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Grafting Techniques for Sustainable Productivity in Vegetable Crops

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Abstract

The practice of grafting used in vegetable production is similar to fruit tree grafting in that it creates a new plant by physically combining two plants with different genetic background, with one providing the shoots (scion) and the other donating the roots (rootstock). At present, vegetable grafting is mainly applied to solanaceous and cucurbitaceous crops, primarily tomato, eggplant, pepper, watermelon, cucumber, and melon. Grafting is an effective IPM tool for managing soil borne diseases.

Introduction

Grafting technology has developed into a unique component in the production of several solanaceous and cucurbitaceous vegetables for improvement of crop productivity and pest management. In vegetables, the availability of disease resistant rootstocks and development of highly efficient grafting techniques has led to expansion in the use of grafts worldwide. Grafting is an alternative approach used in vegetable production to fight against soil borne diseases such as *Fusarium* wilt, bacterial wilt and nematodes since 1920's in Japan and Korea (Thakur *et al.*, 2020). Grafting as a technology for the commercial production was later on adopted for the production of many fruit bearing vegetables which include watermelon, cucumber, melon, tomato, eggplant and pepper, grafted seedlings were used. These seedlings besides providing resistance against biotic and abiotic stresses increase the yield of the cultivars. Consequently, production of grafted seedlings has been commercialized in Japan with the development of specialized facility, such as grafting machine and grafting chamber etc. However, these commercial products have not been introduced to many other countries. Grafting technique is considered eco friendly for sustainable vegetable production because the resistant rootstock reduces dependence on agrochemicals. Grafting improves quality of the plant and is used to induce resistance against low and high temperatures. Growth, yield and fruit quality of the scion is greatly influenced by the type of rootstock used. Due to high post graft mortality of seedlings, this technology is still in infancy in India. For its commercial application in India, sharpening of grafting skills and healing environment need to be consistent.

Grafting in Vegetables

Grafting is the process whereby the top of one plant (the scion) is attached via a graft union to the root system of another plant (the rootstock). The most common objective of grafting is to overcome some limitation of either the scion or the rootstock. For example, the root systems of many crops are susceptible to attack by a range

of persistent soil-borne diseases, pests and nematodes. If resistance to these pest problems can be identified in other cultivars or even in closely related species it may be possible to make crosses that introduce this resistance into the pest sensitive crop. However this crossing process may take years and there are no guarantees of success. A more rapid approach to accessing this pest resistance may be to simply use the pest resistant material as a rootstock. A scion from a high quality, high yielding but disease or pest sensitive cultivar is then grafted onto the resistant rootstock – effectively capturing the strengths of both the high quality scion and the pest tolerant rootstock in a single plant.

Grafting has been used for centuries to improve yields and quality of a range of Horticultural crops especially long lived, high value crops such as grapes and tree fruit. While the potential to use grafting to improve a range of vegetable crops has been long established, commercial utilization of grafting in vegetable crop production has been limited – largely because of a questionable cost or benefit relationship. However, this situation is changing. In the past, vegetable growers commonly used fumigation to control many of the most problematic soil borne disease and nematode problems. However the phasing out of methyl bromide and increasing restrictions on the use of other fumigants is putting pressure on growers to find alternative means of dealing with these pest problems. Using grafting as an alternative to pesticides also fits in with the growing interest in organic or pesticide free production. Grafting may also increase the vigor of the crop, resulting in earlier or higher yields and superior quality. By selecting appropriate rootstocks it may be possible to grow crops using less fertilizer, water or other inputs. There is also the potential to employ rootstocks that will also improve the crop's tolerance of environmental stresses such as temperature extremes and excessive soil salinity.

Growing grafted vegetables was first launched in Japan and Korea in the late 1920's by grafting watermelons to gourd rootstock (Ashita, 1927; Yamakawa, 1983). After the first trial, the cultivated area of grafted vegetables, as well as the kinds of vegetables being grafted, has been consistently increased. At present, most of the watermelons [*Citrullus lanatus* (Thunb.)], Oriental melons (*Cucumis melo* var. *makuwa* Makino), greenhouse cucumbers (*Cucumis sativus* L.), and several solanaceous crops in Korea and Japan are grafted before being transplanted to the field or greenhouse.

Grafting Techniques

There are four methods commonly used in vegetables, viz,

- Approach (tongue),
- Hole insertion,
- One cotyledon (splice), and
- Side grafting.

Approach (Tongue) Grafting

Both rootstock and scion should have one or two true leaves. Cut a 45° downward slit halfway through the rootstock stem below the cotyledons, and cut an identically angled upward slit in the scion stem. The angle and location of the cuts must be relatively precise so the scion can be placed on top of the rootstock. Bring the two cut stems together so they overlap, then attach a clip or securely wrap the joined stems in plastic wrap, foil, or parafilm. Place the joined plant in a transplant tray or small pot. Mist the plant with water and place it on a greenhouse bench. Water the plant as needed. Cut off the top of the rootstock 5 days after grafting. Wait 7 days, and then cut off the bottom portion of the scion.

Advantages

- A relatively simple technique.
- A grafting clip is not essential.
- A high humidity and low light environment is not required for successful healing of the graft union; a normal greenhouse environment is sufficient.
- There is no shoot regrowth from the rootstock.

Disadvantages

- Requires severing of the rootstock top and the scion bottom after the graft union has healed.



Figure 1: Approach grafting method

Hole Insertion Grafting

Rootstock seedlings should have one small true leaf, and scion seedlings should have one or two true leaves. With a pointed probe, remove the true leaf, the apical meristem (undifferentiated cells), and the axillary buds from the top most growing point of the rootstock plant. It is important to remove all of the apical meristem and the axillary buds to prevent future shoot growth of the rootstock. Use the probe to create a hole in the top of the rootstock where the tissue was removed. Cut the scion below the cotyledons at a 45° angle on two sides to form a wedge and insert it into the rootstock. Mist with water and place in healing chamber.

Advantages

- A grafting clip is not essential.
- There is no trimming of unwanted plant parts after healing

of the graft union.

- Tends to have a high success rate.

Disadvantages

- Requires slightly more skill than most other grafting techniques.
- Requires more time to graft than some of the other grafting techniques.
- Requires very careful control of humidity, light, and temperature after grafting.
- High losses may occur if the healing environment is not optimal.
- Regrowth of the rootstock will occur if not all the meristem tissue has been removed.



Figure 2: Hole insertion method

One Cotyledon Grafting

This method (also known as the splice graft) was originally developed by Japanese engineers for use with automated grafting. Due to the procedure’s simplicity, it has become the most commonly used manual grafting method. Rootstock seedlings should have at least one or two true leaves, and scion seedlings should have two or three true leaves. Cut the rootstock at a 60° angle so one cotyledon remains and one is removed. Cut carefully so as to keep the remaining cotyledon firmly attached to the rootstock stem. The angled cut should also remove the apical meristem and both axillary buds. It is important to remove all of the apical meristem and the axillary buds to prevent future shoot growth of the rootstock. If all of the axillary bud tissue was not removed with the cut, use the probe to dig it out. Cut the scion at a 60° angle below the cotyledons, where its diameter matches that of the rootstock. Bring the two cut stem surfaces together, and hold them in place with a grafting clip.

Advantages

A simple technique that is relatively quick and easy to perform. The only task after grafting is to remove the clip. There is no trimming of unwanted plant parts after healing of the graft union.

Disadvantages

- Requires careful control of humidity, light, and temperature after grafting.

- High losses may occur if the healing environment is not optimal.
- Regrowth of the rootstock will occur if all the meristem tissue has not been removed.

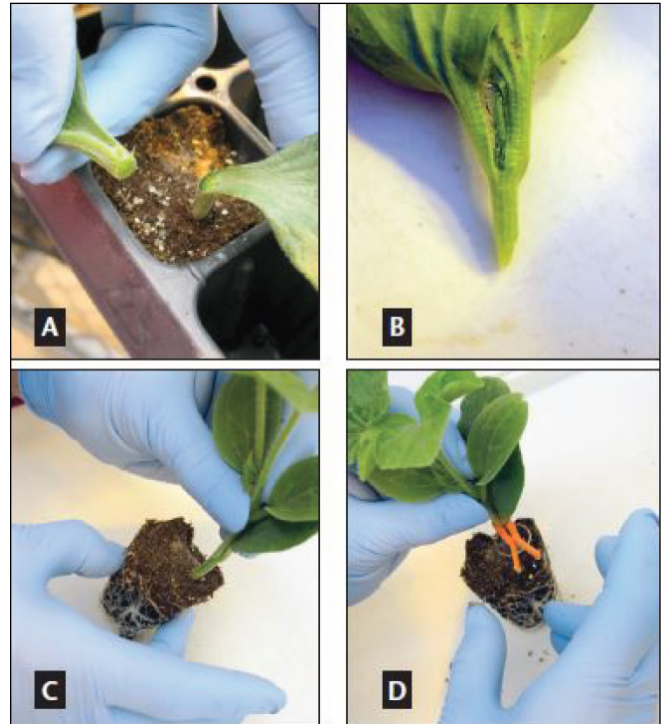


Figure 3: One Cotyledon grafting

Side Grafting

This type of grafting requires rootstock seedlings with at least one true leaf and scion seedlings with one or two true leaves. It is suitable for rootstocks with wide stems. With a sharp knife or razor blade, cut a slit all the way through the stem of the rootstock below the cotyledons. The slit should be just long enough to insert the scion. Insert a probe or toothpick into the slit to hold it open. Cut the scion below the cotyledons at a 45° angle on two sides to form a wedge, and insert the scion into the slit of the rootstock. Remove the probe or toothpick if one was used. This grafting technique with actual plants hold the scion in place with a grafting clip, mist with water, and place in healing chamber. Cut off the top portion of the rootstock 5 days after plants have been removed from the healing chamber.

Advantages

- A relatively simple technique.

Disadvantages

- Requires careful control of humidity, light, and temperature after grafting.
- High losses may occur if the healing environment is not

optimal.

- After the graft union is healed, the top portion of the rootstock must be removed.



Figure 4: Side grafting

Conclusion

Grafting provides a site specific management tool for soil borne diseases. Grafting can affect various quality aspects of vegetables. Rootstock or scion combinations

should be carefully selected for specific and geographic conditions. Identification of compatible disease resistant rootstocks with tolerance to abiotic stresses is the basic requirement for continued success. It reduces the need for soil disinfectants and thereby environmental pollution. Grafting is a rapid alternative tool to the relatively slow breeding methodology aimed at increasing biotic and abiotic stress tolerance of fruit vegetables. Since grafting gives increased disease tolerance and vigour to crops, it will be useful in the low input sustainable horticulture of the future.

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