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Vegetable Grafting Under Water Stress: A Sustainable Approach towards Smart Cultivation

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SUMMARY

Water stress (water scarcity or water logging) is a major yield limiting factor in horticulture, especially for vegetable crops. Researchers are implementing next-gen ideas like identification of tolerant or resistant genotypes, use of mulches, antitranspirants, and polymer to retain soil moisture for getting sustainable yield even under adverse conditions. In this context, grafting has emerged as one of the finest remedies to overcome the productivity related problems under stress conditions such as water stress and salinity stress. Grafting of some high yielding cultivars onto their interspecific as well as intraspecific wild species has proven exceptionally beneficial in stress prone areas. Grafting technology is now widely adopted in various vegetable crops like watermelon, squash, cucumber, bitter gourd, tomato and eggplant etc. This technology is not only found advantageous under abiotic stress but also for biotic stress. Hence, vegetable grafting now-a-days has appeared as a promising substitute tool to the relatively slower conventional breeding programs aimed at increasing tolerance to abiotic and biotic stresses in vegetables. This article principally focuses on the advancements in grafting applications in vegetable crops under water stress conditions.

INTRODUCTION

Vegetables are annual or perennial horticultural crops, with certain sections (roots, stalks, lowers, fruits, leaves, etc.) that can be consumed as a whole or partially, in cooked or raw form (Welbaum, 2015). Vegetables make an important constituent in human diet, and are a major source of bioactive nutrient molecules such as dietary fibre, vitamins and minerals, and non-nutritive phytochemicals (phenolic compounds, flavonoids, bioactive peptides, etc.) (Prodanov *et al*. 2004). Cumulatively influence of these biochemicals decrease the incidences of chronic diseases such as cardiovascular diseases, diabetes, certain cancers, and obesity. The World Health Organization (WHO) has also endorsed daily intake of 5–8 portions (400–600 g) of fruits and vegetables to reduce the risk of micro nutrient deficiency, cardiovascular diseases, cancer, cognitive impairment, and other nutritional health risks (Ülger *et al*., 2018). Due to recurrently occurring drought events, world food production is declining steadily, which may ultimately develop intense food scarcity for ever increasing world population. Climate change-induced abiotic stresses across the globe have induced severe declines in global food production which has been projected above 40% (Bailey-Serres, 2019). During the past 2-3 decades, the Indian subcontinent has perceived frequent drought-like situations that are evident in terms of considerable loss in agricultural production and hence, the country`s socio-economic status. Drought is repeatedly associated with higher temperatures which facilitate evapotranspiration and affects photosynthetic kinetics, thus intensifying the effects of drought and further reducing crop yields (Mir *et al*., 2012). In recent years, occurrence of drought has been increasingly frequent in states Maharashtra, Gujarat, some parts of Rajasthan, Tamil Nadu, Andhra Pradesh, and Telangana. Soil moisture deficiency is the key obstacle in sustainable vegetable production. This moisture deficiency more likely turned into drought like conditions (Kumar *et al*. 2012), which could have exerted a negative impact on the plant growth and resulted in severe productivity losses in vegetable production in many regions of country (Altunlu and Gul, 2012; Liu *et al*., 2014). Drought resistance in plants is a multifaceted quantitative trait controlled by many genes. Hence, imparting the tolerance for drought like conditions into high yielding vegetable genotypes is a great challenge.

Grafting of high yielding varieties of vegetable crop onto wild species of same genus has emerged as a rapid tool to get sustainable yield in water stressed area of the country. Grafting totally alters the physiology of plant. Now a days vegetable grafting practices are being used in Solanaceous and Cucurbitaceous crops, which are usually cultivated in arid and semi-arid areas characterized by long drought periods (Colla *et al*., 2010b, 2011, 2012; Kumar *et al*., 2015a,b). Intraspecific rootstock/scion grafting of vegetables is common because compatibility is higher than that with interspecific grafting (Black *et al*.,2003). Intraspecific grafting has been shown to improve resistance to various environmental stresses such as flood, drought, cold, heat and pathogen stressors. This makes *S. torvum* an ideal contender for tomato interspecific grafting in equatorial regions, where environmental circumstances can make tomato cultivation difficult (Max *et al*., 2009).

Grafting against Drought Stress

Grafting of some high yielding cultivars on *S. tovrum* gives better results under drought like conditions by changing plants growth habit. Petran and Hoover (2014) reported that use of *Solanum tovrum* rootstock under water-stressed conditions induced dwarfness in tomato scions (“Celebrity” and “3212”) and delayed wilting, especially with “3212”. Along with changing growth habit, it is also found responsible for imparting drought avoidance mechanism. Tomato plants grafted onto drought-tolerant rootstocks showed higher water utilization efficiency and higher yield compared with those grafted onto drought-sensitive rootstocks under water stress (Zhang *et al*. 2017, 2019a, b). Liu *et al*. (2016) used sponge gourd Cv. Xiangfei No. 236 as rootstock in water stress conditions and observed better shoot growth, delayed leaf wilting and higher plant biomass as that of non-grafted plants. Similar results were also reported by Penella *et al*. 2014 in Capsicum Cv. Verset under greenhouse conditions. The marketable yield of capsicum was sustained when grafted onto the rootstocks like “Atlante,” “PI-15225,” and “ECU-973”. This effect was observed due to their ability to maintain net photosynthetic rate under water scarcity. Numerous operative rootstocks have been mentioned in literature and are being actively used in breeding programs (Schwarz *et al*., 2010). Sanders and Markhart (1992) described that the osmotic potential of dehydrated scions of grafted bean (*Phaseolus vulgaris* L.) plants was determined by the rootstocks, while the osmotic potential of non-stressed scions was governed by the shoot. Drought tolerance provided by either the rootstock or the scion resulted in improved nitrogen fixation in soybean (Serraj and Sinclair, 1996).

Grafting against Water logging / Flooding Stress

Similar to the drought conditions, grafting technology has been found beneficial against flooding or water logging stress. Bhatt *et al*. (2015) grafted tomato Cv. “*Arka Rakshak*” onto different eggplant (*Solanum melongena* L.) rootstocks [BPLH-1, *Arka Neelkanth* (AN), *Mattu Gulla* (MG) and *Arka Keshav* (AK)] and imposed flooding stress during monsoon season (July-September) at the flowering stage for 6 days by submerging in a tank with the water level at 2.0 cm above the soil surface in the pots. And reported that *Arka Rakshak* grafted onto *Arka Neelkanth* has given a significant higher yield than those of others with better quality. Grafted plants retained their photosynthetic ability and other physiological processes even under flooded conditions, hence fore, they have given better yield. Bahadur *et al*. (2015) grafted *Arka Rakshak* and *Arka Samrat* onto IC-354557, IC-111056, IC-374873 and CHBR-2 and subjected to flooding stress for 4 days during vegetative and flowering stage. From the findings, it is clearly indicated that grafted plants have retained their PS-II much better than non-grafted planted under stress conditions, there was much less reduction in chlorophyll content has been observed under grafted plants. As a result of this, grafted plants produced higher yield even under stress conditions.

Advantages of vegetable grafting

Impart tolerance against various abiotic and biotic stresses

Abiotic Stress : Salinity, Water logging, Water Scarcity, Heavy metal and organic pollutant toxicity, high and low temperature

Biotic Stress: Soil borne disease tolerance, nematode tolerance Chance to get completely new species (wrong: grafting will not effect on genetically, so there is no chance to get completely new species)

- Improved nutrient and water uptake capacity
- Better root and shoot architecture
- Multiple and/or successive cropping can be facilitated

Limitations of vegetable grafting

- Limited adaptation of wild species as rootstock
- Inadequacy of seed material to raise ample rootstocks

- Precise selection of rootstock and scion for a desired objective
- Sometime maturity may be delayed
- Grafting incompatibility
- Higher cost
- Lack of skilled persons
- Require much attention and care for getting successful graft union
- Fruit quality may get altered due to influence of wild species

CONCLUSION

Maintaining food security in continuously changing agro-climate conditions is a greatest challenge to agriculture researchers. Conventional breeding approaches have limited success to meet needs for ensuring food security in present scenario. Therefore, grafting in vegetable crops could be a promising alternative to conventional and transgenic breeding programs for compiling tolerance traits and improving yield potential, yield stability and even product quality under stress conditions.

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