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# Inter-cultivar pollination success rate of Tomato (*Solanum lycopersicum* L.)

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## Abstract

Pollination in tomato plants is crucial for successful fruit development; yet, no research has been undertaken to examine the efficacy of different flower pollination methods in this species. This study aimed to ascertain the pollination success rate of tomato plant cultivars, namely the servo cultivar in comparison to local cultivars. This research constitutes a completely randomized design (CRD) with six treatments, each replicated three times. The findings indicated that the mode of pollination influences the development of tomato plant fruit. Every kind of pollination exhibits a distinct success rate. In the Servo variety of tomato plants, the success rate of pollination was 100% across all methods, except for cross-pollination with a different plant, which had a success rate of 33.33%. In the local tomato plant variety, the success rate after pollination was 100% across all pollination treatments; however, with a different cultivar, the success rate was 66.67%.

**Keywords:** Pollination; *Solanum lycopersicum* L.; Tomato; Cultivar

## 1. Introduction

Tomatoes are a horticulture product with favorable commercial potential, since they are extensively processed and serve as a source of vitamins. They can also serve as a seasoning in diverse cuisines and as an industrial component in processed goods, including tomato juice. Tomatoes are particularly abundant in vitamin C, rendering them effective for the prevention and treatment of different disorders, including mouth ulcers.

Statistics from the Food & Horticulture Service indicate that tomato production in Central Sulawesi rose in 2023. This results from the growth of tomato-growing areas, which have attained 38 hectares. The cultivation area will expand in accordance with production objectives and the growing number of growers. Consequently, tomato output is expected to rise in the future.

Initiatives to mitigate the deterioration in both the quality and quantity of tomato crop yields involve improving growing techniques. Advancements in tomato farming methodologies are continuous. Fundamental plant breeding tactics encompass germplasm collecting and the enhancement of genetic diversity in tomato plants. Several methods, including cross-breeding, can enhance genetic variety. The goal of cross-breeding is to increase genetic diversity in plants through sexual reproduction. Consequently, effective cross-breeding necessitates comprehension of the reproductive mechanisms of flowering plants, including the timing of flowering and favorable climatic circumstances. The crossbreeding procedure necessitates pollination. This procedure is essential for enhancing fruit output quality and increasing genetic variety.

Pollination encompasses several forms of pollination. Darjanto (1990) elucidates that pollination encompasses self-pollination (autogamy), pollination among adjacent flowers (geitonogamy), and cross-pollination (allogamy). Self-pollination happens in hermaphroditic flowers, where pollen from the blossom lands on the stigma of the same bloom.

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Pollination between adjacent flowers refers to the transfer of pollen originating from distinct blossoms on the same plant [7]. Cross-pollination refers to the fertilization of a stigma by pollen originating from distinct blooms on separate plants.

Tomato plants are extensively cultivated in Central Sulawesi. Tomato plants may thrive in both highland and lowland regions, contingent upon the specific variety. The servo variety is the most extensively produced tomato, but the parancina tomato, a local variation, is rarely farmed; both possess distinct benefits. The servo tomato variety is extensively cultivated due to its prolonged fruit resistance; it features oval-shaped fruit with a smooth surface and minimal indentations. In contrast, the local variety is infrequently cultivated, as it lacks long fruit resistance, presenting round or circular fruit with numerous surface indentations [9]

Both tomato plants include hermaphroditic or bisexual blooms, which have stamens (male reproductive organs) and pistils (female reproductive organs), enabling self-pollination. Nonetheless, tomato plants are capable of cross-pollination. Humans frequently engage in cross-pollination to achieve progeny with desired characteristics; nevertheless, the cross-pollination of tomato plants remains largely unexplored, and its application as an educational tool is ambiguous. Consequently, knowledge regarding tomato flower pollination is crucial for both students and the general populace. This necessitates instructional resources that use the study outcomes. Module-based teaching materials serve as a medium for transmitting educational messages and information aimed at promoting learning for students and the broader community.

Consequently, a study is required to determine the success rate of flower pollination in tomato plants and enhance output quality. Consequently, the subsequent inquiries are: What is the success rate of flower pollination in two types of tomatoes? Will the study provide novel cultivars? These questions are essential for the research to be addressed.

## 2. Material and Methods

This research employed a Completely Randomized Design (CRD) with six treatments: P1, P2, P3, P4, P5, and P6, each duplicated three times, yielding a total of 18 experimental units. The interventions in this trial were as follows: P1: Natural P2: Autogamy P3: Human-assisted pollination (anthropogamy) P4: Geitonogamy Pollination P5: Cross-pollination with a distinct plant, pollination using a distinct cultivar. The comprehensive research design is presented in the subsequent Table: 1 and Table 2

**Table 1** Completely Randomized Design for the Servo Variety

| | | | | | |
|---|---|---|---|---|---|
| Flower 1<br>P2 | Flower 2<br>P4 | Flower 3<br>P5 | Flower 4<br>P1 | Flower 5<br>P6 | Flower 6<br>P3 |
| Flower 7<br>P2 | Flower 8<br>P6 | Flower 9<br>P1 | Flower 10<br>P5 | Flower 11<br>P4 | Flower 12<br>P3 |
| Flower 12<br>P5 | Flower 13<br>P6 | Flower 15<br>P4 | Flower 16<br>P3 | Flower 17<br>P1 | Flower 18<br>P2 |

**Table 2** Completely Randomized Design for Local Varieties

| | | | | | |
|---|---|---|---|---|---|
| Flower 1<br>P2 | Flower 2<br>P6 | Flower 3<br>P1 | Flower 4<br>P3 | Flower 5<br>P4 | Flower 6<br>P5 |
| Flower 7<br>P2 | Flower 8<br>P5 | Flower 9<br>P4 | Flower 10<br>P1 | Flower 11<br>P6 | Flower 12<br>P3 |
| Flower 13<br>P4 | Flower 14<br>P2 | Flower 15<br>P5 | Flower 16<br>P6 | Flower 17<br>P1 | Flower 18<br>P3 |

This study was carried out from July to September 2025 at Sidera Village, Sigi Biromaru Regency, Central Sulawesi. Farmers in Sidera Village cultivated and tended to tomato plants. Following the flowering of the plants, pollination was conducted, encompassing various methods of pollination:

Natural pollination, wherein samples were left exposed in the environment and functioned as controls. Self-pollination was conducted under the supervision of the researcher, during which the self-pollinated flowers were enclosed. Human-assisted pollination (anthropogamy), wherein cross-pollination was conducted by researchers, followed by the covering of the fertilized flower samples. Geitonogamy pollination, in which pollen originates from several floral samples yet remains on the same plant. Pollination involving several plants, utilizing pollen sourced from diverse floral samples and distinct species. Pollination involving several cultivars, utilizing pollen from the Servo variety and pistils from indigenous kinds.

The assessment of pollination outcomes is conducted by determining the success rate of pollination, specifically the quantity of fruits produced from cross-pollinated flowers, utilizing the below formula.

**Percentage of successful fertilization = number of flowers that become fruit / number of flowers pollinated**

Additionally, the number of days from pollination to harvest, skin and flesh color, fruit shape, and weight were observed. The data obtained were then analyzed using ANOVA in SPSS.

## 3. Results

Research has been undertaken to analyze the success rate of flower pollination in tomato plants (*Solanum lycopersicum* L.) throughout an 8-week period, encompassing planting, care, and harvesting. The observed metrics were pollination success, stigma receptivity, flower development, duration until fruit harvest, skin and flesh coloration, fruit morphology, and fruit weight.

### 3.1. Flower Development

Flower growth entails monitoring the progression of flowers from the first planting stage, encompassing the transition from flower buds to full bloom. The flowering duration for the Servo tomato type is roughly 6 days, comparable to the local tomato variety, as seen in Figure 1.

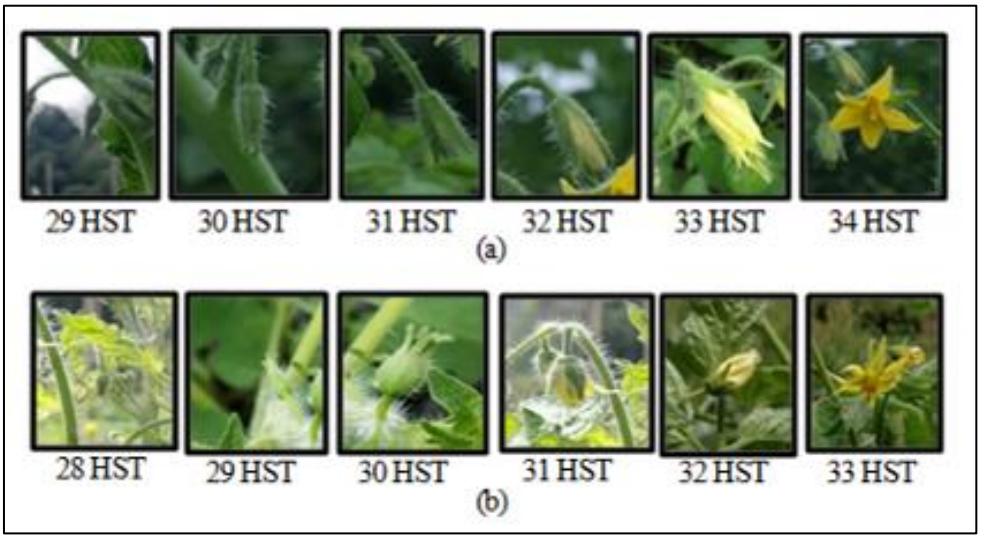



**Figure 1 (**a) Servo variety tomato plant flower, (b) local variety tomato plant fruit. HST is days after planting

### 3.2. Stigma Receptivity

Derived from the examination of fully developed stigmas post-anthesis. The crimson stigma, following treatment with α-Naphthaleneacetic acid/alpha neptyl acetate solution, signifies stigma receptivity, indicating that the stigma is developed and prepared for pollination, as seen in Figure 2.

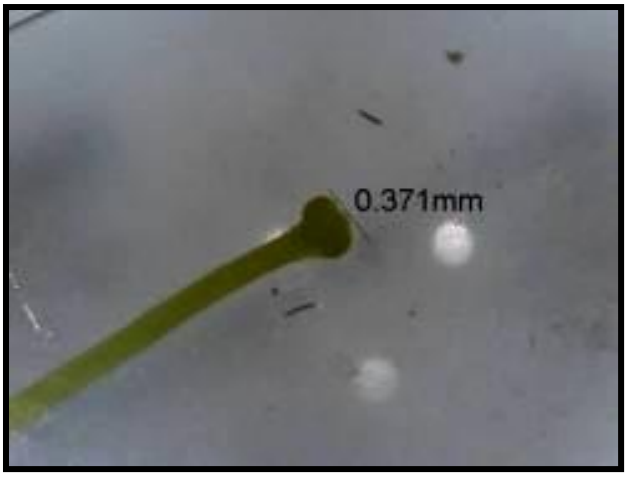
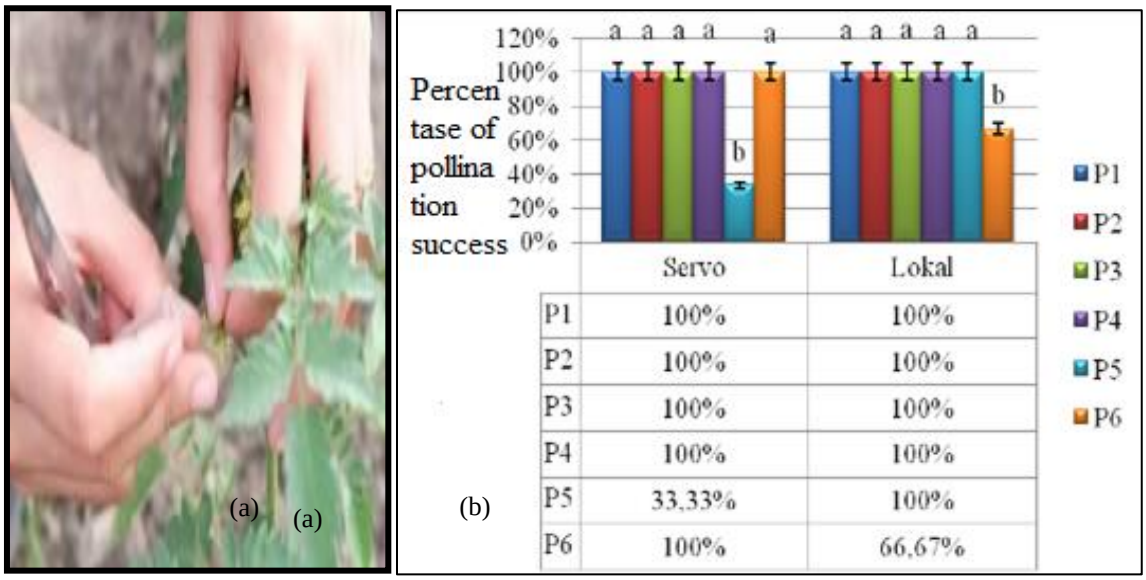



**Figure 2** Stigma receptivity

### 3.3. Pollination Success Rates

Figure 3 illustrates the outcomes of observations on the average success rate of flower pollination in Servo tomatoes and local tomato plants across six distinct treatments.




| | Servo | Lokal |
|---|---|---|
| P1 | 100% | 100% |
| P2 | 100% | 100% |
| P3 | 100% | 100% |
| P4 | 100% | 100% |
| P5 | 33.33% | 100% |
| P6 | 100% | 66.67% |

**Figure 3 (**a) Pollination process in tomato plants, (b) success rate of pollination of tomato flowers of the Servo cultivar and the Local cultivar with seven different pollination type treatments (P1: Natural, P2: Self-pollination, P3: Human-assisted pollination (anthropogamy), P4: Geitonogamy pollination, P5: Pollination with different plants, P6: Pollination with different cultivars)

Figure 3 illustrates a notable disparity in the pollination efficacy between the imported tomato cultivar and the indigenous tomato cultivar. The pollination success of the robotic tomato plant is contingent upon the method of pollination employed. The result is derived from the p-value (sig) in the ANOVA table, which is 0.023, indicating it is less than 0.05 ($P<0.05$). Consequently, it can be asserted that the mode of pollination significantly influences the pollination success of tomato plants. The p-value (sig) in the ANOVA table indicates that various pollination type treatments have distinct impacts on the pollination success of local tomato varieties, with a p-value (sig) of 0.458, which exceeds 0.05 ($P>0.05$). Consequently, it can be asserted that the mode of pollination profoundly influences the pollination success of indigenous tomato varieties.

### 3.4. Fruit Harvest Time

The harvest period for the fruit of the tomato cultivars Servo and Local occurs approximately 15 days apart. Specifically, the harvest for Servo is 60-70 days post-planting, while for Local, it is 70-75 days post-planting.

### 3.5. Skin and Flesh Color

The epidermis and pulp of the Servo tomato type and indigenous tomato cultivars exhibit a red hue and possess a glossy surface. The immature fruit is light to dark green, but during maturation, it transitions to shades of yellow, brilliant or dark red, yellowish red, or dark crimson, as seen in Figure 4.

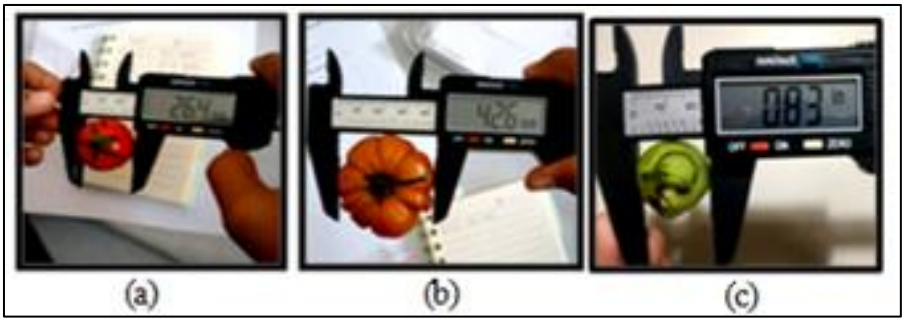



**Figure 4 (**a) fruit of a tomato plant of the Servo variety, (b) fruit of a tomato plant of a local variety, (c) fruit resulting from pollination in treatment P6: pollination with different cultivars

### 3.6. Fruit Shape

Figure 4 illustrates the findings of observations on the average fruit shape of the Servo cultivar and local cultivar tomato plants subjected to six distinct treatments. The fruit of the tomato exhibits a range of morphologies, including oval, smooth round, grooved round, flat-tipped or flat-based round, and irregular forms. The form and dimensions are contingent upon the variation.

### 3.7. Fruit Weight

Figure 5 displays the findings of observations on the average fruit weight of the Servo tomato cultivar and local tomato varieties under six distinct treatments. The variance in fruit weight will also influence the diameter of each variety. Fruit growth mostly relies on food availability and the intensity of competition among growth centers [6].

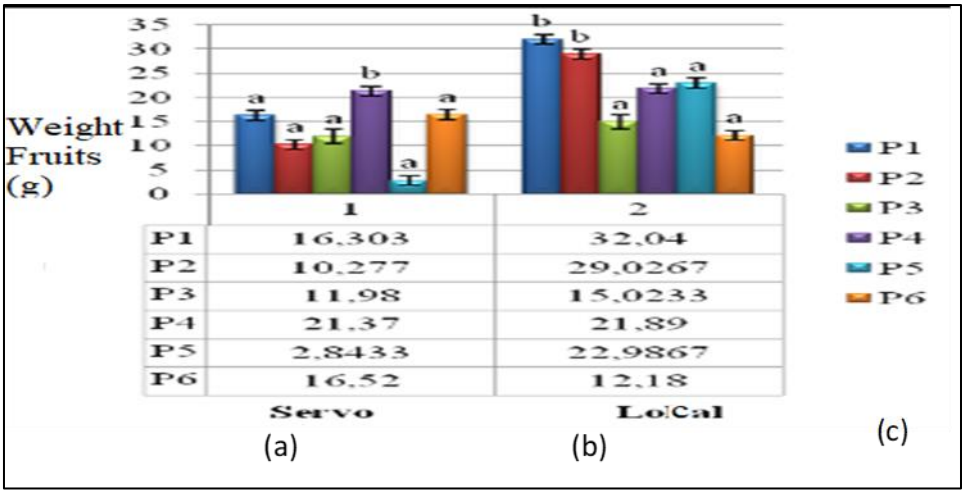



**Figure 5 (**a) fruit weight of local variety tomato plants, (b) fruit weight of Servo tomatoes, (c) fruit weight of pollination results in treatment P6: pollination with different cultivars, (d) diagram of fruit weight of Servo cultivar tomatoes and local cultivars with six different pollination type treatments

Figure 5 illustrates a notable disparity in the weight of fruit between the tomato cultivar Servo and the local tomato variety. The method of pollination affects the weight of the fruit of the tomato cultivar Servo. The p-value (sig) in the ANOVA table is 0.323, which exceeds 0.05 ($P < 0.05$). Therefore, it can be asserted that the method of pollination significantly influences the success of tomato plant fertilization. The p-value (sig) in the ANOVA table indicates that the effect of various pollination types on the weight of local tomato cultivars is not statistically significant, since the p-value (sig) of 0.147 exceeds 0.05 ($P>0.05$). Therefore, it can be asserted that the mode of pollination significantly influences the success of local tomato cultivar pollination.

## 4. Discussion

The research findings indicated that the pollination methods applied to tomato plants influenced their development, as evidenced by the metrics of pollination success rate, stigma receptivity, flower development, time to fruit harvest, skin and flesh coloration, fruit morphology, and fruit weight.

Flower growth entails the progression of flowers from the first planting stage, encompassing the transition from flower buds to full bloom. The flowering duration for the servo type of tomato plant is roughly 9 days, whereas local varieties require about 10 days. Flower buds emerge 29 days post-planting in the servo variety tomato plant, but they appear 28 days post-planting in the local variety. Tomato plants begin blooming around 18–25 days post-planting. The flowering period for each type of tomato plant differs. Pollination transpires 1-2 days subsequent to the flower's blooming (anthesis) [5].

The study's results indicated that the stigma receptivity test, when treated with an α-Naphthaleneacetic Acid/alpha neptyl acetate solution, would exhibit a red coloration. Stigma receptivity signifies that the stigma is fully developed and prepared for pollination. The findings of this study align with prior research by [1], which indicates that the stigma is deemed suitable for pollination when it exhibits a red coloration following treatment with a solution of α-Naphthaleneacetic Acid/alpha neptyl acetate at a pH of 6-7.

The research findings demonstrate that the method of pollination affects the success rate of pollination in tomato plants. The research findings reveal that several pollination cultivars have a poor success rate. The success of crossing is influenced by the quality of the male parent's pollen and the degree of compatibility between the crossing entities. Self-incompatibility, pollination intensity, and meteorological conditions during pollination affect the efficacy of crossover [10]. The success of crossing serves as a metric for assessing the compatibility of the parent plants, and there is a propensity for crossed blooms to abscise, preventing fruit formation. Failure in fruit production during in-plant crossings and cross combinations can lead to ovule abscission and hinder ovule development. Fallen fruit that fails to mature may result from physiological or environmental variables affecting the plant [8]. Darjanto and Satifah (1990) state that embryos and endosperms in pollinated ovules may cease growth due to unsuitable cross combinations, leading to the failure of ovule development or premature abscission before ripening. Hazra et al. (2007) indicated that elevated ambient temperatures in tomato culture can lead to fruit formation failure, aberrant floral development,

diminished pollen viability, reduced flower intensity, ovule abscission, and decreased carbohydrate content in fruits. [4]. indicated that cross-pollination success during the wet season is consistently 95%; however, in the dry season, it declines to 0%.

The cultivation environment influences the proportion of fruit development in tomato plants. A key element affecting the fruit formation % is the quantity of blooms that mature into fruit. If a substantial quantity of flowers blossoms but a minimal number of flowers matures into fruit, the fruit formation percentage will therefore be low.

The harvest period for the tomato plant cultivar Servo is approximately 60-70 days post-planting, while the local cultivar requires 70-75 days, resulting in a variance of ±15 days between the two. The harvesting of tomato fruit occurs when it meets the physical criteria for ripeness, namely when it transitions from orange to red, has a soft feel, and contains a significant amount of water. Both the Servo tomato cultivar and local tomato cultivars have thin, shiny skin and red flesh. When young, the fruit is light green to dark green. As it matures, it becomes slightly yellow, bright or dark red, yellowish red, or yellow, or dark red.

The tomato cultivar Servo has an oval (oblong) fruit form with a length-to-diameter ratio of 1.5-2:1 and a flat surface, whereas local tomato cultivars also possess an oval shape but are somewhat flatter and resemble starfruit. In local tomato varieties subjected to P6 therapy, the resultant fruit morphology diverges from that of the progenitors, exhibiting a spherical shape with a partially smooth surface and undulating features on some areas of the fruit's exterior. The combination of crossings can generate variation in harvest age, seed quantity, and fruit morphology [8]. The fruit of the tomato exhibits a range of morphologies, including oval, smooth round, grooved round, flat-tipped or flat-based round, and irregular forms. The form and dimensions are contingent upon the variation.

The study's results demonstrate that the method of pollination influences the fruit weight of tomato plants. Variations in fruit weight will also influence the diameter of each variety. Fruit growth mostly relies on food availability and the intensity of competition among growth centers [6]. The growth in fruit weight is determined by the quantity of photosynthesis conducted by the plant; a higher rate of photosynthesis leads to bigger food stores, which may be utilized to augment fruit weight. The weight of fruit is affected by post-flowering conditions, such as nutrient availability and favorable or unfavorable environmental factors, which influence carbohydrate production during photosynthesis, ultimately determining fruit weight [2]. Variations in fruit weight are attributable to disparities in fruit enlargement [3].

## 5. Conclusion

The efficacy of flower pollination differs between two tomato types. Each kind of pollination exhibits a distinct success rate. In the servo variety tomato plant, the success rate post-pollination was 100% across all pollination methods, except for cross-pollination with a different plant, which had a success rate of 33.33%. The local variety tomato plant had a 100% success rate for all pollination treatments. However, when a different cultivar was used for pollination, the success rate dropped to 66.67%. New cultivars have emerged from various pollination outcomes, exhibiting fruit morphologies distinct from their parental local variety tomato plants.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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