

# **Grafting Accelerate The Tolerance Against Biotic and Abiotic Stress In Vegetables**

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## **Abstract**

Unfavourable environmental conditions and cultivation practices affect the quality and quantity of vegetable production. In vegetable crops especially in solanaceae and cucurbitaceae families, grafting is a sustainable tool for overcoming the problem of biotic and abiotic stress. First time the people of Japan and Korea adopted this technique to overcome crop loss caused by soil-borne pathogens. In grafting, by use of suitable rootstocks not only quantitative traits but also improve qualitative characters such as heat, salinity and wet-soil conditions.

## **Introduction**

Naturally or artificially union of plant parts for maintaining of vascular continuity between them (Pina and Errea, 2005) and new organism serve as a single plant (Mudge et al., 2009). Grafting is also defined as asexual plant propagation that combines plant parts for surviving together (Besri, 2008). In between stem and root of same species natural grafting is done while artificially tissues of two plant are fused together (Darikova et al., 2011). In this process, under adverse environmental conditions both scion and rootstock can enhance tolerance of grafted plants (Colla et al., 2014). Combination of rootstock and scion cambium leads to successful grafting. Diameters of rootstock and scion stem should be similar during grafting. Moreover, growth rate of scion and rootstock may not be same. For determination of the growth rates of rootstock and scion environment is important factor (Johnson et al., 2011).

At the end of 1920, Korea and Japan started grafting technique. First time watermelon was grafted on the squash (Yamakawa, 1983). Millions of grafted plants like melon, watermelon, cucumber, tomato and eggplant are grown every year in those countries (Morra, 2004). Korea produced maximum amount of watermelon from grafted seedlings followed by Japan and China. Among European countries, Spain is leading in production of grafted seedlings (129 million grafted seedlings) followed by Italy (47 million grafted seedlings) and France (28 million grafted seedlings) (FAO, 2009). After that this technology was adopted by Europe, Middle East, Northern Africa, Central America and other parts of Asia (Kubota et al., 2008). It serves as eco-friendly and sustainable crop management systems due to no chemical utilization (Rivard and Louws, 2008).

Excessive amounts of trace elements, alkaline and saline soils, and drought are the major limiting factors for vegetable production. Utilization of grafting mainly occurred in solanaceae and cucurbitaceae family for increasing the resistant against soil soil-borne diseases (Charles et al., 2012), increase immune system against abiotic stresses (Schwarz et al., 2010 and Roupael et al., 2012) and also improve the quality and quantity of yield as well as uptake of nutrients (Guan et al., 2012). Grafted plant affected as its resistance capacity decrease with influence of pathogen density and some environmental factors like temperature, salinity also hamper physiology of crop.

### **Biotic stress**

Under exposure of plants to biotic stress the activity of plant physiology reduces (Swarbrick, 2006; Bolton, 2009; Massad, 2012) and vegetable production is reduced (Shao, 2008). Now a days, soil borne disease is the most common problem under protected cultivation that affect quality and quantity of vegetables. Use of soil fumigant such as methyl bromide is one of the solutions to control soil borne pathogens but alternatively grafting is one of the natural techniques for bacterial, fusarium and verticillium wilt as well as root-knot nematodes (Crinò et al., 2007; López-Marín et al., 2009). Biotic stress reduces the physiological activity of plant

(Swarbrick, 2006; Bolton, 2009; Massad, 2012) and leads to a reduction in vegetable production (Shao, 2008).

Under protected cultivation soil borne disease is a serious problem and reduces the quality and quantity of vegetables. In protected cultivation, after ban of utilization of methyl bromide grafting is the best alternative practices for control of soil borne disease (Cohen et al., 2007; Crinò et al., 2007 and López-Marín et al., 2009). Generally grafting of melons can be done on bottle gourd, and *C. melo* rootstocks and in very rare case grafting of melon onto luffa (*Luffa cylindrica*) and wax gourd (*Benincasa hispida*). Interspecific *C. moschata* × *C. maxima* hybrid in cucurbita spp. is commonly used as rootstock for protection against soil born diseases and abiotic stresses.

In field and green house condition bacterial wilt *Pseudomonas solanacearum* is a devastating problem in vegetable crops, which infects the plants through the roots, especially during transplanting (King, et al., 2008). During hot and humid weather conditions night shade family (solanaceae) especially affected by bacterial wilt and it has a limiting factor for cultivation. The disease was first reported at Kangra valley in Himachal Pradesh in 1981 on solanaceous texas, remained sporadic in nature till 1985 (Sood and Singh, 1992). The chances of infection are increased by over-watering or periods of heavy rainfall. McAvoy et al., 2012 studied that tomato resistant rootstocks namely, Cheong Gang, BHN 1054 and BHN 998 was grafted with wilt-susceptible tomato cv. BHN 602 in greenhouse as well as field conditions. Grafted plants become more resistance than non-grafted controls against diseases. There is no bacterial wilt was shown when ‘German Johnson’ was grafted onto the resistant genotypes CRA 66 or Hawaii 7996. For fusarium wilt, similar results were found when ‘Maxifort’ rootstock was grafted on ‘German Johnson’ (Rivard and Louws, 2008). According to Matsunaga (2011) resistant to bacterial wilt in *C. frutescens* is not related with fruit size or shape. Against the fusarium wilt, Watermelon is grafted onto hybrid squash, bottle gourd or citron rootstock. During production of egg plant verticillium wilt is a serious problem, so many rootstocks found to be resistant or tolerant to soil pathogens (Daunay, 2008).

Root-knot nematode is a serious problem under protected cultivation. It was observed that more than 90% productive when tomato scion FA189 grafted on Beaufort, Energy and He-man and also enhanced the amount of 15–20% total soluble solid content in grafted plants (Chen et al., 2012). Wang et al 2008 reported, when rainbow 101 tomato cultivar grafted on brinjal rootstock then no galling seen due to presence of peroxidase and superoxide dismutase in control treatment in eggplants. As well root knot nematode resistance species is capable for good fruiting characteristic, (Williamson 1998) so susceptible varieties grafted onto nematode resistant stocks to increase fruiting characteristic. However, (Burelle and Roskopf, 2011) showed that Florida 47 tomato as a scion grafted over three stock of tomato cultivars like Multifort, Tx301 and Aloha given better result with respect to galling, nematode infection in root and soil as compared to non grafted Florida 47 cultivar of tomato.

### **Abiotic stress**

Abiotic stress is one of the most important fears for vegetable production, there is more than 50% of plant species is affected in response to growth and development and affects the crop losses in the field. Water, temperature, light, soil alkalinity, oxygen availability, nutrition and metal ion concentration are important factors (Venema et al., 2011). Salinity is a severe environmental problem in arid and semi-arid regions.

Under environmental-stress condition grafting is serving as useful tool to improve tolerance/resistance power of vegetables (Flores et al., 2010). For enhancement of salinity tolerance through the regulation of Na<sup>+</sup> partitioning in young and mature leaves tomato plant is grafted onto vigorous interspecific hybrids (*S. lycopersicum* X *S. habrochaites*) (Venema et al., 2008). There are two phases in which plants is affected by salinity. In the first phase water stress occur in the root zone due to high salt concentrations where as in second phase accumulation of Na<sup>+</sup> and Cl<sup>-</sup> in leaf tissues that promotes the leaf senescence. Salt and flooding tolerance (Yetisir et al., 2006), enhance water use efficiency (Rouphael et al., 2008), nutrient uptake (Colla, 2010) and alkalinity tolerance (Colla et al., 2010) is improved by grafting.

Interactions between grafting and environmental interactions influence the carotenoid concentration. Huang et al., 2015 found qualitative character of tomato increases by increasing total soluble solids and tartaric acids under salt stress conditions when tomato is grafted on goji plant. It is suitable for fresh-market as well as processing of tomato cultivars. According to Santa-Cruz et al., 2001, showed that grafted plants having good quality of yield greater root-to-shoot ratio (Huang et al., 2009), higher accumulation of compatible osmolytes (Munns and Tester, 2008), ABA and polyamines (PA) in leaves (Liu et al., 2004), greater accumulation of antioxidant in leaves and less amount of NaCl in stems.

Vegetable production is reduced by under heat stress conditions because suboptimal and supraoptimal temperature conditions affects physiology of roots (Qin et al., 2007). Schwarz et al. (2010) observed that reducing in development, water and ion uptake and increase in respiration rate and oxidative damage. Significant increase in radial length of brinjal approx 13per cent by treatment with chilling stress (3 and 6°C), heat stress (35, 40 and 45° C) on it's seedling. Grafting of chilli on sweet paper leads to higher yield under high temperature (Palada and Wu, 2009). Under supraoptimal temperature stress conditions tomato plants grafted onto eggplants reduced electrolyte leakage less membrane damage occurs and retain high number of solutes and water (Abdelmageed and Gruda, 2009). Grafting reduces the negative effect of minerals such as B, Cu, Cd and Mn toxicity (Savvas et al., 2009). In tomato, grafting resulted in the formation of a greater number of internodes and flowers in outdoor cultivation whereas in indoor cultivation, number and total weight of fruits are more (Voutsela et al. 2012).

Under supraoptimal condition grafting does not always depend upon the rootstock/scion combinations but also depend on environmental parameters (Schwarz et al., 2010) as well as contribution of phytohormones (Georgia Ntatsi et al., 2013) and they also observed that phytohormones like abscisic acid, auxin and Salicylic acid serve as key-hormone. Generally, biosynthesis of ABA occurred in shoot but also takes place in the root that promotes tolerance capacity of tomato against sub-optimal temperature.

Water is an important natural source for agricultural as well as horticultural crop production, but these days the problem of water scarcity increases especially in arid and semiarid

areas. So, overcome these problems, utilizing of high yielding genotypes grafted on that rootstock which is capable of more resistance (Satisa et al., 2007). Roupael et al. (2008) observed that 60% more yield when watermelon grafted on rootstock (PS 1313).

Under water deficit conditions the net assimilation of CO<sub>2</sub> and stomatal conductance osmotic potential decreased. It was also found that under drought-condition in the root grafted plants growth rate was significantly increased by improving physiological indexes like Superoxide Dismutase (SOD) and catalase (CAT) activities, proline accumulation and reducing the level of lipid peroxidase. Under the low land tropic to control flood during heat the AVRDC 2003 & 2009 recommends grafting of pepper on chilli accessions and tomato on egg pants 'EG195' or 'EG203'. Sa'nchez-Rodri'guez et al. (2012) reported that two cultivars of tomato Zarina and Josefina which is drought sensitive and Zarina drought tolerant grown as rootstock resulted greater number of fruits per plant, high sugar content as well K and Mg also enhance, ultimately nutritional quality increase.

### **Heavy Metals**

Day by day the concentration of heavy metals increases that is harmful for plant growth, yield, environment as well as human health (Clemens, 2006; Hong-Bo et al., 2010). Under arid and semiarid regions extreme temperature leads to scarcity of good quality water, containing high concentrations of salt such as boron and toxic elements, leads to reduction in marketable fruit yield and result in the accumulation of toxic elements in the edible part of the plant. Some heavy metals like cadmium, arsenic, lead and mercury are released from industry and introduced waste water and soil amendments and creates harmful effect for both plants and humans (Diacono and Montemurro, 2010; Gupta et al., 2010). It was observed that cadmium (Cd) is present in eggplant and it showed harmful impact on human health and physiology of the plants like transport of water, mitochondrial oxidative phosphorylation and as well as also effects the photosynthesis (Feng et al., 2010). In grafting of *S.torvam* and *S. melongena* the percentage of Cd reduced by 67 to 73 in leaf and stem respectively Arao et al. 2008). As per investigation Yamaguchi et al. (2010) with molecular mechanism the amount of Cd uptake by *S. torvum* reduced due to dehydration, transpiration and aquaporin isolates were major constituent. The translocation of Cd

was influenced due to flow of signal from root to shoot zone (Si et al., 2010). Edelstein and Ben-Hur (2007) showed mineral content was less in non-grafted species than grafted one. After grafting of cucumber over different cucurbitacea species. (Savvas et al. 2013) observed that Cucumber plants (*Cucumis sativus*, cv. *Creta*) were grafted, self-grafted, or non-grafted onto rootstocks 'TZ-148' 'Ferro', 'Power', and 'Strong Tosa'. But compatibility improves translocation of Zn, K, Mn in the fruits if Cd content is in stressed however the Ca, Mg and K uptake is less due to presence of Cd in cucumber. In mean while Ni improves the translocation of the macronutrient to plant part.

### **Conclusion**

Nut and shell, Grafting is advance technique in vegetable production which led to reduction in soil pathogen, resistance against low and high temperatures as well anti chlorosis in calcium affected soil, improve mineral uptake, reduce uptake of pollutant, tolerance against salt and flooding hence synthesized the endogenous harmones. Ultimately this is the better technique for reduction the negativity of copper and boron toxicity.

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