Grafting Technique to Eliminate Rootstock Suckering of Grafted Tomatoes

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Abstract. Vegetative grafting has been proposed as a technique for managing diseases in tomatoes under open-field conditions. Over 2 successive years, we investigated the use of grafting under open-field fresh tomato production and found a serious limitation with current grafting techniques, which resulted in recurring rootstock shoot regrowth (“suckering”) from the rootstock cotyledons when left intact. Left unchecked, the regrowth of tomato rootstocks can envelop the experimental scions, which can impact the growth of field-grown tomatoes. In the Fall of 2007, the cultivars Multifort, Aloha, and TX-301 with ‘FL-47’ scions were grafted by a commercial propagator. These grafted plants were planted in a field experiment and after a time period, the number of rootstock suckers was counted and removed. This process was repeated over five time periods. In 2008, we grafted all of the plants below the rootstock cotyledons. During five different time periods spanning 57 d, bud regrowth from the rootstock occurred in all studied rootstocks in 2007. The difference in the 2 years was dramatic. In the first year, the number of plants with rootstock regrowth was as high as 84.6% in some of the plots for ‘Multifort’, 30.7% for ‘Aloha’, and 15.4% for ‘TX-301’. In the second year, with a different grafting technique, no regrowth from the rootstocks was observed. Even when the rootstock regrowth was removed in 2007, the rootstock sprout growth would reappear from the rootstock. The statistical interaction of the percentage of plants with rootstock regrowth for all recorded dates in 2007 was significant for ‘Multifort’ (Tukey-Fischer $P \leq 0.05$) but not ‘Aloha’ or ‘TX-301’. Although the study also contained fumigation treatments, no interaction of soil treatments on root sprouting was observed. Since adopting this method, rootstock regrowth has not been observed in subsequent field experiments for the past 3 years.

The production and consumption of tomatoes in the United States and worldwide ranks it as a major vegetable crop. The use of methyl bromide fumigation for pest control is being phased out under the Montreal Protocol (EPA, 2010). There is also a need to find an alternative pest management program in both sustainable and organic vegetable production. Vegetative grafting is one of these methods and is currently used extensively in a number of countries using methods that produce plants grown in protected environments (Kubota et al., 2008). In the United States, fresh tomato is predominantly grown in the open field using drip or seep irrigation and raised beds covered with plastic mulch. In conventional systems, the soil is fumigated to control weeds and pests. The conditions that exist in the field are quite different from those found in protected agriculture where the plants are covered to give some protection from low-temperature

events. In open-field production, however, there is a complete lack of environmental control, including heavy rainfall events (greater than 5 cm) and numerous soil diseases, pests, and weeds (Hutchinson et al., 2007). Fumigation with methyl bromide (MB) to control field biotic problems in tomato production is being permanently phased out in 2015. A number of alternatives, including other fumigants, are being evaluated but regulations concerning their use may make adoption a problem (Hutchinson et al., 2007; Roskopf et al., 2005). One of the proposed strategies to deal with the loss of MB is the use of plants that are resistant to soil diseases in open-field production by using grafted seedlings. Although adoption of vegetative grafting has taken place in Asia, Europe, and recently Mexico, the use of some type of sheltering cover like high tunnels or netting is generally used. Little information is available concerning the use of grafted plants in unprotected open-field production common in the United States and other areas of the world. Most of the literature published on the subject of vegetable vegetative grafting techniques was developed for protected agriculture (Louws, 2006; Oda, 1999). This report documents an unintended consequence of working with grafted plants when current grafting techniques were used. The problem quite simply is the propensity for rootstocks

of grafted tomato plants to outgrow the scion. The objective of this article is to describe the issue and outline protocols and procedures to substantially reduce rootstock suckering.

Materials and Methods

The open-field experiments were conducted at the U.S. Horticultural Research Laboratory (USHRL), Fort Pierce, FL (lat. 27°26′09.39″ N; long. 80°25′53.38″ W). Soil type at USHRL is Oldsmar sand (Sandy siliceous, hyperthermic: Alfic Arenic Aquads). A split plot experiment with four replications was used to evaluate rootstock/scion combinations in fumigated and herbicide-only-treated soil. Experimental plots consisted of a single raised bed covered with metalized polyethylene film with between-row spacing of 0.92 m and in-row spacing of 0.56 m. Four main plot soil treatments were applied under metalized film (Canslit, Montreal, Quebec, Canada): 1) MB (224 kg·ha⁻¹, 67:33 MB:chloropicrin); 2) iodomethane (112 kg·ha⁻¹, 50:50 iodomethane:chloropicrin), Midas® (Arysta LifeScience Corp., Tokyo, Japan); 3) dimethyl disulfide (467 L·ha⁻¹), 79:21 DMDS:chloropicrin, Paladin™ + chloropicrin, (United Phosphorus, King of Prussia, PA); 4) a herbicide-only control (0.67 kg·ha⁻¹, Dual Magnum™; Syngenta Crop Protection US, Wilmington, DE; 17.51 g·ha⁻¹ Matrix®; DuPont, Wilmington, DE; and 26.89 g·ha⁻¹ Sandea®; Gowen Co., Yuma, AR). Subplot treatments in the primary tomato (*Solanum esculentum*) crop consisted of three rootstocks reported to be resistant to root-knot nematodes (*Meloidogyne incognita*, *M. arenaria*, *M. javanica*): ‘TX301’ (Syngenta Seeds, Minnetonka, MN), ‘Multifort’ (De Ruiter Seeds, Lakewood, CO), and ‘Aloha’ (American Takii, Salinas, CA), and the non-grafted scion, ‘Florida-47’ (Seminis Seed, St. Louis, MO) on its own rootstock. Main plots were 30.48 m long and were split into 7.62-m subplots for each tomato rootstock.

Plant preparation. In Sept. 2007, the plants were grafted and planted by a commercial propagator. In Sept. 2008, the plants were grafted at the USHRL. Scions were seeded in a 242 Speedling™ tray, 6.72 × 3.44 × 0.63 cm (Speedling Corp., Sun City, FL) using Fafard 4P (Fafard, Agawam, MA) germination mix with scion planted 3 d later and grown under greenhouse conditions (29/25 °C day/night). At 23 d, the tomato (two to three true leaf stage) grafting was accomplished using an adaptation of a splice graft held in place by a 1.5-mm silicon grafting clip (BATO, The Netherlands) (Oda, 1995). Studies were 14 plants per plot for each rootstock/scion combination, replicated four times, in four complete blocks designated by fumigation treatment.

Rootstock regrowth. Plants were visually inspected on approximately a weekly basis for the presence of rootstock regrowth (calculated as the percentage of plants with rootstock sprouts). After recording the presence of the rootstock sprouts, they were removed before the next observation. Rootstock regrowth was recorded as adventitious

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growth below the graft union. Results were analyzed using SAS Version 9.1.2 (SAS Institute, Cary, NC) software using the GLIMMIX procedure with Tukey separation at the $P \leq 0.05$ level.

Results and Discussion

Rootstock regrowth typical of the 2007 trial is shown in Figure 1. The meristems regrowth was quite vigorous on all the rootstocks surveyed and in each case, regrowth came from the area of the rootstocks cotyledon. In the 2007 study, there was rootstock adventitious bud growth (ABG) observed regardless of the rootstock used. The ABG on 'Multifort' was the most pronounced with mean values ranging from 57% on the first observation date to 34.1% on the last date observed [57 d after field transplanting (DAT)] (Fig. 2). These were the highest observed for these respective time periods and were significantly different from other rootstocks. 'Aloha' and 'TX-301' had ABG of 3.4% and 2.5%, respectively, at 16 DAT. At 57 DAT, the numbers for 'Aloha' and 'TX-301' increased dramatically to 31.1% for 'Aloha' and 34.2% for 'TX-301' (Fig. 2).

Fig. 1. 'Multifort' rootstock sprout with rootstock bud emerging (RS) below the text box with 'FL-47' scion. Arrow denotes the graft union (GU).

Removing the rootstock's sprouts in the 2007 planting did not deter rootstock regrowth with sprouts still occurring out to over 8 weeks. One explanation for this regrowth is the ability of tomatoes to produce multiple meristems at the cotyledon (Pozueta-Romero et al., 2001; Went, 1944). This explains rootstock shoot regrowth even after root

Fig. 3. Image of incorrect (A) and correct (B) method of grafting tomatoes for open field planting. Method A graft above the cotyledons; Method B graft below rootstock cotyledons. The percent sprouts is calculated from the number of plants with rootstock adventitious bud growth (ABG)/total number of plants assayed.

Fig. 2. Illustration of the progression of regrowth of the rootstock from adventurous buds, 'FL-47' scion, in the Fall of 2007–2008. Differences in statistical significance of mean values are valid only at the same time point (Tukey $P.05 \leq 0.0001$) and are designated by different letters.

sprouts were pruned by tearing the sprout from the stem (which is a commercial practice); however, in subsequent dates, more root sprouts occurred after each removal. Interestingly, between the first removal dates at 16 DAT and 26 DAT, the number of sprouts from the 'Aloha' was 3.4% and at 57 DAT, the number of sprouts increased to 31.4%. In each case of ABG, the shoot emerged from the vestigial cotyledon axillary bud (Fig. 1) for each of rootstock types. The presence of ABG does not correlate with the presence or absence of fumigant treatment and no significance was found between any of the fumigation methods (data not shown). When left unchecked, this rootstock regrowth can easily outgrow the scion and cause abandonment of open-field plots in Florida and other states (Bob Poklemba, Jeremy Taylor, and Josh Freeman, personal communication). Although the axial bud shoots are routinely pruned as a method to improve fruit size, this is an expense that should only be incurred once or twice in a 2-week period after planting (Olson, 2010; Pozueta-Romero et al., 2001; Went, 1944). Two other factors may influence the regrowth of rootstock meristem: the presence of a determinate scion and the high light intensity of open-field production. In 2008 using the technique of grafting below the cotyledon, as shown in Figure 3, we reduced the ABG to 0% for all the rootstocks presented. This style of graft requires lengthened hypocotyls. A method using end-of-day far-red light can aid in the elongation of tomato hypocotyls (Chia and Kubota, 2010).

Conclusion

Elimination of the cotyledon axillary meristems eliminated the regrowth of the rootstock. Since adopting below the cotyledon grafting, the problem of rootstock regrowth has not recurred.

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