Tolerance of Two Grafted Tomato Plants (F1 Mongal and Buru Buru; Calinago F1 and Buru Buru) to Fungal Diseases

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Tomato (Solanum Lycopersicum), a perennial, horticultural crop, can be affected by many pathogens that cause reproductive and vegetative abnormalities. These organisms are often contagious as they can spread rapidly from plant to plant in a field under favourable conditions. Grafting can be an alternative solution to pesticide usage, which can benefit the environment as well as reduce farmers' expenditure while increasing plant yield. It is a plant propagation technique which involves connecting two plant segments to achieve plant union. Buru Buru, a wild member of the Solanaceae family, was used as a rootstock for common varieties of tomato (F1 Mongal and Calinago F1) to determine their tolerance to diseases under greenhouse conditions. Pathogens were introduced to the plants and they were observed for four weeks. The grafting process required a higher amount of Calinago F1 (45) than the F1 Mongal (33) for successful grafts. Results indicated that there were higher performances by the non-grafted F1 Mongal plants compared to the grafted F1 Mongal plants whereas there were higher performances by the grafted Calinago F1 plants compared to the non-grafted Calinago F1. This study demonstrates that there was a significant difference between the grafted and non-grafted entries of each variety with respect to disease incidence and disease severity.

Keywords: tomato, buru buru, graft, diseases.

1 Introduction

Tomato (Lycopersicum esculentum) is a perennial plant that belongs to the family Solanaceae. Tomatoes can take between fifty-five to ninety days to reach maturity and produce ripe fruits. Some have vines that are only eight inches at maturity while some can produce vines that sprawl twenty-five feet at maturity. Their fruits range from small to large sizes and are of an array of colours. Tomatoes grow best in well-drained sites in soil of a slightly acidic pH of 6.2 to 6.8 (Sideman, 2016). Tomato as a perennial plant often doesn't survive beyond a year, especially when affected by diseases. Many troublesome diseases in tomato plants are caused by pathogens that can affect the plants during the vegetative growth phase. Viral, bacterial and fungal diseases that affect roots, stems, leaves and/or fruits of tomato plants, is a major challenge. These infectious organisms live parasitically on plants and may become more active in the reproductive phase of tomatoes (Moore-Landecker, 1996). Diseases are often contagious and can spread from plant to plant in a field, often very rapidly when environmental conditions are favourable (Damicone & Brandenberger, 2015). Tomatoes exposed to diseases can develop soil rot problems, fruit and/or foliage problems. Pesticide usage has since become important to curb the spread of diseases which in turn poses as a hazard to the environment.

Grafting is an ancient, vegetative plant propagation technique that can be used to increase the life-span and productivity of tomato plants, subsequently contributing to the reduced usage of hazardous chemicals. It is accomplished most commonly, by connecting two plant segments, the shoot known as the 'scion' and the root piece called the 'rootstock' (Goldschmidt, 2014). There are many advantages to using the grafting technique, some of which include but are not limited to, perpetuating clones that cannot be economically reproduced from vegetative cuttings because the percentage of cuttings that root successfully is low; taking advantage of rootstocks with superior growth habits, insect and disease resistance, as well as drought tolerance; and repairing large trees or specimen plants that are damaged easily at or slightly above the soil line. Planting several seedlings of the same species around the injured tree and grafting them above the injury often can be used to repair the damage.

Grafting tomato on suitable rootstocks, especially in greenhouse conditions, has positive effects on cultivation performance such as improved fruit yield, number of fruits and fruit weight (Turhan et al. 2011; Khah et al., 2006). Some non-tuberous wild Solanum species have been reported to have high resistance against diseases and are compatible rootstocks of tomato (Ibrahim et al. 2001; McCammon & Honma, 1983; Ozaki 1985; Ali et al., 1990 a, 1990 b, 1992 a, 1992 b). Taylor (2012), grafted blight resistant scion cultivars and a susceptible heirloom scion to soil borne disease resistant rootstock where results showed that grafting and scion type both positively affected plant vigour and disease incidence. Gousset et al., (2005), grafted eggplants with a wild relative of eggplant, Solanum torvum. Morphology, fertility and levels of resistance were assessed against Ralstonia solanacearum. Bacterial wilt symptoms occurred on lower leaves of S. torvum plants tested, without however, causing any plant death. The presence of bacteria serologically detected in roots of symptomless plants, suggested S. torvum to be tolerant to R. solanacearum.

Solanum stramonifolium (Buru Buru), a wild relative of tomato, is an erect shrubby herb with prickles on its stems, branches and leaves that grows about ninety to one hundred and fifty centimetres tall. It bears berries that are whitish but yellow when ripe (Myint, 1994). The aim of this study was to determine if Buru Buru will be a suitable rootstock to common varieties of tomato, F1Mongal and Heat Master, to significantly improve their vegetative performance.

2. Materials and Methods

Project Location. The project was conducted under greenhouse conditions at 92, West Canefield Settlement, East Canje Berbice, Guyana, South America. Climate is generally characterized by two rainy seasons in May-June and November-January and dry seasons for the remaining months. Soil type in the project location is typically clayey.

Potting medium. For optimum growth, undisturbed top soil of the Ithaca Sandy Loam soil was collected from lands south of the Corentyne Highway from Palmyra Village to Rose Hall Town, Berbice, Guyana. These soils were collected for placement into the planting bags to use under greenhouse conditions for the grafted plants. Promix potting medium was purchased from the Caribbean Chemicals Guyana Limited (Georgetown, Guyana) and was used for seedling germination. Ingredients include sphagnum peat moss, peat humus, limestone, mycorrhizae, controlled release fertilizer and perlite.

Planting material. Buru Buru plants were collected in the project location from wild plants of the same phenotype. Tomato seeds were purchased from the Caribbean Chemicals Guyana Limited.
Experimental Design. The Completely Randomized Design (CRD) was used, with four treatments and three replicates of each treatment.
Treatment Design. There were four treatments, namely, Treatment one – Control1 (F1 Mongal); Treatment two (2) – Control2 (Calinago F1); Treatment three (3) – Grafted F1 Mongal; and Treatment four (4) – Grafted Calinago F1. Each experimental unit contained five plants and was replicated thrice resulting in a total of sixty plants being used.

Experimental Management. Tomato and Buru Buru plants were planted in seedling trays to germinate and grow until suitable stalk girth was achieved. In the interim, farms affected by common diseases of the Solanaceae family were visited. Fruit samples of plants displaying disease symptoms such as stunting, yellowing, sunken spots, rots or lesions were collected and pathogens were identified by the Head of Department of Pathology and Entomology at the National Agricultural Research and Extension Institute (NAREI). Pathogens that cause Anthracnose and Fusarium Wilt were identified on the plant samples.

Figure 1: Symptomatic tomato samples

Plants of suitable stalk girth then were grafted and held in place by plastic grafting clips. After the grafting process, plants were left to heal for fifteen days and the plastic clips were removed. Symptomatic plant samples were then mixed with water and introduced into the soil of grafted and non-grafted plants.

Figure 2: Grafted plants

Figure 3: Healed, grafted plants

The grafted and non-grafted plants were sprayed with two insecticides – Abamectin and Hyperkill- in rotation at 0.64 ml/L. Plants were monitored and watered daily. All observations were recorded and scored using the scoring sheets in Table 1 and Table 2.

Treatment				
Disease Incidence	Week 1	Week 2	Week 3	Week 4
None				
Affected plants				

Table 1: Scoring sheet for the disease incidence of plants. Source: Manandhar et al. 2016

Treatment					
Severity	Severity Scale	Week 1	Week 2	Week 3	Week 4
0	No visible symptoms				
1	Small brown spot,1-10% leaf/stem area/ Onset of wilting				
3	Brown sunken spots, 11-30% leaf/stem area/ Wilting of most leaves				
5	Brown spots on 31-50% leaf/stem area/ All leaves wilted				
7	Circular sunken spots on 51-75% leaf area/ Stalk collapsing				
9	Circular to irregular spots on 76-100% leaf area/ Plant dead				

Table 2: Scoring sheet for the disease severity of plants. Source: Manandhar et al. 2016

Parameters of Interest. The parameters that have been used for this study includes the percentage of plants to survive the grafting process, disease severity and disease incidence.

Statistical Analysis. The Statistics 10 Software Package was used to generate summary statistics and tables from the raw data collected. Microsoft Excel was used to construct tables and graphs.

3 Results and Discussion

The survival rate of the grafted plants has been low after the graft. The F1 Mongal grafts resulted in 52% survival compared to 36% for the Calinago F1 grafts as seen in Figure 6. Success rates obtained in grafting can be a function of (a) compatibility of the rootstock and scion, (b) grafting technique and (c) conditions under which the exercise is carried out. With respect to the latter two factors, it should be noted that these are largely controlled by the researcher and can have varying impacts depending on the level of experience and

the availability of suitable laboratory conditions. In the case of this study, both of these considerations would have been less than desirable

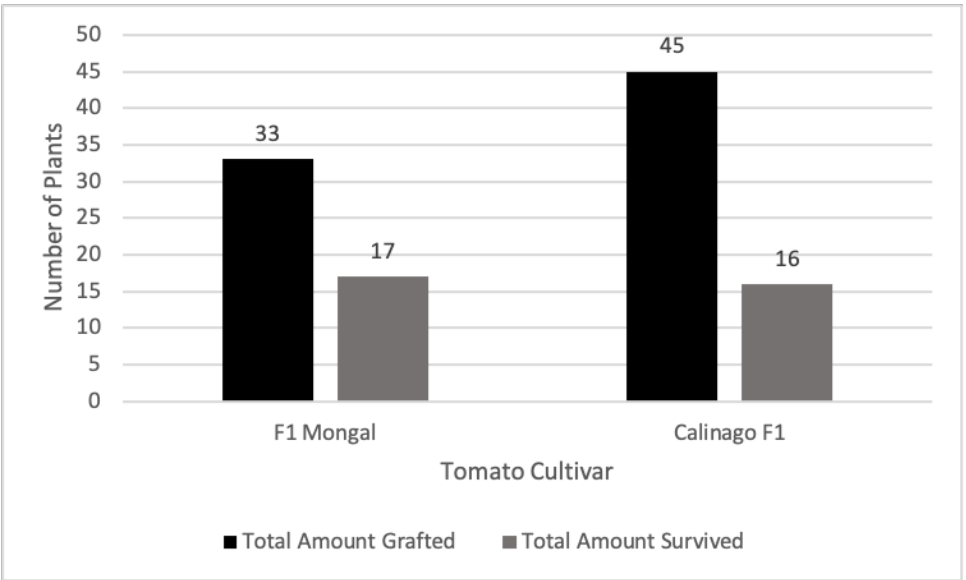

Figure 4: Number of plants to survive the grafting process

The grafting technique used in this study was the splice technique. The scions and rootstocks were cut to a 45° angle. Given the relatively soft nature of the plant tissue used in this study using the splice graft technique, success in repeating the procedure would have been largely a function of experience. This may have been a contributory factor to the high number of deaths among grafted plants. Davis et al., (2008) stated that there can be rootstock/scion incompatibility in a graft. According to Andrews and Marquez (1993), graft incompatibility often results from environmental factors or lack of skill by the grafter. Under the right grafting conditions, graft incompatibility could be due to: failure of rootstock to create a strong union, failure of grafted plant to grow or the premature death of the rootstock or scion after grafting. Graft incompatibility can also be due to physiological incompatibility, tissue and structure difference, phytohormones and biochemical characteristics.

Bausher (2013) examined the graft angle and its relationship to tomato plant survival. Scions 'FL-47' and 'Rutgers' were grafted at angles 20°, 45° and 70°. Increases in the graft angle resulted in a greater survival of grafted plants from 79% (20°), 81% (45°), and 92% (70°). These studies therefore demonstrate that the angle can significantly impact graft integrity and plant survival.

Figure 5 represents the disease incidence in plants for the four treatments after four weeks of exposure to pathogens. With reference to the number of plants affected by diseases, there were differences between the amount of the grafted and non-grafted plants of each cultivar. In general, less of the non-grafted F_1 Mongal appeared to be affected by any disease when compared to the grafted F_1 Mongal plants. Similar results were achieved in a study done by

Ibrahim *et al.,* (2001), on graft compatibility of Wild *Solanum* as a rootstock of Tomato in Bangladesh. Higher disease incidence was recorded in non-grafted plants when compared to the other grafted plants.

The results indicated that the Calinago F1 cultivar may have benefited from grafting to a slightly greater extent than the F1 Mongal cultivar. Less of the grafted Calinago F_1 plants appeared to be affected by any disease when compared to the non-grafted Calinago F_1 plants.

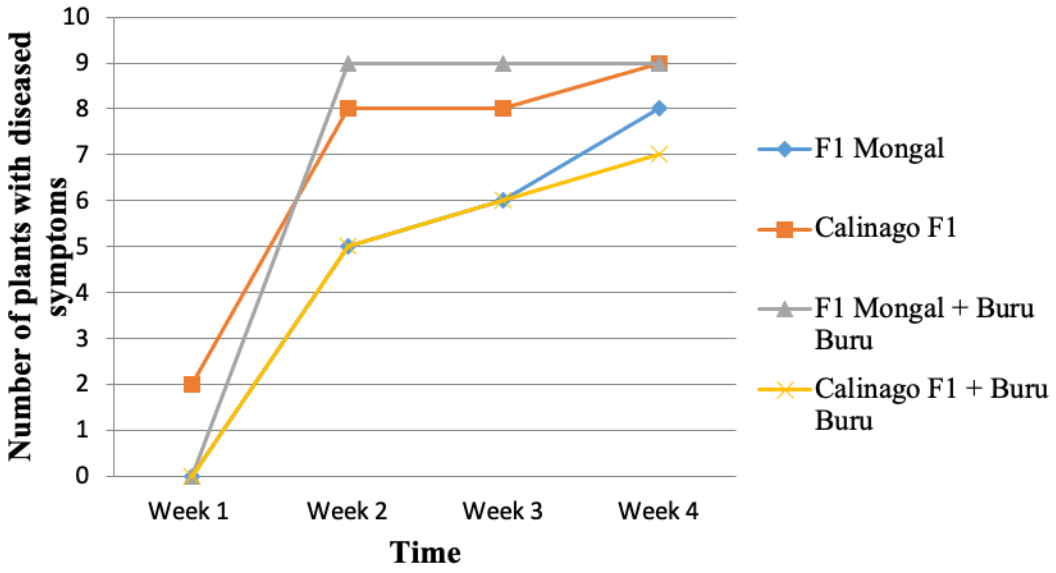

Figure 5: Disease incidence of plants

The disease severity of the plants, represented in Table 3, over four weeks between the treatments of non-grafted and grafted plants indicated that there were differences among entries for each treatment scored 0. McAvoy *et al.*, (2012) did greenhouse experiments with tomatoes which indicated that there was significant reduction in all rootstocks in bacterial wilt incidence as indicated by the percentage of plants wilted and the disease severity compared to a susceptible scion 'BHN 602'.

There were not many differences among the treatments for scores 1, 3 and 5. More grafted F_1 Mongal plants were scored 7 rather than the non-grafted F_1 Mongal plants. More of the non-grafted Calinago F_1 plants were scored 9 when compared to its grafted entry. Although Figure 5 indicated that disease incidence was higher in the grafted F_1 Mongal than in its non-grafted entries, the number of deaths of the grafted plants of the F_1 Mongal cultivar was less than its non-grafted entries.

In the presence of infectious organisms, grafted scions in relation to disease incidence and severity, could become infected due to the inability of the plant to tolerate diseases. The onset of this phenomenon is usually due to factors such as: (a) lack of cellular recognition,

(b) wounding responses, (c) presence of growth regulators or (d) incompatibility toxins which can affect scion and fruit quality (Andrews and Marquez, 1993).

Just as important, this study has had a number of limitations. While limited time (8 weeks) has been a constraint, a similar study being carried out in an open-field conditions may have varying results due to a change to a less ideal environment. An ideal environment with favourable conditions has been perpetuated to eliminate any external factors that could have influenced the results of this study and the objectives to test the disease incidence and severity of the grafted plants.

Treatment 1 (F_1 Mongal)					
Severity	Severity Scale	Week 1	Week 2	Week 3	Week 4
0	No visible symptoms	15	10	9	7
1	Small brown spot,1-10% leaf/stem area/ Onset of wilting	0	2	1	2
3	Brown sunken spots, 11-30% leaf/stem area/ Wilting of most leaves	0	0	1	1
5	Brown spots on 31-50% leaf/stem area/ All leaves wilted	0	0	1	0
7	Circular sunken spots on 51-75% leaf area/ Stalk collapsing	0	0	0	1
9	Circular to irregular spots on 76-100% leaf area/ Plant dead	0	3	3	4
Treatment 2 (Calinago F_1)					
Severity	Severity Scale	Week 1	Week 2	Week 3	Week 4
0	No visible symptoms	13	7	7	6
1	Small brown spot,1-10% leaf/stem area/ Onset of wilting	0	1	1	2
3	Brown sunken spots, 11-30% leaf/stem area/ Wilting of most leaves	0	1	1	1
5	Brown spots on 31-50% leaf/stem area/ All leaves wilted	0	1	1	0
7	Circular sunken spots on 51-75% leaf area/ Stalk collapsing	0	2	1	1
9	Circular to irregular spots on 76-100% leaf area/ Plant dead	2	3	4	5
Treatment 3 (F_1 Mongal and Buru Buru)					
Severity	Severity Scale	Week 1	Week 2	Week 3	Week 4
0	No visible symptoms	15	6	6	6
1	Small brown spot,1-10% leaf/stem area/ Onset of wilting	0	2	2	2

3	Brown sunken spots, 11-30% leaf/stem area/ Wilting of most leaves	0	1	1	0
5	Brown spots on 31-50% leaf/stem area/ All leaves wilted	0	2	1	0
7	Circular sunken spots on 51-75% leaf area/ Stalk collapsing	0	2	2	3
9	Circular to irregular spots on 76-100% leaf area/ Plant dead	0	2	3	4
Treatment 4 (Calinago F_1 and Buru Buru)					
Severity	Severity Scale	Week 1	Week 2	Week 3	Week 4
0	No visible symptoms	15	10	9	8
1	Small brown spot,1-10% leaf/stem area/ Onset of wilting	0	1	1	3
3	Brown sunken spots, 11-30% leaf/stem area/ Wilting of most leaves	0	1	2	1
5	Brown spots on 31-50% leaf/stem area/ All leaves wilted	0	1	1	0
7	Circular sunken spots on 51-75% leaf area/ Stalk collapsing	0	1	1	0
9	Circular to irregular spots on 76-100% leaf area/ Plant dead	0	1	1	3

Table 3: Disease severity of plants in four weeks

4. Conclusion

The grafting process revealed that the grafted F_1 Mongal plants had a higher survival rate than the grafted Calinago F_1 plants. Generally, the survival rate of both cultivars has been low which could be attributed to several factors including grafting techniques and grafting angles. For the purpose of deriving optimum results, different grafting techniques, grafting angles and varieties for rootstock and cultivars should be used in succeeding studies. Although the survival rate of the grafted F_1 Mongal has been higher than the grafted Calinago F_1, the disease incidence and severity was lower in the non-grafted plants than the grafted F_1 Mongal plants. Additionally, the disease incidence and severity were lower in the grafted Calinago F_1 than the non-grafted Calinago F_1 though the survival rate of the grafted plants was below 50%. Results can vary if this study is conducted in an open field as opposed to a greenhouse setting. The grafted plants can also be grown and observed past maturity to determine the effects of the graft on their reproductive cycle and outcome.

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