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Technology Package for High Vegetables Production through Innovative Way of Grafting and Protected cultivation

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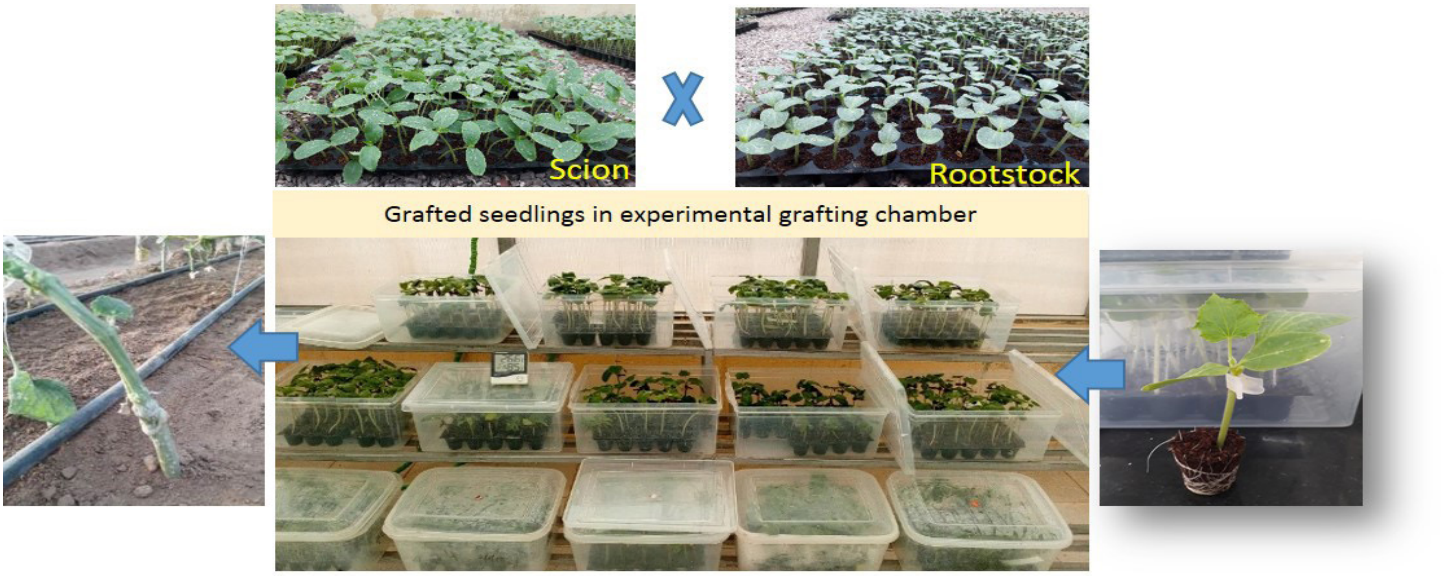
Grafting vegetable plant is relatively a new approach to confront various issues related to their growth in challenged environments. It can help manipulate plant's ability by integration of traits imparting tolerance to stresses with those of commercial genotypes within a short time to enable their successful cultivation under growth limiting environments. For past several years, a team at CAZRI has been striving its efforts towards development of sustainable strategy to deliver plants that could grow successfully under sub-optimal conditions of arid regions by deploying package of technology in select group of vegetables. A success story of the same is presented wherein, it has been demonstrated that the use of grafted seedlings of suitable graft combinations will change the perception of farmers towards greenhouse cultivation in the challenging environments of (semi)arid regions.

Vegetables play a crucial role in balancing our heathy diet by ensuring supply of protective nutrients (e.g., vitamins, minerals, fibers). At country level, there has been a great impetus in vegetable production in past decade (2000s) as witnessed by new heights achieved every year since 2012-13 that recently reached to a record level of 193mt production, enabling meeting of everyone's requirement of 300g. However, vegetable yield per unit area (productivity) which is hovering around 17th a^{-1} is not that much encouraging. There is a lot to do to make this venture a sustainable one so as to meet growing population's food and nutritional demands and farmer's prosperity more so in view of shrinking arable lands and water resource. Rajasthan is one such state where state's average productivity is very low (~10 t ha^{-1}), and with respect to the demand and supply of vegetables, it is a highly deficit (nearly by78%). Hence, most part of local vegetables demands is met through transport from other States. Despite paying more, consumers have to end up with relatively less fresh produce which is harvested a few days ago and transported from far places. Consequently, the consumers are forced to compromise with the quality and shelf life. Transportation from other states adds to the environmental issues due to consumption of fossil fuels. Hence, it is rather more appropriate to increase local production at least of selected vegetable crops as also encouraged by Government's concept of "vocal for local" in the interests of both farmers and consumers. However, growing vegetables under open fields is a bit challenging in arid and semi-arid areas, where number of environmental factors become hurdle to achieve satisfactory yield and quality. Scarce water availability, poor water holding capacity of soils, coupled with high environmental temperatures prevailing in arid and semi-arid areas are major limiting factors that gives poor vegetables yields.

In view of plants limited intrinsic capability to perform optimally under prevailing harsh environment, growing crops under artificially created favourable environments under protected condition (polyhouse and nethouse) seems to be a viable option. Protected cultivation is rapidly growing in horticulture sector across the world. Its growth is much faster in Rajasthan, where vegetable cultivation in open field is challenging than many other parts of the country. Among the common vegetable crops grown under protected structures cucumber is predominantly grown in about 90% greenhouses. Seedless (parthenocarpic) cucumber (also called Biet Alpha, Lebanese or mini cucumber) is the choicest crop of greenhouse growers as it fetches higher price than normal field grown cucumber. Besides, it is relatively short duration crop (100 to 120 days) and production can be extended in either direction of growing season and even can be taken during off-season (e.g., in winter) under protected conditions.

On the other hand, issues such as prevalence of soil-borne diseases and nematodes in intensified production system, relatively poor soil and water quality, less water availability, high radiation and temperatures are major ones which pose challenges to successful and sustainable protected cultivation in this region. CAZRI has been striving hard by researching and providing technical backup to the growers to make this venture successful in this region. There are some innovative approaches identified which has brought little to great success. Among these, grafting vegetables onto identified rootstocks has been remarkable technique to increase production by minimizing the adverse effects of biotic and abiotic factors. Particularly, grafting in cucumber has been a great success to augment its yield particularly under challenging soil and aerial environments.

Systematic efforts were made in past years at CAZRI, Jodhpur to deal with growing issues related to cucumber cultivation under common naturally ventilated ployhouses and nethouse structures in arid and semi-arid regions. In cucumber, several genotypes from public and private sectors belonging to pumpkin, bottle gourd, sponge gourd, fig-leaf gourd were tested for their efficacy as rootstocks under diverse environments (water stress, high temperature stress and soil pathogens) in different growing conditions and seasons. The most exciting part was the identification of best graft combination involving interspecific hybrid rootstock NS-55 for grafting of commercial scion cultivars Terminator and Y-225. The advantage



of grafted cucumber was an increase >50% yield even under soil borne disease infected soils coupled with high-temperatures during summer, whereas about 30% under normal condition. Further, there was no reduction in fruit yield under water deficit condition, where 20% less water was supplied throughout growing period as compared to normal plants than received optimum irrigation. For successful and sustainable cultivation inside protected structures high temperature, less water, poor water quality due to salinity and soil borne pathogens are main hurdle in cucumber production and grafting onto suitable rootstocks can take care of all these issues very effectively. Effectiveness of grafting in overcoming these constraints has also been successfully demonstrated at farmer's field.

Grafted cucumber performance at famers' field

The performance of grafted cucumber was tested in the polyhouse (1000 m^2 naturally ventilated polyhouse) maintained by Mr. Ramchandra Rathore of village Rohicha Kalan, Jodhpur. The results were very impressive. It was grown during summer by transplanting at end of February and final harvesting was done by first week of June. Around 500 seedlings of grafted cucumber (Y-225 grafted onto NS-55) were transplanted along with normal (non-grafted) cucumber seedlings of Y-225 under close supervision of CAZRI scientists. Total 3000 seedlings (including grafted ones) were planted at spacing of 45cm x 45 cm (RxP) in paired row on raised beds. A randomized planting was followed by placing grafted plants at three different locations (beds) and all plants received similar post-transplant care and other agronomic treatments. Mr. Ramchandra ji being very innovative and skillful farmer was very critical for the comparison of grafted plants with normal (non-grafted) ones. As per his observation and recording, the grafted plants produced on an average 3 to 3.5 kg fruits per plant as compared to normal plants which ranged from 2 to 2.5 kg per plant during summer season. This means the yield increase was around 50% over normal cucumber plants. He observed broader and greener leaves, no issue of damping off, higher flowers and fruit set, less capsule drop (fruit abortion), and lesser foliar disease (e.g., downy mildew) in grafted plants. In contrast, about 5% plants died and had to be replaced due to damping off in the post transplanting period in non-grafted cultivars. According to him, grafted plants use in polyhouse is a viable option for better production and profit by attaining the minimized production risks that each farmer has to suffer. He observed precocity in bearing by 7 to 10 days in grafted plants. Under unprecedented situation that arose due to COVID 19 and subsequent lockdown he was compelled to sell his initial harvested produce locally at lower price until Govt. lifted restriction to farmers to sell produce in main Mandis. Despite these, he was very happy to see the overall impact of grafted plants. He himself shared his success among other farmers through social media (e.g., facebook and whatsup) to educate others about the importance or adoption of latest technology.

Farmer is receiving grafted cucumber seedlings

Farmer is transplanting grafted seedlings

Another interesting and crucial intervention was the use of solar-pump operated rain-harvested water as the farmer did not have ground water source to irrigate the greenhouse crops. More so the ground water in that area is highly saline in nature having EC >15 dS m^{-1}. The water harvesting storage structure of HDPE polyethylene lining open pond having top length × width × height of 75'x45'x10' and bottom length × width of 25'×55' with a full storage capacity of 10 lakh liters was created. The rain water was collected from the roof of polyhouse as well as his adjoining open fields. During rainy season 2019, pond was full and the stored water could sustain nearly two crops one during August to December, 2019, during which water was replenished whenever there was rain, so almost pond was full by end of the rainy season. Another crop was taken during February to May, 2020. He was invariably short of water for nearly 25 days amounting to about 2.0 lakh liters, which he had to manage from outside to successfully manage the second crop. According to our estimates about 40 to 50% water stored in such water harvesting structures is annually lost through evaporation. Our intervention of using evaporation reduction approach has shown potential to provide greater security of water supply in these structures and also in the region. So, the scientists covered the surface by using thermocol (polystyrene) balls of two different sizes (4mm and 8mm). The combination of balls reduced open area from 21.5% (control) to 1.87%.

Water storage pond without thermocol ball

Water storage pond with surface covered with thermocol balls

This helped conserving about 70% of water loss caused by evaporation thus could save ~3 lakh L water in post rain (of 2019) period up to April, 2020. The water quality was also not adversely affected due to use of thermocol balls in pond at farmers' field even after 8 months of its application.

In addition to the experiments and demonstration of grafting technology made at the Institute in two preceding seasons and subsequent field demonstration at farmer's field. The success was shared amongst other growers of adjoining areas who were quite impressed with package of technology resulting in high production (through grafted seedlings) as well as saving of water (through thermocol balls). This has resulted in increasing demands of grafted cucumber seedlings for greenhouse cultivation.

Grafted cucumber

Future thrust:

Considering the demand of fresh vegetables in areas otherwise unfavorable production in open field a complete package need to be adopted beginning from harvesting of rainwater in HDPE lined ponds, its pumping through use of solar pumps coupled with irrigation of grafted vegetables seedlings through drips under naturally ventilated polyhouse. Sustenance of availability of water through checking of evaporative loss of water by use of thermocol bolls ensures critical input for high vegetable production. This technology package curtails the dependency on chemicals (insecticides, pesticides and anti-transpirants) for high production of vegetables even in arid environments through proper selection of scion and rootstocks.

Grafted vs non-grafted cucumber