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Suitability of tomato (*Solanum lycopersicum*) grafting onto eggplant rootstocks for production in Cambodia

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Abstract

In Cambodian, vegetables are difficult to grow in the wet season due to the wet conditions. Vegetable grafting is a horticultural technique used to take advantage of genetic resources of multiple plant species in order to address seasonal challenges. This study evaluated the suitability of eggplant rootstocks used for tomato grafting for production in Cambodia. Three different eggplant rootstocks (i.e., local, market-available, and recommended eggplant cultivars) were grafted with the tomato scions, using cleft grafting methods. The grafted seedlings were planted in the field to determine plant growth and productivity. The results show that the survival rates and productivity of grafted tomatoes were significantly greater than non-grafted plants. Grafting tomato scions onto local or market available eggplant rootstocks can be used to deal with problem of too much water or rain at atypical times for tomato production in Cambodia.

Keywords: climate change, flooding, hot-wet conditions, local rootstocks, vegetable grafting.

Introduction

In Cambodian, vegetables are difficult to grow in the hot and wet conditions but bring higher price in the market, and remain important for nutrition at home. Vegetable production can address human nutritional needs; however, production is hampered by seasonal changes, particularly in the rainy season. During the rainy season when soils are saturated, the production of certain vegetables is challenging. Due to the difficulty in production, vegetables in the rainy season fetch a higher price in the market, and remain important for nutrition at home. Vegetables are seasonally produced due to weather conditions, e.g., too wet or hot, causing unsuitable conditions for plant growth and productivity. Vegetables are imported to the country to meet the local demand (In et al., 2015). There are three main strategies to deal with the above problems: i). Modify environment to improve drainage and keep rain off of the plants (e.g., improving drainage with raised beds and organic matter additions to soil, mulching to suppress soil-borne disease, and excluding rain with plastic structure, etc.); ii). Use plants adapted to wet environments (e.g., *Piper sarmentosum, Acacia pennata, Ipomoea aquatica,* etc.*);* and iii). Graft to take advantage of genetic resistance of rootstock to saturated soils.

Vegetable grafting is a horticultural crop technique to take advantage of genetic resistance to enhance plant growth and productivity (Lee & Oda, 2003). Grafting tomato scions onto selected rootstocks can minimize problems caused by flooding and soil-borne diseases (Black et al., 2003; Bletsos & Olympios, 2008; Lin et al., 2008). The rootstock asa host plant has been a major strategy for managing bacterial wilt in tomato (Hayward, 2000). Use of grafted seedlings has become a widespread horticultural practice in many parts of the world (Pogonyi et al., 2005). Grafted plants benefit from utilization of vigorous rootstock genotypes to increase water and nutrients uptake for increased productivity (Ruiz & Romero, 1999; Leonardi & Giuffrida, 2006; Turhan et al., 2011). Tomatoes are difficult to grow during hot-wet conditions in Cambodia. This study was to evaluate suitability of eggplant rootstocks used for tomato grafting for production in Cambodia.

Methods

The experiment was conducted during the end of the hot dry season and into the early-wet seasons of 2018 at the experimental site of the National University of Battambang, Cambodia (13.0840452 N, 103.2175077 E; 20 m above sea level). The soil of the experimental plot had a pH 6.27 (Soil:1N KCl; 1:5), organic matter content 3.38%, total nitrogen 0.17%, available P (Olsen) 40 ppm, exchangeable K 1.82 (meq/100 g soil), and particle size: 47.55% of clay, 33.33% of silt, 19.24% of sand (textural

class of clay). Average monthly temperatures and daily rainfall during the experiment are presented in Fig. 1.

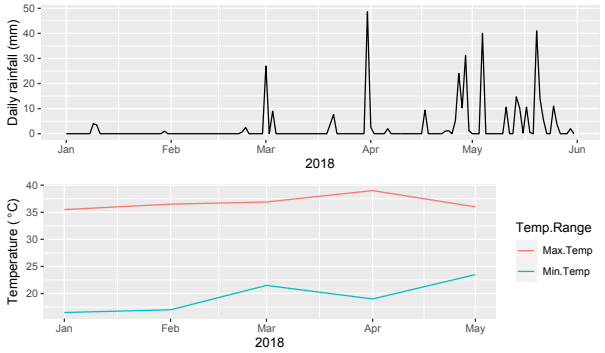

Fig. 1: Average monthly temperatures and daily rainfall during the experiment at the experimental site, collected from January to May 2018.

Three different eggplant rootstocks, i.e., local eggplant (Local EG), market-available eggplant (EG59), and recommended eggplant (EG190) varieties were grafted with Yellow Pear tomato, *Solanum lycopersicum* (*syn*. *Lycopersicon esculentum*), and planted in the field to measure disease resistance, growth and productivity. The Yellow Pear is yellow, sweet variety, and often eaten as fresh vegetable. Rootstock seeds were sown 15 days earlier than scion seeds in seedling trays (104 cells) filled with a mixture of soil, rice-hush ash and coconut fibre (volume 1:1:2). Seeds of scions were sown on 15 days later (due to the difference in growth rates) in seedling trays (60 cells) filled with the same previous mixture. The trays were placed in 50% shade until full germination.

Cleft technique was applied for the grafting (Johnson et al., 2011). The scion and the rootstock were cut off with a razor blade just above the cotyledons at a maximum of 3 cm above the medial line. Scion and rootstock were connected using a silicon-grafting clip. After grafting, both graft combinations were placed immediately into a healing chamber with inside relative humidity of nearly 90%, with air temperatures at 28 – 30 °C, following Marsic and Osvald (2004). The exposure to direct sunlight was prevented. When wilting was observed, foliar spraying of grafted plants with water was effective in improving survival. Grafts were treated in the healing chamber for 7 days then moved to the 50% shade for another 7 days to ensure full recovery prior to transplanting in the field. The grafted plants were field-transplanted in a randomized complete block design (RCBD) with four replicates. Each experimental plot consisted of 2 rows, 1.2 m wide × 2 m long (plot area = 2.4 m2), and 50 cm × 70 cm plant spacing subjected to the common agricultural practices. During growth stage, the soil of the experimental plot was under both hot and wet conditions.

To evaluate the disease resistance of eggplant rootstocks with tomato varieties grafted onto them, maximum plant height, total fruit yield per plant, and survival rate of the grafted and un-grafted plants were measured. Sixteen plants in each treatment (4 plants * 4 replicates) were measured till the end of the experiment. Survival rate of the grated and non-grafted plants was tested, using χ^2 test. To test the significance of difference in means of each variable for multiple groups, one-way analysis of variance or the Kruskal–Wallis test (Kruskal & Wallis, 1952) was used due to the data having an unnormal distribution. Tukey's test (Tukey, 1949) was applied to compare all possible pairs of mean for each variable. The 'ggplot2' R package (Wickham, 2011) was used for statistical analyses, with the R software, version 3.3.3 (R Core Team, 2017).

Results

At the end of the field experiment, the survival rates of grafted plants were 75%, 69%, and 69% for EG190, EG59, and Local EG, respectively, those were greater than the non-grafted ones (37%), showing that the grafted plants benefited from the rootstocks to improve disease resistant in stress environment, i.e., too wet or hot conditions (Fig. 2). The statistical test showed significant different between the grafted plant and non-grafted plant ($P < 0.05$). For the plant growth and development, the non-grafted tomato group (survived plants) was significantly higher than the grafted tomato groups ($P < 0.05$) for the maximum plant height (Fig. 3), and the number of branches per plant (Fig. 4). Although they grew taller with more branches, there were few survived plants left in the field. The grafted plants had a non-significant difference among the different rootstock-groups.

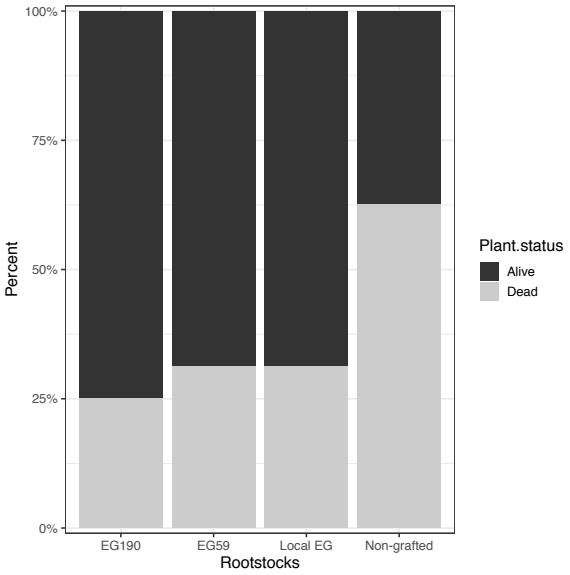

Fig. 2: Proposition of dead and alive plants for the grafted and non-grafted tomato plants at the end of the field experiment.

For plant productivity, the total fruit yield per plant of the tomato grafted with EG190 eggplant rootstock was significantly greater than the others, either with EG59, Local-EG rootstocks or non-grafted plants (Fig. 5).

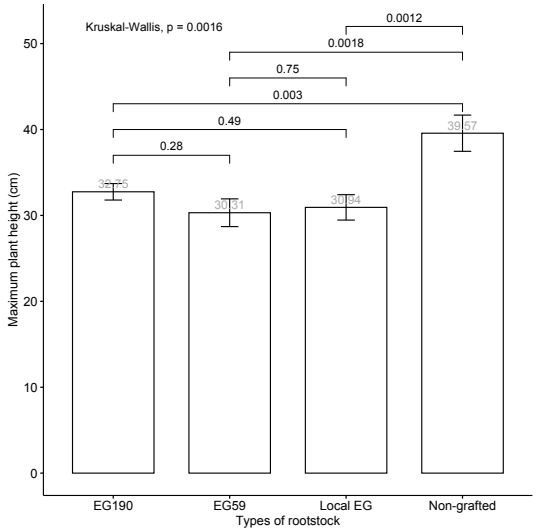

Fig. 3: Maximum plant height of the graft and non-grafted plants (n = 16).

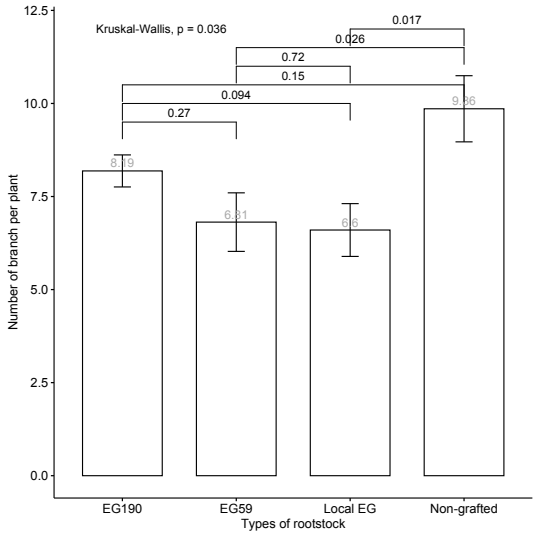

Fig. 4: Number of branches per plant of the graft and non-grafted plants (n = 16).

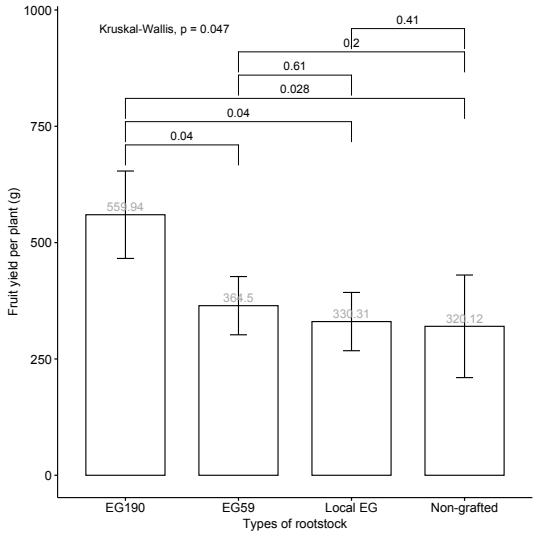

Fig. 5: The total fruit yield of the graft and non-grafted tomato plants (n = 16).

Discussion

The non-grafted plants grew bigger and had more branches but they were low survival rate, with less productive in terms of fruit. Survival rate of tomato plants growing in stress conditions (too wet or hot) could be improved by using grafted seedlings. The local eggplant or market available eggplant cultivars could be used as rootstocks for the grafted seedling of tomato plants. Vegetable grafting is a horticultural crop technique to take advantage of genetic resistance (Lee & Oda, 2003). Likewise, suitable rootstocks of tomato grafting can improve tomato growth performance (Marsic & Osvald, 2004). Tomato can minimize problems caused by flooding and soil-borne diseases through grafting tomato scions onto selected rootstocks (Black et al., 2003). The EG190 was the greatest eggplant rootstock of grafting tomato compared to those of the local eggplant and the market available eggplant. The local eggplant and available market eggplant were good enough to use instead of EG190 when it is not available. Grafted plants benefit from utilization of vigorous rootstock genotypes to increase water and nutrients (e.g., phosphorus and nitrogen) uptake for increased yield (Ruiz & Romero, 1999; Leonardi & Giuffrida, 2006; Turhan et al., 2011).

Overall, tomato plant survival rate and productivity can be improved by grafting tomato scions onto local or market available eggplant rootstocks. The tomato grafting can be used as an innovative horticultural crop technique to deal with problem of too much water or rain at atypical times for tomato production in Cambodia. Cambodian farmers as well as plant nursery owners might benefit from grafting techniques for vegetable seedlings commercialization.

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