Improving Crop Resilience Through Vegetable Grafting

Aditya Parashar
M.Sc. Vegetable Science, Central Agricultural University, Imphal
*Corresponding Author: parasharaditya343@gmail.com

Global climate change represents the biggest abiotic threat to plant and human health and has been given immense consideration worldwide due to its potential impact on agricultural practices. Globally, environmental stressors are the primary cause of crop failures and, on average, result in a 50% yield decrease. Importantly, vegetable production is prone to a broad spectrum of these abiotic environmental stresses. More commonly soil borne pathogens are most destructive and causes a serious crop loss in vegetables like tomato, brinjal, pepper, watermelon, cucumber.

The commercial use of vegetable grafting is a relatively recent innovation. 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.

The first attempt in vegetable grafting was done by grafting watermelon (*Citrullus lanatus*) onto pumpkin (*Cucurbita moschata*) rootstock in Japan and Korea in the late 1920s. Among the Solanaceous crops, aubergine (*Solanum melongena L.*) was first grafted on to scarlet onto scarlet aubergine (*Solanum integrifolium* Lam.) was started in the 1950s.

Scenario in India

In India, grafting work has been started in IIHR, Bangalore by Dr. R M Bhatt and his associates. TNAU, Coimbatore has done work on brinjal grafting using Solanum nigrum as rootstock. NBPGR regional station, Thrissur, Kerala have done work on cucurbit grafting by taking *Momordica cochinchinensis* as rootstock with success rate of 98%. CSKHPKV, Palampur initiated work on grafting in cucurbits solanaceous vegetables and have identified more than 22 rootstocks of these vegetables.

More than 400 vegetable producers in India's Andhra Pradesh state have taken to cultivating grafted

vegetables in an attempt to double their incomes through increased yields. Farmers are reporting around 30-50% increase in yields from use of grafted varieties over traditional varieties. The farmers, from villages around Kuppam town of Chitoor district, are being provided grafted seedlings as part of an ICRISAT-led project, 'Doubling farmers' income through grafted vegetable seedlings in Andhra Pradesh. Department of Vegetable Crops, Horticultural College and Research Institute, TNAU, Coimbatore, Tamil Nadu initiated research on vegetable grafting in brinjal to mitigate root-knot nematode (*Meloidogyne spp*.) and dry root rot (*Macrophomina phaseolina*) incidence during 2008. The technology was standardised and released during the year 2016. Currently, the department is producing grafted brinjal plants and supplying to the farmers on request basis @ 7 Rs per graft. Some private players are also involved in grafting. One amongst them is 'VNR Seed Private Limited' in Chhattisgarh which is supplying grafted brinjal, tomato, cucumber, muskmelon and watermelon seedlings resistant to bacterial wilt to farmers

An unorthodox approach

Now-a-days, grafting promises to be an effective unorthodox tool over slow conventional breeding methods against various biotic and abiotic stresses. The plants developed through conventional methods reflect the genotype (G) × environment (E) interaction only, whereas a grafted plant brings two different genotypes together and shows effective interaction of rootstock (R)× scion (S)× environment (E) thereby determining the positive and negative influence of rootstocks on plant performance and fruit quality of scion.

Grafting not only provides vigour to the plant but also provides resilience against adverse environmental conditions and soil-borne pathogens. It also improves resource uptake capacity of plant and increases its resource use efficiency. Grafting enhances the soil biological properties by increasing the population of bacteria and actinomycetes with a great potential to protect plants against many pathogens.

Grafting: Bridge to Sustainable Resilience Building

For sustainable vegetable production on in the developing countries, eff orts are being focused on low cost, effective and simplified grafting technologies, i.e., low-cost healing chambers and grafting tubes as well as open-pollinated rootstock varieties or those developed from wild species.

Among all management tactics, vegetable grafting is considered as eco-friendly for sustainable vegetable production as a result of the resistant rootstock reduces the dependency upon agrochemicals needed for treating the soil-borne diseases and has opened a new vista in organic farming of vegetables. This tactic has rapidly expanded due to intensification of production practices, reliance on susceptible cultivars to satisfy specific market demands, a global movement and local invasion of novel pathogens, accrued use of organic practices, the fast adoption of high tunnel production systems.

Additionally, grafting provides advantages to manage abiotic stress, to reduce reliance on chemical and fertiliser inputs, and to boost fruit quality. Recently, with emphasis on multi tactic approaches to manage soil-borne pathogens vegetable grafting has emerged as a very important integrated pest management to manage soil-borne diseases of vegetable crops.

Prerequisites for vegetable grafting

Breeding host-resistant rootstocks

Host resistance can be generally classified into two categories: vertical resistance (resistance is governed by single genes) and horizontal resistance (resistance is controlled by multiple genes). Oftentimes, the horizontal resistance can be accidentally lost by continuous selection for horticultural characteristics. Several cucurbitaceous and solanaceous rootstocks are selected from wild germplasm, and therefore they are more likely to maintain non-differential/horizontal resistance to a wide range of pathogens.

Ways to achieve resilience through grafting

There are numerous studies describing the use of grafting techniques on different vegetable crops to improve tolerance against a broad spectrum of environmental stresses.

Flooding Resilience

It has been documented that grafting has been used by many research groups in various vegetable crops to improve flooding tolerance. Tomato is an example of a globally grown vegetable that is sensitive to flooding. The interspecific grafting of tomato to improve flooding

tolerance. In this experiment, a commercial tomato cultivar, Arka Rakshak, was grafted onto four egg- plant rootstocks, such as

BPLH-1, Neelkanth, Mattu Gulla, and Arka Keshav. In a recent study, tomato hybrids (Arka Rakshak and Arka Samrat) were grafted onto eggplant rootstocks (IC-354557, IC-111056, IC-374873, and CHBR-2) and exposed to waterlogged conditions.

Observations revealed that there were no symptoms of leaf chlorosis or plant wilting and less of a reduction in chlorophyll at all plant growth stages. In contrast, the un-grafted plants experienced 41–100% reduction in chlorophyll content after 96 h of waterlogged stress, while the plants wilted and died 4–7 days after the stress was removed.

Drought Resilience

Although breeding and biotechnological interventions have resulted in some new drought-tolerant crop varieties, these advances have been mostly limited to cereal crops. water availability is highly affected by climate change which influences crop productivity, specifically that of vegetable crops, and total crop failures are common.

Therefore, grafting could be used to decrease production losses and increase the water use efficiency (WUE) during water scarcity.

Studies have showed that the antioxidant enzymes varied in fruits of non-grafted and grafted plants under drought stress. In cucumber, it has been documented that grafting improved the WUE by affecting the ABA biosynthesis pathway which enhanced plant growth and yield. Osmotic manipulations occurred in accordance with the water stress level when sensitive pepper plants were grafted with the relatively tolerant rootstocks. Another study which compared drought-tolerant rootstocks for watermelon concluded that wax gourd is a better rootstock than bottle gourd under drought-prone conditions.

thermal stress resilience

Temperature extremes can result in vegetable production losses by promoting wilt and necrosis, retarding the rate of truss appearance, and impacting the timing of fruit ripening. Vegetable crops are highly sensitive to both low and high temperatures.

In Morocco, *C. ficifolia* is the preferred root-stock for cucumbers and is an excellent rootstock for low soil temperature tolerance, particularly for spring production in winter.

Grafting tomato onto wild tomato rootstock exhibited the high relative growth rate of shoots and higher root mass ratios under low temperature as compared to selfed and non-grafted plants. Therefore, the results of study document the wild tomato (*Solanum habrochaites*) accession (LA) 1777 as another rootstock option when managing suboptimal root zone temperature in tomato and other solanaceous vegetable crops.

Salinity Resilience

About 7% of the world area and close to 20% of the arable irrigated land are affected by soil salinity. Many strategies have been employed in order to overcome this issue including breeding for salt-tolerant vegetable crops has also been considered, but the complex polygenic trait that evokes salt tolerance requires several cycles of plant breeding.

In the past decade, studies have investigated the salt tolerance of grafted vegetable crops and most of the studies have concluded that grafting is a highly efficient way to improve salt tolerance. When bottle gourd was used as a rootstock, the salt tolerance capacity of watermelon plants improved several-fold.

In the case of muskmelon, interspecific squash rootstock (*Cucurbita maxima* × *Cucurbita moschata Duch.*) increased salt tolerance, along with plant biomass and leaf area, in the grafted muskmelon compared to non-grafted control plants.

Conclusion

In conclusion, grafted vegetables have great potential in mitigating the environmental (biotic as well as abiotic) stressors in an eco-friendly and sustainable manner.

This grafting technique coupled with other resilient agricultural techniques such as less and less use of agrochemicals and more use of organic solutions such as Panchgavya can help build the resilience to the agro-ecosystem.

In India, where grafted vegetables are slowly coming into trend, more research and study need to be undertaken so as to create awareness among the local farmers to adopt this new technology and increase their income. Parts of India such as North-Eastern Region is full of potential of wild germplasms that must be rediscovered and exploited to create more such tolerant rootstocks that could be further used for crop improvement and grafting.

* * * * * * * *