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Research Article

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Standardization of Grafting in Okra on Tolerant Rootstocks

M. Sathamhussain[1*], V. Swaminathan[2] and R. Arunkumar[3]

[1,2]Department of Horticulture, Agricultural College and Research Institute AC&RI,

[3]Krishi Vigyan Kendra (KVK), Tamil Nadu Agricultural University, Madurai, Tamil Nadu

*Corresponding Author E-mail: satham333@gmail.com

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ABSTRACT

Four exotic rootstock (EC 755655, EC 755656, EC 755657 and EC 755658) were grafted onto Arka Anamika, PA4, Bihar local-3 and Pusa Sawani scions to determine compatibility. Experimental design included 20 days old scion on 20 days old stock, 20 days old scion on 30 days old stock and 30 days old scion on 20 days old stock compared with survival percentage of 16 grafts. Here 16 grafts as treatments. Day's vs. grafts were also compared to further explore grafts options. Average number of days for graft fusion and survival rate measured for each scion/rootstock combination. T_{16} *– EC 755658 + Arka Anamika grafts had the highest grafting success rate rootstock graft union 8.07 days and 89.00 percentages. While all other rootstock genotypes had statistically similar and higher success rate. There was no significant difference in time to graft fusion among any grafted genotypes. High compatibility was observed in 30 days old scion on 20 days old stock suggest it. Potential use as a intraspecific grafting rootstock in area where access to seed in readily available.*

Key words: *Okra, Graft, Genotype, Rootstocks*

INTRODUCTION

Okra, (*Abelmoschus esculentus (L)* Moench.) is a dicotyledonous, belonging to the order Malvales, family Malvaceae and genus *Abelmoschus* (syn. Hibiscus)[22]. It is an important vegetable crop widely grown in the tropical and subtropical regions of the world. Okra is a short duration farmer's friendly crop. It is the source of rotary income for the Indian farmers to meet out the farm expenditure.

Okra is a short duration farmer's friendly crop. It is the source of rotary income for the Indian farmers to meet out the farm expenditure. Okra is affected by biotic and Abiotic stress factors. Among thus YVMV incidence is the most serious disease which requires vigorous spraying of chemicals to control its spread. However, once the plant gets infected the whole plant turn yellow including its fruits which renders the market quality of the produce. Okra yellow vein mosaic virus is a most important viral disease of okra causing majority of yield loss. This *Begomo virus* belongs to family *Gemini viradeae* which covers many of the crop viruses.

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In India, Okra production got major setback due to the severe incidence of yellow vein mosaic disease caused by Gemini virus in India. The existing commercial varieties/ hybrids are vulnerable to yellow vein mosaic disease.

It has been observed that, degree of resistance varies from locality to locality and season to season. The different virus strains and vector strains plays an important role in expression of disease. The available commercial varieties/hybrids are highly susceptible to the YVMV. The infested plants bears whitish yellow fruits, which are not fit for marketing and therefore, farmers suffers from economic losses. Efforts made by number of scientists for identification of resistant sources[14]. However, so far, reported sources do not show consistent performance under different agro climatic conditions. Therefore present investigation was undertaken to identify resistant/tolerant sources against yellow vein mosaic virus in okra.

Intraspecific rootstock/scion grafting of vegetables is common because compatibility is higher than with interspecific grafting[22]. Intraspecific grafting has been shown to increase resistance to various environmental pressures such as flood, drought, cold, heat and pathogen stressors. However, in some cases the transferred tolerance is not strong enough or a certain desired environmental tolerance does not yet exist within the rootstock germplasm of that species[27]. Vegetables with certain environmental susceptibilities could have grafting-compatible relatives within the same genus that possess a natural resistance to a specific stress. Thus, interspecific grafting could be used to broaden rootstock diversity when environmental pressures surpass the advantages that can be provided by intraspecific grafting alone. With the above the possibility conventional breeding methods had been employed for resistant breeding in okra for more than half a decade in India. Effort for development of resistant varieties and maintenance of resistance is still in progress. Hence forth an alternative breeding as management strategy has to be involved to impact the above the problems.

Grafting is a horticultural technology that combines two plants, the scion and the rootsock, to create a plant with desirable features from both parts[23].

While the scion will produce fruit with the desired characteristics, the rootstock will provide resistance against soil-borne diseases and/or nematodes. In the 1920s, Japan and Korea started the commercial use of vegetable grafting to enable watermelon production in areas with high-*Fusarium* wilt pressure[11]. In addition to providing disease and nematode resistance, grafting can improve the plant’s ability to tolerate environmental stress and increase its fruit quality and yield[11].

Vegetable grafting has been successfully performed in crops, such as eggplants, tomatoes, peppers, watermelons, cucumbers, and melons[23].

Vegetable grafting is nowadays extremely popular in some countries and is mainly used to improve plant tolerance to biotic stresses occurring particularly in intensive agro-systems. This technique has also been proposed as a way to enhance vegetable tolerance to abiotic stresses, since under such conditions plant show various disorders negatively affecting yield and quality of produce[12]. Therefore many genotypes have been screened for their resistance in order to individuate rootstocks tolerant to specific or multiple stressing conditions.

The present studies were determining the compatibility between okra genotypes for grafting, and ascertain the effects of different rootstocks**.** In horticulture crops, the qualitative of varieties/ hybrids were by both by sexual and asexual propagation with the above view, with large inter incompatibility hindrance a new innovative was initiated through asexual disease suppression initiative one such programme is vegetable grafting.

MATERIAL AND METHODS

The experiment was conducted at the college Orchard, Agricultural College and Research

Institute, Madurai, Tamil Nadu Agricultural University, Coimbatore. Geographically area located at 9º 54' N latitude and 78º 54' E longitude at an altitude of 147 m above mean sea level. The experiment was conducted in FCRD with two replications. A total of sixteen grafts were maintained per treatment per replication. The plants were grafted by cleft grafting method which is detailed below. In previous studies at Agricultural College and Research Institute, Madurai (unpublished data). During 2015 collected four wild genotypes *viz.,*, EC75565, EC755656, EC7556557 EC755658 obtained from AVRDC, Taiwan were identified for their YVMV immunity under natural conditions in various seasons and Arka Anamika, Pusa sawani, PA-4 and local-3 were utilized for this investigation. It was revealed that the germination of these accessions was very slow and also exhibited post dormancy in growth. The seedlings attained graftable size only after 65 days sowing. We were 210 days cuttings collected from mother plant. EC755655, EC755656, EC7556557 and EC755658 were found to be immune to YVMV under natural conditions. The presence of multiple shoot formation in wild genotypes indicates the possibility of propagation through cuttings and parents can be maintained as clone.

RESULTS

The genotypes/varieties were also grafted with okra Exotic accessions by cleft grafting method and observations were recorded for days taken for graft union, grafting success number of leaves and stem girth of grafts. Mean data of treatments were recorded during the course of investigation and subjected to statistical analysis.

The mean data for number of days taken for union of grafts ranged between 8.07 to 12.46 days. Among the 16 graft combinations earlier graft union was observed in T_{16} (EC 755658 + Arka Anamika) 8.07 and delayed union in T_7 (EC 755656+ PA-4) 12.46 days. Seven genotypes exceeded the grand mean of 9.63.

The observation on, age of scion, stock and type of grafting tube on success percent of grafts are as follows. The observation of 20 days old scion grafted on 20days old rootstock reveal that the treatment at T_{16} (EC 755658 + Arka Anamika) whole tube had higher compatibility rate of 86.69 per cent than the split opened tube i.e. 85.65 while lower compatibility ratio was observed T_{10} (EC 755657 + Local-3) i.e. 53.12 and 49.25 per cent with whole tube and split open tube respectively. Irrespective of the treatments success per cent was higher in tube 73.21 and lower in split open tube i.e. 71.13.

The observation on 20 days old scion grafted on 30 days old stock reveal that the treatment T_{16} (EC 755658 + Arka Anamika) recorded higher compatibility in both tube 92.12 per cent and split open tube 89.65 per cent. The mean compatibility success per cent of the tube and split open tube ranged between 61.23 to 92.12 per cent.

The observation on 30 days old scion grafted over 20 days old rootstock reveal that the treatment T_{16} recorded higher compatibility per cent of 88.00 per cent in tube and 89.00 in split opened tube. The lower compatibility was observed in T_6 (EC 755656 + Local-3) i.e. in tube it was 45.12 per cent and in split opened tube it was 56.21 per cent.

Irrespective of the age of the scion the treatment T_{16} (EC 755658 + Arka Anamika) recorded higher compatibility 89.55 per cent and it was significantly different from other treatments.

The grafts girth of the sixteen graft combinations at the time of planting ranged from 1.21 to 2.20. Among the sixteen graft combinations T_{16} (EC 755658 + Arka Anamika) recorded thicker graft girth 2.20 and it was significantly different from other treatments. Thinner stem girth was recorded in T_6 (EC 755656 + Local-3) 1.21. Six treatments exceeded the grand mean 1.62.

The number of leaves of the sixteen graft combinations at the time of planting ranged from 3.10 to 4.40. Among the sixteen graft combinations the T_{16} (EC 755658 + Arka Anamika) recorded the higher number of leaves (4.40) and it was significantly different from other treatments. The lower number of leaves was recorded T_6 (EC 755656) with (3.10). Seven grafts exceeded the grand mean of 3.45.

DISCUSSION

Graftage is a process that involves the joining together of plant parts by means of tissue regeneration in which the resulting combination of parts achieves physical union and grows as a single plant[9]. Grafting requires the junction of scion (the cultural variety) onto a rootstock generally a wild species expressing higher levels of resistance against soil borne pathogens and/or more tolerance to particular soil and environmental conditions.

The primary purpose of grafting vegetable worldwide has been aimed to provide resistance to soil borne diseases. Alternatively, grafting onto resistant rootstock might control the soil borne diseases[2].Wild rootstock expressed higher level of resistance against soil borne pathogens and or more tolerance to particular soil and environmental conditions (19-3-8). It was presumed as the primary method of avoidance when the rootstock was resistant to the pathogen[10]. It has been shown that resistant rootstocks physically limited the movement of organisms from soil to scion[7]. It was shown that when resistant rootstock was used as the scion to graft onto susceptible rootstock, the resistant plant succumbed to the disease[16].It would appear in most cases of resistance that substances translocated from the rootstock to the scion were not a factor, although translocation was known to occur[5].

The exotic collections viz., EC 755655, EC 755656, EC 755657, and EC 755658 grafted with four okra accessions *viz*., Pusa Sawani, Local-3, Pusa A-4 and Arka Anamika were subjected to assess their grafting success, days for graft union and girth of grafts.

Although a rootstock material has good sprouting trait, it should produce sufficient “graft-take” when grafted with a scion. The grafting success depends on many factors such as size of scion and rootstock, culture condition, grafting method, tissue and structure differences, physiological and biochemical characteristics, growing stage of rootstock and scion, phytohormone the environment and all these play the major role in success of grafting[4].The graft incompatibility could occur both at early stage because vascular connection could not form properly after grafting. Grafting incompatibility as reviewed by was different from graft failure[1], which often resulted from environmental factors or lack of skill of the grafter. When grafting conditions have been successfully ensured, graft incompatibility could be attributed to other factors such as failure of the grafted plants to grow or premature death of either rootstock or scion after grafting.

In the present investigation, cleft grafting was done during the months of December to January (2015-2016) with four exotic collection species and four okra types and the grafts were placed inside the shade net to ensure the cut surface is not dried.

The overall grafting success among the genotype revealed that the grafting success was more with EC 755658 as compared to other species. This is presumed from the fact that the species would have better adaptability to the prevailing climate led to more success and the method followed was cleft grafting which suits more for this species. Similar findings were reported in tomato[17].

In the present study, grafting was done only during December-January months and high humidity normally prevailed during the subsequent months. The prevalence of humidity would have favoured better success in graft, which could be related to moisture relationship of exposed callus layers of both scion and rootstock forming bridge between them. Similar results were well documented in other crops like cashew[24] and moringa[15].

Considering the Okra accessions, the grafting with genotypes EC 755658 was found to record higher success rate, which is in agreement with the reports[20]. The present study, the highest grafting success was noticed in the graftage 20 days scion grafted on 30 days stock reveal that the treatment EC 755658 recorded higher compatibility in both tube 92.12 per cent and split open tube 89.65 per cent. Even though, grafting was successful the grafts with EC 755658 combination showed incompatibility by way of sudden wilting and reduction in initial plant population.

Similarly, among the Okra accessions as scion, Pusa A-4 showed relatively higher grafting success compared to other scion types. This indicated the influence of scion materials on grafting success with a rootstock[26] also obtained variations between scion cultivars on grafting success. The higher grafting success with COBH 2 on *S. torvum* combination might be attributed to relatively closer affinity between the scion and stock.

Further, the lower survival rate of grafts depends on the species and cultivar incompatibility, and different type's tube which was confirmed by the mortality rate indicated that a detailed study on incompatibility is very much essential. The studies on graft incompatibility in okra genotypes revealed that most of the okra scions could be grafted on to several rootstock species, which however could be changed by the grafting methods and growing environments. This confirmed the finding[17].

Physiological incompatibility has also been reported which occurred as a result of lack of cellular recognition, wounding responses, presence of growth regulators and incompatibility toxins. In the present study, the graft combinations with EC 755658 had higher survival rate of 92.12 per cent[6] observed similar findings that grafting of eggplant on wild *Solanum* species had high affinity with survival rate of more than 95 per cent.

The number of days taken for graft union is an important trait, which indirectly increases the yield of crop plants. As soon as the union of graft is completed, it can be transplanted and allowed to grow to show its performance. The present study, grafts with EC 755658 rootstock took the least number of days for union. Among them, the graft combination EC 755658 + Arka Anamika registered the least number of days for graft union.

The highest number of days for graft union was noticed in the grafts with EC 755656 as rootstock, which showed that the union depended on the species used and the rootstock / scion interactions. The days to graft union were less in the combination of EC 755658 +Arka Anamika, which might be due to the quicker / faster intimate contact of stock / scion, where the cambial region, capable of meristamatic activity by producing parenchymatic cells which soon intermingle and interlock, producing the callus tissues that fill the space between the two components connecting the scion and rootstock. This mechanism was slow in the graft partner EC 755656 + Pusa A-4 with more number of days for graft union in this study. This finding is in line with who concluded that efficient callus formation was important for the formation of quicker graft union and survival of the scion[18]. It was suggested that ability to form callus was positively correlated with grafting success and the seedlings with thicker leaves were found better for grafting because it could maintain higher moisture content facilitating faster graft union.

Graft girth of the grafts has indirect effect on plant stature and yield. The higher graft girth allows the plants to grow vigorously due to heavy foliage and more branches[6]. In the present investigation, all the graft combinations were observed for stem girth of grafts at the time planting. Among the different graft combinations, the grafts with EC 755658 + Arka Anamika as rootstock registered the thicker girth at the time planting.

The number of leaves per plant of the grafts has indirect effect on plant stature and yield. The higher number allows the plants to grow vigorously due to heavy foliage and more branches[6]. In the present investigation, all the graft combinations were observed for number of leaves of grafts at the time planting. Among the different graft combinations, the grafts with EC 755658 as rootstock registered the number of leaves at the time planting. This finding is similar to who reported that grafting cultivars with *S. torvum* rootstock had higher number of leaves[25].

Table 1: Mean age of scion and rootstock for graft compatibility (%)

Treatments	20 old days scion on 20 days old stock		20 days old scion on 30 days old stock		30 days old scion on 20 days old stock		A X B X C
	T	S	T	S	T	S	Mean
T1	79.45	76.32	86.35	72.12	78.12	69.45	76.97
T2	56.54	56.21	69.45	59.65	61.24	56.40	58.76
T3	75.64	69.23	78.56	76.85	73.65	69.56	73.92
T4	77.56	73.45	88.65	76.14	76.15	71.25	77.20
T5	77.65	72.36	84.12	81.23	78.45	73.21	77.84
T6	59.45	61.23	65.35	61.23	45.12	56.21	58.10
T7	77.65	72.65	79.65	73.65	59.54	69.54	72.11
T8	83.12	82.31	85.65	80.12	76.58	73.54	80.22
T9	77.65	73.21	78.99	80.12	79.45	73.12	77.09
T10	53.12	49.25	69.58	79.48	59.56	71.21	64.86
T11	79.50	85.00	84.12	82.83	84.00	82.00	82.91
T12	82.45	83.25	84.56	80.12	82.69	81.25	82.39
T13	79.65	82.45	78.65	85.64	73.45	79.65	79.86
T14	56.23	59.63	66.25	69.65	65.32	67.23	64.05
T15	65.21	62.35	79.54	72.12	68.54	65.25	68.84
T16	86.69	85.65	92.12	89.65	88.00	89.00	89.55
Mean	**73.21**	**71.13**	**79.47**	**76.29**	**71.87**	**71.74**	**74.04**
	SEd			**CD (P0.05)**			
A	**0.460**			**0.690**			
B	**0.196**			**0.391**			
C	**0.146**			**0.286**			
A X B X C	**1.61**			**3.18**			

T* - Tube S* - Split open tube

Table 2: Mean performance stocks on days taken for graft union

Treatments	Days taken for graft union
T_1- EC755655 + Pusa Sawani	8.28
T_2- EC755655 + Local-3	9.47
T_3- EC755655 + PA-4	11.11
T_4- EC755655 + Arka Anamika	8.40
T_5- EC755656 + Pusa Sawani	8.58
T_6- EC755656 + Local-3	9.27
T_7- EC755656 + PA-4	12.46
T_8- EC755656 + Arka Anamika	9.75
T_9- EC755657 + Pusa Sawani	10.73
T_{10}- EC755657 + Local-3	9.31
T_{11}- EC755657+ PA-4	11.12
T_{12}- EC755657 + Arka Anamika	9.43
T_{13}- EC755658 + Pusa Sawani	10.34
T_{14}- EC755658 + Local-3	12.39
T_{15}- EC755658 + PA-4	8.16
T_{16}- EC755658 + Arka Anamika	8.07
Grand mean	**9.63**
SEd	**0.77**
CD (p=0.05)	**1.65**

Table 3: Mean performances of grafts stem girth and number of leaves at the time transplanting

Treatments	Grafts girth (cm)	Number of leaves per grafted plants (nos.)
T_1- EC755655 + Pusa Sawani	1.75	3.25
T_2- EC755655 + Local-3	1.72	3.45
T_3- EC755655 + PA-4	1.55	3.32
T_4- EC755655 + Arka Anamika	1.85	3.69
T_5- EC755656 + Pusa Sawani	1.56	3.10
T_6- EC755656 + Local-3	1.21	3.36
T_7- EC755656 + PA-4	1.57	3.85
T_8- EC755656 + Arka Anamika	1.56	3.45
T_9- EC755657 + Pusa Sawani	1.51	3.39
T_{10}- EC755657 + Local-3	1.52	3.25
T_{11}- EC755657+ PA-4	1.64	3.45
T_{12}- EC755657 + Arka Anamika	1.74	3.15
T_{13}- EC755658 + Pusa Sawani	1.47	3.55
T_{14}- EC755658 + Local-3	1.55	3.74
T_{15}- EC755658 + PA-4	1.58	3.30
T_{16}- EC755658 + Arka Anamika	2.20	4.40
Range	**1.21-2.20**	**3.10-4.40**
Mean	**1.62**	**3.45**
SEd	**0.09**	**0.25**
CD (P=0.05)	**0.19**	**0.54**

CONCLUSION

Evaluation of Okra varieties are done not only for fruit yield but also for the quality parameters and for resistance to biotic factors like yellow vein mosaic virus incidence and pod borer. The current trend is being organic and the major bottleneck is the resistance breakdown in resistant cultivars. Conventional breeding methods like Line x Tester, mutation breeding are being employed in development of improved cultivars in the existing population. However, none of the varieties are stable for their resistance for a longer period. Frequent breakdown of resistance may be due to genetic factor of the genotype or development of new strains for disease propagation is of major concern in okra. Hence, alternate management methods are prerequisite to overcome the present situation. This technique has also been proposed as a way to enhance vegetable tolerance to abiotic stresses, since under such conditions plant show various disorders negatively affecting yield and quality of produce.

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REFERENCES

1. Andrews, P. K. and C. S. Marquez. Graft incompatibility. *Hort. Rev.,* **15:** 183-232 (1993).
2. Balaz, F. Possibilities of grafting certain watermelon cultivars on *Legenaria vulgaria* to prevent *Fusarium* wilt**.** *Hort. Abst.,* **60 (5):** 5-8 **(**1982).

3. Cohen, R., Y. Burger, C. Horev, A. Koren and M. Edelstein. Introducing grafted cucurbits to modern agriculture: The Israeli experience. *Plant Dis.,* **91:** 916-923 (2007).
4. Davis, A.R., P. Perkins-Veazie, R. Hassell, S.R. King and Z. Xingping. Grafting effects on vegetable quality. *Hort. Sci.,* **43 (6):** 1679-1672 (2008).
5. Edelstein, M., Y. Tadmor, F. Abo-Moch , Z. Karchi and F. Mansour. The potential of *Lagenaria* rootstocks to confer resistance to the carmine spider mite, *Tetranychus cinnalarinus* (Acari: Tetranychidae) in cucurbitaceae. *Bull. Entomol. Res.,* **90:** 113-117 (2000).
6. Feng, D.X., B.D. Li and Y. Wang. Effects of grafting on the resistance to verticillium wilt and on the biological characteristics of eggplant. *China Veg.,* **4:** 13-15 (2000).
7. Grimault, V., B. Gelie, M. Lemattre, P. Prior and J. Schmit.Comparative histology of resistant and susceptible tomato cultivars infected by *Pseudomonas solanacearum*. *Physiol. Mol. Plant Path.,* **44:** 105–123.(1994).
8. Gullino, M.L., A. Camponogra, G. Gasparrini, V. Rizzo, C. Clini and A. Garibaldi. Replacing methyl bromide for soil disinfection the Italian experience and the implication for other countries. *Plant Dis.,* **87:** 1012-1021 (2003).
9. Janick, J. Horticultural Science. 4th ed.p. W.H. Freeman and Co., New York. 339-346 (1986).
10. King, S.R., A.R. Davis, W. Liu and A. Levi. Grafting for disease resistance. *Hort. Sci.,* **43(6):** 1673-1677 (2008).
11. Kubota, C., M. McClure, N. Kokalis-Burelle, M. Bausher, and E. Rosskopf., Vegetable grafting: History, use, and current technology status in North America. HortScience 43:1664–1669 (2008).
12. Lee, J.M., C. Kubota, S.J. Tsao, Z. Bie, P. Hoyos Echevarria, L. Morra, and M. Oda. Current status of vegetable grafting:Diffusion, grafting techniques, automation. *Sci. Hort.* **127:** 93–105 (2010).
13. Miller SA, Karim AN, Razaul M, Baltazar AM and Rajotte EG, *et al*. Developing IPM packages in Asia. Globalizing Integrated Pest Management– A Participatory Research Process. *Hort Science* **43:** 2104-2111 (2005).
14. Prabhu T, Warde SD and Ghante PH. Resistant to okra yellow vein mosaic virus in Maharashtra. *Veg. Sci.* **34 (2):** 119-122 (2007).
15. Punithaveni, V. Studies on propagation techniques in moringa (*Moringa oleifera* L.) types. *M.Sc. (Hort.) thesis,* Tamil Nadu Agricultural University, Coimbatore (2010).
16. Obrero, F.P., M. Aragaki and E.E.Trujillo., Tomato bacterial wilt inoculation of susceptible scions grafted to resistant rootstock. *Plant Dis. Reporter,* **55:** 521-522 (1971).
17. Oda, M, S. Akazawa, T. Mori and M. Sei., Growth and yield of tomato plants grafted using a grafting instrument. Bull. National Res. Inst. *Veg. Ornam. Plants. Tea A,* **10:** 33-38 **(**1995).
18. Ogata, T., Expression and mechanism of graft incompatibility. In. K. Kawase (ed.). Chracteristsics and application of rootstocks in fruit trees, Nobunkyo. P. **38-40. (**1995).
19. Ozbay, N. and S.E. Newman., Fusarium crown and root rot of tomato and control methods. *J. Plant Path.,* **3 (1):** 9-18 (2004).
20. Rahman, M.A., M.A. Rashid, M.M. Hossain, M.A. Salam and A.S.M.H. Masum., Grafting compatibility of cultivated eggplant varieties with wild *Solanum* species (2002).
21. Rivard, C.L. and F.J. Louws., Grafting to manage soil borne diseases in heirloom tomato production. *Hort. Sci.,* **43(7):** 2107-2111 (2008).
22. Schippers RR African Indigenous Vegetables. An overview of the cultivated Species. Chatham, UK: Natural Resources Institute/ACP-EU Technical centre for Agricultural and rural Cooperation. (2000).

23. Simonne, D.D. Treadwell, M. Davis and J.M. White., Effect of water pH on yield and nutritional status of greenhouse cucumber grown in recirculating hydroponics. J. Plant Nutrition 31:2018-2030 (2008).
24. Swamy, K.R.M., R. Singh and E. Mohan., Correlation of success in softwood grafting with weather parameters. *South Indian Hort.*, **38 (6):** 297-300 (1990).
25. Tai, S. F., H. Y. Huang, Y. Sung, M. J. Tseng and W. N. Chang., Growth dynamic of grafted tomato plants using different eggplant rootstocks. *Res. Bull. KDARES,* **16 (3):** 1-7 (2004).
26. Vanjana, T., V.P. Neema, R. Rajesh and K.P. Mammootty., Graft recovery at *piper nigrum L*. runner shoots on *Piper colubrinum L*. rootstocks as influenced by varieties and month of grafting. *J. Trop. Agric.*, **45(1-2):** 61-62 (2007).
27. Zijlstra S and Nijs APM Effects of root systems of tomato genotypes on growth and earliness, studied in grafting experiments at low temperature. Euphytica 36: 693-700 (1987).