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Graft success percent of tomato PKM 1 with different flood tolerant solanaceous rootstocks

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Abstract
Tomato (*Solanum lycopersicon)* is the one of the most essential and consumed vegetable in the world. A change in the climatic conditions provides the way for biotic and abiotic stress in the vegetable crops. Grafting makes the plants to overcome the stress condition and it provides answer for the quest of stress condition and this was practised in tomato, brinjal, watermelon, etc. to overcome the stress situation like drought and salinity and no studies on waterlogging were reported. Hence a study was proposed to screen the compatible grafts of tomato for flooding condition during vegetative stage based on the previous studies at the Department of Crop Physiology, TNAU, Coimbatore. Different Solanaceous flood tolerant rootstocks are *Solanum torvum*, *Solanum sysimbriifolium*, *Solanum aculeatissimum*, LE 828 were grafted with scion, a commercial tomato plant PKM 1. Cleft grafting was practised and graft of *Solanum torvum* * PKM 1 recorded higher graft success percentage of 96%. Then the grafted plants were transplanted and subjected to flooding stress in the submergence tank and the different parameters recorded after 7 days of flooding were graft success percentage, number of leaves, shoot height, leaf area, total chlorophyll content. Graft LE 828 * PKM 1 showed better performance compared to other grafts in normal irrigated condition while in flooding condition graft *Solanum torvum* * PKM 1 performed better compared to other grafts of tomato genotypes in flooding. Hence the solanaceous rootstock LE 828 and *Solanum torvum* can be used as stress tolerant rootstock overcoming the climate change constrain in future.

Keywords: tomato, rootstock, scion, grafting, flooding

Introduction

Tomato (*Solanum lycopersican* L) is one of the widely cultivated and consumed vegetable. It contains carbohydrates, vitamins, minerals, aminoacids and carotenoids content (Draie., 2017) [4] and used for industrial purposes for making value added products like ketchup, sauce etc. Predominate amount of lycopene gives intense red colour to tomato and high levels of antioxidants (Takeoka *et al.,* 2001) [6]. Despite the properties of tomato, its production is limited by biotic and abiotic stress. Grafting is a technique evolved to overcome the multiple stress condition like biotic and abiotic stress by the joining the root stock and scion of different plants making into one plant (Zeist *et al.* 2017) [27]. Root stock selection is very important for grafting (King *et al.*,2010) [12] and Petran (2013) [18] stated that grafting overcomes abiotic and biotic stress and *Solanum torvum* reported as the best rootstock for interspecific grafting for egg plant by overcoming and giving resistance to soil borne pathogens, root knot nematodes, flood and drought conditions. Age of the plant, time and duration of flooding influences the tolerant potential of the plant (Kozlowski, 1997) [13]. In successful graft union development, changes such as callus formation, cell differentiation, organ regeneration, network communication established between the rootstock and scion at the graft region (Stegemann and Bock., 2009) [20].

Bletsos and Olympios (2008) [2] stated that egg plants grafted on *Solanum torvum* having a good compability between rootstock and scion and strong root system and healthy plants and grafted plants produce higher yields and improved fruit quality (Xu et al., 2005) [24]. Another factor flooding causes yield reduction and quality of the crops. The effect of changing climatic condition results in smaller or greater levels of determinatal effect to plants. Flooding is one of the abiotic stress factor affects the plant system and creating the devasting response on plant growth, reduction of yield and production also affected (Normile, 2008) [17]. In Flooding, the anaerobic condition due to standing water (waterlogged) for more time around the root system have negative impact over the normal functions in plants and creates the disturbance to growth, nitrogen fixation, yield and ultimately leads to plant death at various stages (Hasanuzzaman *et al*., 2016) [7]. Tomato is a flooding sensitive crop and the present study was proposed to screen the compatible grafts of tomato cultivar PKM1 grafted with different solanaceous rootstocks for flood tolerant condition.

Materials and Methods

In this study, compatible grafts were screened for flooding tolerance using different solanaceous rootstock and scion PKM 1. The experiment was carried out in the pot culture and submergence tank at the Department of Crop Physiology (11˚N latitude, 77 ̊E longitude; 426.7 MSL), Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India and the experimental period from November 2019 to April 2020 in the factorial randomized block design (FCRD).

Seedlings of different Solanaceous rootstocks are *Solanum torvum*, *Solanum sysimbriifolium*, *Solanum aculeatissimum*, LE 828 and the scion is the commercial tomato variety PKM 1 were used for grafting. Scion seeds were sown after the rootstocks are grown for some days, One month old scion is suitable for grafting because the stem diameter is enough for the rootstocks diameter. Gibberllic acid (GA) enhances the germination of the seed and seeds are treated with GA 500ppm for the overnight. Then the seeds are sown in portrays containing mixture of vermicompost and coirpith. Rootstocks are transplanted into polybags by one plant per bag for aiming to increase the stem growth and development for grafting.

Rootstock and scion with three to four true leaves, having equal stem diameter of rootstock and scion are selected for grafting and the method of grafting was cleft grafting. Essential things needed for grafting is steel blade, grafting clips and polythene covers. Carbon steel blades are used for cutting the stem portion, grafting clips for the fixing the rootstock and scion portion, polythene covers for covering the grafted plants. Grafting was carried out in shady greenhouse and then the grafted plants are taken to the healing chamber in the net house to avoid the direct sunlight and for enhancing the survival rate of the grafted plants. Water is given to the grafted plants in the spray form for controlling the wilt and improving the survival rate. Emerging side shoots are removed from the grafted plants because it restricts the growth and nutrient uptake. After 20 days, the healed grafts are counted in percentage basis for graft success percentage. Grafted plants are transplanted into pots containing mixture of red soil: FYM: sand in the ratio of 3:2:1 and submergence tank. Pot culture taken as control and submergence tank as treatment.

After 10 days of transplanting, grafted plants in the submergence tank were subjected to flooding for 7 days during the vegetative stage of the tomato. Water was maintained in the tank to 5centimeter above the soil. After 7 days of flooding, water was drained and parameters were recorded. Shoot length was measured from the base of the shoot to the apical portion of the plant and the mean was worked out and expressed in cm and the number of expanded true leaves was counted from the plant. Leaf area per plant was measured by using a Leaf Area Meter (LICOR, Model LI 3000) and expressed as cm^2. Total chlorophyll content was measured by using method of Yosida *et al.* (1976) [26] and expressed in mg g^{-1}. Data were statistically analysed by SPSS software package and critical difference calculated at five percent probability.

Results and Discussion

In the present study, compability of rootstock and scion was identified by graft success percentage (Table 1). Grafting provides the opportunity for overcoming the biotic and abiotic stress by attaching the two plant different parts and its complex process heals the rootstock and scion union after grafting. Significantly highest graft success percentage was recorded by the graft *Solanum torvum* * PKM 1 of 96% followed by *Solanum sysimbriifolium* * PKM 1 (68%), *Solanum acculeatissimum* * PKM (65%) and LE 828 * PKM 1 (62%). Xu *et al* (2015) [25] inferred that growth and development of grafted plants is based on the influence of rootstock and growth habit nature. Graft union takes place 7-8 days after grafting through the formation of xylem and phloem vessels (Fernadez-Garcia *et al.*, 2004b) [5]. Appropriate rootstock gives successful graft union establishment with scion in grafting (Turhan *et al*, 2011) [22] and Kawaguchi *et al.*, (2008) [11] stated that poor connection and failure of graft was due to low interaction towards rootstock and scion and hence less morphological growth. Healing process was triggered by the cambium formation by callus that fills the void area between rootstock and scion parts and establishing the connection between the vascular portion of rootstock and scion (Martinez-Ballesta *et al*., 2010) [15]. The establishment of vascular connection regulates the water and nutrient uptake and indicates the compability of rootstock and scion (Moore, 1984) [16].

Dhivya. R (2013) [3] studies reported that cleft grafting have higher successful rate with *Solanum torvum* as rootstock with scion of TNAU Tomato hybrid scion CO-3. The formation of callus tissue bridges the grafted region by spreading the gap between grafted regions and fusing with the proliferation layer. This adhesion of callus allows the interconnection of opposing plasmodesmata and allows the flow of xylem exudates between rootstock and scion tissues thereby increasing survival in graft combinations (Tamilselvi and Pugalendhi, 2017) [21]. The grafts recording lower grafting percentage have the improper connection of vascular tissuses, less morphological affinity between the rootstock and scion (Kawaguchi *et al.*, 2008) [11] and in compability of the species (Zeist *et al.*, 2017) [27]. The selected rootstocks should have high vigourous character and tolerance to stress condition such as water and salt stress (Ahn *et al.* 1999; Wei *et al.*, 2006; Rivero *et al.*, 2003) [1, 23, 19]. Growth and morphology of the grafted plants depends on the stock-scion compatibility. Under controlled condition, among the grafts significantly highest plant height (Table 2) was recorded in the graft LE 828 * PKM 1 (23.28 cm) followed by the graft *Solanum torvum* * PKM 1 (20.54) and the non-grafted PKM 1 recorded 28.76 cm under the control condition whereas in the flooding condition significantly highest plant height was recorded in the graft *Solanum torvum* * PKM 1 (18.95 cm) followed by the graft *Solanum acculeatissimum* * PKM 1 (17.56 cm) and non-grafted PKM 1 recorded 21.33 cm. The cultivar PKM 1 recorded higher plant height was comprehended as the vegetative growth duration was not hindered by the grafting technique as observed in the different grafts.

Flooding affects the plant growth, root growth (Jackson and Colmer, 2005) [9] due to waterlogged condition around the root system and the reduction in the leaf number occurs through wilting and senescence (Jackson, 1956) [10]. Number of leaves in the grafts (Table 2) were observed under the control condition among the grafts, LE 828 * PKM 1 recorded more number of leaves (5.3) followed by the graft *Solanum torvum* * PKM 1 (5.0) while in flooding condition significantly number of leaves recorded in the graft *Solanum torvum* * PKM 1 (4.7) was more compared to other grafts. Hsiao et al (1976) [8] stated that decreasing leaf area is due to the loss in turgor of the leaf due to flooding which may deter the leaf cell expansion process. Among the grafts under control condition highest leaf area (Table 3) was recorded in the graft LE 828 * PKM 1 (63.05 cm^2) while in the flooding condition the significantly highest leaf area was recorded in the graft *Solanum torvum* * PKM 1 (51.92 cm^2) followed by the graft *Solanum acculeatissimum* * PKM 1 (45.23 cm^2) and the non-grafted PKM 1 recorded (38.97 cm^2). Flooding stress causes the symptoms of yellowing, wilting etc and the decrease in leaf nitrogen content resulted decrease in the chlorophyll pigments (Kumar et al., 2013) [14] and hence reduction in the chlorophyll content (Table 3). In the present study, under the controlled condition LE 828 * PKM 1 recorded significantly higher chlorophyll content (1.55 mg g^{-1}) followed by the graft *Solanum acculeatissimum* * PKM 1 while in the flooding condition highest chlorophyll content was recorded in the graft *Solanum torvum* * PKM 1 (0.93 mg g^{-1}) followed by *Solanum acculeatissimum* * PKM 1(0.85 mg g^{-1}) and the non-grafted PKM 1 recorded chlorophyll content of 0.58 mg g^{-1}. Hence, it can be concluded that under flooding condition, graft of *Solanum torvum* * PKM 1 performed better in terms of significantly greater plant height, leaf number, leaf area and chlorophyll content followed by *Solanum acculeatissimum* * PKM 1 while in the controlled condition among the grafts, the growth and morphology was better in LE 828 * PKM 1.

Table 1: Graft success percentage (%) of tomato cv. PKM 1 grafted with different solanaceous rootstocks

Treatments (Rootstock*scion)	Graft success Percentage (%)
LE 828* PKM 1	62.86
Solanum torvum * PKM 1	96.00
Solanum sysimbriifolium * PKM 1	68.00
Solanum acculeatissimum * PKM 1	65.00
Mean	72.97
SEd	0.45
CD (P=0.05)	1.05

Table 2: Shoot height (cm) and number of leaves of tomato cv. PKM 1 grafted with different solanaceous rootstocks

Treatments (Rootstock*scion)	Shoot height (cm)			Number of leaves		
	Control	Flooding		Control	Flooding	
T_1- PKM 1 (Non-grafted)	28.76	21.33		6.0	3.7	
T_2-LE 828* PKM 1	23.28	16.04		5.3	4.0	
T_3-*Solanum torvum* * PKM 1	20.54	18.95		5.0	4.7	
T_4-*Solanum sysimbriifolium* * PKM 1	20.12	16.53		4.0	3.7	
T_5-*Solanum acculeatissimum* * PKM 1	18.93	17.56		4.7	4.3	
Mean	22.33	18.08		5.0	4.1	
	G	F	G×F	G	F	G×F
SEd	0.43	0.27	0.61	0.31	0.20	0.45
CD (P=0.05)	0.89	0.56	1.27	0.66	0.42	0.93

Table 3: Leaf area (cm^2) and Total Chlorophyll content (mg g^{-1}) of tomato cv. PKM 1 grafted with different solanaceous rootstocks

Treatments (Rootstock*scion)	Leaf area (cm^2)			Total Chlorophyll Content (mg g^{-1})		
	Control	Flooding		Control	Flooding	
T_1- PKM 1 (Non-grafted)	71.32	38.97		1.60	0.58	
T_2-LE 828* PKM 1	63.05	42.91		1.55	0.81	
T_3-*Solanum torvum* * PKM 1	54.94	51.92		1.50	0.93	
T_4-*Solanum sysimbriifolium* * PKM 1	56.87	44.68		1.52	0.82	
T_5-*Solanum acculeatissimum* * PKM 1	57.73	45.23		1.53	0.85	
Mean	60.78	44.74		1.54	0.80	
	G	F	G×F	G	F	G×F
SEd	1.09	0.69	1.55	0.02	0.01	0.03
CD (P=0.05)	2.29	1.44	3.24	0.05	0.03	0.07

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