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A study of potential of grafting technology: Strategy for yield enhancement and disease management in *solanaceous* vegetables

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ABSTRACT

Grafting in vegetables, particularly in Brinjal (Eggplant) and Capsicum (Bell pepper), is a horticultural technique that involves joining the stem or shoot of one plant (the scion) onto the rootstock of another plant. This method offers various benefits, including enhanced disease resistance, improved yield, and better tolerance to environmental stressors. This study was conducted at Krishi Vigyan Kendra (KVK)'s Instructional farm & also on farmers' field in the year 2022-2024 to examine the effect of grafted open field Capsicum (Capsicum annuum) & Brinjal (Solanum melongena) family-Solanaceae for controlling the soil borne disease problem and improving yield and quality of Capsicum & Brinjal. In Brinjal, grafting has shown promising results in combating soil-borne diseases such as Fusarium wilt and Bacterial wilt, which are significant constraints in its cultivation. By grafting onto disease-resistant rootstocks, growers can mitigate these risks and ensure a healthier plant establishment. Additionally, grafting can contribute to increased fruit yield, quality, and uniformity. Similarly, in capsicum cultivation, grafting offers solutions to challenges like soil-borne pathogens and environmental stresses. Grafted plants exhibit improved vigor, better nutrient uptake, and resilience against diseases such as Phytophthora blight and Root-knot nematodes. Results showed the need for systematic identification and evaluation of wild relatives, germplasm collections, and specific rootstock-scion combinations to optimize graft compatibility and performance. However, the study also encountered certain challenges, including the need for precise grafting techniques to ensure high survival rates and compatibility between scion and rootstock. Additionally, variations in environmental conditions and limited availability of suitable disease-resistant rootstocks posed constraints in achieving consistent results across locations.

Keywords: *Grafting technology; Yield Enhancement; Disease Management; Solanaceous Vegetables; Wild rootstocks; Soil borne diseases; disease-resistant rootstocks*

Introduction

In most major cultivated crops, a genetic yield plateau has been reached due to the extensive release of germplasms exhibiting maximum diversity within species. Despite continuous efforts, the development of new, superior cultivars through traditional plant breeding often requires several years to over a decade. In this context, advanced horticultural techniques such as grafting provide a valuable complementary approach to plant breeding in some crop families. Grafting enables the rapid exploitation of existing elite scion varieties by combining them with rootstocks that possess desirable traits such as disease resistance, abiotic stress tolerance, and enhanced nutrient uptake. This strategy significantly boosts productivity and crop resilience without the lengthy breeding cycles typically required to introgress these traits into a single genotype.

Historically, grafting is believed to have originated in China as early as 1560 B.C. and gained prominence during the Roman era. Over time, the technique has been widely adopted in commercial horticulture across Europe, the Middle East, North Africa, Central America, and Asia. Since the 1920s, countries like Japan and Korea have systematically used grafting in vegetable production, particularly to combat persistent soil-borne pathogens such as *Fusarium spp., Ralstonia solanacearum* (causing bacterial wilt), and root-knot nematodes.

From a plant breeding standpoint, grafting represents an integrative approach that bypasses genetic recombination barriers while still offering physiological and functional improvements at the whole-plant level. The process involves the union of two genetically distinct plant parts: a scion (shoot system) and a rootstock (root system), selected for their complementary strengths. This chimeric formation allows for enhanced adaptability to varied growing conditions and rapid phenotypic improvement.

For solanaceous and cucurbit crops, grafting methods such as hole insertion, tongue approach, and splice grafting are most commonly employed, either manually or through semi-automated systems. Inpresent study an investigation is being made on the work carriedout at the *Center of Excellence for Vegetables* under Krishi Vigyan Kendra (KVK) where grafting trials and technology dissemination have been ongoing since 2006, contributing significantly to the development of resilient cultivation models for vegetables like Brinjal and Capsicum.

In conclusion, while traditional plant breeding remains foundational for long-term genetic gain, grafting stands out as a powerful, short-term intervention to enhance crop performance using the existing varietal spectrum. It holds immense potential in overcoming biotic constraints, improving yield stability, and supporting sustainable intensification in vegetable crops.

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Materials and Methods

Present study was carried out by Krishi Vigyan Kendra (KVK) on KVK instructional farm as well as selected farmers' filed as Field Level Demonstrations (FLDs) which were compared farmer's regular plots with following methodologies.

A. Grafting Methodology:

Grafting in vegetable crops now-a-days has emerged as a promising and an alternative tool to the relatively slow conventional breeding methods aimed at increasing tolerance to abiotic stresses and soil pathogens in fruit vegetables such as tomato.

It is seen tomatoes are difficult to grow during rainy season. Flooding, water-logged soils, diseases, and high temperatures can lead to incidence of collar rot disease in tomato. The Main objective of grafting tomato scions onto selected rootstocks of Eggplant & Capsicum is minimizing problems caused by flooding and infections caused by soil-borne diseases which tolerance to collar rot. If the objective is achieved it leads to healthy growth of tomato seedling to plant in field of farmer promising a good harvest. Sometimes, the use of grafted tomato plants can be the difference between harvesting a good crop and harvesting no crop at all.

1. Objectives of grafting in different Vegetables Crops as per issues identified during Praticipatrory Rulal Aprisal study :

a. Tomato - Tolerance to *bacterial wilt* (*Ralstonia solanacearum*), *Fusarium oxysporum*, Nematodes (*Meloidogyne sp*), *Verticillium dahlia*.

b. Eggplant & Capsicum - Tolerance to *bacterial wilt* (*Ralstonia solanacearum*), *Fusarium oxysporum*, *Verticillium alboatrum*, *Nematodes*, Low temperatures, induction of greater vigour.

c. Cucumber - Tolerance to *Fusarium wilt, Phytophthora melonis*, Low temperature.

d. Watermelon - Tolerance to *Fusarium wilt* (*Fusarium oxysporum*), Low temperature, draught tolerance, wilting due to physiological disorder.

e. Muskmelon - Tolerance to *Fusarium wilt* (*Fusarium oxysporum*), low temperature, wilting due to physiological disorder, *Phytophthora* disease.

2. Advantages & solutions identified through grafting

a. Tolerance to soil-borne diseases: Grafting is used to get rid of soil-borne diseases such as *Fusarium wilt* in Cucurbitaceous crops (*e.g.* Cucumber, Melon etc.) and Bacterial wilt in Solanaceous crops (*e.g.* Tomato, Pepper etc.) [1, 2, 3].

b. Tolerance to abiotic stresses: To induce resistance against low and high temperature, grafts were generally used. For the production of fruiting vegetables under the winter greenhouse conditions, tolerance to extreme temperature is crucial [4].

c. Effect on fruit quality: Grafting is an effective approach to improve fruit quality under both optimum growth conditions and salinity. The fruit quality of the shoot, at least partially, depends on the root system [5].

d. Plant vigour promotion: The root systems of selected rootstocks, much larger and more vigorous, can absorb water and nutrients more efficiently as compared to non-grafted plants [6].

e. High yield: When plants are cultivated in problematic soils, grafts have been used to improve yield [7, 8, 9,10.]

B. Comparison:

Data of FLD over Farmers practice were evaluated through calculating formula:

$$\% \text{ YIOFP} = \frac{\text{Average Demonstration Plot Yield} - \text{Farmers average Plot Yield}}{\textit{Farmers average Plot Yield}}\ X100$$

Where, % YIOP= Per cent yield increase over farmers practice

Results

Farmers cultivating Brinjal (Eggplant) and Capsicum (Bell Pepper) are facing a wide range of challenges that significantly affect crop yield, quality, and profitability. One of the major concerns is the persistent attack of various pests and diseases, both above and below the soil surface. Soil-borne pathogens such as *Fusarium* and *Pythium* cause wilting and root decay, leading to severe plant mortality and economic losses. In addition, the crops are highly susceptible to biotic and abiotic stresses, including pest pressure, temperature fluctuations, and water stress, which hinder plant growth and productivity. Nutrient deficiency in the soil further aggravates these problems, often resulting in poor vegetative growth, flower drop, and low-quality produce [12, 13]. Another critical issue is the limited availability of quality planting material. Farmers often rely on locally available or unverified seed sources, which may not be resistant to local diseases or environmental stressors. Moreover, the short crop duration of Brinjal and Capsicum, combined with their low yield potential and inconsistent fruit quality, makes it difficult for growers to achieve sustainable income. On-field diagnosis of crop problems is also inadequate, with many farmers lacking the technical knowledge or resources to identify and manage emerging issues effectively. Furthermore, the absence of proper training in scientific crop production practices and the unavailability of practical reference materials leave a significant knowledge gap. These limitations collectively lead to poor crop performance and substantial economic impact. Therefore, there is an urgent need for technological interventions such as vegetable grafting. This method can provide an effective solution to many of the prevailing issues by enhancing disease resistance, improving nutrient uptake, increasing stress tolerance, and ultimately boosting yield and quality. Grafting technology thus holds great promise for empowering farmers with sustainable and resilient vegetable production systems [14, 15, 16, 17].

Vegetable grafting presents a practical and impactful technological intervention to combat soil-borne diseases in crops like Brinjal and Capsicum. From an extension perspective, the approach begins with creating awareness among farmers about the causes, symptoms, and economic impact of diseases such as *Fusarium wilt* and *Root rot*. Introducing the concept of grafting and its role in using disease-resistant rootstocks helps farmers understand how this technique can protect crop health while preserving desirable scion traits. Guiding farmers in selecting appropriate rootstocks and providing hands-on training in grafting methods like splice or cleft grafting ensures effective adoption. Field demonstrations that compare grafted and non-grafted plants allow farmers to witness the benefits directly. Additionally, economic analyses showcasing improved yields and reduced dependence on chemical inputs make a strong case for adopting grafting as a cost-effective and sustainable disease management strategy.

In this regard KVK Baramati & the *Center of Excellence* for Vegetable conducted the trails on both framers field & KVK instructional farm analyzed the data. Results, obtained from mutilation trails were significantly increased the performance of crop & Yield [Figure No 5 & 6]. Data obtained from case studies on farm trails in Capsicum & Brinjal indicates that increase in production is 26.47 % in Capsicum and 25 % in Brinjal against control & treated Plots. (Table No. 1).

Total yield was found to increase from 17 to 21.5 tones/acre in capsicum and 14.4 to 18 Tones/acre in Brinjal. Notably, the incidence of soil born disease was 0.0 %. In Capsicum net profit was in Indian Rupees *i.e.* Rs. 2,45,000 in treated while in control plots they received Rs 1,34,800. Similarly, in Brinjal net profit was Rs. 1,52,100 in treated while in control plots they received Rs. 95,400. Total expenditure was quite high due to grafting seedlings but crop duration was increased along with fewer requirements of disease & pest controlling inputs. [10, 14,15,16].

Figure 5- Assessment on farmers Field on Vegetables grafting Technology in capsicum
(Source- KVK Pune-I, Farmers field photo)

Figure 6- Assessment on KVK Instructional farm on Vegetables grafting Technology in Brinjal
(Source- KVK Pune- I Instructional Farm photo)

Table 1 Case Studies of the farmers on Vegetables Grafting Technology

Sr. No.	Description / Information	Capsicum		Brinjal	
		Control	Treated	Control	Treated
1.	Total Yield (tons/acre)	17	21.5	14.4	18.00
2.	Soil Born Diseases (%)	30.5 %	0 %	28.5 %	0 %
3.	Total Expenditure (Rs.)	Rs. 1,23,200	Rs. 1,42,000	Rs. 1,06,500	Rs. 1,16,300
4.	Total Income (Rs.)	Rs. 2,58,000	Rs. 3,87,000	Rs. 2,01,900	Rs. 2,78,400
5.	Net Profit (Rs.)	Rs. 1,34,800	Rs. 2,45,000	Rs. 95,400	Rs. 1,52,100
Increase in Crop Production(%)		26.47 %		25 %	

Discussion

From present findings, it can be concluded that the implementation of vegetable grafting technology has yielded highly positive outcomes for farmers cultivating Brinjal and Capsicum. On average, crop production has increased by 25–30 %, while the average net income has risen by 90–95 %, with some farmers even doubling their annual earnings due to improved yield, superior fruit quality, and reduced pest and disease incidences. The crop duration has also been extended by 35–58 days, allowing for a longer harvesting period and higher cumulative returns. According to feedback from contact farmers, better quality and taste of produce have led to a 25–35 % increase in market price [8, 16].

From a plant breeding perspective, the implementation of vegetable grafting technology in Brinjal and Capsicum serves as a powerful complementary strategy to conventional breeding approaches. While traditional breeding methods remain essential for long-term genetic improvement, they often require extended periods to develop new cultivars with combined traits for yield, quality, and resistance. Grafting enables the rapid deployment of elite scion varieties by pairing them with robust rootstocks that confer resistance to soil-borne pathogens, tolerance to abiotic stress, and improved nutrient uptake without the need for lengthy genetic introgression [16,17]. Similar technology was studied for hybridization between *Carthamus Tinctorius* and *Helianthus Annuus* [18]. The technology of grafting, when followed by selection and hybridization, has the potential to be a game changer in plant breeding; however, more research-oriented and extensive work is needed to fully realize it's potential [17, 18].

However, the study also encountered certain challenges, including the requirement for precise grafting techniques to ensure high survival rates and compatibility between the scion and rootstock. Additionally, variations in environmental conditions and the limited availability of suitable disease-resistant rootstocks constrained consistent performance across different locations. To address these challenges, KVK Baramati's Center of Excellence on Vegetables trained technical staff and field workers to perform precise grafting, resulting in higher success and survival rates. Furthermore, the adoption of advanced grafting technologies, such as grafting robots (e.g., AFGR 800s capable of performing approximately 800 grafts per hour), significantly enhanced efficiency and uniformity. Environmental challenges and rootstock scarcity were mitigated through the use of protected cultivation structures and the identification of locally adapted rootstocks via exposure visits, followed by extensive trials and evaluations for refinement.

These findings highlight the necessity for continued research focused on optimizing grafting techniques, rootstock-scion compatibility, and environmental standardization to achieve sustainable and scalable outcomes in vegetable grafting technology.

Conclusion

The current findings demonstrate that grafting significantly enhances productivity, extends crop duration, improves fruit quality, and increases market value, thereby accelerating the realization of genetic gains already present in existing varieties. This approach not only bridges the gap between current genetic potential and field-level performance but also supports sustainable intensification under diverse agro-climatic conditions. However, for widespread adoption and optimized outcomes, plant breeders must focus on identifying and developing rootstock lines with broad-spectrum resistance and high compatibility across a range of commercial scions. Integrating grafting into breeding programs can thus expedite the delivery of improved technologies to farmers, offering a resilient, cost-effective, and scalable solution for modern vegetable cultivation.

Future scope

The future scope of vegetable grafting in Brinjal and Capsicum includes developing region-specific and disease-resistant rootstocks, standardizing grafting techniques, and integrating the technology with protected cultivation systems. The use of grafting robots and automation can enhance precision and large-scale production. Further research on rootstock-scion compatibility, molecular characterization, and long-term performance is essential.

Capacity building through farmer training and policy support will promote commercialization and adoption, making grafting a key tool for sustainable and climate-resilient vegetable production. This technology has the potential to significantly reduce the time, cost, and effort required to develop and introduce new improved varieties.

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Contributions
Dr. Dheeraj Shinde, finalized, methodology and written draft and editing.
Mr. Yashwant Jagdale, performed data collection, and analysis and reviewing.
Both the authors read the manuscript and approved it.

References

1. Khopade R.Y., Sawargaonkar G.L., Rakesh S., Moses S. D., Kishore K. K., Yeshwanth Siddam Y., Singh R. and Jat M. L., Vegetable grafting: a scientific innovation to enhance productivity and profitability of tomato growers under climate change, *Frontiers in Agronomy,* 2025, 1-12. DOI 10.3389/fagro.2025.1514673 https://www.frontiersin.org/journals/agronomy/articles/10.3389/fagro.2025.1514673/full

2. Oda, M., Grafting of vegetables to improve greenhouse production. *Foodand Fertilizer Tech. Center.* 1999, www.agnet.org/library/eb/480/ Accessed Dec. 7, 2007.

3. Juan C. Á. H., Javier Z. C. R., and Cesar Le. A. M., Adaptation of a Grafting Method for *Carica papaya* Based on Seedling Behavior, Hort Science, 2019, 54, 6, 982-987. https://doi.org/10.21273/HORTSCI13800-18

4. Venema J.H., Dijk B.E., Bax J.M., Hasselt P.R. and Elzenga J.T.M., Grafting tomato (*Solanum lycopersicum*) onto the rootstock of a high-altitude accession of *Solanum habrochaites* improves suboptimal-temperature tolerance. *Env. and Exp. Bot.* 2008, 63, 359-367.

5. Flores F.B., Sanchez-Bel P, Estan M.T., Morales B., Campos J.F., Egea M.I., Romojaro F. and Bolarin M.C., The effectiveness of grafting to improve tomato fruit quality. *Sci. Hort.* 2010, 125, 211-217.

6. Salehi-Mohammadi R., Khasi A., Lee S.G., Huh YC, Lee J.M. and Delshad M. Assessing survival and growth performance of Iranian melon to grafting onto Cucurbita rootstocks. *Korean J. of hort. Sci. and Tech.* 2009, 27 (1), 1-6.

7. Kacjan Marsic N., and Oswald J. The influence of grafting on yield of two tomato cultivars grown in a plastic house. *Acta. Agri. Slov.,* 2004, 83 (2), 243-249.

8. Kamal B. E., and Esraa A. A., Huseein Jasim, Technologies of Grafting in Vegetable Crops (Review). *International J. Adv. Engg. & Manage. Res.* 2020, 05, 21-35.

9. Khah, E.M., E. Kakava, A. Mavromatis, D. Chachalis, and C. Goulas, Effect of grafting on growth and yield of Tomato (*Lycopersicon esculentum Mill.*) in greenhouse and open-field. *J. Applied Hort.,* 2006, 8, 3-7.

10. Scheffer, R.P., Grafting experiments with *Fusarium wilt* resistant and susceptible tomato plants. *Phytopathology*, 1957, 47: 30.

11. Marquez, P.A., Sanchez, C.E., Influence of the variety, rootstock and harvest time on the quality and maturity indices in Bell pepper. *Nova Sci.,* 2017, 19, 1–23.

12. Gisbert, C., P., Sanchez-Torres, M.D.Raigón, and F. Nueza, Agronomic performance and fruit quality of pepper grafted plants. *J. Food Agr. Environ.*, 2010, 8, 116-121.

13. Rouphael, J., Schwarz, D., Krumbein, A., Colla, G., Impact of grafting on product quality of fruit vegetables. *Sci. Hortic.*, 2010, 127, 172–179.

14. Davis, A. R., Perkins-Veazie P., Hassell R., Levi A., King S. R., and Zhang X., A Grafting effects on vegetable quality. *Hort Science,* 2008, 43, 1670-1672.

15. Alvarez, H. J. C., Agronomic performance and incidence of diseases in tomato grafted plants (*Solanum lycopersicum L.*). *Acta Agron.*, 2012, 61, 117–125.

16. Louws, J.F., Rivard, L.C., Kubota, C., Grafting fruiting vegetables to manage soil borne pathogens, foliar pathogens, arthropods and weeds. *Sci. Hortic.,* 2010, 127, 125–146.

17. King, S.R., Davis, A.R., Zhang, X., and Crosby, K., Genetics, breeding and selection of rootstock for *Solanaceae* and *Cucurbitaceae. Sci. Hortic.,* 2010, 127, 106–111.

18. Jambhale N. D., An attempt of hybridization between *Carthamus Tinctorius* and *Helianthus Annuus* aided by Grafting. Indian J. Genet., 1994, 54 (3): 235-241.