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Review Article

Grafting: A Tool to Improve Yield and Stress Tolerance in Vegetables

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Abstract

The main purpose of grafting in vegetable crops is to increase yield under biotic and non livings stresses such as temperature, drought, salinity, sicknesses and pest damage etc. vegetable grafting in vegetable has been in progress since twenty years and the area under grafting of vegetable crops is (more and more) ever-increasing. Grafting of vegetable crops is having opportunity to spread out area under unstable agro-eco-systems and it has a capacity to increase per unit area production and productivity. Grafting of vegetable crop is one of the cheapest and other choice tools to long and slow breeding procedures in development of challenging varieties.

Keywords: *Grafting; Yield; Vegetables*

Introduction

Grafting in vegetable crop is a skill of joining together two plant parts and grows as a sole plant [1]. Resistant roots stocks are one of the best tools for vegetable production using grafting in vegetable crops. Grafting in vegetable crop is new one but it has been practiced in fruit plants thousand years ago. Joining of vegetable crop reduces dependence on the farming of chemicals for the production of organic vegetable [2]. Desired rootstocks using Joining of vegetable crop induce resistance and tolerance against biotic and abiotic stress, better produce and quality, survival rate. In world, vegetable joining is getting (quality of being liked a lot or done a lot) in case of cucurbits, tomato, eggplant and pepper using energetic and disease resistant rootstocks to secure/make sure of (good) enough yields where biotic and nonliving stresses limits the working well and getting a lot done [3-5].

History

In Japan and Korea during the late 1920s, the first effort in vegetable grafting was done by joining watermelon on the pumpkin root stock [6]. Lee and Oda, [3] reported that the self joining was used as a way of method to produce large sized gourds fruit. However, the aim of managing soil diseases the commercial joining of vegetables only started in the early 20th century [7]. In 1950s, eggplant was first joined on to bright red on to bright red eggplant (*Solanum integrifolium* Lam.) [8]. In almost the same way, joining of tomato (*Solanum lycopersicum* L.) was in progress in the 1960s [3]. The proportion of joined Solanaceous and Cucurbitaceous vegetable crops had improved

in Japan (59%) and in Korea (81%) by 1990 [9]. Joining work on vegetable crop has been started by Dr. R. M. Bhatt and his co-workers/ his friends at IIHR, Bangalore, India. Brinjal joining using *Solanum nigrum* as root stock has done in Tamilnadu Agricultural University, Coimbatore. Cucurbit joining by taking *Momordica cochinchinensis* as rootstock has done at National Bureau of Plant Genetic Resources station, Kerala with 98% success rate.

Importance and use of vegetable grafting

Resistance to biotic and abiotic stresses

The watermelon joined on to the rootstock of bottle gourd improves flooding tolerance under heavy or loamy soils. Anonyms [10] 2013 reported that cucurbits joined on pumpkin provide (time period with not enough rain) tolerance in sandy soil. 60% increase in yield when mini watermelons joined on to a rootstock of PS1313. Low temperature and quality resistance have been found in Cucumber joined on rootstock of Shintoza type [11]. Under greenhouse cultivation the watermelon joined on to saline tolerant rootstocks increases yield around 81% [12]. Goreta., *et al*. [13] found that the weight of shoot and area of leaf increases when watermelon Cv. Fantasy joined on rootstock of Strongtosa. In greenhouse condition, soil bore sicknesses and some of the biotic stresses cause damage in vegetable production [3,14].

Improve the qualitative and quantitative traits

Root system play major role in fruit quality of shoot [15]. Higher marketable yield and fruit quality has been found in grafted plants [16]. Quality and yield will be increased when eggplants joined on *S. torvum* and also increased the fruit size. Joining and rootstock type can affect the quality characteristics [17]. Quality characters are influenced by the rootstock [18]. No big differences in total solids by "Ox-heart" tomato joined on to two interspecific crosses [19]. Further research is needed regarding improvement of qualitative traits through grafting techniques.

Flowering and harvest period

'Shintosa' type rootstocks delayed flowering in watermelon, wax gourd, bottle gourd and pumpkin [20]. It causes early development of female flowers as compared to other gourd [21]. Quality characters are affected by date of flowering and harvesting time of fruit. Less evidence about joining effects on flowering and earliness has been found. Due to the growth of scion plants the late flowering in joined plants may be occurred.

Essential necessary things for vegetable joining

1. **Rootstock/Scion Selection**: Selection of root stock and scion is the single most important step in grafting. 2 - 3 true leaf stage is appropriate time for joining. Proper physiological stage is the best stage for grafting operation.

2. **Compatibility of graft**: Both scion and rootstock must compatible to each other. Different methods and techniques are used to hold together tightly to the cut surfaces. Water and nutrients supplied from the rootstock to the scion for rapid growth and development of the graft union.

3. **Joining aids**: Plastic tub, Gloves, Tubes, Joining Blade, Grafting clips and Pins are most commonly used aids for grafting.

4. **Screening house**: It should be built with 60 mesh nylon net. Double door systems of screening house are used to reduce the entrance of insect.

5. **Healing of joins**: Healing is most very important to provide good/willing conditions to help callus formation of joined seedlings. In healing room, temperature should be 28 - 29^{0}C with 95% relative humidity for 5 - 7 days in partially shaded place to encourage callus development at union. It helps in development of better union by maintaining the micro climate. The main aim is to create surrounding conditions by controlling temperature and humidity [22].

Methods of grafting in vegetables

A grafting method to be employed varies with the kind of crop being grafted, preferences and experience of growers [9,23] and the kind of grafting machines or robots available [23]. The most common methods for grafting fruit vegetables are tube, tongue approach and cleft grafting.

Tongue/approach grafting

Cucumber and melon plants use "tongued approach grafting" which includes two stems cut on an angled slit on the rootstock and a downward angled slit on the scion, which provide tongue-like silt on each stem. A graft union can be obtained after interlocking and sealing these tongues. When both rootstock and scion develop well, the top of the rootstock is cut off five days after grafting and the bottom of the scion is cut off seven days after the top of the rootstock is removed [24].

Cleft grafting

This practice takes extra time as compared to splice grafting. Cut the scion stem just about 5 mm below the cotyledons; insert the trimmed scion into the rootstock, hold it tightly together place a plastic clip around the graft union [25].

Hole insertion/Top insertion grafting

In general, watermelon plants prefer the "hole insertion grafting" which removes the true leaf from the rootstock along with the growing point. A bamboo needle is then used or a 1.4-mm size is drilled a bit to open a slit along one side on the hypocotyl of the rootstock and then a scion is inserted with about 40-degree-angle cut on both end into the rootstock [24].

Splice grafting/tube grafting/one cotyledon splice grafting

Tomato plants are produced by "splice grafting" which is done by a single slanting cut, removal of one rootstock cotyledon attached with the growing point. The scion is then cut and matched with the two cut surfaces together, are held with a grafting clip or silicone sleeve [24]. The aforementioned methods are mainly used for grafting disease-resistant rootstocks in vegetable crops.

Pin grafting

The main stem gets about a ¼" in diameter, then cut the Maxi forts down to about 2" from the soil level, cut off the other tomato, now called a scion,1 at a matching diameter point and put them together, wrapping or putting a 'Japanese grafting pin' device on the join to hold them together. The stems need to be the same diameter so that the cambium layers line up so plant can grow.

Post graft healing environment

The healing chamber should be maintain to proper temperature, humidity and light for all vegetable crops. Healing chamber temperature is usually 5°F higher than the micro climate temperature while the temperature inside the chamber can be higher if sunlight hits the chamber. Temperatures inside the chamber should not drop below 70°F. Plant seedlings can die, if a temperature goes above 90°F inside the chamber. 48 - 72 hours after grafting is very crucial during the healing period, therefore, it is necessary to maintain the humidity and temperature. Raise the RH to about 95% inside the chamber by spraying of water few hours before grafting; before placing the newly grafted plants in the chamber moist them properly [26].

Moreover, the effect of root stock on scion and scion on root stock (Stionic effect) also determines the suitability/compatibility of root stock and scion shoot as well as grafting methods in vegetable crops as per the table 1.

Vegetable crops (Scion)	Rootstock	Grafting method
Eggplant	*Solanum torvum*	Tongue and cleft method
	S. sissymbrifolium	Cleft method
	S. khasianum	Both tongue and cleft methods
Tomato	*S. pimpinellifolium*	Only Cleft method
	S. nigrum	Tongue and cleft methods
Cucumber	*Cucurbita moschata*	Hole insertion and tongue method
	C. maxima	tongue method
Water melon	*Benincasa hispida*	Hole insertion and cleft method
	Cucurbita moschata	Hole insertion and cleft method
	C. melo	Cleft method
	C. moschata × C. maxima	Hole insertion method
	Lagenaria siceraria	Splice Grafting
Bitter gourd	*C. moschata*	Hole insertion and tongue method
	Lagenaria siceraria	Hole insertion
Bottle gourd	*C. moschata, Luffa spp.*	Hole insertion

Table 1: *Compatible rootstocks and grafting methods used in vegetable crops.*

Limitations in grafting of vegetable crops

A variety of limitations related with the production, management and supervision of grafted plants is as follow:

- This practice is labour intensive and required expert people.
- Time management is necessary for sowing of rootstock and scion seeds.
- For graft healing controlled environment is required.
- Incompatibility of rootstock and scion is found in the early stages or subsequent to transplantation in field situation.
- Seed borne pathogens can increase in the nursery which spread the risk of pathogen.
- People working grafting job in protected structure face the problems of pressure and uneasiness, particularly in April - June, September and October [27].

Conclusion

Grafting can efficiently mitigate the adverse effects of biotic and abiotic stress conditions. In India there are now many commercial vegetable nurseries producing grafted seedlings, but high prices prevent small and marginal farmers from purchasing the seedlings. Vegetable grafting is a new technique and many were aware of grafting for fruit crops; they had never tried the method with vegetables. Grafted vegetable plants can offer early fruiting and heavy yield.

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