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Evaluation of different grafting methods and rootstocks in watermelon grown in Egypt

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ABSTRACT

Grafting is an alternative approach to reduce crop damage resulting from soil-borne pathogens and increase plant abiotic stress tolerance, which in turn increases crop production. The purpose of this study was to determine the effect of three grafting methods [Tongue approach (TAG), Hole insertion (HIG) and Side grafting (SIG)] on plant growth and fruit yield of watermelon (*Citrullus lanatus*) 'Aswan F_1' that was grafted onto three rootstocks ('Nun 6001 F_1', 'Strongtosa F_1' and 'Tetsukabuto F_1') which are hybrids between *Cucurbita maxima* and *Cucurbita moschata*. TAG had significant higher main stem length, number of lateral stems, number of male flowers per plant, fruit yield per plant and fruit weight comparing to other grafting methods (SIG and HIG). However, number of leaves, number of female flowers per plant and sex ratio were not significantly different in all grafting types. Vegetative growth and fruit yield showed highest values when the 'Nun 6001 F_1' rootstock and TAG were used. The lowest number of male flowers and sex ratio were found when the 'Nun 6001 F_1' rootstock and HIG method were used. However, the lowest number of female flowers was found in non-grafted plants. Among the 3 grafting methods tested, TAG seems to be the best grafting technique for watermelon. However an interaction between the grafting method and the used rootstock also seems to exist.

1. Introduction

Grafting herbaceous types of plants is used for various purposes, particularly for the commercial greenhouse production of selected vegetable crops. The rootstock is grafted shortly after seed germination while the plants are quite small. Such material is generally very soft, succulent, and susceptible to injury (Yamakawa, 1982; Hartmann et al., 1997). The advantages of vegetable grafting have been reported by many workers. Grafts were used to induce resistance against low and high temperatures (Rivero et al., 2003; Venema et al., 2008), enhance nutrient uptake (Colla et al., 2010a), increase synthesis of endogenous hormones (Dong et al., 2008), improve water use efficiency (Rouphael et al., 2008), reduce uptake of persistent organic pollutants from agricultural soils (Otani and Seike, 2007), improve alkalinity tolerance (Colla et al., 2010b), raise salt and flooding tolerance (Martinez-Rodriguez et al., 2008; He et al., 2009), and reduce the negative effect of heavy metal toxicity (Savvas et al., 2010).

Previous evaluation indicated that vigorous root system of the rootstock can absorb water and nutrients (Lee and Oda, 2003; Salehi-Mohammadi et al., 2009) much more efficiently when compared to non-grafted. It can also exhibit excellent tolerance to serious soil-borne diseases (Ioannou, 2001; Crinò et al., 2007). Grafting is associated with noticeable increases in fruit yield in many fruit-bearing vegetables such as tomato (Chung and Lee, 2007), watermelon, cucumber, melon, pepper and eggplant (Lee and Oda, 2003). However, there are several conflicting reports concerning the changes in fruit quality due to grafting and whether grafting is an advantageous or deleterious (Proietti et al., 2008; Flores et al., 2010). However, with the restriction in using methyl bromide for soil fumigation, growers become aware of using grafted transplants to manage soil-borne diseases. There are few reports on vegetables grafting under the Egyptian conditions due to the limited use of this technique in commercial production which is attributed to the high cost of rootstocks and facilities.

For many years grafting has been viewed as an option only in areas where labor costs are minimal such as Egypt. The major obstacles for wide spread use are the labor intensive and high labor cost necessary to successfully produce grafted transplants (Memmott, 2010). Numbers of influential factors are affecting the choice of grafting techniques including the ease and technicality of grafting, success rate, and overall cost (Davis et al., 2008; Hassell et al., 2008; Lee, 1994). Several different watermelon grafting techniques are available today. The TAG is one of the original grafting methods performed (Lee and Oda, 2003). However, the one cotyledon

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splice grafting and HIG are most commonly used today in commercial production. The TAG is relatively simple to graft with higher success rate and the growth uniformity (Hassell et al., 2008; Oda, 1995). The TAG continues to be preferred by inexperienced growers because of its technical simplicity, high success rate, and the little care needed since it does not require healing chambers (Lee and Oda, 2003). However this technique occupies twice the amount of space and is costly to maintain (Cushman, 2006).The HIG is favored by experienced watermelon growers because of growing space and performance (Lee and Oda, 2003). On the other hand, it requires slightly more skill than most other grafting techniques, and careful control of humidity, light, and temperature after grafting (Cushman, 2006). SIG is unpopular due to the failure of vascular bundles to align sufficiently for a strong healing to occur to secure the proper graft (Memmott, 2010). Also, SIG can experience high loses due to poor environmental control and possible disease under high humidity conditions (Cushman, 2006).

The interaction between grafting method and used rootstock has been described. Kawaide (1985) reported that TAG was most popularly used for watermelon grafting on the *Lagenaria siceraria* rootstock. Also, Ito (1992) and Lee (1994) indicated that the grafting methods of watermelon plants differed according to the used rootstocks. The HIG method was used with *L. siceraria* and *Benincase hispida*, while TAG was the most proper method when watermelon plants grafted into interspecific hybrids, *Cucurbita pepo*, *Cucurbita moschata* and *Sicyos angulatus*.

This experiment was conducted to examine the effectiveness of the interaction between three grafting methods (Tongue approach, Hole insertion and SIG) and three rootstocks ('Nun 6001 F_1', 'Strongtosa F_1' and 'Tetsukabuto F_1') on improving plant growth and fruit yield of watermelon 'Aswan F_1'.

2. Materials and methods

A field experiment was conducted at the Experimental Research Farm of the Faculty of Agriculture, Suez Canal University, Ismailia Governorate, Egypt to test the effect of three different grafting methods and three different rootstocks on plant growth performance, sex ratio, and fruit yield of watermelon 'Aswan F_1'. Grafting combinations were as follows: "Aswan F_1/Nun 6001 F_1" (scion/rootstock), "Aswan F_1/Strongtosa F_1", "Aswan F_1/Tetsukabuto F_1" and "Aswan F_1" (non-grafted, control).

2.1. Plant material

Watermelon (*Citrullus lanatus*) 'Aswan F_1' (Sakata Company, Japan) was used as non-grafted control. This cultivar is widely grown in commercial production of watermelon in Egypt, especially in Ismailia Governorate. The hybrids 'Nun 6001', 'Strongtosa' and 'Tetsukabuto' (*Cucurbita maxima* × *C. moschata*), released by Nunhems Zaden (The Netherlands), Syengenta Seeds (The Netherlands) and Takii (Japan), respectively, were used as rootstocks. 'Nun 6001 F_1' is from the most popular rootstocks commercially available for watermelon grafting worldwide (Miguel et al., 2004; King et al., 2010).

The seeds of the rootstocks were sown in a greenhouse at Tabarak Farm, Technogreen Co., Salhya, Ismailia, Egypt, 10–14 days earlier than the seeds of the scions to ensure similar stem diameters at the grafting time. Seeds were sown in 130-cell styrofoam trays under greenhouse conditions. The trays were filled with soil mixture (peatmoss, vermiculite and perlite mixes in 1:1:1 v/v/v). The environmental conditions for germination were 24–28 °C and 85–90% relative humidity.

Grafting methods were as follows:

Tongue approach grafting (*TAG*): After rootstock and scion have fully developed the first true leaf, plants were pulled out from the tray (Fig. 1a) and laid on a table (before doing the grafting, trays were heavily watered) and the growing point of rootstock was removed. A cut with 35° to 45° angle into the hypocotyl of rootstock approximately halfway was made with a razor blade and an oppositely angled cut was made on the hypocotyls of the scion (Fig. 1b and c). The two cut hypocotyls were placed together (Fig. 1d), then sealed with aluminum foil to help healing and prevent the graft from drying out (Fig. 1e). The two plants were then transplanted into a seedling tray with bigger cell (49-cell styrofoam trays) that can hold the two root plugs (Fig. 1f). The grafted seedlings were placed under plastic tunnel in the healing chamber under optimum temperature (25–30 °C) and humidity (>85% RH). Hardening process started four to five days after grafting by opening the tunnel for one hour followed by wetting the grafted plants with water before sealing the tunnel again. The tunnel was again opened for half a day in the sixth day and the tunnel plastic cover was removed entirely in the seventh day of grafting. After trays have been placed in the greenhouse, water was given only as needed. The stem of the scion was cut off 2 weeks after the grafting (Fig. 1e).

Hole insertion grafting (*HIG*): Seedling trays were maintained at 30 °C for germination. When both cotyledons and first true leaf started to develop, the rootstock plant was ready to graft (≈7 to 10 days after sowing) (Fig. 2a). A hole on the upper portion of the rootstock hypocotyls was made (Fig. 2b), and then the growing point of the rootstock was removed with a razor blade (Fig. 2c). The scion was then cut on a 35° to 45° angle on both sides of the hypocotyls (Fig. 2d). The scion was then inserted into the hole made in the rootstock and the cut surfaces were matched together and held with a grafting clip (Fig. 2e). Grafted plants were transferred to a humidity chamber or healing room. After the healing process was completed, grafted plants were then transferred and maintained at 24 to 30 °C in the greenhouse until the scion is connected well with the rootstock (Fig. 2f).

Side grafting (*SIG*)*:* When both cotyledons and first true leaf started to develop, the rootstock plant was ready to graft about 7 to 10 day after sowing (Fig. 3a). The growing point of rootstock was removed with a razor blade, a slit was cut on the hypocotyl of the rootstock with a razor blade (Fig. 3b). A 35° to 45° angle cut on both sides was done on the hypocotyl of the scion (Fig. 3c). The scion was then inserted into the slit in the hypocotyl of the rootstock (Fig. 3d). The two cut surfaces were matched together and held with a grafting clip (Fig. 3e). Grafted plants were transferred to a humidity chamber or healing room. Plants were maintained in the greenhouse until the scion was connected well to the rootstock (Fig. 3f).

Twelve plants per graft combination and treatment were transferred to a greenhouse after the grafts have been established (3 weeks after grafting). The cultivation was carried out using a surface irrigation system and normal fertilization for watermelon. The grafted plants were then planted in the soil at 2.0 m row spacing, with a 12.0 m row length, spaced 1.0 m apart, and grown in the open field. A randomized complete block design was adopted with 3 replications, each consisting of 4 plants. The grafted and control plants were cultivated from 18 March 2009 to 17 June 2009. Pesticides application followed the standard cultural practices.

The following measurements were recorded:

(a) Main stem length (cm/plant), number of lateral stems and leaves, all of them after 7 weeks from the cultivation in the field.
(b) Flower characters, such as number of male and female flowers (measured weekly from 15 April to the end of experiment).