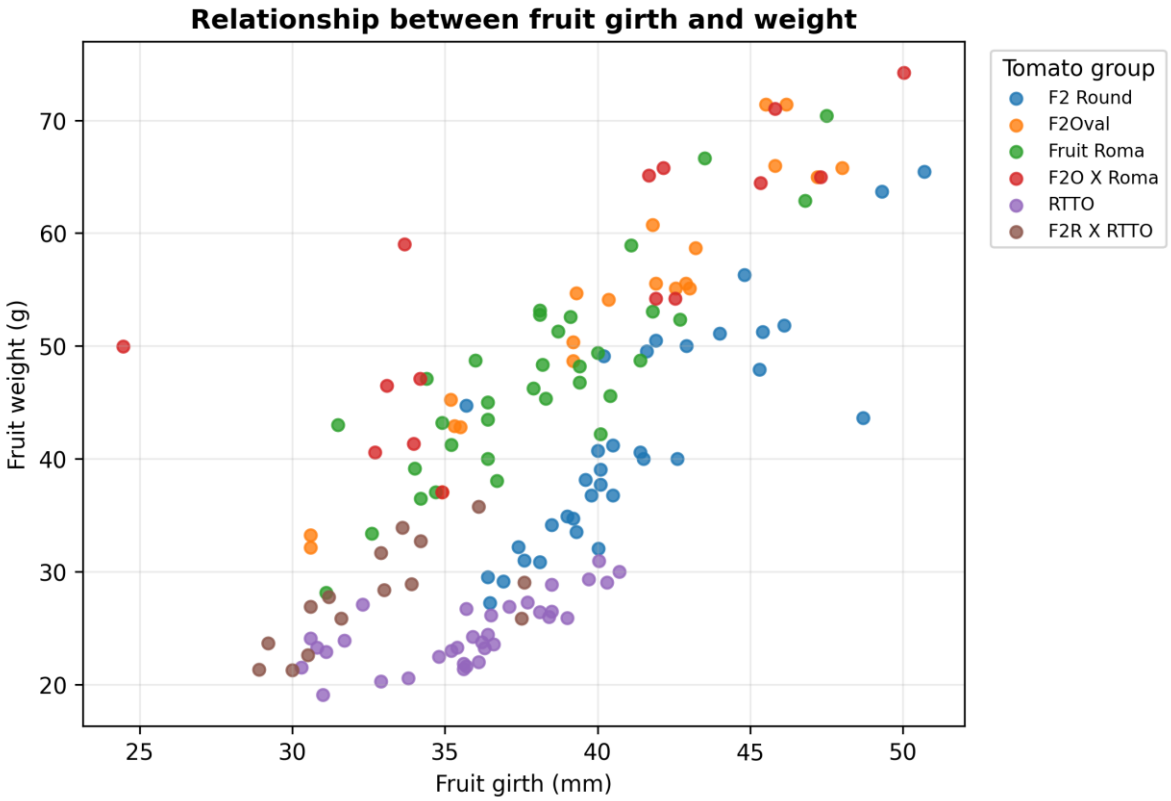


Figure 6. Relationship between fruit girth and fruit weight.

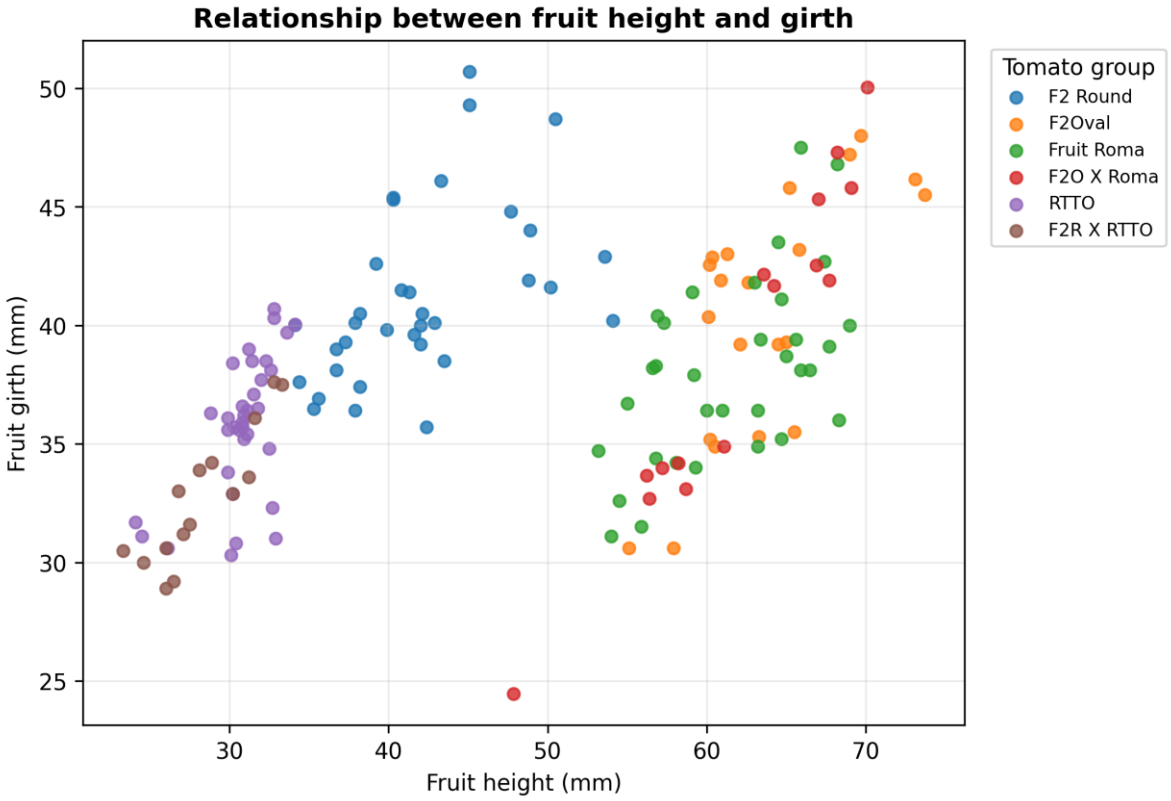


Figure 7. Relationship between fruit height and fruit girth.

6. Correlations within each tomato group

Group	n	Height–weight rho	Girth–weight rho	Height–girth rho
F2 Round	34	0.796	0.846	0.601
F2O X Roma	15	0.676	0.740	0.939
F2Oval	21	0.675	0.941	0.669
F2R X RTTO	15	0.735	0.750	0.890
Fruit Roma	33	0.714	0.783	0.513
RTTO	34	0.619	0.728	0.564

Within-group coefficients were positive for all three trait pairs in all six groups. The height–weight association ranged from rho = 0.619 in RTTO to 0.796 in F2 Round. The girth–weight association was strongest in F2Oval (rho = 0.941). The height–girth association was strongest in F2O X Roma (rho = 0.939) and F2R X RTTO (rho = 0.890).

6. Discussion

The present descriptive assessment indicates clear differences in the observed fruit size profiles among the six tomato groups. F2O X Roma and F2Oval had the highest mean fruit weights, while F2Oval, F2O X Roma and Fruit Roma had the greatest mean fruit heights. F2 Round had the highest average girth.

The strong positive association between height and weight suggests that fruit height was an important dimension associated with fruit mass in this collection. Girth was also positively associated with weight, although the relationship was weaker than that between height and weight.

The CV results provide a complementary view of uniformity. RTTO showed relatively low CV values for weight, height and girth, suggesting that its measured fruits were comparatively uniform in this sample. F2 Round showed the highest relative variability in weight and height, while F2O X Roma showed the highest variability in girth.

7. Overall Summary

The preliminary analysis was conducted to characterize fruit weight, height and girth among six tomato groups. Descriptive statistics were used to summarize the average fruit characteristics and their variation. Coefficient of variation was calculated to assess the relative uniformity of fruit measurements, while histograms and boxplots were used to examine the distribution, spread and potentially unusual observations.

Furthermore, Spearman correlation analysis was conducted to see the relationships among the three fruit characteristics. The results showed strong positive associations between fruit height and weight ($\rho = 0.873$) and between fruit girth and weight ($\rho = 0.701$), while fruit height and girth showed a moderate positive association ($\rho = 0.530$). Correlation analyses within each group also showed positive associations among the measured traits.

Overall, the findings provide preliminary information on the physical characteristics and variability of fruits among the six tomato groups. However, tomato groups were grown in unreplicated plots and fruits were harvested in bulk, the findings should be interpreted as descriptive observations rather than evidence of statistically confirmed varietal differences. Further replicated trials are recommended to validate the observed characteristics and evaluate yield, fruit quality and disease response.

8. Conclusions

The six tomato groups showed distinct descriptive profiles for fruit weight, height and girth. F2O X Roma had the highest mean fruit weight (55.71 g), F2Oval had the highest mean fruit height (63.62 mm), and F2 Round had the highest mean fruit girth (41.22 mm). RTTO had the lowest mean fruit weight and relatively low CV values across the three traits, indicating comparatively uniform fruit measurements in the current sample. Fruit height and weight had a strong positive overall association, while girth and weight had a strong positive association and height and girth had a moderate positive association. These findings provide preliminary fruit characterization but do not establish statistically significant varietal differences, yield superiority, hybrid vigour, disease tolerance or broad adaptation.

Appendix A. Analysis definitions

Statistic	Meaning
Mean	Arithmetic average of the recorded fruit measurements.
Standard deviation (SD)	Absolute spread of observations around the mean.
Coefficient of variation (CV)	SD divided by mean and multiplied by 100; relative dispersion.
Spearman rho	Rank-based measure of the direction and strength of a monotonic association.

9. Recommendations and Future Research

Based on the preliminary findings, the following recommendations are proposed:

1. Continue the backcrossing program involving F2 progenies and their respective parental lines to recover desirable parental characteristics and identify promising breeding materials.
2. Maintain and evaluate the resulting progenies in subsequent generations to identify stable and desirable fruit characteristics.
3. Conduct replicated field trials to validate the observed differences in fruit characteristics among the tomato groups.
4. Assess yield performance, fruit quality, shelf life and disease responses under different agro-ecological conditions.
5. Select promising breeding lines based on a combination of desirable agronomic, fruit-quality and resistance characteristics for further evaluation and possible release.

10. References

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