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Review

Current status of vegetable grafting: Diffusion, grafting techniques, automation

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ABSTRACT

Vegetable production with grafted seedlings was originated in Japan and Korea to avoid the serious crop loss caused by infection of soil-borne diseases aggravated by successive cropping. This practice is now rapidly spreading and expanding over the world. Vegetable grafting has been safely adapted for the production of organic as well as environmentally friendly produce and minimizes uptake of undesirable agrochemical residues. The number and size of commercial vegetable seedling producers has increased markedly reflecting the increase in farmers' preferences for grafted seedlings of high-quality and better performance. In addition to the widely recognized advantages of disease tolerance and high crop yields, grafting technology is also highly effective in ameliorating crop losses caused by adverse environmental conditions such as low soil temperature and high soil salts, especially under protected cultivations where successive cropping or continuous farming is routinely practiced. Grafted seedlings are much favored in hydroponics farming systems where the chances of rapid spread of noxious diseases, once infected, is high. Active research has been focused to develop efficient rootstocks and handy grafting tools. In addition, researchers are eager to develop grafting machines or robots to reduce the higher price of grafted seedlings. The quality of grafted transplants is extremely important to maximize high-quality crop yield. Use of grafted vegetables has increased with the increased use of improved soil mix or substrate, farmer's preferences for better seedlings, efficient management of nursery systems, lower prices of grafted seedlings, and efficient nationwide delivery and/or transportation system. Improved grafting methods to cut down the labor cost for grafting and subsequent handling of plug-grown grafted transplants will contribute further to the increased use of grafted vegetables worldwide.

Contents

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1. Introduction

Even though grafting has been practiced in fruit trees for thousands of years, vegetable grafting has been only recently widely adapted on a commercial scale (Ashita, 1927; Sakata et al., 2007). Old records on vegetable grafting can be found in Chinese as well as in Korean and Japanese writings. The commercial use of vegetable grafting is a relatively recent innovation. The wide use of plastic films for the production of vegetables in the late 1950s provided the momentum for generalized production and use of grafted vegetables. The early use of grafted vegetables was associated with protected cultivation which involves successive cropping. Commercial vegetable grafting originated in Japan and Korea and was practiced for about 30 years. It was introduced to Western countries in the early 1990s and is currently being globally practiced using local scion cultivars and introduced rootstocks. Fortunately, seed companies have been able to select and/or breed well-adapted scion cultivars for intensive growing. Even though the benefits of using grafted seedlings are widely recognized, many other factors must be carefully considered to ensure successful cultivation and satisfactory income with this new technology. For example, generous use of chemical fertilizers and synthetic pesticides should be minimized for the production of environmentally friendly produces, in which interest has been exploding in recent years (Cushman and Huan, 2008; Davis et al., 2008; Kubota et al., 2008; Lee and Oda, 2003; Sakata et al., 2007). It has been well-known that the use of proper rootstocks can minimize the problems associated with successive cropping and stress tolerance (Heo, 2000; Hoyos Echeverria, 2010; Lee, 1994; Lee et al., 1998; Lee and Oda, 2003). The increasing awareness and interest in fresh horticultural produce has rapidly expanded among people of all ages and locations who seek safe, environmentally friendly, and functional foods. Fast foods are now regarded as dangerous in many developed countries and obesity is currently defined as a disease, rather than a symbol of health and prosperity. Many Asian people have been consuming more horticultural crops as compared to those living in western countries, especially vegetables. However, because of the very limited total and per capita cultivation area, intensive use of the land is inevitable to secure food and earnings for the majority of farmers. Intensive land use is most frequently performed by multiple or successive cropping even in temperate zone areas (Lee et al., 2008). In the southern parts of Korea, it is not usual to find watermelon growers producing 3–4 crops per year in the same greenhouse. The farmers usually apply heavy amount of chemical fertilizers and frequent pesticides treatment to the densely planted vines to obtain high crop yield and earnings. Since the plants are cultivated under the protected structures year-round, they frequently are subjected to extreme environmental conditions in the high tunnels during off-season cultivation (Lee, 2008). As a result farmers frequently encounter various problems caused by successive as well as off-season cropping such as heavy infection of soil-borne diseases, low temperatures during the winter, high humidity in the high tunnels, insufficient light intensity, and lack of well-balanced fertilization. The plants and the fruits grown under these stressful conditions frequently suffer from heavy incidence of soil-borne diseases, suboptimal temperature stresses, various physiological disorders, and quality deterioration.

Table 1
Major advantages and disadvantages of using grafted vegetable transplants.

Advantages	Disadvantages
Yield increase	Additional seeds for rootstocks
Shoot growth promotion	Experienced labor needed
Disease tolerance	Wise selection of scion/rootstock combinations
Nematode tolerance/resistance	Different combinations for cropping season
Low temperature tolerance	Different combinations for cropping methods
High temperature tolerance	High price of seedlings
Enhanced nutrient uptake	Increased infection of seed-borne diseases
Enhanced water uptake	Excessive vegetative growth
High salt tolerance	Fruit harvesting may be delayed
Wet soil tolerance	Inferior fruit quality (taste, color and sugar contents)
Heavy metal and organic pollutant tolerance	Increased incidence of physiological disorders
Quality changes	Symptoms of incompatibility at later stages
Extended harvest period	Different cultural practices should be applied
Multiple and/or successive cropping allowed	Higher prices of grafted seedlings
Convenient production of organic wastes	
Ornamental values for exhibition and education	