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Review: Use of Wild Species and Grafting for Abiotic Stress Management in Vegetable Crops

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ABSTRACT

Grafting is a process in which two living parts are joining together to grow as a one and the method used to improve crop production. To overcome fusarium wilt, the first grafted vegetable seedlings used were for watermelon plants grafted on bottle guard. Since then this technology is being widely adopted in vegetable crops. Now a day's mostly watermelon, cucumber and various solanaceous crops are grafted before transplanting in the field. The use of grafting is increasing day by day due to its ability to provide tolerance to biotic stress such as soil borne pathogen, and to abiotic stresses such as cold, salinity drought and heavy metal toxicity. For getting higher production mainly female plant were grafted on male plant. It was seen that more than 22 rootstocks of tomato, chilli, brinjal and cucurbits are used for bringing resistant from bacterial wilt and nematodes have been identified till now but still the interactions between rootstock/scion are unrevealed which results in loss of fruit quality, loss in production, shorter post harvesting time become shorter, and incompatibility between rootstock and scion are seen mostly. The selection of rootstock and scion cultivars must be done carefully so to avoid any loss.

Keywords Grafting, Scion, Stress, Vegetable, Resistant.

INTRODUCTION

Grafting can be defined as the natural or deliberate fusion of plant parts so that vascular continuity is established between them and the resulting genetically composite organism functions as a single plant.

Vegetable grafting is a tool for the development of a distinct plant source that aids in the dramatic drop of plant vulnerability to biotic and abiotic stress, and the reduction of production costs by minimizing plant protection chemicals (Pradeepkumara *et al*. 2022). It was introduced to Western countries in the early 1990s and is currently being globally practiced using local scion cultivars and introduced rootstocks. The wide popularization of protected cultivation using

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greenhouse technology for the production of vegetables in the late 1950s provided the momentum for generalized production and use of grafted vegetables. In current era of organic and sustainable agriculture generous use of inorganic chemical fertilizers and synthetic pesticides should be minimized for the production of ecofriendly produces (Sakata *et al.* 2007). Continuous cropping is unavoidable in greenhouses, which again leads to reduction in yield and quality of the produce due to the menace of soil borne pathogens and nematodes. Since soil sterilization can never be complete, grafting has become an essential technique for the production of repeated crops of vegetables grown in both greenhouse and open field condition. It has been well- established that the use of suitable rootstocks can minimize the problems associated with modern agriculture like successive cropping and different stress tolerance (Hoyos and Echeverria 2010). 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 .

As a result farmers frequently encounter various problems other than soil borne pathogens caused by successive as well as off-season cropping such as low temperatures during the winter, high humidity in the high tunnels, insufficient light intensity, and lack of well-balanced fertilization. The produces grown under these heavily stressed conditions frequently suffer from heavy incidence of soil-borne diseases, abnormal abiotic stresses. (Kyriacou *et al*. 2016).

Which lead to physiological disorders, and quality deterioration in addition to the widely recognized advantages of disease tolerance and high crop yields through vigorous attainment of nutrients, 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.

Background of vegetable grafting

The first time of vegetable grafting was done along with rootstock of watermelon (*Citrullus lanatus*) and pumpkin (*Cucurbita moschata*) in Japan and Korea in the late 1920s (Leonardi, 2016). Self-grafting was used as a technique to produce large-sized gourds fruits, as reported in a Chinese book written in the 5th century and Korean book written in the 17th century.. However, commercial grafting of vegetables only originated in the early 20th century with the aim of managing soil borne pathogens .Among the Solanaceous crops, aubergine (*Solanum melongena* L.) was first grafted on to scarlet onto scarlet aubergine (*Solanum integrifolium* Lam.) was started in the 1950.

Grafting against abiotic stress

Grafting for cold tolerance

Cold stress is one of the most important factors the crop plants of temperate and subtropical regions are facing through chilling and freezing injury thus affecting the yield and quality parameters. Especially the production of vegetables in areas of cold and even mild climate conditions are affected severely during the winter (sometimes during spring also) due to chilling and suboptimal- temperature conditions. The temperature limit for growth of most of the chilling-sensitive fruit vegetables, such as pepper, brinjal, cucumber, tomato and melon is about 8–12°C. Tomato grafted onto a cold-tolerant rootstock revealed a higher capacity to adjust their root/shoot ratio to suboptimal root- temperature (Venema *et al*. 2008). This might be due to the functional equilibrium established between root and shoot of the grafted plant, allowing the root system to overcome restrictions in water and nutrient uptake. For watermelon, grafting onto Shin- tosa-type (an interspecific squash hybrid, *Cucurbita maxima* × *C. moschata*) rootstocks is used to advance the planting date during cool periods. For cold tolerance in cucumber, fig leaf gourd (*Cucurbita ficifolia*) and bur cucumber (*Sicosan gulatus* L.) are popularly used as rootstocks. Fig leaf gourd has got a distinctive trait with an optimum root temperature requirement of around 15°C, which is 6°C lower than that of cucumber roots. These two rootstocks also improved the vegetative growth and early yield at suboptimal temperatures. Also reported that grafting of a cucumber scion onto a squash rootstock (*Cucurbita moschata*) could tolerate suboptimal temperatures compared with a self- grafted one. Scions grafted

onto low- temperature tolerant cucurbit a rootstocks.

Stomata much later compared with scions grafted onto sensitive ones, or scions grafted onto their own. Thus, transpiration is maintained and such plants perform better and experience cell death later. In contrast, cold-tolerant tomatoes, such as *S. habrochaites*, decline the stomatal conductance resulting in a stomatal closure, while the stomata of cold-sensitive species remain open until chilling temperatures of 5^0C, due to which, they became flaccid and suffered damage.

Grafting for high temperature tolerance

High temperatures above the optimal range required for plant growth leads to a series of complex morphological, physiological, biochemical and molecular changes that affect plant growth and productivity adversely by different means such as growth reduction, decrease in the photosynthetic rate, increase in respiration, assimilate partitioning towards the fruits, osmotic and oxidative damage, reduced water and ion uptake/movement, cellular dehydration. Since brinjals are better adapted to tropical hot conditions with better tolerance against high soil temperature, the use of brinjals as rootstocks for tomato at higher temperature seemed to be more promising (Abdelmageed and Gruda 2009), although it lead to decreased total fruit dry weight. However, testing brinjals grafted onto a heat-tolerant rootstock (cv Nianmaoquie) seemed to be promising and resulted in a prolonged growth stage and yield increase. In pepper highest yields were recorded under high- temperature conditions for rootstocks recommended by the AVRDC such as *C. Annuum* cv Toom-1 and 9852-54. Various grafting techniques to increase the effect of temperature and humidity by using controlled environmental conditions grafting using local resources is still limited in warm, humid agro ecosystems.

Grafting against water stress

For reducing the yield loss and improving the water use efficiency in the drought prone areas, use of moisture stress tolerant rootstocks in grafting can be a viable option (García-Sánchez *et al*. 2007). Grafted mini-watermelons onto a commercial rootstock (PS 1313_: *Cucurbita maxima* × *Cucurbita moschata*) under moisture stress condition, produced 60% higher marketable yield than ungrafted melons (Rouphael *et al*. 2008.) on his grafting experiments with ABA deficient mutants of tomato showed that stomata can close independently of the leaf water status suggesting that there is a chemical signal produced by the roots that controls stomatal conductance. For managing such problems in the lowland tropics, the AVRDC recommends growing tomatoes on brinjals 'EG195' or 'EG203' and pepper on chili accessions 'PP0237-7502', 'PP0242-62' and 'Lee B' (AVRDC 2009). The vigorous root system of *Solanum torvum* and resistance to soil diseases or pests, tolerance to abiotic stress, selective absorption of available soil nutrients conferred a high degree of vigour to the scion (Hu *et al*. 2006) have also suggested that improved nutrient uptake in grafted seedlings increases photosynthesis under week sunlight conditions and such conditions generally prevails during rainy season under south Gujarat conditions. Drought responsive trait affects the crop quality and yield when grafted under water- stressed conditions. It is observed that when tomato hybrid "Beaufort" (*Solanum lycopersicum* L. × *Solanum habrochaites* S.) grafted onto rootstock ("Resistar") reduced the plant growth due to occurrence of water stress condition. (Petran 2013) reported that when tomato scions ("Celebrity" and "3212") onto turkey berry rootstock (*Solanum torvum* S.) under water-stressed conditions helps in delayed wilting of plant. According to (Nilsen *et al*. 2014) concluded that when (*Capsicum annuum* L.cv Verset) grafted onto the rootstocks "Atlante," "PI-15225," and "ECU-973" under water-stresses conditions helps in improving the marketable yield of crop by maintaining the photosynthetic rate (Al-Harbi *et al*. 2017). This when grown under full or deficit irrigation reign tomato cv Faridah grafted onto the tomato hybrid "Unifort" (*Solanum lycopersicum* L. × *Solanum pimpinellifolium* L.) results in the expanding of yield. (López-Marín *et al*. 2017) Some eggplant genotypes are resistant to waterlogging. Using eggplant as the rootstock may overcome wilting and rotten roots under waterlogged conditions. Drought, one of the most severe and complex abiotic stresses, is increasingly occurring due to global climate change and adversely affects plant growth and yield. Grafting is a proven and effective tool to enhance plant drought resistance ability by regulating their physiological and molecular

processes (Yang *et al*. 2022).

Grafting for plant vigour promotion

As a generalized observation, the root systems of rootstocks are extensively spread over large area inside soil and more vigorous, as a result of which they absorb water and nutrients much more efficiently as compared to non-grafted plants, due to this particular occurrence, in case of grafted plants less fertilizers are recommended sometimes. As reported by Salehi-Mohammadi *et al*. 2009.

The differences in quality, yield and earliness in brinjal could be attributed to the different growth characteristics of the cultivars and to their compatibility with the rootstock. Thus, showed that *Solanum torvum* is a vigorous rootstock, and a graft combination of a vigorous cultivar with an equally vigorous rootstock reduces the amount of fertilizer required for the same yield. Earliness could also be associated with the high vigour of the rootstock have mentioned that the earliness was observed mainly in the interspecific hybrids, respective between *S. melongena* and *S. aethiopicum* or *S. incanum* disease resistance. The not grafted brinjals variant yield (Aragon F_1) harvest was only of 44.6t/ha, with over 15t less than the registered yield of grafted brinjals variant (Bogoescu and Doltu 2015).

Grafting for yield increase

Many researchers has reported an increase in yield of produce which may be due to higher plant vigour, protection against biotic and abiotic stresses. Through the years, vegetable grafting has come a long way since its origin in Japan and China. Even though the benefits of using grafted seedlings are now fully recognized over the world, production of uniform, healthy grafted seedlings at reasonable prices is the key point for wider use, especially in those countries with limited experience. Use of grafting could improve fruit and nutritional quality. An increased levels of heavy metals such as cadmium, mercury, lead, arsenic, in farming constitute a rising hazard to plant growth, development, and yield, even also for human health and environment. Plant growth and development is influenced by physiological processes (e.g., photosynthesis) that depend on environmental factors to proceed optimally (Oladosu *et al*. 2018) the solutes associated with fruit quality are translocated in the scion through the xylem, whereas quality traits, e.g., fruit shape, skin color, skin or rind smoothness, flesh texture and color and soluble solids concentration are influenced by the rootstock.

CONCLUSION

Grafting is an eco-friendly technique which promotes organic vegetable production. In India, grafting can also helps in the reduction of the problems created by vegetables industry and also reduced the use of fertilizers and pesticides leads to increases in yield and quality of produced also improved. When watermelon is grated on inter-specific cucurbit rootstocks then texture is affected leads to increase of firmness in pulp. Nursery production and management is labor intensive. To solve this problem, scientist trying to develop new technique, equipment and reducing the cost of labor and improves the efficiency of grafting with the help robots. Grafting application helps in reducing in the occurrence of soil borne infections leads to reduction in toxicity level vegetables and environmental pollution. From this it was concluded that use of modern and indigenous techniques helps in the reduction of input used by grafting in horticulture of future.

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