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GRAFTING TECHNIQUES IN CUCURBITS

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Abstract

Grafting is the uniting of two living parts of plant i.e., rootstock and scion. The main aim to adopt various grafting techniques is to avoid soil-borne diseases. In cucurbitaceous crop, due to less arable land and off-season demand the grafting techniques has been adopted. Mainly in watermelon, melon, bitter gourd, summer squash, cucumber of the cucurbitaceous family, grafting is preferred as it showed various resistance to biotic and abiotic stresses. Use of rootstocks can enhance plant vigor by healthy uptake of soil nutrients, avoidance of soil pathogens, salinity, drought, soil varying temperatures and increment in plant production and fruit quality. Grafting was first used in Japan during late 1990's by grafting watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] onto pumpkin [*Cucurbita moschata* Duchesne ex. Poir] rootstocks. Rootstock-scion combinations has affected the pH, flavor, sugar, carotenoid content, and texture of a fruit in the crop. The rootstock and scion should be chosen with care to control loss.

Keywords: Cucurbitaceae, watermelon, cucumber, bitter gourd, summer squash, rootstocks, scion, vigor, carotenoid, biotic stress, abiotic stress

INTRODUCTION

Propagation is a process by which new plants grow from a variety of sources such as seeds, cuttings and other plant parts. There are two types of propagation i.e. sexual and asexual, in sexual it is carried out through seeds and in asexual it is carried out through various ways like cutting, layering,

grafting, budding. Grafting is an asexual mode of propagation which involves joining together of two living plant parts to produce a single living plant. The upper portion of the plant part which produces fruits is known as scion and the lower portion is known as root stock. It is an ancient practice, widely carried out in fruit trees and in recent days it is carried out with vegetables for forming a commercial vegetable industry (Sakata *et al*., 2007) The cultivation of grafted vegetable plants is an old practice started in Korea and Japan at the end of the 1920s by an activity when watermelon plants were grafted onto squash rootstock. Grafting in eggplants was started in the 1950s, with the grafting of cucumber around 1960s. As per recent source, it has spread throughout Asia and Europe. In 2000, a total of 700 million grafted vegetable crop plants were used in Japan and Korea (Edelstein,2004). Currently, 81% of Korean and 54% of Japanese vegetable cultivation use grafting technologies. Although grafting is a popular technique for increasing vegetable production in East Asia, it is not much used in the Indian subcontinent. Grafting can be applied on a number of vegetable crops, but due to intensive labor involvement, it is mostly practiced on cucurbits. Grafting affects absorption and translocation of phosphorus, nitrogen, magnesium, and calcium (Gluscenko and Drobkov, 1952; Ikeda *et al*., 1986; Kim and Lee, 1989; Pulgar *et al*., 2000; Ruiz *et al*., 1997). Grafted seedlings result in high yields, eradicate soil-borne diseases and hence improves fruit quality. Grafting is considered safe for the production of organic and environment friendly by minimizing uptake of undesirable agro-chemicals residues. The grafting of plants develops tolerance against salt stress, temperature variation and heavy metals that are present in the soil. Grafting is a tool used in vegetable crops to improve production. It consists of the usage of vigorous plant to replace the root system of a cultivar of economic interest but that should be susceptible to one or more stress conditions (Gaion *et al*., 2018). Due to limited availability of cultivable land and high market demand for off-season cucurbitaceous vegetable crops, for which those are grown under unfavorable conditions. These conditions include cold, dry, wet or low- light winter greenhouses. Continuous cropping of those cucurbitaceous crops raises pests, soil-borne pathogen, etc for which it can cause severe crop loss and in order to get rid of arising problems i.e. use of chemical pest control which is expensive and not always effective and in return can be harmful to the environment (Davis *et al*., 2008). Grafting can overcome many of these problems. For which currently many countries has adapted grafting as a routine technique in continuous cropping systems (Lee *et al*.,2008).

WHAT CUCURBITACEOUS CROPS ARE GRAFTED

A. WATERMELON

Watermelon (*Citrullus lanatus*) is an important vegetable crop grown in Egypt. Grafting watermelon has become much involved in the production area of watermelon (Mona *et al*., 2013). The main purpose for grafting watermelon has been to induce resistance to soilborne pathogens, such as root-knot nematodes, *Fusarium oxysporum* f. sp. niveum, and Verticillium spp. (Davis *et al*., 2008; Lee *et al*., 2010; Louws *et al*., 2010). In Spain, a high proportion (more than 90%) of watermelon plants is grafted using the one cotyledon method (Miguel and Maroto, 2000).Watermelon scion are harvested (1 or 2 d) after they emerge, rinsed with clean water, and

then treated with fungicides or disinfectant, e.g., Physan 20 or peroxyacetic acid/hydrogen peroxide, to minimize the microorganism damage to the graft. The rootstock should have good tolerance to abiotic stress, resistance to soilborne diseases, and not negatively affect fruit quality (Hassel *et al*., 2008). Tongue approach grafting was not requiring careful control of humidity, light, and temperature after grafting. Normal greenhouse environment is sufficient. Splice graft was the best grafting technique in survival rate followed by hole insertion grafting. Splice grafting and tongue approach grafting were not requires to remove the shoots grown from the rootstocks, whereas it doesn't give any shoots from the rootstocks. Splice grafting gave highly significant increment in all characteristics under study compared with the other methods and control in both seasons. In watermelon, splice graft is best grafting method in most characters under studies which is followed by hole insertion and then tongue approach grafting. Interspecific hybrids is commonly used in case of watermelon for creating resistance against Fusarium wilt. For seedless watermelon production Balabash gourd *Lagenaria siceraria* is grafted with the cuttings from terminal growing point of the main stem and lateral branches 6-10cm in length 0.45-0.6 cm in diameter, cuttings included two nodes, buds and leaves, cuttings included one node, bud and leaf. The rootstock 'Shintoza' and 'Super Shintoza', a *C. maxima* × *C. moschata* hybrid, created resistance to watermelon when cultivated in Fusarium infested soils; the rootstocks increased fruit size and yield compared to those of nongrafted plants (Álvarez-Hernández *et al*., 2015; Miguel *et al*., 2004). The 'Super Shintoza' rootstocks also provide tolerance to Verticillium wilt, which lowers the microsclerotia incidence, survival structure of Verticillium spp., and maintenance of fruit yield (Dabirian *et al*., 2017). Under drought condition, grafting of mini-watermelon cv. Ingrid onto 'PS 1313' rootstock (*C. maxima* × *C. moschata*) resulted in greater yield and yield water use efficiency (calculated by dividing fruit yield by seasonal crop evapotranspiration) compared to nongrafted plants (Rouphael *et al.*, 2008). When watermelon plants were exposed to low potassium (K), use of 'Hongdun' (*C. lanatus*) and 'Jinxinzhen No. 4' (*C. moschata*) as rootstocks reduced shoot dry weight losses due to increased potassium uptake (Huang *et al*., 2013). Watermelon growers use rootstock of bottle gourd and pumpkin to improve fruit quality and sensory parameters such as taste and pulp texture, although these rootstocks have less resistance to soilborne pathogens (Fallik *et al*., 2016; King *et al*., 2010; Kyriacou *et al.,* 2016; Villocino and Quevedo, 2015). Proietti *et al*., (2008) demonstrated that mini-watermelon grafted onto the commercial hybrid rootstock 'PS 1313' (*C. maxima* × *C. moschata*) increased the lycopene concentration by 40% than the fruits from ungrafted plants. The total sugar content of watermelons grafted onto bottle gourd (*L.siceraria*) rootstock was reported to be lower than in self-rooted watermelons (Yao *et al*., 2003; Qian *et al*., 2004; Liu *et al*., 2006). Proietti *et al.*, (2008) indicated that mini watermelon grafted onto the commercial hybrid rootstock 'PS 1313' (*C. maxima* × *C. moschata*) shows higher titratable acidity (TA), and a higher TSS/TA ratio, which increases flavor as it creates a balance in between sweetness and acidity.

B. MELON

Melon (*Cucumis melo L*.) is one of the most economically important and widely cultivated vegetable crops in the Mediterranean region. Muskmelon is one of the top ten fruit crops grown

widely in the world for their delicious sweetness, high nutrient quality and flavor. The most acquiring quality of muskmelon is their sweetness, closely related to the soluble sugars content. Leaves are the main photosynthetic organs in plants and thus the source of sugar accumulation in fruits since sugars are translocated from leaves to fruits. Grafting Zhongmi1 muskmelon on Riben Strong (GR) or Shengzhen1 (GS) rootstocks increased chlorophyll on the leaves thus, increasing in photosynthesis and carbohydrate metabolism due to grafting which improves the fruit quality and yield in muskmelon. Wax gourd and squash, used as rootstocks, induce resistance to nematodes (Meloidogyne incognita and M. javanica) and the fungus *Stagonosporopsis* spp., respectively (Galatti *et al*., 2013; Ito *et al*., 2009). King *et al*. (2010) stated that during rootstock development, two types of diseases must be considered: wilts, caused mainly by *Fom*, and root and stem rot diseases, including that caused by *M. cannonballus*, *Macrophomina phaseolina*, and *Stagonosporopsis* spp. However, it has been difficult to develop melon cultivars that are completely resistant to Fom, because the pathogen has four distinct races (0, 1, 2, and 1,2; Dhall, 2015; Zink and Thomas, 1990). Three dominant genes confer resistance to different Fom races: *Fom*-1 and *Fom*-3 confer resistance to races 0 and 2 and *Fom*-2 confers resistance to races 0 and 1 (Zink and Gubler, 1985; Zink *et al*., 1983). A set of recessive genes was discovered (*Fom*-4) that controls resistance to *Fom* race 1,2 (Oumouloud *et al*., 2010, 2013). Due to the unavailability of resistant melon cultivars, farmers use rootstocks that can provide better growth and production in fields infested with *Fom*, because rootstocks tolerant to all races have been discovered (Oumouloud *et al*., 2013). A scion from cv. Piel de Sapo was grafted onto a portion of the melon cv. Sienne, which was an intermediate and which was grafted to the rootstock 'Shintoza' (*C. maxima* × *C. moschata*). 'Shintoza', a vigorous rootstock, provided higher uptake of minerals and water, which increased shoot biomass and fruit yield without affecting fruit quality (Bautista *et al*., 2011). However, double grafting may not be cost effective because of the increased labor required. when the cv. Dikti was grafted onto 'RS 841', an interspecific hybrid, it exhibited higher nitrate uptake and improvement of photosynthesis and biomass production (Neocleous, 2015). To control monosporascus vine decline, which is caused by the soil-borne pathogen *Monosporascus cannonballus* rootstocks were grafted but were not effective against pathogen but were vigorous enough for crop development in the presence of pathogen.

C. CUCUMBER

Cucumber (*Cucumis sativus* L.) is one of the vegetable crops mostly grown in plastic greenhouses in the Mediterranean region, because of the short growing cycle and its high economic value in off-season harvest. Fusarium and Verticillium wilt are soil borne diseases appears mostly in greenhouse cultivation as it is irregular and intensive and effects on the cucumber production. The control for this soil borne diseases is the fumigant, methyl bromide (MB) which has toxic effect on the respective diseases as it penetrates deep into the soil and kills pathogen that are not accessible to other fumigants, but in 1992 the Copenhagen Amendment of the Montreal Protocol listed methyl bromide as the substances that deplete the ozone layer. Many other ways adopted after this situation they are use of crop rotation, use of resistant cultivars and alternatively, grafting resistant cultivar onto resistant rootstock, use of soilless growing system. Thus, the interspecific

hybrid RS 841 F1 (*Cucurbita maxima* × *Cucurbita moschata*), helped in increasing marketable yield for growing cucumber in perlite. Fig leaf gourd (*Cucurbita ficifolia*) is a proper rootstock found for cucumber as it shows resistance to fusarium wilt (Lee and Oda, 2003), along with low temperature tolerance for which it is preferred in the winter production season. Cucumber fruit harvested plant when grafted onto Fig leaf gourd rootstock showed increase in vitamin C. The rootstock ISHc Shintosa gives resistant to fusarium wilt as well as tolerance to heat and preferred for summer production season. Cucumber plants grafted onto *Cucurbita moschata* showed tolerance to both fusarium wilt as well as phytophthora blight (Sakata *et al*., 2008; Takahashi and Kawagoe, 1971). Burr cucumber (*Sicyosangulatus L*.) also provides fusarium wilt resistance with root knot nematode control in other hand it is susceptible to damping-off and gummy stem blight (Sakata *et al*., 2008). Grafting cucumber cv. Jinchun No. 2 onto 'Chaojiquanwang' rootstock (*C. moschata*) gave result by lowering sodium content in the scion. The same rootstock has a higher tolerance to salinity (Huang *et al*., 2013).

D. BITTER GOURD

Bitter gourd (*Momordica charantia L*.) is another important cucurbitaceous crop grown in India. Its fruit is nutritious in nature and is rich in vitamins, iron, minerals, phosphorous and dietary fiber. In bitter gourd production in India the serious infestation i.e., root knot nematode and fusarium wilt. The root knot nematode species *Meloidogyne incognita* is major pest that causes loses in quality and quantity of production and showed high pathogenic potential on bitter gourd (Singh *et al*., 2012; Gautam and Poddar, 2014). Bitter gourd scion 'Palee F1' as grafted onto 'pumpkin (*Cucurbita moschata*)' rootstock had positive effects on vegetative growth, earliness, yield and fruits production. Scion of bitter gourd (*Momordica charantia*) is grafted with sponge gourd (*Luffa cylindrica*) rootstocks. Sponge gourd found to be better rootstock that resulted in earliness to flowering, fruit size and yield of grafted plants. Grafting can be a useful tool in the breeding of bitter gourd and production of plants at cheaper price. For which, the farmers were benefited with decline in their expenditure on the seed cost along with reduction in the cost of cultivation. Cleft grafting bitter gourd shoot as scion on luffa sp. as rootstock, has been found useful incase to prevent Fusarium wilt caused by *Fusarium oxysporoum* f.sp. *momordicae*.

CONCLUSION

Grafting enacts providing beneficial contributions to crop production and its growth. It has been used for many years over several Asian countries and is increasing its popularity in Europe. By several research and findings, it has been found that grafted plants with good rootstock or scion give resistance to several biotic and abiotic stresses. Several problems such as inadequate knowledge of grafting, additional costs for labor and rootstock seeds and its maintenance. Despite of having those problems grafting has been found really beneficial like avoidance of soil-borne pathogens, low cost of fertilizers and irrigation water due to extensive root system of rootstocks, lengthening of harvesting duration, control over soil salinity, reduced cost of soil fumigation. It has also created job opportunities for unemployed peoples. More awareness about the techniques and benefits of grafting should be spread among farmers and communities as it contributes greatly to agricultural production.

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