Graft Compatibility Between Eggplant Rootstocks and Hybrid Tomato (*Solanum lycopersicum* Mill.) Cultivars

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Abstract

Tomato grafting has proven to mitigate some soil-borne diseases and abiotic stresses as well as improve plant growth, yield and fruit quality. However, in Tanzania the graft compatibility between eggplant rootstocks and hybrid tomato cultivars has not yet been explored. Therefore, the objective of this study was to evaluate graft compatibility between eggplant rootstocks and hybrid tomato cultivars grown in Tanzania. The study was conducted at Sokoine University of Agriculture (SUA) Morogoro, Tanzania and the experiment was laid out in a Complete Randomized Design with three replications. Hybrid tomato cv. Assila and Monica were each cleft-grafted onto eggplant EG190, EG195 and EG203 rootstocks, healed for six days in a healing chambers, hardened for seven days under a shade of 30% and later transplanted in the open field. Data were subjected to Analysis of Variance using GenStat v.14 statistical package (VSN International, UK) and treatment means were separated based on Tukey's Test at P≤0.05. Results reveal that grafting eggplant EG190, EG195 and EG203 rootstocks with hybrid tomato cultivars significantly led to partial incompatibility based on higher incidence of adventitious roots at the graft union (p=0.001), plant wilting (p=0.001) and death (p=0.001) after transplanting in the field. Similarly, grafting these eggplant rootstocks significantly reduced plant height (p=0.001) and stem diameter (p=0.001) of tomato cv. Assila and Monica in comparison to ungrafted controls. Conversely, grafting these eggplant rootstocks significantly advanced flowering (p=0.008) and fruit harvest (p=0.001) of tomato cv. Assila and Monica compared to ungrafted controls. Further studies are required to determine rootstocks that are vigorous enough to carry the scions of hybrid tomato cultivars for improved graft compatibility and plant growth.

Key words: Grafting, Flowering, Harvesting, Adventitious roots, Assila, Monica

Introduction

Tomato (*Solanum lycopersicun* Mill.) is Tanzania's most important vegetable crop, contributing to 51% of total vegetable production (Mamiro *et al.,* 2015). It is the most important crop for cash and domestic uses produced mostly by small and medium-scale farmers in large areas of Tanzania Mainland (Meya *et al.,* 2014). Tomato fusarium wilt disease and root knot nematode are some of the most devastating tomato diseases in the country. Tomato is also constrained by abiotic stresses such as salinity, drought, excessive heat and declining soil fertility (Minja *et al.,* 2011).

Pesticide application is the major pest management strategy of tomato pests in the country (Maerere *et al.,* 2010; Mamiro *et al.,* 2015) usually applied on a weekly or bi-weekly basis (Mtui *et al.,* 2015). This frequent pesticide application exacerbates both the costs of production, potential for human health and environmental risks associated with pesticides (Maerere *et al.,* 2010; Meya *et al.,* 2014; Mtui, *et al.,* 2015). Ineffectiveness of some pesticides, unaffordability of effective ones by resource limited farmers and inadequate know-how on their appropriate use are other appreciable setbacks (Mtui *et al.,* 2010; Meya *et al.,* 2014). Disease resistant varieties are limited (Minja *et al.,* 2011) and when available, they are often overwhelmed by novel pathogens and higher disease pressure (Cerkauskas, 2005; Louws *et al.,* 2010; Michel *et al.,* 2010). This leaves

farmers with few options for managing soil-borne diseases and therefore at the mercy of these stresses.

Grafting technology can be employed by farmers that cannot afford soil steaming and pesticides. Today grafting is also being employed to enhance crop response to a variety of abiotic stresses, and improve plant growth, yield and fruit quality (Rivero *et al.,* 2003; Louws *et al.,* 2010; King *et al.,* 2010; Schwarz *et al.,* 2010; Rivard and Louws 2011). For example, Black *et al.* (2003) recommends rootstocks EG195 and EG203 to manage tomato fusarium wilt disease under hot arid and wet conditions. Graft success of 86-100% has been reported between eggplant rootstocks and local tomato cultivar grown in Tanzania (Msogoya and Mamiro, 2016). Hybrid tomato cultivars such as Monica, Anna, Assila, Shanty, and Eden have become popular in the country due their high yield though some are susceptible to tomato fusarium wilt disease. Grafting eggplant rootstocks onto hybrid tomato cultivars could increase their tolerance to soil-borne diseases. However, there is limited information on the graft compatibility between eggplant rootstocks and hybrid tomato varieties grown in Tanzania. Therefore, the objective of this study was to evaluate the graft compatibility between eggplant rootstocks and hybrid tomato cultivars grown in Tanzania.

Materials and Methods

Description of the study area

The study was conducted at Sokoine University of Agriculture (SUA) in Morogoro, Tanzania. The study area for field experiment was located 6°05'S, 35°37'E and at an elevation of 568 m above the sea level. The experiment was conducted in the open field between March and July 2017. The rainfall pattern in the study area was bimodal with the short rains from November to December and the long rains from February to May. The annual rainfall ranges between 800 and 950 mm (Kisetu and Teveli, 2013).

Grafting experiment was carried out a palm leaf-thatched house consisting of dark and transparent healing chambers. In both chambers temperatures and relative humidity were monitored using a thermo-hygrometer (Dickson TH550, The Dickson Company, Addison, IL) and maintained by misting at 22-25◦C and 90-95%, respectively (Black *et al.,* 2003; Kubota *et al.* 2008; Ozores-Hampton and Frasca, 2013). Doors of the healing chambers were opened whenever relative humidity rose above 95% (Ozores-Hampton and Frasca, 2013).

Sowing and pricking

Scion seeds for hybrid indeterminate tomato cv. Monica and semi-determinate tomato cv. Assila were purchased from local agro-dealers in Morogoro. Seeds for eggplant EG190, EG195 and EG203 rootstocks were obtained from Asian Vegetable Research and Development Centre in Taiwan. Seeds were sown in seedling trays filled with compost before pricking them into 7.0 cm diameter and 10.0 cm long polythene tubes. Eggplant rootstocks were sown three weeks earlier than tomato scion cultivars to secure comparable seedling stem diameters at grafting time (Tamilselvi and Pugalendhi, 2017).

Experimental designs

Grafting experiment

The experiment was laid out in a completely randomized design with six treatments each replicated three times. The treatments consisted of graft combinations namely EGG190/Assila, EGG195/Assila, EGG 203/Assila, EGG190/Monica, EGG195/Monica and EGG 203/Monica. A replicate consisted of 30 grafted seedlings. Before grafting, the working surfaces and grafters' hands were disinfected with 70% ethanol to minimize possible contamination (Rivard and Louws, 2011). Grafting was performed in a palm leaf-thatched grafting house when rootstock and scion seedlings were 42 and 21 days old, respectively. Tomato cv. Monica and Assila seedlings were each cleft-grafted (Black *et al,* 2003) onto EG190, EG195 and EG203 rootstocks. The graft union was secured with a grafting tape and grafts were mist-sprayed before transferring them into the dark chamber where they were healed for three days. The grafts were then transferred to a transparent chamber and healed further for three days. The grafted seedlings were finally hardened off for seven days under a shade that allowed 30% of

the light prior to transplanting in the field.

Field experiment

The field experiment was laid out in a randomized complete block design with eight treatments replicated three times. The graft treatments namely EG190/Asilla, EG190/Monica, EG195/Asilla, EG195/Monica, EG203/Asilla and EG203/Monica were transplanted in the open field. Ungrafted Asilla and Monica served as controls. Each replicate comprised of 12 plants spaced at 60 cm x 60 cm with a 100 cm wide walkway between adjacent plots. The experiment was carried out under a drip irrigation system. NPK compound fertilizer (17:17:17) was applied as top dressing at the rate of 150 kg per ha three weeks after transplanting. All cultivars were staked three weeks after transplanting. Suckers developing below the graft interfaces were removed on a weekly basis to protect tomato scions. Ridomil Gold (Metalaxyl-M 40g/kg + Mancozeb 640/kg) was applied weekly against fungal diseases at a rate of 3 g L^{-1} of water. Coragen 20 SC (Chlorantraniliprole) was applied at a rate of 0.25 ml L^{-1} of water against South American leaf miner (Tuta absoluta). Sumectin 10 EC (Emamectin benzoate) was applied to manage other insect pests. The crop was kept weed-free by weeding using hand hoe.

Data collection

Graft success

The number of grafts that survived at the end of stay in each healing environment (dark, transparent healing chambers, and nursery for hardening off) was recorded. Percentage grafting success was computed as shown below.

$$Grafting\ success = \frac{Number\ of\ successful\ grafts \times 100}{Total\ number\ of\ grafts}$$

Plant growth

Data were collected from 12 plants on number of plants that formed adventitious roots at the graft interface, number of wilting plants, number of dead plants, days to first flower set and days to first harvest. Data were also collected on plant height and diameter at first fruit harvest. Plant height was measured from the root collar to the growing point using a 2-m ruler. Stem diameter was measured at 20 cm from the soil surface with a digital vernier calliper (USDA-AMS, Burlingame, CA).

Data analysis

Data were subjected to Analysis of Variance (ANOVA) using Genstat v.14 Statistical package (VSN International, UK) and treatment means were separated based on Tukey's Honest Significant Difference ($p \leq 0.05$).

Table 1: Grafting success of eggplant rootstocks with hybrid tomato scions at seedling stage

Treatment	Graft success (%) chamber		
	Dark healing chamber	Transparent healing chamber	Nursery hardening off stage
EG190/Assila	93	90ab	83
EG195/Assila	100	100b	90
EG203/Assila	97	80a	80
EG190/Monica	100	100b	100
EG195/Monica	100	100b	90
EG203/Monica	100	93b	90
Grand mean	99.0	96.0	90.0
CV (%)	3.2	7.7	10.7
P-Value	0.300	0.008	0.243

Means in the same column followed by the same letter are not significantly different (P≤0.05) based on Turkey's Honest Significant Difference. CV= coefficient of variation

Results

Grafting success between eggplant rootstocks and hybrid tomato

Result show that EG203/Assila graft combination had significantly (p = 0.008) lower graft success in the transparent healing chamber than EG195/Assila, EG190/Monica, EG195/Monica and EG203/Monica (Table 1 above).

Grafting significantly (p=0.001) increased the incidence of adventitious roots at graft union in both tomato cv. Assila and Monica (Table 2). Similarly, grafting significantly (p=0.001) increased the incidence of plant wilting (p=0.001) and plant death (p=0.001) in both tomato cv. Assila and Monica compared to the ungrafted controls (Table 2).

The results of the present study unveil a high compatibility been eggplant rootstocks and hybrid tomato cultivars with graft success ranging from 80 to 100% at transparent healing chamber. The high graft success observed in this study is supported by Msogoya and Mamiro (2016) who also reported graft success of 86-100% for eggplant rootstocks/local tomato cultivar graft combinations. Likewise, Marsic and Osvald (2004) observed a graft success of 100% for tomato cv. "Monroe" grafted onto "Beaufort" rootstock and graft successes of 92 and 93 % for tomato cv. "Belle" onto "Beaufort" and "PG 3" rootstocks, respectively.

On the contrary, eggplant rootstock/Assila and rootstock/Monica graft combinations had

Table 2: Graft success of eggplant rootstocks and tomato scion hybrid tomato at field level

Treatment	Incidence of adventitious roots (%)	Incidence of plant wilting (%)	Incidence of plant death (%)
EG190/Assila	100f	3.3c	2.3c
EG195/Assila	53.3cd	2.6b	1.8ab
EG203/Assila	80.0e	2.9bc	1.0a
Assila	0.0a	1.0a	1.0a
EG190/Monica	100f	3.3c	2.4c
EG195/Monica	43.3c	2.8b	1.3ab
EG203/Monica	73.3e	2.6b	1.0a
Monica	0.0a	1.0a	1.0a
Grand mean	55.93	1.9	1.3
CV (%)	13.18	7.8	28.3
P-Value	0.001	0.001	0.001

Means in the same column followed by the same letter are not significantly different (P≤0.05) based on Turkey's Honest Significant Difference. CV = coefficient of variation

Growth of grafted tomato plants

Grafting resulted in a significant (p=0.008) reduction of number of days to first flowering (p=0.008) and number of days to first fruit harvest (p=0.001) in both tomato cv. Assila and Monica (Table 3). Similarly, grafting significantly reduced plant height (p=0.001) and stem diameter (p=0.001) at first harvest in both tomato cv. Assila and Monica.

Discussion

Graft compatibility between eggplant rootstocks and hybrid tomato

partial incompatibility expressed by higher incidences of adventitious roots at the graft interface. Adventitious roots at the graft union are triggered by accumulation of carbohydrate and auxin (Kawaguchi *et al.,* 2008). The accumulation of carbohydrate and auxin at the graft union is due to limited vascular continuity between the rootstocks and scions which prevents free translocation of water and nutrients (Ives *et al.,* 2012). Tamilselvi and Pugalendhi (2017) reported partial incompatibility in bitter gourd/cucurbit graft combinations owing to discontinuous xylem elements in the graft

Table 3: Effect of grafting eggplant rootstocks on plant growth parameters of hybrid tomato cultivars

Treatment	Days to first flowering	Days to first harvest	Plant height at first harvest (cm)	Stem diameter at first harvest (mm)
EG190/Assila	22.0a	65.7a	60.4a	6.4a
EG195/Assila	22.0a	66.0a	89.2f	9.3b
EG203/Assila	22.0a	64.7a	74.2de	8.8b
Assila	26.33g	71.3b	112.2g	12.2cd
EG190/Monica	22.3ab	64.0a	55.3a	6.3a
EG195/Monica	23.7ab	66.0a	70.7b	9.2b
EG203/Monica	24.0cd	65.0a	74.2bc	9.0b
Monica	25.7ef	72.3bc	109.6g	10.9c
Grand mean	27.2	70.06	95. 8	10.5
CV (%)	2.4	1.4	8.8	11.6
P-Value	0.008	0.001	0.001	0.001

Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$) based on Tukey's Honest Significant Difference and CV= coefficient of variation

union, which express itself as plant grows and water requirement increases. Ives *et al.* (2012) also observed development of adventitious roots at the graft union of pepper/tomato heterografts due to partial incompatibility.

The high incidence of plant wilting and death of EG190/ Monica and EG190/Assila graft combinations in this study was due to reduced water and nutrient transport from the roots to the scions. Tai *et al.* (2004) observed stunted growth and subsequent death of all Capsicum/Solanum heterografts due to limited vascular continuity and water translocation. These observations are also supported by Oda *et al.* (2005) who reported that the reduction in water and nutrient transport to the scion is due to low hydraulic conductance. Heterografts such as tomato scions/eggplant rootstock graft combinations usually exhibit partial incompatibility, which further impairs water and nutrient translocation from the rootstock to the scions in comparison to homografts (Kawaguchi *et al.,* 2008; Goldschmidt, 2014). Martinez-Ballesta *et al.* (2010) also stressed that eggplant root systems are smaller than tomato rootstocks, which restricts xylem hydraulic conductivity to absorb water and nutrients from the soil and translocate them towards the scions.

Effect of rootstocks on plant growth of hybrid tomato cultivars

Results of this study show that grafting reduced plant height and stem diameter, and enhanced flowering and fruit maturity. These findings concur with Khah *et al.* (2011) who reported the same trend in both greenhouse and open field eggplant/tomato graft combinations. Enhanced flowering is an important aspect in fruit vegetable production as it advances harvesting to secure good market prices (Davis *et al.,* 2008; Lee *et al.,* 2010). The low plant heights and small stem diameters in tomato cv. Assila and Monica grafted onto eggplant rootstocks in this study is comparable to reports in previous studies. For instance, Ibrahim *et al.* (2001) reported that wild solanum rootstock/tomato cv. "BARI tomato 3" graft combination resulted in shorter plants than the ungrafted ones. Non-vigorous rootstocks have been reported to reduce plant growth of scions (Bletsos and Olympios, 2008). Similarly, tomato grafted onto eggplant rootstocks (less vigorous) exhibits limited growth than self-rooted plants (Rivero *et al.,* 2003; Louws *et al.,* 2010; Rivard and Louws, 2011; Schwarz *et al.,* 2010). Plant height and diameter are positively correlated with the number of fruits and fruit size as also reported earlier (Abdelhafeez *et al.,* 1975). The enhanced dwarfism of the grafted tomato cv. Assila and Monica in this study

could be attributed to slow water, mineral and sugar translocation across the graft union (Ives *et al.,* 2012) caused by limited vascular system continuity and few vascular bundles at the graft union (Tai *et al.,* 2004).

Conclusion

Grafting eggplant EG190, EG195 and EG203 rootstocks onto hybrid tomato cv. Assila and Monica advances plant flowering and fruit harvest. However, grafting leads to partial incompatibility after transplanting, which decreases plant height and diameter, and increases the incidence of plant wilting and death. Further studies are required to determine rootstocks that are vigorous enough to carry scions of hybrid tomato cultivars in order to improve graft success and plant growth.

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