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GRAFTING: KEY TOOLS FOR QUALITY AND QUANTITY VEGETABLE CULTURE

Abstract:

Grafting of vegetable seedlings is a unique horticultural technology practiced for many years in Asia to overcome issues associated with intensive cultivation using limited arable land. This technology was introduced to Europe and other countries in the late 20th century along with improved grafting methods suitable for commercial production of grafted vegetable seedlings. Later, grafting was introduced to North America from Europe and it is now attracting growing interest, both from greenhouse growers and organic producers. Grafting onto specific rootstocks generally provides resistance to soil borne diseases and nematodes and increases yield. Grafting is an effective technology for use in combination with more sustainable crop production practices, including reduced rates and overall use of soil fumigants in many other countries. Nevertheless, there are issues identified that currently limit adoption of grafted seedlings. One issue unique to Asia is the large number of seedlings needed in a single shipment for large-scale, open-field production systems. Semi- or fully-automated grafting robots were invented by several agricultural machine industries in the 1990s, yet the available models are limited. The lack of flexibility of the existing robots also limits their wider use. Strategies to resolve these issues are discussed, including the use of a highly controlled environment to promote the standardized seedlings suitable for automation and better storage techniques.

Introduction:

India is 2nd largest producer of vegetables in the world after china. Average productivity of vegetable in India is 17.58 tons/ ha (Anonymous, 2013) as compare to Japan and other European countries. So there is huge need to improve productivity by means of new techniques. A number of studies have shown that grafting can be increase the production per unit area. Several researches have been said that grafted plants are more resistance to soil borne disease like, Fusarium wilt. Grafting of Muskmelon on *Cucurbita* rootstock decreased boron uptake by the grafted plants and reduced the effect of high boron concentration in the water on fruit yield & quality under saline and effluent irrigation. Though grafting is old age practices in other countries like China, Japan and some other European countries where land is intensive and continuous cropping is common. Grafting of a susceptible scion to a resistance root stock can provide a resistance cultivar without the prolonged screening and selection required to breed resistance into a cultivar. Intergeneric grafting is used in production of many fruit bearing vegetable like Cucurbitaceous and Solanaceous vegetables. Cucumber (*Cucumis sativus* L.) grafted on pumpkin (*Cucurbita moschata* L.), Watermelon (*Citrullus lanatus*) on White gourd (*Benincasa hispida* Cogn.). Interspecific grafting is generally applied to eggplant (*Solanum melongena* L.). Scarlet eggplant (*S. integrifolium* Poir.) and Solanum torvum are popular rootstock for eggplant production (Rodriguez-Burruezo, *et al.*, 2008).

Objective:

For successful rising of the crop under biotic and abiotic stress, precocity, improvement of quality and other horticultural attributes. Further crop wise objective is given in Table 1.

Table 1. Crop wise objective of grafting

Vegetable	Objective of grafting
Bitter gourd	Tolerance to Fusarium (*Fusarium oxysporum* f. sp. *momordicae*) (Lee, *et al*., 1998)
Cucumber	Tolerance to Fusarium wilt, *Phytophthora melonis*, cold hardiness, favourable sex ratio, bloomless fruit
Eggplant	Tolerance to bacterial wilt, (*Pseudomonas solanacearum*) *Verticillium albo-atrum*, *Fusarium oxysporum*, low temperature, nematodes, induced vigour and enhanced yield (Oda *et al*., 1996)
Melon	Tolerance to Fusarium wilt (*Fusarium oxysporum*), wilting due to physiological disorder, Phytophthora disease, cold hardiness, enhanced growth
Tomato	Tolerance to corky root (*Pyrenochaeta lycopersici*), *Fusarium oxysporum* f.sp. *radicis-lycopersici*, better colour and greater lycopene content (Oda *et al*., 1996), tolerance to nematode (Oka, *et al*., 2004)
Watermelon	Tolerance to Fusarium wilt (*Fusarium oxysporum*), wilting due to physiological disorder, cold hardiness and drought tolerance (Oka, *et al*., 2004)

Rootstock for grafting:

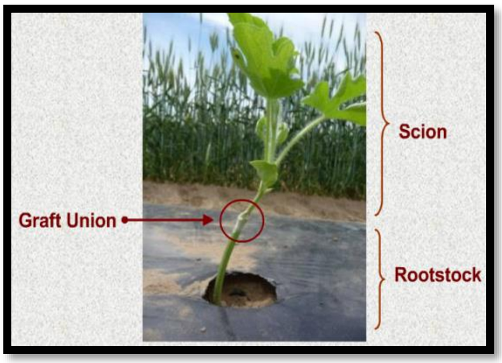
Intergeneric grafting is used in production of many fruit bearing vegetables. *i.e*. Muskmelon are being grafted to bottle gourd (*Lagenaria siceraria* (Mol.) Standl.), Pumpkin (*Cucurbita moschata* L.) bitter gourd (*Momordica charantia* L.) and tomato (*Lycopersicon esculentum* L.) on Brinjal (*Solanum melongena* L.). Other suitable and adaptable rootstocks are given in Table 2.

Table 2. Rootstock for grafting of vegetables

Scion	Rootstock
Cucumber	*Cucurbita moschata*, *Cucurbita ficifolia*, *Cucurbita maxima* *Sicyos angulatus*
Melon (for open field)	*Cucurbita sp.*, *C. moschata* X *C. maxima*, *Cucumis melo*
Melon (for greenhouse)	*Cucumis melo*, *Benincasa hispida*, *Cucurbita spp.* *C. moschata* X *C. maxima*
Watermelon	*Citrullus lanatus*, *Cucurbita maxima*
	C. moschata, *C. moschata* X *C. maxima*, *Lagenaria siceraria*
Bitter gourd	*Cucurbita moschata*, *Lagenaria siceraria*, *Luffa aegyptica*
Tomato	*Lycopersicon pimpinellifolium*, *L. esculentum* *Solanum nigrum*
Eggplant	*Solanum torvum*, *Solanum integrifolium*, *Solanum melongena* *Solanum nigrum*

What is Grafting?

Grafting is propagation technique where two portions of plant which have similar organic texture are joined in such a manner so as to continue their development as a single plant.



Care should be taken while grafting

1) It is important to increase the chances of vascular bundle of scion and rootstock to come into contact (Oda *et al.*, 1996) by maximizing the area of cut surface that are spliced together and by pressing spliced cut surface together.
2) Cut surface should not be allowed to dry out.
3) It should be carried out in a shady place or in polycarbonate house.
4) Expose the scion and rootstock to sunlight for two-three days before grafting.
5) Make sure that scions and rootstock have similar diameter of stem. (Oda *et al.*, 1996)

Materials

1) Scion seedlings at a beginning of first true leaf stage. The true leaf size is 2-3 mm.
2) Rootstock seedlings at a first true leaf stage. The long hypocotyls (7-9 cm) are desirable.
3) The true leaf blade size is ~2 cm.
4) Scalpel with handle works the best for this grafting method.
5) Perforating tool. A plastic soldering tool works well. Alternatively you can create a tool by sharpening the edge of bamboo chopsticks (pencil sharpener works great).

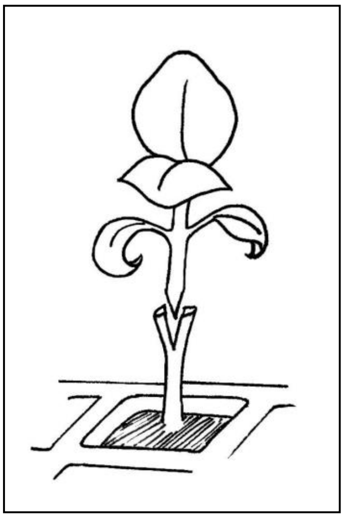
- New trays filled with well moistened substrate.

Types of grafting:

Grafting methods involve such techniques as cleft grafting, tube grafting, whip grafting, tongue grafting, spliced grafting, flat grafting, saddle grafting, bud grafting, hole insertion grafting, and tongue approach grafting etc. These methods of grafting are briefly described as under:-

1) Cleft grafting

Tomato plants are mainly grafted by this method of grafting as shown in Fig. 1. For practicing this method of grafting, seeds of the rootstocks are sown 5-7 days earlier than those of the scion. The stem of the scion (at the four leaf stage) and the rootstock (at the 4-5 leaf stage) are cut at right angles, each with 2-3 leaves remaining on the stem. The stem of the scion is cut in a wedge and the tapered end fitted into a cleft cut in the end of the rootstock. The graft is held firm with a plastic clip.



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2) Tube grafting

This method of grafting was developed by Lee, *et al.* (1998). It makes possible to graft smalI plants grown in plug trays two or three times faster than the conventional method and is quite popular among Japanese seedling producers. Plants in small cells must be grafted at earlier growth stage and requires tubes with a smaller inside diameter. First the rootstock is cut at a slant. The scion is cut in the someway. Elastic

tubes with side slit are placed onto the cut end of the rootstock. The cut ends of the scions are inserted into the tube, splicing the cut surfaces of the scions and root stocks together. While practicing the tube grafting in eggplant the seeds of *S. lorvum* must be sown a few days earlier than those of the other rootstock species.

3) Tongue approach grafting

Melons and other cucurbitaceous plants are generally grafted by this method. It gives higher survival ratio because the root of the scion remains until the formation of the graft union. In this method, seeds of cucumber are sown 10-1 3 days before grafting and pumpkin seeds 7-10 days before grafting, to ensure uniformity in the diameter of the hypocotyl of the scion and rootstock. The shoot apex of the rootstock is removed so that the shoot cannot grow. The hypocotyl of the scion and rootstock are cut in such a way that they tongue into each other, and the graft is secured with a plastic clip. The hypocotyl of the scion is left to heal for 3-4 days and then crushed between the fingers. The hypocotyl is cut off with a razor blade three or four days after being crushed.

4) Slant cut grafting

Recently this method of grafting has got popularity. It has been developed for robotic grafting. In this method, it is essential to remove the first leaf and lateral buds when a cotyledon of rootstock is cut on a slant.

5) Mechanized grafting

Grafting is arduous task and efforts are being made to reduce the labour required. Attempts have been made to mechanize grafting since 1987. There are several basic factors which govern the success of grafting by machine or robot such as seedling shape, location of cut, seedling gripping, cutting method, fixing materials and tools etc. (Herde, et al., 1999). Grafting robots for plug have been developed by combining the adhesive and grafting plates (Kurata, 1994; Oka, *et al.*, 2004). This robot makes it possible for eight plugs of tomato, eggplant or pepper to be grafted simultaneously. Recently a fully automatic grafting system for Cucurbitace is vegetables have been designed (Fernandez-Garcia, et al., 2002) in which seedling quality estimation is clone by using fuzzy logic and neural network. Further, healing chamber with controlled atmospheric condition has also been designed to enhance the survival of graftage.

- **Effects of grafting:**

(i) **Vigour**. Rootstocks affect the growth and yield of scion plants and are often performed to provide vigor. However some rootstocks may also depress the growth and yield of scion plants.
(ii) **Stress tolerance**. Tolerance to temperatures, drought, flooding and salt stress may be influenced by the rootstock. The increased performance at low soil temperature with rootstocks is one of the main benefits of the grafting.

- **Problems associated with Grafting:**

Various problems are commonly associated with grafting and cultivating grafted seedlings. Major problems are the labor and techniques required for the grafting operation and post graft handling of grafted seedlings for rapid healing for approx. 7 to 10 days. An expert can graft 1200 seedlings per day (150 seedlings per hour), but the numbers vary with the grafting method. Similarly, the post graft handling method depends mostly on the grafting methods. In general, the problems could be minimized or easily overcome by careful cultural management and wise selection of scion and rootstock cultivars.

Conclusions:

Grafting vegetable plants onto resistant rootstocks is an effective tool that may enable the susceptible scion to control soil borne diseases, environmental stresses and increase yield. However, in these cases, the characteristics of the three areas might be affected by grafting as a result of the translocation of metabolites associated with fruit quality to the scion through the xylem and/or modification of the physiological processes of the scion. Possible quality characteristics showing these effects could be fruit appearance (size, shape, color, and absence of defects and decay), firmness, texture, flavor (sugar, acids, and aroma volatiles) and health-related compounds (desired compounds such as minerals, vitamins, and carotenoids as well as undesired compounds such as heavy metals, pesticides and nitrates). Grafting is an effective technology for use in combination with more sustainable crop production practices, including reduced rates and overall use of soil fumigants in many other countries. Thus, by vegetable grafting increase the production as well as quality attributes and reduce the cost of cultivation of the farmers.

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GREEN MANURING: A SUSTAINABLE APPROACH FOR SOIL HEALTH IMPROVEMENT

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Introduction

Green manuring, the practice of plowing or turning fresh green plant matter into the soil, is a sustainable approach to improve soil fertility and health by adding organic matter, nutrients, and promoting beneficial microbial activity. Green manuring improve its fertility, structure, and organic matter content, often using crops like legumes. It increases the soil fertility by direct addition of nitrogen to the soil through symbiosis and it also improves the soil structure, water holding capacity and microbial population of soil by addition of humus or organic matter. Upon decay, green manures enrich the soil with organic matter and to a lesser extent with nutrients such as N and P. Ample time for the green manure to decompose should be allowed between its incorporation in the soil and the planting of the next crop.

Dhaincha (*Sesbania aculeata*) is the most commonly used green manure among the farmers, although cultivation of sun-hemp and guar is also in vogue. Leguminous crops should be preferred as a green manure crop since it adds a lot of nitrogen into soil due to *Rhizobium* symbiosis. Incorporation of leguminous crop producing 8 to 25 tons of green matter per hectare will add up about 60 to 90 kg of N/ha, which is equivalent to application of three to ten tones of farmyard manure on the basis of organic matter and its nitrogen contribution.

Crops which are most commonly used for green manuring in our country are Dhaincha (*Sesbania aculeate*), Sunn hemp (*Crotolaraia juncea*), senji (*Melilotus parviflora*), berseem (*Trifolium alexandrinum*) etc. Sunn hemp is dominant among green manure crops and is well suited in almost all parts of the country; it also fits in well with the sugarcane, potato, garden crops and the second season paddy in southern India and with irrigated wheat in the north. Dhaincha as a green manure crop does well performs well in the waterlogged and alkaline soils.

Biomass production and N accumulation of green manure crops

Crop	Incorporation Age (Days)	Dry matter (t/ha)	N accumulated (kg/ha)
Sesbania aculeata	60	23.2	133
Sunn hemp	60	30.6	134
Cow pea	60	23.2	74
Pillipesara	60	25.0	102
Cluster bean	50	3.2	91
Sesbania rostrata	50	5.0	96