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# The impact of trellising strategies on the production and quality of determinate tomato types

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One of the Zimbabwe's most popular vegetables is Tomato (*Lycoperscicon esculentum*) due to its income-generating potential and nutritional value .In the dry season of 2019 (months of May-October), a 3 x 4 factorial experiment in Randomly selected Full Block Design comprising three replications was conducted in Mazandaran area to investigate the impact of trellising strategies on the determinate tomato cultivars' yield and quality. Staking and weaving, caging, ground culture (control), single pole staking, and Roma, Floridade, and Rio Grande types were used for trellising. Caging resulted in the most significant ($p<0.05$) quantity of fruits per plant, the maximum marketable output, and the highest total yield. In the caging trellising system, a comparable decrease in unmarketable yield was also observed. The trellising methods of single pole, staking, and weaving led to a low commercial tomato yield. The staking and weaving yields and that of the single pole staking were significantly identical. Tomato genetic variety may also have a role in determining the fruit quality, as proven by Roma's better marketable output compared to Rio Grande and Floridade.

**Keywords: caging, number of fruits; marketable yield; staking and weave; single pole; and unmarketable yield**

## INTRODUCTION

Tomatoes are one of the most significant vegetables farmed by Zimbabwe's smallholder farmers. It has a large number of vital elements for their nutrition. Carbohydrates, proteins, dietary fiber, calcium, iron, magnesium, manganese, vitamins (A, B, C, K, pyridoxine, thiamine, and foliates), phosphorus, carotene –a, zeathin, potassium, carotene –b, and lycopene are all found in them (Gholamin and Khayatnezhad 2020, Karasakal, Khayatnezhad et al. 2020, Abdolhakim 2021, Bi, Dan et al. 2021, Sun, Lin et al. 2021). A larger proportion of the rural Zimbabwean population is employed in agricultural cultivation and marketing. The crop also provides a source of revenue for small-scale farmers (Gilreath and Stall 2005, Anderson, Ellsworth et al. 2019, Jia, Khayatnezhad et al. 2020, Alerto 2021, Cheng, Hong et al. 2021).

Despite the tomato's economic importance in Zimbabwe, their cultivation has a number of obstacles, including high cost of production transit, inadequate marketing, diseases and pests, and so on. Tomato cultivation's pests and diseases had led to a significant yield and quality reductions. Farmers' failure to get pesticides to manage pests and diseases has aggravated the situation (Vincent and Thomas 1961, Karasakal, Khayatnezhad et al. 2020, Arjaghi, Alasl et al. 2021). Tomato trellising, on the other hand, can help to tackle pests and diseases. Plant trellising is more feasible and cost-effective for resource-limited farmers in the area (Zitsanza 2000, Gul, Rahman et al. 2010, Gholamin and Khayatnezhad 2020, Elsayied Abdein 2021, Ma, Ji et al. 2021, Ma, Khayatnezhad et al. 2021). Trellising, according to Saunyama and Knapp (2003), suppressed red spider mites in tomato. This was ascribed to enhanced spray penetration into lower leaf surfaces owing to trellising. Trellising led to an upright crop that enhanced air penetration, lowering the rates of fungal disease assaults and allowing for easier mobility when carrying out activities like as spraying (Farhadi, Fataei et al. 2020, Gholamin and Khayatnezhad 2020, Ghomi Avili and Makaremi 2020, Ren and Khayatnezhad 2021). The upright orientation also boosts photosynthetically active radiation, enhancing tomato output and quality (Kader and Morris 1976, Jalili 2020). Pollination was also improved through trellising tomatoes and vine damage was minimized during harvesting (Yin, Khayatnezhad et al. 2021).

Cutting the staking poles and trellising the plants consumes a lot of effort with this technique. It significantly contributes to deforestation, leading in an unsustainable system of production (Khayatnezhad and Nasehi 2021). In addition, there is significant fruit and blossom drop as a result of shaking while attempting to cater for ongoing growth. As the fruits would be exposed to direct sunshine, fruit disorders like cat face and sun scalds will be a concern. Staking and weaving, wire trellising, caging, post and twine trellising, and string trellising are just a few of the trellising systems utilized across the world. Oklahoma State University researchers studied the performance and economics of four alternative tomato training techniques and discovered that staking and weaving generated higher quality and production (Mariatou and Kwaramba 1999, Gholamin and Khayatnezhad 2020, Khayatnezhad and Gholamin 2020, Si, Gao et al. 2020, Li, Mu et al. 2021). There is little data on the effectiveness of these trellising systems on cultivars widely cultivated by smallholder farmers.

## MATERIALS AND METHODS

### Research Methodology

The research was carried out in Mazandaran Province, Iran. The field experiment was carried out in Randomized Complete Block Design with a 3x4 factorial layout and three replications. The first element was tomato species of the Floridade, Roma, and Rio Grande levels. The second element was trellising methods, which included staking and weaving, caging, single pole staking, and ground culture / no support system (control).

On May 24, 2019, the seeds were planted with the rate of 1kg per square meter with a basal dressing of compound D (7% N: 14 % P: 7% K) and cut to a depth of 5 cm. The row spacing of plant was 20cm, while the in-row spacing was 2cm. The seed was planted at a depth of 2.5cm and then covered with grass mulch and sand. For 5 weeks after seeding, watering was done daily, and 6 weeks after sowing, hardening off was done by progressively decreasing water for one week.

The area was ploughed to a depth of 20 cm with an ox-drawn mould board plough. It was split into 35 m2 (7m x 5m) blocks for the study, three blocks existed, and the gradient acted as the blocking factor. For basal dressing, a spot application of Compound D (7 percent N, 14 percent P, 7 percent K) fertilizer at a rate of 1333 kg/ha was used. The seedlings were transferred through using water planting method 7 weeks after seeding. The inter-row spacing was 75cm, while the in-row spacing was 30cm.

Karate was drenched for cutworm control shortly after transplanting, while Cabaryl and Diamethoate 40% E.C were treated for African boll and aphid worm control, respectively. In a 2-week cycle, Mancozeb and copper ox-chloride were sprayed alternately to prevent disease and control.

At week three after transplanting, 5g/plant (222kg/hectare) of Ammonium Nitrate (34, 5% N) was administered as a topdressing. Tomatoes were trellised a week after they were transplanted. Staking was accomplished with gum tree poles and T2 twine for tying. Caging was conducted all at once, whereas single pole staking, staking, and weaving were completed in a continual fashion to catch crop development, which was usually done on fortnight basis.

The sample plants' bloom count per cluster was counted and recorded. Each cluster was counted for the total number of completely mature fruits produced. On all picks, the diameter of the fruit was measured by a ruler and veneer calipers while harvesting. Unmarketable output included pest-damaged, rotten, and other tomatoes with physiological issues including cracking, cat facing, and sun scorching. The marketable yield included tomatoes with no defects, no decaying, and no pest damage which are marketable acceptable crops. The marketable and unmarketable yields summation equaled the total yield.

Genstat 14$^{th}$ edition was used for the Analysis of Variation (ANOVA). At a 5% level of significance, mean separation was performed using Least Significant Differences.

## RESULTS AND DISCUSSION

**Flower count per plant**

On the number of flowers per plant, no interaction (p>0. 05) existed between trellising method and variety. Moreover, as shown in Table 1, significant difference (p0. 05) existed between the varieties in terms of the flowers number per plant. Floridade has the most significant (p0.05) flower number per plant, whereas Roma and Rio Grande have the lowest significant flower number per plant. The variations might be due to genetic variances between the species. This is analogous to the findings of Snow (2013), who discovered considerable variability in the quantity of flowers per plant amongst tomato genotypes.

**Table 1: Effects of variety on number of flowers per plant**

| Treatments | Flowers/plant (square root) |
|---|---|
| Floridade | 4.129 $^{b*}$ (15.95) |
| Rio grand | 3.636 $^{a}$ (12.70) |
| Roma | 3.750 $^{a}$ (13.40) |
| P-value | P<0.001 |
| C.V % | 4.6 |
| $LSD_{0,05}$ | 0.1491 |

*-means with same letter in the column are not significantly different at p<0.05

CV - Coefficient of Variation

LSD - Least Significance Difference.

Figures in brackets are the original means where data was transformed.

**Fruits number per plant.**

On the amount of fruits per plant, no interaction (p>0.05) existed between variety and technique. Yet, as indicated in Table 1, there was a significant difference (p0.05) in the quantity of fruits per plant across the trellising systems. Caging produced the most fruits per plant (p0.05), but it was not statistically different from staking, ground culture, and weaving. This might be ascribed to less exposure of flowers to sunlight as a result of denser foliage, as well as less disruptions on the plant caused by the caging method. As indicated in Table 2, single pole staking produced the fewest fruits per plant (p0.05). Some researchers discovered that single pole staking causes greater damage to the leaves, lowering the photosynthetic area of the plant that provides food, inducing the early abscission of flowers, and leaving just the fruits that can be maintained by the plant (Muhibbu-din 2020, Zhang, Khayatnezhad et al. 2021, Zheng, Zhao et al. 2021, Zhu, Liu et al. 2021, Zhu, Saadati et al. 2021).

**Table 2: Effects of trellising methods on number of fruits per plant**

| Treatment | Squared number of fruits/cluster |
|---|---|
| Caging | 2.894 $^{b}$ (5.775) |
| Ground culture | 2.855 $^{b}$ (5.550) |
| Staking and weave | 2.816 $^{ab}$(5.458) |
| Single pole staking | 2.736 $^{a}$ (5.175) |
| P-value | P<0.049 |
| CV % | 4.1 |
| LSD | 0.1129 |

**Fruit diameter**

In Table 3, a significant (p0.05) difference was observed between the varieties, with Floridade and Rio Grande having the largest significant fruit diameters and Roma having the smallest significant fruit diameters. According to Peng et al., the variances are caused by genetic variations between the varieties (2021). Floridade and Rio Grande may have the same genetic make-up that regulates fruit diameter, which may differ from that of the Roma variety.

**Table 3: Effects of variety on fruit diameter**

| Treatment | Fruit diameter (cm) |
|---|---|
| Rio grand | 7.305 $^{b}$ (7.305) |
| Floridade | 7.192 $^{b}$ (7.1925) |
| Roma | 5.757 $^{a}$ (5.756) |
| P-value | P<0.001 |
| CV % | 7.2 |
| LSD | 0.4128 |

**Unmarketable yield (t/ha)**

Table 3 shows that ground culture had the most significant (p0.05) unmarketable yield. In comparison to trellising, so many of the fruits under this treatment were deemed unmarketable because they were in touch with soil moisture, which aggravated fungal infections, and many other fruits were also exposed to sunlight. More sun-scalded, rotting, and pest-damaged fruits resulted from ground cultivation. This is consistent with the findings of Some researchers (Gholamin and Khayatnezhad 2021, Ojaghi, Fataei et al. 2021, Sadigh, Fataei et al. 2021, Sasani, Fataei et al. 2021, Sun and Khayatnezhad 2021), who found that trellising and pruning the plants reduced disease occurrences, fruit rots, and fruit damage. According to Nyakanda (1997), when the plants of tomato are not trellised, they enable damaging fungal spores to penetrate the fruits and leaves through factors like moist leaves, poor air circulation, and rain-splattered soil.

There was no significant difference between single pole staking versus staking and weaving. Unmarketable output from cages was the least significant (p0.05). More caging system fruits were of good quality, as shown by the high commercial output for this approach, as illustrated in Figure 1.

**Table 4: Effects of trellising methods on unmarketable yield**

| Treatments | Unmarketable yield(t/ha) |
|---|---|
| Ground culture | 482.2 $^{c}$ (3941.75) |
| Single pole staking | 365.1 $^{b}$ (273.83) |
| Staking and weave | 347.0 $^{b}$ (260.24) |
| Caging | 174.6 $^{a}$ (130.61) |
| P-value | P<0.001 |
| CV % | 30.7 |
| LSD | 102.7 |

### Marketable yield (t/ha)

Figure 1 shows that caging had the greatest significant (p0.05) marketable yield. According to Suárez et al. (2008), fruit cages keep fruit off the ground, shield it from direct sunlight, minimizing disorders like sun scorching and cracking, and minimizes insect assaults on fruit. Ground culture produced the least significant marketable yield and did not differ statistically from staking and weave and single pole staking. While trellising with a single pole, weaving, and staking minimizes the production of unmarketable fruits (Table 3), it is clear that these two methods diminish marketable output, most likely owing to direct sunlight exposure and pest assault, exactly similar to the ground culture (Khayatnezhad and Gholamin 2020, Guo, She et al. 2021, Hou, Li et al. 2021). The results also revealed a significant (p0.05) difference across varieties (Figure 2), with Roma producing the maximum commercial yield. This shows that the genetic composition of the tomato also has a role in determining fruit quality.

### Total yield (t/ha)

On the total yield, there was no interaction (p>0.05) between technique and variety. Nevertheless, there was a significant (p0.05) difference in total yield across trellising strategies (Figure 3). The caging strategy had the greatest impact on total yield (p0.05). This was owing to a larger quantity of fruits per plant, as indicated in Table 1, as well as fewer fruit diseases and rots, as demonstrated by the greatest marketable and minimum unmarketable yields (Figures 1 and 2). The cultivation of dense foliage in cages may have also led to the best total output by directing more nutrients to the fruits (Khayatnezhad and Gholamin 2021, Tao, Cui et al. 2021, Wang, Shang et al. 2021). Furthermore, the most significant (p0.05) total yield belonged to Roma, whereas Rio Grande and Floridade had the lowest significant total yield (Figure 4). This is consistent with previous findings that Roma had the best marketable output as compared to Rio Grande and Floridade (Figure 2). The differences are most likely attributable to genetic variability amongst the varieties (Huang, Wang et al. 2021, Khayatnezhad and Gholamin 2021, Xu, Ouyang et al. 2021). Rio Grande and Floridade may share the same genes because there were no significant differences in fruit diameter, marketable and unmarketable yield.

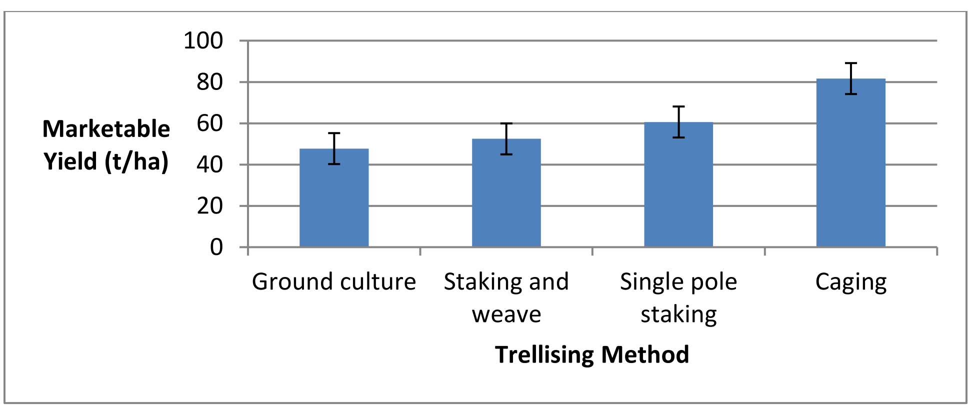


**Figure 1: Effects of trellising methods on marketable (t/ha)**

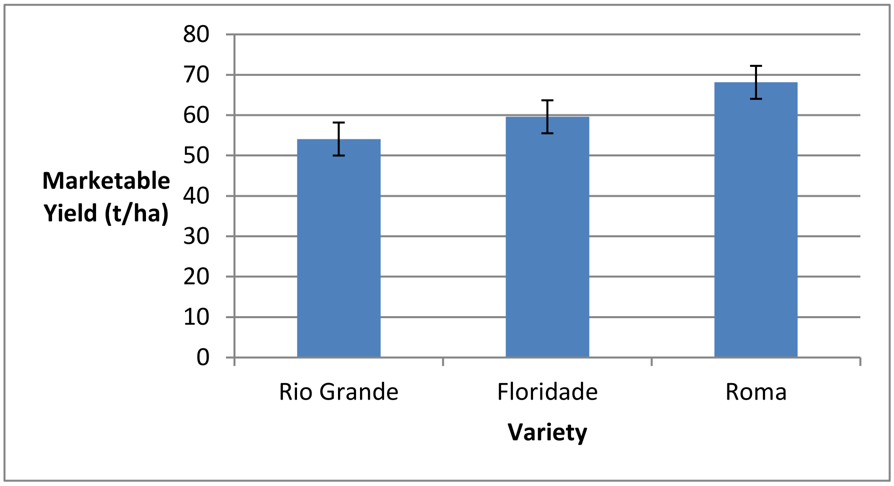


**Figure 2: Effects of varieties on marketable yield (t/ha).**

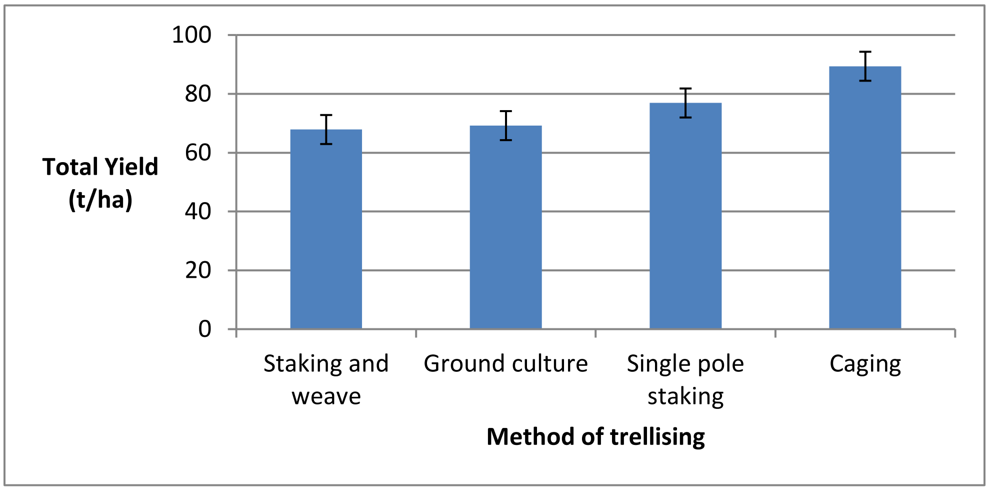


**Figure 3: Effects of trellising methods on total yield (t/ha)**

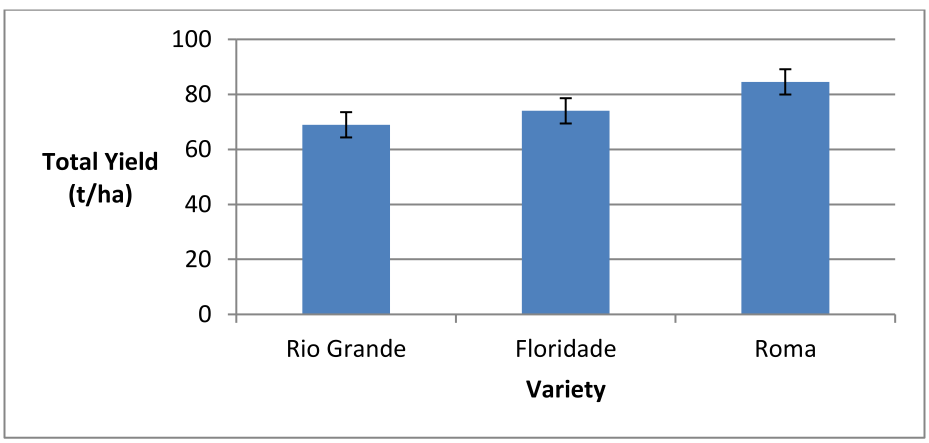


**Figure 4 Effects of variety on total yield (t/ha**

## CONCLUSION

The caging trellising technique led to more fruits per plant, the lowest unmarketable yield, and the most marketable output. Trailing decreases the production of unmarketable fruits regardless of trellising type utilized. Single pole, staking, and weaving trellising methods are not suggested for improving tomato quality since they lead to a poor commercial yield. Tomato genetic variability may potentially have an influence on the fruit quality.

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## CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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## AUTHOR CONTRIBUTIONS

Sina Mohammad zadeh conducted, planned, Analyzed the data, wrote manuscript and interpreted the results and involved in manuscript preparation. All authors read and approved the final version.



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