EVALUATION OF ROOTSTOCK AND SCION IN BRINJAL (*Solanum melongena* L.) FOR GROWTH, YIELD AND FRUIT QUALITY

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BY

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B. Sc. (Hort.)

THESIS SUBMITTED TO Dr.Y.S.R. HORTICULTURAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

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JULY, 2017

DECLARATION

I**, Ms. Tejashwini Rathod.,** hereby declare that the thesis entitled **"EVALUATION OF ROOTSTOCK AND SCION IN BRINJAL (S*olanum melongena* L.) FOR GROWTH, YIELD AND FRUIT QUALITY"** submitted to Dr. Y.S.R. Horticultural University, Venkataramannagudem, for the degree of Master of Science in Horticulture (Vegetable Science) is the result of original research work done by me. I declare that no material contained in the thesis has been published earlier in any manner.

Place: Venkataramannagudem. **Name :** Tejashwini Rathod

Date: **ID. No. :** VHM/15-33

CERTIFICATE

Ms. TEJASHWINI RATHOD has satisfactorily prosecuted the course of research and the thesis entitled **"EVALUATION OF ROOTSTOCK AND SCION IN BRINJAL (*Solanum melongena* L.) FOR GROWTH, YIELD AND FRUIT QUALITY"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date: **(S. SHANKAR HEBBAR)**

Place: Venkataramannagudem. MAJOR ADVISOR

CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF ROOTSTOCK AND SCION IN BRINJAL (*Solanum melongena* L.) FOR GROWTH, YIELD AND FRUIT QUALITY"** submitted in partial fulfillment of the requirements for the degree of Master of Science in Horticulture (Vegetable Science) of Dr. Y.S.R. Horticultural University, Venkataramannagudem, is a record of the bona-fide research work carried out by **Ms. TEJASHWINI RATHOD** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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VR GUDEM

JULY 2017 **(TEJASHWINI RATHOD)**

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LIST OF ABBREVIATION

$	:	Dollar
%	:	Percentage
/	:	Per
µg	:	Microgram
µl	:	Microlitre
^{O}C	:	Degree Celsius
ANOVA	:	Analysis of Varience
Ca	:	Calcium
CD	:	Critical Difference
cm	:	Centimetre
cm^2	:	Centimetre square
cm^3	:	Centimetre cube
Cu	:	Copper
CV	:	Co-efficient of Varience
cv.	:	Cultivar
d	:	Days
DAT	:	Days After Transplanting
DTPA	:	Diethylene Triamine Penta Acetic acid
dS/m^2	:	Deci siemens per metre square
EC	:	Electrical Conductance
et al.	:	Co-workers
etc	:	So on
Fe	:	Iron
g	:	Grams
g/p	:	Grams per plant
i.e.,	:	That is
INR	:	Indian Rupees
IU	:	International Unit
K	:	Potassium
Kg	:	Kilograms
kg/m^2	:	Kilograms per metre square
kg/ha	:	Kilograms per hectare
Km/h	:	Kilometres per hour
L	:	Litres
LAI	:	Leaf Area Index
M	:	Molar
m	:	Metres
mg	:	Milligram
Mg	:	Magnesium
ml	:	Millilitre
mm	:	Millimetres
Mn	:	Manganese
MT	:	Metric tonnes

MSL	:	Mean Sea Level
N	:	Nitrogen
No.	:	Numbers
no. of	:	Number of
P	:	Phosphorous
pH	:	Potenz (-log $[H^+]$)
RH	:	Relative Humidity
RKN	:	Root Knot Nematode
SEm	:	Standard Error of Mean
T	:	Temperature
Via	:	Through
viz	:	Namely
Zn	:	Zinc

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ABSTRACT

An investigation was conducted on grafting in brinjal during *rabi* season of 2016-17 with the major objectives of monitoring the changes induced by different rootstock-scion combinations in terms of plant growth and fruit quality of brinjal at ICAR-IIHR.

The experiment was laid out in randomized block design with three brinjal hybrids Mahyco-9, Lalitha and Sharpova grafted onto *Solanum torvum* Swartz and non grafted were used as control. The effect of rootstock on the agronomic characteristics of the three brinjal cultivars, allow a series of considerations on the feasibility of this technique in the cultivars tested. The grafted plants produced maximum yield than non-grafted ones when grown for the potential economic value. Graft success was recorded about 85 to 87% in all the rootstocks and scion combinations, on an average it was reported 85%. Overall vegetative growth was highest in grafted plants. Maximum plant height was recorded in grafted Mahyco-9. The highest number of branches was recorded in grafted hybrid Lalitha. Number of leaves was recorded maximum in grafted Lalitha. Leaf, stem, root dry weight and leaf area index were recorded maximum in Mahyco-9 and the highest fruit dry weight was recorded in grafted Sharpova. A positive effect of grafting was recorded when *Solanum torvum* Swartz was used as rootstock. Flowering was early in grafted Mahyco-9 followed by grafted Lalitha. Days taken for 50% and 100% flowering in self rooted and grafted Lalitha took minimum number of days. Fruit set, number of fruits, yield per plant was recorded maximum in grafted Mahyco-9. The highest fruit length was recorded in grafted Mahyco-9 whereas, fruit diameter and volume was recorded highest in grafted Sharpova. Grafted Mahyco-9 performed best in flowering and yield characters when *Solanum torvum* Swartz was used as rootstock.

Chapter I

Introduction

Chapter I

INTRODUCTION

Brinjal (*Solanum melongena* L.) is also known as aubergine and eggplant. It is one of the widely distributed and cultivated species of *Solanaceae* family. It is believed to have originated in Indo-Burma region. Brinjal display a wide range of fruit shapes and colours, ranging from oval or egg shaped to long club-shaped and from white, yellow, green through degrees of purple pigmentation to almost black.

In addition to India, other major brinjal producing countries are China, Turkey, Japan, Egypt, Italy, Indonesia, Iraq, Syria, Spain and Phillipines. India contributes for an area of 6.8 million ha and production of 1270.6 MT to the global production and ranks second to China. Brinjal covers 8.14% of total vegetable area and produces 9% of total vegetable production in India. In India it is well distributed in Orissa, Bihar, Karnataka, West Bengal, Andra Pradesh, Maharashtra and Uttar Pradesh (NHB, 2016).

Grafting is an art and technique in which two living parts of different plants are joined together in a manner that they would unite together and subsequently grow into a composite plant. The grafting of vegetables is a technical procedure that is carried out manually or with the aid of special equipment (simple machines or robots). The following steps are involved (a) Selection of the rootstock and scion (b) Application of the selected grafting method (c) Healing of the wounded cut surfaces (d) Evaluation of the grafting success (e) Acclimatization (hardening) of the grafted seedling under suitable environmental conditions so as to become strong enough to withstand the shock of transplantation, *e.g.*, to the field or greenhouse.

The use of *Solanum torvum* Swartz as rootstock was reported to confer resistance to *Verticillium* wilt, *Fusarium* wilt, bacterial wilt and root knot nematode (King *et al*., 2008; Sebahattin *et al.,* 2009). Grafting is highly effective in ameliorating crop losses caused by adverse environmental conditions (Schwarz *et al.,* 2010).

Nowadays grafting is regarded as a rapid additive tool to the relatively slow breeding methodology which aimed at increasing environmental stress tolerance of fruit vegetables in short duration. Cultivation of vegetable grafts permits not only pest resistance and high yields but also ameliorates crop losses caused by adverse environmental conditions. It has also been observed that grafting brinjal on wild species affects various physiological processes of a plant which in turn provide better opportunity to survive well and perform better in adverse climatic conditions. The use of vegetable grafts will be most successful when complemented with sustainable farming system practices (Kubota, 2008). Grafting imprints resistance to pathogenic agents and soil pests, tolerance to abiotic stress factors, improves water and nutrient absorption and increases the graft vigor (King *et al*., 2010; Lee, 1994).

Grafting of eggplant cultivars on perennial and wild Solanaceous species was proved to increase yield and availability period of the fruits (Gisbert *et al.,* 2011; Lee, 1994).

Thus, owing to the importance of brinjal cultivation in India and the beneficial effects incurred by grafting over wild rootstock, the present investigation was planned for "Evaluation of rootstock and scion in Brinjal (*Solanum melongena* L.) for growth, yield and fruit quality" with the following objectives:

- To study the effect of grafting on the production potential *viz*, growth, yield and quality
- To study the economics of grafting
- To study the rootstock-scion interaction

Chapter II

Review of Literature

REVIEW OF LITERATURE

In this chapter, an attempt has been made to survey the literature regarding studies on "Evaluation of rootstock and scion in brinjal (*Solanum melongena* L.) and other related crops for growth, yield and fruit quality".

2.1 ROOTSTOCK AND SCION PARAMETERS

2.1.1 Days taken for Germination

Johnson (1985) reported that the brinjal scion took 6-8 days for germination. Further Bletsos *et al*. (2003) reported that *Solanum torvum* Swartz took 20 days for germination. Similarly, Gousset *et al*. (2005) reported that *Solanum torvum* Swartz took two weeks for germination.

Gisbert *et al*. (2011) concluded that germination of cv. Black Beauty seeds of brinjal was observed in 3 to 4 days after sowing.

2.1.2 Days taken to reach grafting stage

Oda *et al.* 2005 reported that brinjal scion was ready for grafting at 3-4 unfolded true leaf stage (21-28 days). Further, they also reported that *Solanum torvum* Swartz rootstock was ready for grafting at 3-4 true leaf stage (55-60 days).

Gisbert *et al*. (2011) reported that brinjal scion at 2-3 true leaf stage (25-35 days) was ready for grafting whereas, rootstock *Solanum torvum* Swartz rootstocks plants having 3-4 unfolded true leaves (40-50 d old) were ready for grafting.

2.2 OBSERVATION ON GRAFTED PLANT

2.2.1 Days and condition taken for graft healing and hardening

De Ruiter (2006) suggested that the optimal temperature range for healing of grafted tomato is 21 to 22°C with a maximum temperature range of 28 to 29°C.

Oda (2007) suggested that a temperature range of 28 to 30°C is optimum is to heal the grafts. Further, healing environment should be maintained between 85% and 100% RH for both tomato and cucurbit plants (Davis *et al*., 2008; Rivard and Louws, 2008).

Onduso (2014) reported that in tomato 80% of relative humidity ensured high graft success and took five days to heal the grafts.

Healing is the most critical process of grafted seedling production. A temperature range of 25-30 ^{o}C, relative humidity of 85-90% and low light intensity are required for healing (Pardeep *et al*., 2015)

2.2.2 Graft success (%)

Bletsos *et al*. (2003) reported that the percentage of graft success of cv. Tsakoniki on *Solanum torvum* was 84.4% and 80.8% in 1998 and 1999 respectively, while on *S. sisymbrifolium* graft success was 77.2% and 74.8%.

Yetisir and Sari (2003) showed that survival rate was minimum (65%) in *Cucurbita* type rootstocks and maximum (95%) in *Lagenaria* type rootstocks.

Nina and Joze (2004) reported that the survival rate of tomato transplants grafted onto 'Beaufort' and 'PG 3' rootstocks using the cleft grafting method was 100% with cv. 'Monroe' and 92 to 93% with cv. 'Belle' whereas, with the tube grafting method the survival rate was 79 to 92% with cv. 'Monroe' and 88% with cv. 'Belle'.

Gisbert *et al*. (2011) revealed that 98%, 100%, 90%, 100% and 100% graft success were recorded in self grafted cv. Black Beauty, Black Beauty on *S. torvum*, Black Beauty on *S. macrocarpum*, Black Beauty on *Solanum incanum* × *S. melongena* and Black Beauty on *S. melongena* × *S. aethiopicum* respectively.

Mohamed *et al*. (2012) reported that survival percent of grafts when cv. Aswan F_1 grafted on 6001 F_1, Strontosa F_1 and Tetsukabuto F_1 was 100%, 100% and 83.3% in 2010 and 100% in all combination in 2011.

Hsiu-fung and Yung- fu (2013) reported that cucumber cv. ‘Tainan No. 1’ was grafted by approach grafting onto two different rootstocks. Survival rates when grafted onto *Cucumis* and *Cucurbita* were 80% and 78%, respectively.

Bizhen *et al*. (2014) reported that graft survival exceeded 92% in all eighteen tomato commercial rootstocks and five scion varieties with a study wide average of 97%.

2.2.3 Cost of graft plant production.

Barrett *et al*. (2012) investigated cost benefit analysis using grafted transplants for root knot nematode management in organic heirloom tomato

production and revealed that when heirloom tomato cultivar Brandywine was grafted onto the rootstock ‘Multifort’ the cost of rootstock seeds accounted for 36% ($0.28/plant) (18.05 INR) of the total cost of the grafted transplants and 46% of the cost difference between grafted and non grafted plants.

Desire *et al.* (2013) concluded that the estimated costs of grafted and non grafted transplants were $0.67 (43.19 INR) and $0.15 (9.67 INR) per plant, respectively, resulting in an additional cost of $3020.16 per acre for using grafted transplants as compared to non grafted plants.

2.3 GROWTH OBSERVATIONS AND YIELD PARAMETERS

2.3.1 Plant height (cm)

Bletsos *et al.* (2003) reported that seedlings of eggplant cv. Tsakoniki when grafted on *Solanum torvum* Swartz recorded a mean plant height of 124 cm and 116 cm during 1998 and 1999 respectively.

Khah (2005) concluded that height of plant was the highest (90.9 cm) in Rima grafted tomato rootstocks Primavera whereas, the lowest plant height was recorded (72.6) in control.

Davis *et al*. (2006) reported that height of watermelon plant cv. SF800 when grafted on gourd was 430.8 cm, on squash was 418.5 cm and under control 430.8 cm.

Khah *et al*. (2006) reported that in tomato cv. Big Red grafted onto rootstock Primavera recorded the highest plant height of 48.44 cm, 91.88 cm and 106.38 cm at 30, 60 and 96 DAT whereas, the lowest plant height (38.00 cm) was recorded in self grafted cv. Big Red at 30 DAT and in control (80.31 cm and 94.19 cm) at 60 DAT and 96 DAT respectively in greenhouse. Further, in open field cv. Big Red grafted onto rootstock Heman recorded the highest plant height of 53.75 cm, 67.7 cm and 75.13 cm whereas, the lowest plant height was recorded on rootstock Primavera 46.44 cm, 62.50 cm and 69.13 cm at 34, 89 and 130 DAT respectively in open field.

Bekhradi *et al*. (2011) reported that when watermelon cv. Charleston Gray was grafted onto Ferro recorded the highest main stem length (4.98 m) whereas, the lowest plant height was recorded (3.40 m) in control.

Mohamed *et al.* (2012) reported the highest length of main stem (265.67 cm and 241.8 cm) in watermelon cv. Aswan F_1 grafted on rootstock 6001 F_1 and Aswan F_1 on Tetsukabuto F_1 in 2010 and 2011 respectively whereas, the lowest plant height was recorded in control (135.17 cm and 195.0 cm).

Petropoulos *et al.* (2012) reported the highest plant height (15.7 cm and 14.2 cm) when Sugar Baby grafted onto Rootstock 841 F_1 whereas, the lowest plant height was recorded in control (5.1 cm and 7.6 cm) at 34 days after grafting at 8 °C and 16 °C respectively.

Petropoulos *et al*. (2012) reported the highest plant height (8.18 cm and 13.0 cm) when Crimson Sweet grafted onto Rootstock 841 F_1 whereas, the lowest plant height was recorded under control (5.6 cm and 7.8 cm) at 34 days after grafting at 8°C and 16°C respectively.

Johnson *et al.* (2014) reported that the highest plant height (2467.95 mm) was recorded when eggplant cv. Epic grafted on to Beaufort.

Petropoulos *et al*. (2014) recorded that the highest plant height (150.7 cm) was recorded when watermelon cv. Obla F_1 grafted onto TZ 148 (*Cucurbita maxima* × *Cucurbita moschata*) whereas, the lowest plant height was recorded (108.5 cm) in self rooted Obla F_1.

Sayed *et al*. (2014) reported that when cucumber cv. Hady grafted onto the rootstock Ferro recorded average plant height of 69.33 cm, 67.67 cm and 196.50 cm in summer planting whereas, 51.00 cm, 118.30 and 163.0 cm in winter planting at 30, 60 and 90 days respectively.

Pardeep *et al.* (2016) reported the highest plant height of capsicum (160.44 cm) when grafted on chilli rootstock (PI-201232) whereas, on brinjal rootstock (VI-047335) plant height was recorded the lowest (110.35 cm) which was quite low as compared to chilli rootstocks.

Sabatino *et al*. (2016) concluded that the highest plant height (62.80 cm) was recorded in brinjal ecotype B_1 grafted on *Solanum torvum* Swartz and the lowest plant height was recorded (56.6 cm) in non grafted B_3 ecotype at 35 days, whereas, at 60 days of planting, plant height was highest (110.4 cm) in B_2 grafted on *S. torvum* Swartz further, the lowest plant height was recorded in non grafted B_2.

Sanjeev *et al*. (2016) recorded that the maximum plant height (87.64 cm) was recorded in followed by grafted Surati Ravaiya Pink (84.12 cm) whereas, minimum plant height (77.71 cm) was recorded in control self rooted Surati Ravaiya Purple.

2.3.2 Number of leaves

Yetisir and Sari (2003) reported that when watermelon cultivar Crimson Tide was grafted onto rootstock Gold Tosa (GT) the highest average number of leaves per plant (287) was recorded whereas, the lowest number of leaves (109) was recorded in control at 50 days after transplanting.

Mohamed *et al.* (2012) reported that the highest number of leaves (127.25 and 141.0) of cv. Aswan F_1 when grafted on rootstock 6001 F_1 and Aswan F_1 on Tetsukuto F_1 in 2010 and 2011 respectively and the lowest leaf number was recorded in control (135.17 cm and 195.0 cm respectively).

Petropoulos *et al.* (2012) reported that the highest leaf number (4.3 and 5.2) was observed when Crimson Sweet grafted onto Rootstock Molina (*Lagenaria siceraria* f. *clavata*) at 34 days after grafting at 8°C and 16°C respectively whereas, the lowest number of leaves were recorded under control (3.8 and 4.6).

Petropoulos *et al.* (2012) reported that the highest leaf number was recorded when Sugar Baby grafted onto Rootstock Molina (*Lagenaria. siceraria* f. *clavata*) at 34 days after grafting at 8°C and 16°C was 4.5 and 5.6 in first year whereas, onto rootstock 841 F_1 number of leaves was recorded about 7.1 and 6.3 respectively in second year. Further the lowest leaf number was observed under control 4.8 and 5.6 in first year whereas, 6.0 and 5.8 in second year at respective temperatures.

Petropoulos *et al*. (2014) recorded the highest leaf number when watermelon cv. Obla F_1 grafted onto TZ 148 (32.3) and lowest number of leaves was observed in self rooted Obla F_1 (25.0). In 1^{st} order lateral stem leaf number was recorded the highest (53.0) when cv. Obla F_1 grafted onto TZ 148 and recorded the lowest leaf number (41.5) in self rooted Obla F_1

Sabatino *et al*. (2016) recorded the highest number of leaves (53) in brinjal ecotype B_4 grafted on *Solanum torvum* Swartz whereas, the lowest leaf number was observed in non grafted B_2 ecotype (29.4 leaves).

2.3.3 Number of branches

Davis *et al*. (2006) reported that number of laterals of watermelon cv. SF800 when grafted on gourd was 18.3, on squash was 18 and under control it was recorded 16 laterals per vine.

Bekhradi *et al*. (2011) studied the effect of three cucurbit rootstocks on vegetative and yield of 'Charleston Gray' in watermelon and reported that cv. Charleston Gray when grafted onto *Cucurbita pepo* recorded the highest number of laterals (10.96) and the lowest number of laterals (8.42) was recorded under control.

Mohamed *et al.* (2012) reported that the highest number of laterals (24.17) of watermelon cv. Aswan F_1 grafted on rootstock 6001 F_1 and on Tetsukabuto F_1 recorded about 23.00 laterals in 2010 and 2011 respectively.

2.3.4 Number of flowers

Khah *et al*. (2006) reported that in tomato cv. Big Red self rooted recorded the highest number of flowers per cluster (24.44) and the lowest flower number was recorded in self grafted plants per cluster (21.50) in greenhouse. Whereas, in open field rootstock Primavera recorded the highest number of flowers per cluster (13.37) and the lowest leaf number (11.39) was recorded in control.

Mohamed *et al*. (2012) reported the highest number of male flowers (55.8 and 36.0) was recorded in watermelon cv. Aswan F_1 grafted on rootstocks 6001 F_1 and Aswan F_1 on Tetsukabuto F_1 in 2010 and 2011 respectively. Further highest number of female flowers of cv. Aswan F_1 grafted on rootstock Strongtosa F_1 was 31.6 and Aswan F_1 on Tetsukabuto F_1 was 15.25 flowers in 2010 and 2011 respectively.

2.3.5 Days taken for 50% flowering and full flowering

Yetisir and Sari (2003) revealed that when watermelon cultivar Crimson Tide was grafted onto rootstock *Cucurbita maxima* (CMA) resulted in early male (95.32 days) and female flowering (103.87 days) from sowing to first flowering

whereas, control took 102.62 and 111.25 days from sowing to first flowering respectively.

Sharma (2006) revealed that, the brinjal cultivar PPL showed 100 per cent flowering after 35-45 days after planting.

Gunjeet *et al.* (2008) investigated 622 landraces of brinjal and revealed that, the plants took on an average of 41 days after transplanting for 50 per cent flowering.

Madhur *et al.* (2009) evaluated 30 genotypes of brinjal and reported that, the days required for 50 per cent flowering was 99 days after sowing further reported that, the mean number of days required for complete flowering is 110 days after sowing.

Quamruzzaman *et al.* (2009) analysed the genetic divergence in 19 genotypes of eggplant and observed that, the number of days for 50 per cent flowering ranged from 78 days to 91.5 days.

2.3.6 Number of fruits

Bletsos *et al*. (2003) reported that seedlings of Tsakoniki when grafted on *Solanum torvum* Swartz recorded about 20.3 and 6 fruits during 1998 and 1999 respectively.

Colla *et al*. (2006) reported the highest mean number of fruits (6.5 fruits) observed when cv. Tex grafted onto rootstock Macis (*Lagenaria siceraria*) fruits at salinity 2.0 dS/m^2 whereas, the lowest number of fruits was recorded (4.3 fruits) in control at salinity 5.2 dS/m^2.

Gisbert *et al*. (2011) reported the highest number of fruits (15.8) in cv. Black Beauty on rootstock *Solanum incanum* × *S. melongena* whereas the lowest fruit number was recorded (7.6) in cv. Black Beauty on *S. macrocarpum*.

Pardeep *et al.* (2016) reported the number of fruits per plant was 24.70 in rootstock of capsicum PI-201232.

Sanjeev *et al*. (2016) reported that maximum numbers of fruits (34.36) were recorded in grafted Surati Ravaiya Purple followed by self rooted Surati Ravaiya Purple (25.04) whereas, minimum numbers of fruits per plant (12.96) were observed in control self rooted Surati Ravaiya Purple.

2.3.7 Fruit set percentage (%)

Abdelmageed and Gruda (2009) reported that the highest fruit set was recorded at a temperature of 26/20 °C when UG 82-B grafted on eggplant rootstock Black Beauty was (53.8 %) whereas, lowest fruit set was recorded (17.1 %) when UG 82-B grafted on tomato rootstock Summerset.

Sanjeev *et al*. (2016) reported that fruit set percentage was maximum (71.64 %) in grafted Surati Ravaiya Purple followed by grafted Surati Ravaiya Pink 69.01 % whereas, minimum fruit set (63.66 %) was recorded in control self rooted Surati Ravaiya Purple.

2.3.8 Leaf area and Leaf area index

Yetisir and Sari (2003) reported that when cultivar Crimson Tide was grafted onto rootstock Gold Tosa (GT) recorded the highest leaf area (88.87 cm^2) whereas, the lowest leaf area was recorded (41.08 cm^2) in rootstock 216 at 25 days after planting whereas, Crimson Tide grafted onto rootstock Gold Tosa (GT) recorded the highest leaf area (134.9 cm^2) whereas, the lowest leaf area was recorded onto rootstock P360 (84.0 cm^2) at 50 days after transplanting.

Khah (2005) concluded that the highest leaf area (5.20 cm^2) was recorded in Rima grafted tomato rootstocks Primavera whereas, control recorded the lowest leaf area (1.12 cm^2).

Khah *et al*. (2006) reported that cv. Big Red grafted onto Heman recorded the highest leaf area (10923 cm^2) and the lowest leaf area (7598.10 cm^2) was recorded in self grafted in greenhouse whereas, in open field, rootstock Heman recorded the highest leaf area (4949.0 cm^2) further, the lowest leaf area was recorded in self grafted cv. Big Red (3997.0 cm^2).

Abdelmageed and Gruda (2009) reported that, leaf area of 2915.9 cm^2 was recorded at a temperature of 37/27 ^{0}C in Summerset self grafted plants whereas, at a temperature of 26/20 ^{0}C self rooted Summerset was recorded about 4060.6 cm^2.

Petropoulos *et al*. (2012) reported that the highest leaf area (44.9 and 44.9 cm^2) was observed when Sugar Baby grafted onto Rootstock 841 F_1 whereas, control recorded the lowest leaf area (34.5 and 38.8 cm^2) at 34 days after grafting at 8°C and 16°C in first year respectively. Further, recorded the highest leaf area

(45.0 and 40.1 cm^2) onto rootstock Molina whereas, leaf area was recorded the lowest under control (37.4 and 34.7cm^2) in second year at respective temperature.

Petropoulos *et al*. (2012) reported that the highest leaf area was recorded when Crimson Sweet grafted onto rootstock Molina (*Lagenaria. siceraria* f. *clavata*) at 34 days after grafting at 8°C and 16°C was 45.9 and 46.6 cm^2 during first year respectively. Whereas, onto rootstock *Lagenaria. siceraria* f. *pyrotheca* (47.6 and 51.6 cm^2 respectively) during second year. Further, the lowest leaf area was recorded in control 39.9 and 43.8 cm^2 during first year and 39.9 and 44.0 cm^2 during second year at respective temperature.

Petropoulos *et al*. (2014) recorded the highest leaf area when cv. Obla F^1grafted onto TZ 148 (*Cucurbita maxima* × *Cucurbita moschata*) 1820.6 cm^2 whereas, the lowest leaf area was recorded (1108.5 cm^2) in self rooted Obla F_1.

2.3.9 Yield

Bletsos *et al*. (2003) reported that seedlings of Tsakoniki when grafted on *Solanum torvum* Swartz recorded the fruit yield of 2867 g and 993g during 1998 and 1999 respectively.

Yetisir and Sari (2003) reported that when cultivar Crimson Tide was grafted onto rootstock Skopje (*Lagenaria* hybrid) recorded the highest fruit yield of 13.26 kg/m^2 whereas, the lowest yield was recorded onto rootstock P360 (*Cucurbita* hybrid) about 1.89 kg/m^2.

Nina and Joze (2004) used two cultivars as scion were 'Monroe' and 'Belle', and as rootstock 'PG 3' and 'Beaufort'. Two grafting methods were applied: cleft grafting and tube grafting. Results showed that cv. 'Monroe' under cleft grafting recorded yield of 4718.0 g/plant and under Tube grafting about 3091.0 g/plant whereas in cv. Belle under cleft grafting yields 3004.0 g/plant and under Tube grafting yield was recorded about 3591.3 g/plant.

Khah (2005) reported the yield per plant was recorded the highest (15.3 kg/plant) when Rima grafted tomato rootstocks Primavera whereas, the lowest yield was recorded in control (9.5 kg/plant).

Colla *et al*. (2006) reported the highest mean yield of fruits (11.1 kg per plant) when cv. Tex grafted onto rootstock Ercole (*Cucurbita maxima*) at salinity

2.0 dS/m^2 whereas, the lowest yield was recorded in control (4.9 kg per plant) at salinity 5.2 dS/m^2.

Alexios *et al*. (2007) reported that grafting increased fruit size, resulting in higher yields than in the non grafted control. Further stated that the fruits from grafted plants had a thicker rind and slightly lower total soluble solids content than the fruits from non grafted plants.

Alan *et al*. (2007) concluded that grafting resulted in higher yield by increasing in both fruit number and weight, however, no significant effect on fruit quality such as fruit index, rind thickness, and soluble solid contents on grafted plants was observed.

Besri (2008) recorded the average yield of melon and watermelon plants grafted on different Cucurbita hybrids (*C. maxima* x *C. moschata*) as rootstocks were much higher than the yields of the non grafted plants. The yield increase was 44 % and 84 % for melon and watermelon respectively.

Gisbert *et al*. (2011) recorded the highest yield per plant (6.9 kg) in Black Beauty on rootstock *Solanum incanum* × *S. melongena* and the lowest yield (3.4 kg) was recorded in was Black Beauty on *S. macrocarpum*.

Turhan *et al*. (2011) studied the effects of grafting on different rootstocks on tomato fruit yield and quality and concluded that the fruit yield of Yeni Talya on Beaufort 6.77 kg per plant and stated that the fruit index (diameter/length), number of fruits/truss and fruit weight were significantly influenced by grafting.

Petropoulos *et al*. (2014) recorded the highest yield (88008 kg/ha) when cv. Obla F_1 grafted onto TZ 148 (*Cucurbita maxima* × *Cucurbita moschata*) whereas the lowest yield (50233 kg/ha) was recorded in self rooted Obla F_1.

Sayed *et al*. (2014) reported that when cucumber cv. Hady grafted onto the rootstock Ferro in summer planting recorded the highest early fruit yield of 2.668 kg/m^2 and total yield of 11.668 kg/m^2 whereas, in winter planting early yield of 3.583 kg/m^2 and total yield of 14.750 kg/m^2 was recorded.

Pardeep *et al*. (2016) evaluated chilli and brinjal rootstocks for growth, yield and quality of bell pepper (*Capsicum annuum* L. Var. *Grossum* sendt.) under protected conditions and reported that the highest fruit yield per plant (2.47

kg) was recorded with the chilli rootstock PI-201232, followed by VI-037556 (1.97 kg) and AVPP0205 (1.91 kg) which were statistically at par.

Sabatino *et al*. (2016) concluded that the highest yield per plant was recorded in ecotype B1 grafted on *Solanum torvum* Swartz about 4.38 kg and the lowest yield was recorded in non grafted B4 ecotype about 1.82kg.

Sanjeev *et al*. (2016) reported the highest fruit yield in grafted Surati Ravaiya Purple (44.46 t/ha) followed by self rooted Surati Ravaiya Purple (31.67 t/ha) whereas, lowest yield was recorded in control self rooted Surati Ravaiya Pink (17.60 t/ ha).

2.3.10 Number of fruits per plant

Yetisir and Sari (2003) reported that when cultivar Crimson Tide was grafted onto rootstock Skopje (*Lagenaria* hybrid) recorded the highest number of fruits (2.4 fruits/plant) whereas, the lowest number of fruits was recorded (1.0 fruits/plant) onto rootstock *Cucurbita moschata* (CMO).

Nina and Joze (2004) studied the influence of different grafting methods on the success of grafting and fruit yield of two tomato cultivars (*Lycopersicon esculentum* Mill.) was studied the cultivars used as scion were 'Monroe' and 'Belle', and as rootstock 'PG 3' and 'Beaufort'. Two grafting methods were applied: cleft grafting and tube grafting. Results showed that cv. 'Monroe' in cleft grafting recorded in 20.1 fruits per plant and in tube grafting recorded 16.1 fruits. In cv. Belle in cleft grafting recorded 20.1 and in tube grafting recorded 13.7 fruits per plant.

Davis *et al*. (2006) investigated that rootstock effects on plant vigor and fruit quality in watermelon and reported that cv. SF800 when grafted on gourd recorded 10 fruits, on squash recorded 16 fruits whereas, under control 18 fruits per vine was recorded.

Alexios *et al*. (2007) studied fruit yield and quality of watermelon in relation to grafting and reported that the mean number of fruits per plant was similar for both the grafted and non grafted plants irrespective of root stock the fruit yield was significantly higher in the grafted plants than in the non-grafted control.

Abdelmageed and Gruda (2009) reported the highest number of fruits (12.8) was recorded at a temperature of 26/20 °C in Summerset grafted on eggplant rootstock Black Beauty whereas, the lowest fruits ((10.2) was recorded in self rooted UG 82-B.

Petropoulos *et al*. (2014) recorded the highest (13972) number of fruits per hectare when cv. Obla F_1 grafted onto TZ 148 (*Cucurbita maxima* × *Cucurbita moschata*) whereas, the lowest fruit was recorded (7867) in self rooted Obla F_1.

Sabatino *et al*. (2016) concluded that the highest number (16.34) of fruits per plant was recorded in ecotype B_4 grafted on *Solanum torvum* Swartz whereas, the lowest (4.79) fruits per plant were recorded in non grafted B_3 ecotype.

2.3.11 Average fruit weight (g)

Bletsos *et al*. (2003) reported that the seedlings of Tsakoniki when grafted on *Solanum torvum* Swartz recorded mean fruit weight of 137.7g and 226.5 g during 1998 and 1999 respectively.

Yetisir and Sari (2003) reported that when cultivar Crimson Tide was grafted onto rootstock Skopje (*Lagenaria* hybrid) recorded the highest fruit weight (8.80 kg) whereas, the lowest fruit weight (2.03 kg) was recorded onto rootstock *Cucurbita moschata* (CMO).

Colla *et al*. (2006) reported that highest mean weight (1.89 kg) fruit was observed when cv. Tex grafted onto rootstock Ercole (*Cucurbita maxima*) at salinity 2.0 dS/m^2 whereas, the lowest fruit weight was recorded (1.13 kg) in control at salinity 5.2 dS/m^2.

Khah *et al*. (2006) reported that the cv. Big Red grafted onto Heman gave highest fruit weight of 7568.16 g and 2096.25 g while, lowest fruit weight was recorded in 4995.16 g and 1771.88 g in greenhouse and open fields respectively.

Abdelmageed and Gruda (2009) reported that the highest fruit weight was recorded at temperature of 37/27 and 26/20 °C in Summerset self rooted plants was 13.13 g and 284.00 g respectively in tomato.

Sebahattin *et al*. (2009) reported that when eggplant Faselis was grafted on *S. torvum* Swartz, mean fruit weight increased by 20%.

Victoria and Francisco (2009) recorded an increase in average fruit weight in watermelon grafted plants compared to non grafted plants varied from 13% to 28%.

Turhan *et al*. (2011) compared the fruit characteristics of Yeni Talya on Beaufort were with those of non grafted plants where the weight of fruit was (202.09 g/fruit) significantly influenced by grafting.

Alessandra *et al*. (2013) recorded the average weight of fruits was significantly higher in all the grafted plants (274.2 g) especially for big sized cultivars. Birgah characterized by big sized fruit and recorded the highest average fruit weight (321.8 g) whereas, Longo (lengthened shape fruit) produced fruits of 184.1g on average.

Johnson *et al*. (2014) reported that the highest fruit weight was recorded when eggplant cv. Epic grafted on to Beaufort was 0.50 kg whereas the lowest fruit weight was recorded in self grafted plants.

Petropoulos *et al*. (2014) recorded highest fruit weight (6.4 kg) when cv. Obla F_1grafted onto TZ 148 (*Cucurbita maxima* × *Cucurbita moschata*) whereas the lowest fruit weight was (6.3 kg) in self rooted Obla F_1.

Sayed *et al*. (2014) reported that when cucumber cv. Hady grafted onto the rootstock Ferro recorded an average weight of fruits (70.67, 69.67 and 69 g) in summer planting whereas, average fruit weight (68.67, 68.67 and 69 g) in winter planting at 30, 60 and 90 days respectively.

Pardeep *et al*. (2016) studied the evaluation of chilli and brinjal rootstocks for growth, yield and quality of bell pepper (*Capsicum annuum* L. Var. *grossum* Sendt.) under protected conditions and reported that the average weight of fruits per plant was 99.73 g in rootstock of capsicum PI-201232.

Sanjeev *et al*. (2016) reported the maximum fruit weight (73.43 g) was recorded in grafted Surati Ravaiya Pink followed by self rooted Surati Ravaiya Pink (73.06 g) whereas, the minimum fruit weight (69.02 g) was recorded in self rooted Surati Ravaiya Purple (control).

2.3.12 Per cent of bacterial wilt (%)

Onduso (2014) investigated the management of bacterial wilt of tomato by use of resistant rootstock and the results strongly indicated that the bacterial wilt

disease severity and incidence was reduced when wilt susceptible Anna F_1 variety was grafted on Shin Cheong Gang rootstock. Grafting susceptible Anna F_1 tomato variety on Shin Cheong Gang variety reduced bacterial wilt incidence by 95% and on rootstock variety Cheong gang by 92%.

High bacterial wilt tolerance was also reported by Lu *et al*. (2004) when wild Chinese tomato cultivars were used the varieties were reported to have reduced disease incidence up to 100% as well as delaying the symptoms when compared with non grafted susceptible varieties.

2.3.13 Dry matter accumulation and partitioning at final harvest.

Khah (2005) recorded the highest fresh weight (89 g) and dry weight (12.8 g) in Rima grafted tomato rootstocks Primavera whereas, the lowest leaf fresh and dry weight was recorded (17.7 g and 3 g) in control respectively.

Khah (2005) concluded that leaf fresh and dry weight was maximum (196.3 g and 25 g respectively) in Rima grafted tomato rootstocks Primavera whereas, the lowest leaf fresh and dry weight (52.7 and 7.9 g respectively) was recorded in control.

Khah *et al*. (2006) reported that cv. Big Red grafted onto Primavera recorded the highest stem fresh weight and dry weight of 283.78 g and 60.69 g respectively whereas, on rootstock Heman recorded the lowest stem fresh and dry weight of 204.30 g and 36.30 g respectively in greenhouse. Further, in open field self grafted tomato recorded highest stem fresh weight and dry weight of 208.33 g and 31.90 g and the lowest fresh and dry weight of stem was recorded in control (163.75 g and 25.65 g respectively).

Khah *et al*. (2006) reported that cv. Big Red grafted onto Primavera gave highest leaves fresh weight and dry weight of 980.28 g and 153.54 g respectively whereas, on self rooted cv. Big Red recorded the lowest stem fresh weight and self grafted dry weight of 766.33 g and 26.42 g in greenhouse respectively. Further, in open field cv. Big Red onto Heman recorded the highest stem fresh weight and dry weight of 351.25 g and 33.34 g and the lowest onto rootstock Primavera fresh weight and dry weight of 300 g and 27.82 g respectively.

Khah *et al*. (2006) reported that self grafted cv. Big Red recorded the highest fresh and dry weight (2840.00 g and 39.58 g respectively) whereas, the lowest fresh and dry weight was recorded in control (1740.00 g and 26.42 g respectively) in open field.

Colla *et al*. (2008) concluded that the percentage of shoot biomass weight reduction was significantly lower in watermelon plants grafted onto pumpkins rootstocks as compared to those grafted onto the bottle gourd rootstocks and the non grafted plants.

Abdelmageed and Gruda (2009) recorded that the highest leaf fresh weight (193.1 g) and dry weight (23.16g) were recorded with a temperature of 26/20 °C whereas, fresh weight (144.6g) and dry weight (18.30 g) with a temperature of 37/27 °C in summer set self grafted plants.

Bekhradi *et al*. (2011) reported that when cv. Charleston Gray was grafted onto *Cucurbita pepo* resulted the highest fresh weight of plant (1872.1 g) and dry weight of (447.5g) whereas, the lowest fresh and dry weight was recorded under control (698.1 g 209.1 g respectively) on an average.

Mohamed *et al*. (2012) reported when cv. Aswan F_1 grafted on rootstock Tetsukabuto F_1 recorded the fresh shoot weight of 1853.3 g/plant and dry weight of 501.55 g/plant and shoot dry weight percentage was 27.06 %.

2.4 VISUAL OBSERVATION ON STOCK-SCION INTERACTION

The grafting effects on vegetable quality and reported that abnormal fruit quality issues reported for *Cucumis melo* include persistent green color in the suture stripe, fruit fermentation, fibrous flesh, and off-taste (Chung, 1995; Kamiya and Tamura, 1964; Koutsika-Sotiriou and Traka-Mavrona, 2002; Lee, 1989; Lee *et al*., 1998; Muramatsu, 1981; Davis *et al*., 2008).

In general fruit shape constitutes a trait predominantly governed by scion genotype and little affected by environmental or cultural factors, hence the effect of grafting has been circumstantial and mostly minimal (Marios *et al*., 2017).

2.4.1 Fruit shape and colour

Yetisir and Sari (2003) reported that the quality, rind thickness and fruit shape of grafted watermelon were greatly influenced by grafting, but the results were dependent on the rootstock used.

2.4.2 Fruit diameter (cm)

Edelstein *et al*. (2004) showed that number of leaves, stem length and fresh weight of melon plants increased using 22 different Cucurbita spp. rootstocks. It was demonstrated that rootstocks effected the number of nodes and lateral branches and the vigor of grafted watermelon plants was improved when grafted onto a gourd rootstock.

Turhan *et al*. (2011) studied the effects of grafting on different rootstocks on tomato fruit yield and quality and concluded that Swanson on Beaufort recorded a fruit index of 1.35.

Francisco *et al*. (2014) studied the influence of three rootstocks on yield and commercial quality of "Italian sweet" pepper and reported that Palermo onto Tresor the highest values (50.19 mm) whereas, non-grafted Palermo recorded the lowest values (49.87 mm).

Johnson *et al*. (2014) reported that highest fruit diameter (9.7 cm) was recorded when eggplant cv. Epic grafted on to Beaufort whereas, the lowest fruit diameter (8.07 cm) was recorded onto rootstock *Solanum aethiopicum*.

Sayed *et al*. (2014) reported that when cucumber cv. Hady grafted onto the rootstock Ferro gave the highest average fruit diameter of 30.17 mm, 31.17 mm and 30.50 mm at 30, 60 and 90 days respectively in summer planting whereas, during winter planting an average fruit width of 25.67 mm, 25.67 mm and 27.33 mm was recorded at 30^{th}, 60^{th} and 90^{th} day after planting.

Pardeep *et al*. (2016) reported that Indra grafted on to rootstock Pant C-1 gave maximum fruit width of 7.29 cm followed by Indra on Surajmukhi 7.31cm.

Sanjeev *et al*. (2016) recorded maximum fruit diameter in grafted Surati Ravaiya Purple (7.62 cm) followed by self rooted Surati Ravaiya Purple (7.56 cm) whereas, minimum fruit diameter (6.00 cm) was recorded in control (self rooted Surati Ravaiya Purple).

2.4.3 Fruit length (cm)

Davis *et al*. (2006) reported that fruit length of cv. SF800 when grafted on gourd was 33.1cm, on squash was 31.3 cm and under control was recorded 31cm.

Bekhradi *et al.* (2011) reported that cv. Charleston gray was grafted onto Ferro gave fruit length of 39.33 cm and on *Cucurbita pepo* recorded the lowest fruit length of 36.58 cm.

Johnson *et al*. (2014) reported that the highest fruit length was recorded when eggplant cv. Epic grafted on to Beaufort (20.29 cm) whereas, the lowest fruit length was recorded (18.22 cm) onto rootstock *Solanum aethiopicum*.

Sayed *et al*. (2014) reported that when cucumber cv. Hady grafted onto the rootstock Ferro recorded the highest average fruit length (15cm, 14.17 cm and 15 cm) at 30^{th}, 60^{th} and 90^{th} day respectively in summer planting whereas, in winter planting grafted cv. Hady was recorded the highest fruit length (15.17 cm, 15.0 cm and 15 cm).

Pardeep *et al.* (2016) reported that the chilli rootstock AVPP0205 resulted in longer fruits (8.52 cm) whereas, brinjal rootstocks resulted in to fruit length of 7.74 cm to 7.66 cm in capsicum plants.

Sanjeev *et al*. (2016) reported maximum fruit length in grafted Surati Ravaiya Pink (8.1 cm) followed by self rooted Surati Ravaiya Pink 8.06 cm whereas, minimum fruit length (6.71 cm) was recorded in control self rooted Surati Ravaiya Purple.

2.4.4 Fruit volume (ml)

Davis *et al*. (2008) studied the grafting effects on vegetable quality and reported that, the scion variety effected the final size, yield, and quality of fruit in grafted plants, but rootstock effects can drastically alter these characteristics. There are many conflicting reports on changes in fruit quality resulting from grafting.

Chapter III

Material and Methods

Chapter III

MATERIAL AND METHODS

The investigation on "Evaluation of rootstock and scion in Brinjal (*Solanum melongena* L.) for growth, yield and fruit quality" was conducted at the farm of Indian Institute of Horticulture Research, Division of Vegetable Crops, Block-8, Hessaraghatta, Bengaluru during 2016-17. In this chapter, the material used for the research and methods followed are presented below.

3.1 EXPERIMENTAL SITE

The experimental site is located at an altitude of 890 m above Mean Sea Level (MSL) with 13°N latitude and 17°37' E longitude.

3.2 WEATHER CONDITION

The average rainfall of the area is about 850 mm. The minimum temperature at the experimental site ranged from 11^0C to 28^0C and maximum temperature ranged from 20.2^0C to 35^0C. Soil is red sandy loam with a pH 6.4. Relative humidity ranged from 26 to 80 per cent. The meteorological data recorded during the period of research is presented in Appendix-I.

3.3 SOIL NUTRIENT STATUS

Soil nutrient status of the experimental field is presented in Appendix-II

3.4 EXPERIMENTAL DETAILS

The field experiment was laid out in Randomized Block Design (RBD), with three varieties after subjected to grafting during October 2016.

3.4.1 Evaluation of rootstock and scion in Brinjal (*Solanum melongena* L.) for growth, yield and fruit quality

Crop	: Brinjal
Number of treatments	: 07
Replications	: 03
Design	: Randomized Block Design (RBD)
Season	: *Rabi*, 2016-17
Spacing	: 1.2 m × 0.6 m
Bed size	: 4.8 m × 3.6 m

Location : Division of Vegetable crops, ICAR-IIHR Bengaluru.

3.4.1.1 Treatment details

T_1	Myhco-9 on *Solanum torvum*
T_2	Lalitha on *Solanum torvum*
T_3	Sharpova on *Solanum torvum*
T_4	Myhco-9 own root (non grafted)
T_5	Lalitha own root (non grafted)
T_6	Sharpova own root (non grafted)
T_7	Arka Anand own root (non grafted) (control-BWR)

3.4.1.2 Description of varieties

Mahyco-9: A very strong plant with good canopy, high yielding variety with a long uniform shaped fruits. This variety is known for having less seed content and good taste. Seeds were collected from reliable source.

Lalitha: Bear in cluster and colour is purple. A good size fruits with 100-120 g per fruit and resistance to bacterial wilt. Seeds of the variety were collected from reliable source.

Sharpova: It is known for its size and oval shape, suitable for cultivation in indoor and outdoor condition. Good firmness of the fruit with dark purple skin colour. Seeds were collected from reliable source.

Arka Anand: It is resistant to bacterial wilt and high yielding variety. The fruits bear in uniform shape. Seeds were collected from reliable sources.

3.4.1.3 Seed treatment and sowing

The seeds of *Solanum torvum* were soaked in water for 24 hours before sowing to facilitate early and good germination. Seeds of rootstock were sown 4 weeks before the scion seeds. To overcome the problem of uneven germination, the rootstock seeds were sown in trays containing sterilized coco peat and later transplanted to 98 celled pro-trays at two leaf stage.

3.4.1.4 Nursery raising and grafting

Before grafting scion and rootstock were exposed to sunshine for two to three days.

Three cultivated varieties *viz*., Mahyco-9, Lalitha and Sharpova were grafted onto the *Solanum torvum* Swartz rootstock using "side grafting". Non grafted seedlings were used as a control and Arka Anand was used as control for bacterial wilt screening.

Grafting was carried out when the scion seedlings attained 2-3 true leaf stage (20-25 d) and the rootstock was at 3-4 true leaf stage (55-60 d). Grafting was carried out in moist chambers where, same thickness scion and root stock were cut at 45^0 and joined by using plastic clips (Plate 3.1).

The grafts were transplanted thirty five days after sowing in scion plants and sixty days in rootstock plants. After grafting the grafts were placed in labelled trays before being taken to moisture chambers. This process was carried out to ensure high grafting success. The grafted seedlings were transferred to humidified chambers with a relative humidity of 85-95 per cent for five days to allow the graft union to heal, then light was gradually increased and relative humidity was decreased. Then the seedlings were transferred to the normal nursery where healing process was allowed for two weeks before they were transplanted. Plants were grown under natural light conditions. During the whole crop cycle, air temperature inside the graft chamber was recorded daily presented in Appendix-III.

3.5 COLLECTION OF DATA IN NURSERY

3.5.1 Rootstock and Scion parameters

3.5.1.1 Days taken for Germination

The observation was recorded at everyday by visual observation and the number of emerged seedlings were counted.

3.5.1.2 Days taken to reach grafting stage

It was recorded based on seedling height, number of leaves and days required to reach correct stage of grafting.

3.5.2 Observation on RH, Temperature and Light inside the graft chamber

The observations were recorded at every hour inside the graft chamber, mist chamber and outside in both sun and shady condition. Temperature and

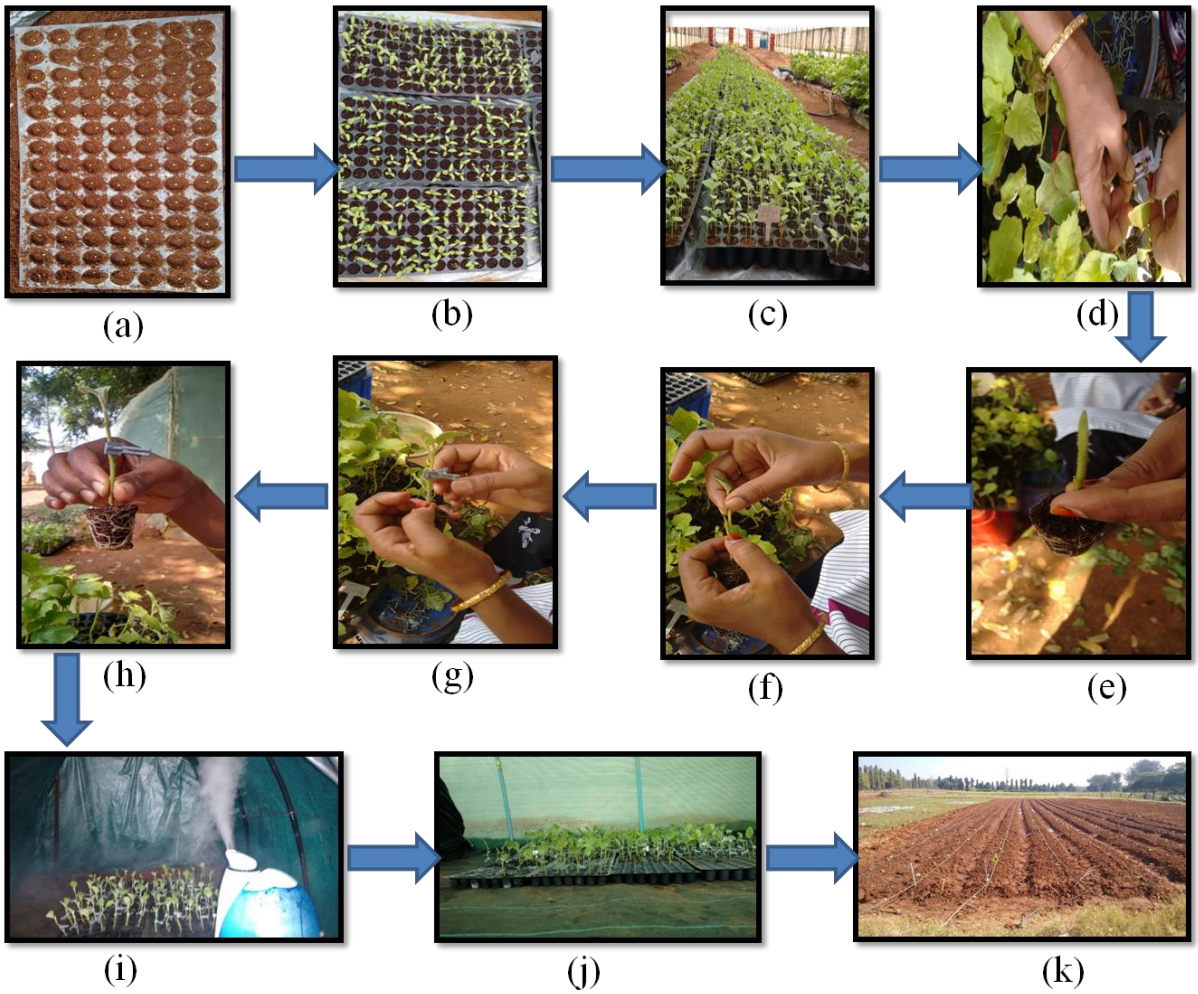

Plate 3.1: Procedure of grafting
(a): Seeds were sown in pro-trays
(b): Germination of seeds
(c): Seedlings were ready for grafting
(d): By using blade the rootstocks and scions were cut
(e): Rootstock is cut at an angle of 45^0 upwards
(f): Scion is cut at an angle of 45^0 downwards
(g): joining of rootstock and scion at cut portion
(h): Clipping of rootstock and scion for better graft union
(i): Healing of grafts under favourable environmental condition
(j): Hardening of grafts
(k): Transplanted to main field

humidity was recorded with the help of Hygrometer in the mist chamber (Appendix-III).

3.5.3 Observation of grafted plant

3.5.3.1 Days taken for graft healing

The observation was recorded after 3 days of grafting by removing the grafting clips.

3.5.3.2 Days taken for graft hardening

The observation was recorded on the basis of visual characters of grafted seedlings.

3.5.3.3 Graft success (%)

Graft success was recorded at 5^{th}, 10^{th} and 15^{th} days after grafting and on the day transplanting, 7^{th}, 14^{th} and 30^{th} day after transplanting based on wilting of the grafts at healing region. It is calculated by number of plants died to the total number plants multiplied by hundred and it is expressed in percentage.

3.5.3.4 Cost of graft plant production

The price of the inputs that were prevailing at the time of their use was taken into account to work out the cost of grafting production shown in Appendix-IV.

3.6 PREPARATION OF EXPERIMENTAL FIELD

The selected experimental plot was brought to a fine tilth by one ploughing, two harrowings and one levelling. Beds of 80 cm width were made using tractor drawn bed former and the beds were spaced 40 cm apart. Transplanting of grafted seedlings to the main plot was done 20 days after grafting when the grafts were at 3-4 true leaf stage. Field layout is depicted in Figure 3.1.

3.6.1 Application of manures and fertilizers

Well decomposed farmyard manure was applied at a rate of 20 t/ha at the time of field preparation. Fertilizers at a rate of 150:100:150 kg/ha in the form of urea, single super phosphate and murate of potash was applied. Half a dose of nitrogen and potash and full doses of phosphorus fertilizers were applied at the time of transplanting and other half dose of nitrogen and potash was top dressed in a single dose after 30 days of transplanting.

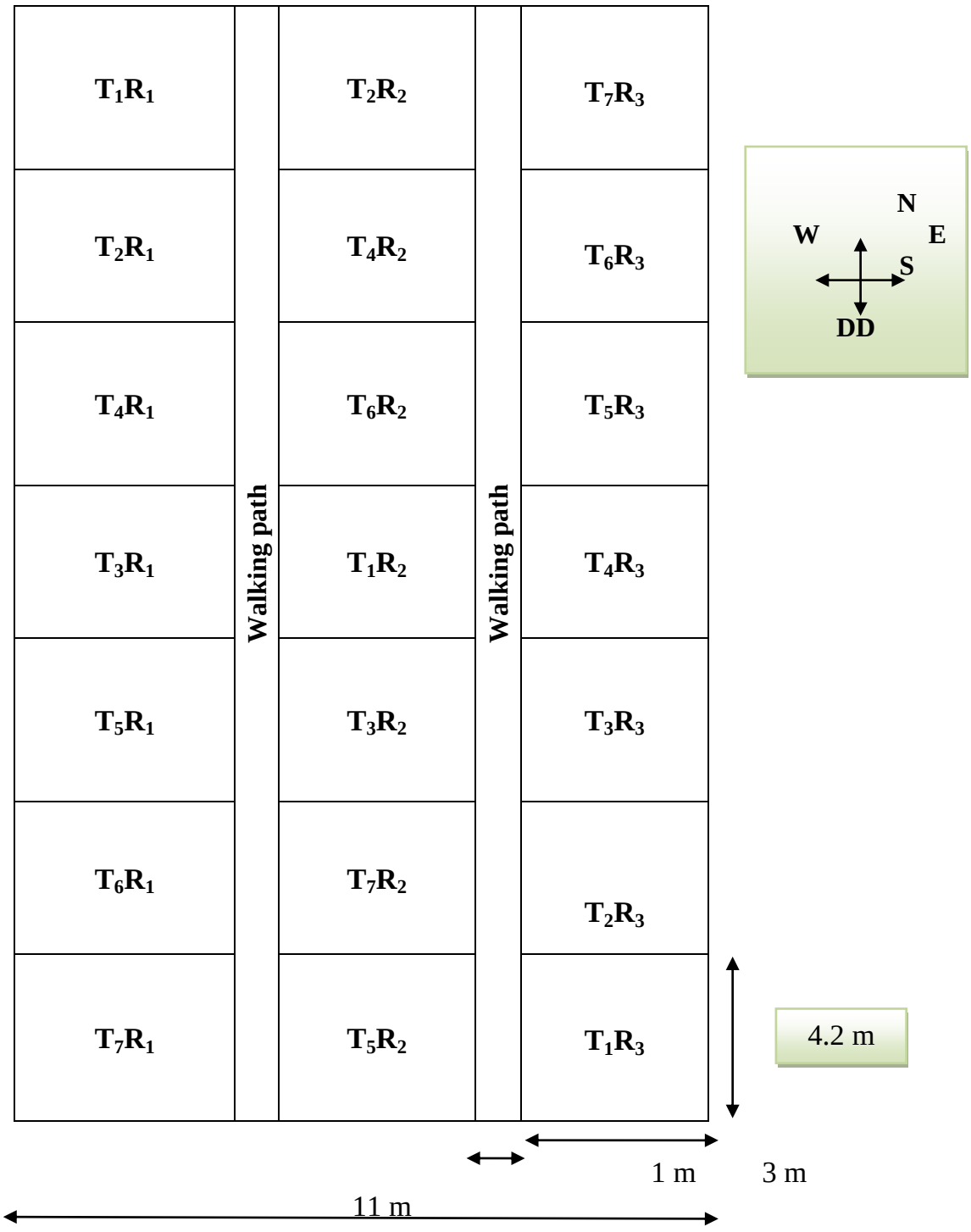

Figure 3.1 Layout of the field experiment

Plate 3.2: General field view of the experiment

3.6.2 Inter cultivation

Hand weeding was carried out as and when necessary during the cropping period. Irrigation was given at an interval of 10 to 15 days depending on soil moisture and climatic conditions. Shallow inter hoeing operation was also taken up within 3 to 4 days after every irrigation to maintain good crop. Timely plant protection measures were taken to protect crop from pest and disease infection. General field view was depicted in 3.2.

3.7 COLLECTION OF EXPERIMENTAL DATA

3.7.1 Vegetative parameters

Observation on various parameters of vegetative, flowering and yield parameters were recorded. Five plants from each plot was selected and randomly tagged.

3.7.1.1 Plant height (cm)

Plant height was recorded by measuring the length from base to the tip of apical top most leaf. The readings were taken from the tagged plants and average was worked out and expressed in centimetres.

3.7.1.2 Number of leaves

Total number of leaves was recorded by counting individual leaf at monthly intervals till five months. The readings were taken from the tagged plants and average was worked out and expressed in numbers.

3.7.1.3 Number of branches

Total number of branches was recorded by counting individual branch at monthly intervals till five months. The readings were taken from the tagged plants and average was worked out and expressed in numbers.

3.7.1.4 Days taken for 50 per cent flowering and full flowering

Days to 50 per cent flowering was recorded by observing the number of days required by 50 per cent of the plant population to flower from the date of sowing and the total number of days required for 100 per cent of the plant population to flower was recorded from the date of sowing from each plot. Average was worked out and expressed in percentage.

3.7.1.5 Number of flowers

Total number of flowers per plant was recorded at monthly interval till four months from tagged plants by counting of individual flower. Average was worked out and expressed in numbers.

3.7.1.6 Fruit set percentage (%)

Percentage fruit set was recorded from tagged plants by taking into account the total number of fruits set per plant to the total number of flowers produced per plant. Flowers were tagged to record the observation. Fruit set percent was worked out by randomly selecting 50 flowers per plot during 60-90 days after transplanting.

3.7.1.7 Leaf area index

Leaves were collected from whole plant and individual leaf area was calculated by using leaf area meter.

3.7.1.8 Per plant yield and yield per hectare

Fruit yield was recorded separately for individual plants for total plot. The total fruit yield per plant was also recorded by weighing the total number of fruits produced in each plant at every harvest and was expressed in kilograms. Yield per hectare was estimated by total number of plants to the plant spacing and was expressed in tons.

3.7.1.9 Number of fruits per plant

Total number of fruits per plant was recorded from tagged plants at every interval by counting of individual fruit.

3.7.1.10 Average fruit weight (g)

Average weight of fruits per plant was also recorded from tagged plants by weighing of individual fruits.

3.7.1.11 Per cent of Bacterial wilt (%)

Plants were screened for bacterial wilt incidence at 30 DAT, 60 DAT, 90 DAT, 120 DAT and at final harvest of crop.

3.7.1.11.1 Assessment of bacterial wilt infection

Disease incidence in the field was determined by visual assessment using signs and symptoms. Diagonal sampling method was used where plants were

systematically picked from field for assessment. Sampled plants were checked for bacterial wilt symptoms including wilting and stem discoloration and findings were recorded. Percentage disease incidence per bed was calculated by dividing the affected plants by the total plants assessed multiplied by hundred. Field diagnostic tests for bacterial wilt were carried out by cutting a Brinjal stem of about eight centimeter in length picked from the root base of a wilted plant and the stem portion placed in a clear glass beaker filled with clear water. The presence of oozing milky exudates from the cut stem section indicates that the pathogen was *Ralstonia solanacearum* (Goszczynska *et al*., 2000).

3.8 VISUAL OBSERVATION ON STOCK-SCION INTERACTION

3.8.1 Fruit shape and colour

To estimate the fruit shape and colour, five individual fruits were selected from each treatment at mature stage from grafted plants to compare with non grafted plants by visual observation.

3.8.2 Fruit diameter (cm)

To estimate the fruit diameter, five individual fruits were selected from tagged plants at mature stage and their diameter was recorded in centimetres using scale.

3.8.3 Fruit length (cm)

To estimate the fruit length, five individual fruits were selected from tagged plants at mature stage and their length was recorded in centimetres using scale.

3.8.4 Fruit volume (ml)

To estimate the fruit volume, five individual fruits were selected from tagged plants at mature stage and their volume was recorded by using water displacement method.

3.9 STATISTICAL DESIGN

Observations on vegetative characters were recorded by calculating the mean of five plants per plot. Fruit characters were recorded by randomly selecting five flowers and fruits. As all the studies were done in the field under moderate temperature and light conditions, Randomised Block Design (RBD) was employed for the experiments. The data were subjected to analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1967). Critical difference values were calculated at five per cent probability where 'F' test was significant.

Chapter IV

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

The present study titled as "Evaluation of rootstock and scion in Brinjal (*Solanum melongena* L.) for growth, yield and fruit quality" was conducted at the farm of Division of Vegetable Crops, Block-8, Indian Institute of Horticulture Research, Hessaraghatta, Bengaluru during 2016-17. The results obtained are presented in this chapter under appropriate headings and subheadings with tables.

4.1 ROOTSTOCK AND SCION PARAMETERS

4.1.1 Days taken for germination

Significant differences were recorded for days taken for germination (Table 4.1). Among all treatments Mahyco-9 (T_1) took minimum number of days (5.00) for germination which was followed by Lalitha and Sharpova (T_2 and T_3) (5.25) was on par with Arka Anand (T_5) (5.50) however, *Solanum torvum* Swartz took maximum days (15.25) for germination.

Soft seeded nature of hybrid variety Mahyco-9 resulted in early germination. *Solanum torvum* took maximum days for germination that may be species character. Since *Solanum torvum* is a wild species which may be having hard seed coat and prolonged seed dormancy that may result in erratic, poor and late germination. This result was in agreement with Gisbert *et al*., 2011. Further, Sanjeev *et al.,* 2016 stated that *Solanum torvum* Swartz is a highly vigorous relative of eggplant but its poor, irregular and erratic germination due to long dormancy in seeds limits practicability as rootstock.

4.1.2 Days taken to reach grafting stage

Significant differences were recorded for days taken to reach grafting stage among all treatments (Table 4.2). Mahyco-9 (T_2) took less number of days (19.2) from germination to reach grafting stage which was followed by Sharpova (T_4) (19.4) whereas, *Solanum torvum* Swartz (T_1) recorded maximum (45.0) number of days from germination to reach grafting.

Fastest germination exhibited by Mahyco-9 obviously resulted in minimum number of days to reach the grafting stage.

Table 4.1. Days taken for germination in rootstock and scion seeds

Treatments	Mean
T_1: *Solanum torvum* Swartz	15.25
T_2: Mahyco-9	5.00
T_3: Lalitha	5.25
T_4:Sharpova	5.25
T_5: Arka Anand	5.50
SEm±	0.24
CD @ 5%	1.51
CV %	19.10

Note: Number of replications : 04

Table 4.2. Days taken to reach grafting stage after germination in rootstock and scion.

Treatments	Mean
T_1: *Solanum torvum* Swartz	45.0
T_2: Mahyco-9	19.2
T_3: Lalitha	20.4
T_4:Sharpova	19.4
SEm±	0.21
CD @ 5%	0.63
CV %	5.60

Note: Number of replications : 05

4.2 OBSERVATION OF GRAFTED PLANT

4.2.1 Days taken for graft healing

There was no significant difference among the treatments for days taken to graft healing, however days taken for graft healing was 4 to 5 days (Table 4.3). This might be due to better union of vascular tissues at the graft union. The grafted seedlings were transferred to humidified chambers with a relative humidity of 80% for five days to allow the graft union to heal. (Onduso, 2014)

4.2.2 Days taken for graft hardening

There is no significant difference between the treatments, however days taken for graft hardening was 14 to 15 days (Table 4.3). (Onduso, 2014) Under normal condition nursery seedlings took two weeks to heal before transplantation. For grafting there is a need to acclimatize the grafts for better establishment in field.

4.2.3 Graft success (%)

There was no significant difference among the treatments. However, the graft success was recorded about 85 to 87% (Table 4.3), which was reported by Nina and Joze. 2004 in tomato, with the tube grafting method, the survival rate was 88%. It might be due to favorable condition provided in the graft chamber *i.e*, relative humidity of 85-90 % and a temperature range of 21 to 32 ^{0}C with 50 Lux light under the low tunnel or graft chamber.

4.3 GROWTH OBSERVATIONS

4.3.1 Plant height (cm)

At all the intervals all the treatments were significantly different in all the intervals except at 30 DAT, however at 30 DAT grafted Mahyco-9 (T_1) recorded the highest plant height (21.33 cm) followed by grafted Lalitha (T_2) (20.33 cm) and the lowest (13.73) in self rooted Lalitha (T_5). (Table 4.4)

Significant differences in plant height at 60th day were observed (Figure 4.1). Mahyco-9 (T_1) grafted variety gave the highest (50.87 cm) plant height among all the treatments followed by grafted Lalitha (T_2) (49.13) and the lowest (34.53) plant height was recorded in self rooted Lalitha (T_5). Further, self rooted Mahyco-9 (T_4) is on par with self rooted Arka Anand (T_7).

Table 4.3. Days taken for graft healing, graft hardening and percent rate of graft success.

Treatments	Days Taken for Graft Healing	Days taken for graft Hardening	Graft success (%)
T1 :M-9 on *S. torvum* Swartz	4.00	14.00	85.86
T2: Lalitha on *S. torvum* Swartz	4.00	14.29	85.86
T3 : Sharpova on *S. torvum* Swartz	4.33	14.86	86.14
SEm±	0.11	0.12	0.13
CD @ 5%	NS	NS	NS

Note; Number of replications : 07

At 90 DAT grafted Mahyco-9 (T_1) recorded the highest plant height (81.27 cm) followed by grafted Lalitha (T_2) (80.13 cm) which was on par with Mahyco-9 (T_1) and the lowest was recorded (57.87 cm) in self rooted Lalitha (T_5) which was on par with self rooted Sharpova (T_6) (58.07 cm) and control Arka Anand (T_7) (58.93 cm) and same findings was reported by Khah *et al*. 2006 in tomato cv. Big Red onto rootstock Heman.

At 120 DAT grafted Mahyco-9 (T_1) recorded the highest plant height (91.47cm) followed by grafted Sharpova (T_3) (89.20 cm) which was on par with Mayco-9 (T_1) whereas, the lowest (70.80 cm) was recorded in self rooted Lalitha (T_5). Further self rooted Sharpova (T_6) (80.40 cm) which was on par with Arka Anand control (T_7) (79.27 cm). These findings are in line with the findings of Khah (2005) where height of plant was the highest in Rima grafted tomato rootstocks Primavera and the lowest in control.

This result is in accordance with Lee (1994) and Ioannou (2001) who found that grafted plants were taller and more vigorous than self rooted ones.

Initially growth rate was slow in grafted plants, which may be due to slow growth of grafts and slow rate of acclimatization in field condition. During 60^{th}, 90^{th}, and 120^{th} DAT the grafted plant recorded maximum plant height, as *Solanum torvum* Swartz has good root systems which ensured more plant height and vigorous growth, which absorbs more water and nutrients.

The rootstock`s vigorous root system is often capable of absorbing water and nutrients more efficiently than scion roots and serves as a good supplier of endogenous plant hormones (Lee,1994). Cytokinins are the major plant hormones known to be synthesized principally in roots. Eggplant showed significant amount of xylem sap when the plant was cut off after considerable growth. This xylem sap, which is greatly influenced by rootstock even in the same scion cultivars, is known to contain fairly high concentration of minerals, organic substances and plant hormones such as cytokinins and gibberllins which influence the rootstock to absorb the water and nutrients from the soil.

4.3.2 Number of leaves

At all the intervals all the treatments showed significant differences for number of leaves (Table 4.4) however, at 30 DAT grafted Lalitha (T_2) recorded

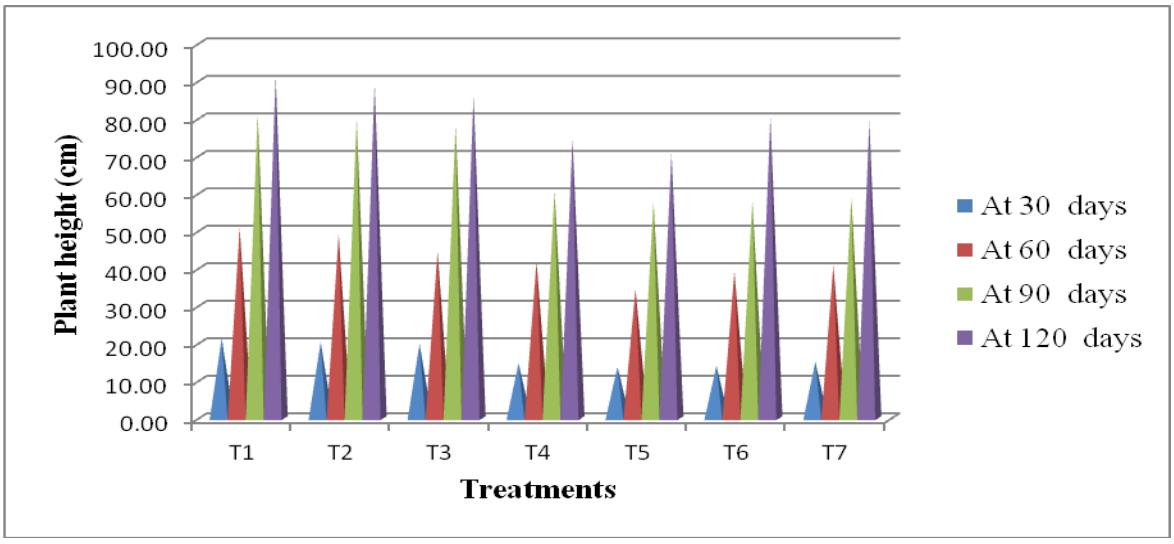

Figure 4.1 Plant height (cm) of hybrid varieties in grafted and non grafted conditions

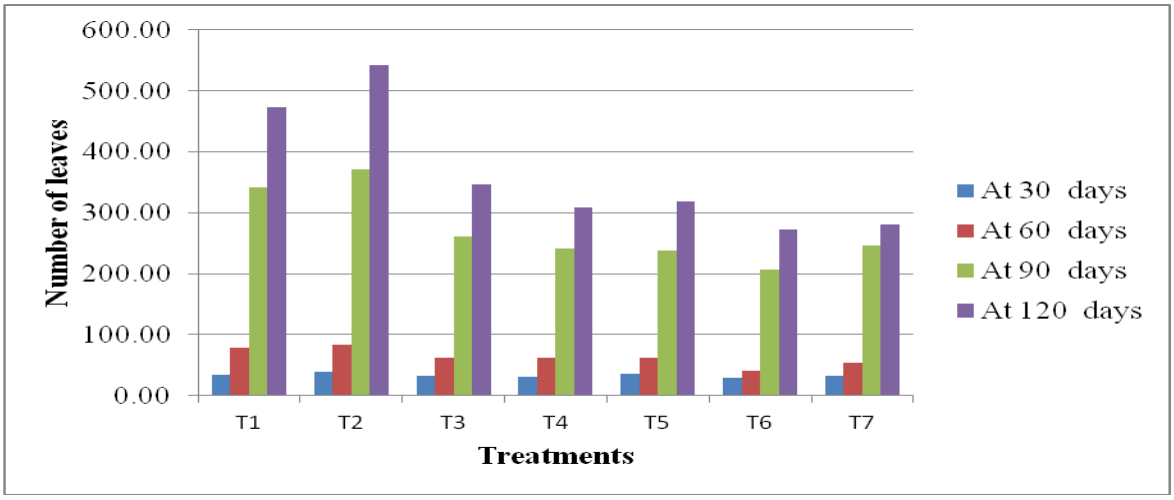

Figure 4.2 Number of leaves of hybrid varieties in grafted and non grafted conditions

the highest (38.33) number of leaves followed by grafted Mahyco-9 (T_1) (33.73) whereas, the lowest number of leaves (29.47) was recorded in self rooted Sharpova (T_6). Further grafted Sharpova (T_3) (31.73), Mahyco-9 (T_4) (31.60) and self rooted Arka Anand (T_7) (31.93) were on par with each other (Figure 4.2).

At 60 DAT grafted Lalitha (T_2) recorded the highest number of leaves (84.20) followed by grafted Mahyco-9 (T_1) (78.33) whereas, self rooted Sharpova (T_6) recorded the lowest number of leaves (41.27). Further grafted Sharpova (T_3) (62.40), self rooted Mahyco-9 (T_4) (61.60) and self rooted Arka Anand (T_7) (61.47) were on par with each other.

At 90 DAT grafted Lalitha (T_2) recorded the highest number of leaves (371.00) as compared to other treatments followed by grafted Mahyco-9 (T_1) (341.80) whereas in self rooted Sharpova (T_6) lowest number of leaves (206.13) was observed. Further self rooted Mahyco-9 (T_4) (241.87) and self rooted Lalitha (T_5) (238.67) and self rooted Arka Anand (T_7) (246.87) were on par with each other.

At 120 DAT grafted Lalitha (T_2) recorded the highest number of leaves (541.93) as compared to other treatments followed by grafted Mahyco-9 (T_2) (473.07) whereas, the lowest number of leaves (273.20) was recorded in self rooted Sharpova (T_6).

Grafting caused an increase in leaf area and leaf number. The vigorous root system of rootstocks is often capable of absorbing water and plant nutrients more efficiently than scion roots and serves as a good supplier of endogenous hormones (Heo, 1991; Jang, 1992; Kato and Lou, 1989). Grafted plants on vigorous rootstocks can uptake more plant nutrients and utilize them more efficiently than non grafted plants (Ruiz and Romero, 1999). Similar results were observed by Sabatino *et al.*, 2016.

4.3.3 Number of branches

At 30, 90 and 120 DAT all the treatments showed significant differences whereas, at 60 DAT there is no significant difference among the treatments for number of branches (Table 4.4).

Table 4.4. Effect of rootstock and hybrid varieties on plant height (cm), number leaves of ad number of branches in grafted and non grafted conditions

	At 30DAT			60 DAT			90 DAT			120 DAT		
Treatments	**Plant height**	**Number of leaves**	**Number of branches**	**Plant height**	**Number of leaves**	**Number of branches**	**Plant height**	**Number of leaves**	**Number of branches**	**Plant height**	**Number of leaves**	**Number of branches**
T_1	21.33	33.73	3.47	50.87	78.33	9.87	81.27	341.80	11.87	91.47	473.07	14.60
T_2	20.33	38.33	4.47	49.13	84.20	11.13	80.13	371.00	13.07	89.20	541.93	15.07
T_3	19.93	31.73	2.60	44.60	62.40	7.60	78.40	261.27	9.13	86.07	347.20	11.27
T_4	14.73	31.60	3.13	41.87	61.60	8.60	60.80	241.87	10.40	74.53	308.00	13.93
T_5	13.73	35.00	3.53	34.53	61.47	8.40	57.87	238.67	10.73	70.80	317.80	12.73
T_6	14.00	29.47	2.40	39.27	41.27	7.40	58.07	206.13	8.20	80.40	273.20	10.20
T_7	15.13	31.93	3.13	40.87	53.27	8.73	58.93	246.87	9.27	79.27	281.47	11.33
SEm±	0.26	0.64	0.04	0.55	2.03	0.15	0.80	4.84	0.20	1.08	2.68	0.21
CD at 5%	0.56	1.40	0.14	1.20	4.43	0.33	1.75	10.50	0.44	2.36	5.85	0.47
CV %	NS	8.22	8.10	5.47	13.64	7.38	5.03	7.53	8.35	5.63	3.14	7.20

T_1 : Mahyco-9 on *Solanum torvum* Swartz, **T_2** : Lalitha on *Solanum torvum* Swartz, **T_3** : Sharpova on *Solanum torvum* Swartz, **T_4** : Mahyco-9 own root, **T_5** : Lalitha own root, **T_6** : Sharpova own root, **T_7** : Arka Anand own root (BWR)

DAT : Days after transplanting, **CV** : Co-efficient of variance, **CD @ 5%** : Critical difference at 0.05 level of significance, **SEm±** : Standard error of mean

At 30 DAT grafted Lalitha (T_2) recorded the highest branches per plant (4.47) followed by grafted Mahyco-9 (T_1) (3.47) whereas, self rooted Sharpova (T_6) recorded the lowest number of branches (2.40) (Figure 4.3).

At 60 DAT grafted Lalitha (T_2) recorded the highest branches per plant (11.13) followed by grafted Mahyco-9 (T_1) (9.87) whereas, the lowest number of branches(7.40) was recorded in self rooted Sharpova (T_6) which is on par with grafted Sharpova (T_3) (7.60).

At 90 DAT grafted Lalitha (T_2) recorded the highest number of branches (13.07) followed by grafted Mahyco-9 (T_1) (11.87) whereas, the lowest number of branches (8.20) was recorded in self rooted Sharpova (T_6). Further, grafted Sharpova (T_3) (9.13) was on par with self rooted Arka Anand (T_7) (9.27) and self rooted Mahyco-9 (T_4) (10.40) was on par with self rooted Lalitha (T_5) (10.73).

At 120 DAT grafted Mahyco-9 (T_1) recorded the highest number of branches (15.07) followed by grafted Lalitha (T_2) (14.60) which was on par with grafted Mahyco-9 (T_1) whereas, the lowest number of branches (10.20) was recorded in self rooted Sharpova (T_6). Further, grafted Sharpova (T_3) (11.27) was on par with self rooted Arka Anand (T_7) (11.33). These findings are in line with the findings of Davis *et al*. (2006).

The influence of the rootstock on the mineral content in aerial plant parts may be attributed to the physical characteristics of the root system, such as lateral and vertical development, which result in enhanced uptake of water and minerals. The vigorous root system of the rootstock enhanced better growth of scion which was resulted in more number of branches in grafted plants (Salehi-Mohammadi *et al*., 2009) these results are in close conformity with Davis *et al*., 2006.

4.3.4 Number of flowers

All the treatments were significantly different at all stages of growth (Table 4.5). At 30 DAT grafted Mahyco-9 (T_1) recorded the highest number of flowers (11.93) followed by grafted Lalitha (T_2) (11.80) which was on par with grafted Mahyco-9 (T_1) whereas, in self rooted Sharpova (T_6) recorded the lowest number of flowers (9.67). Further self rooted Arka Anand (T_7) (10.13) was on par with self rooted Lalitha (T_5) (10.27) whereas, grafted Sharpova (T_3) (9.60),

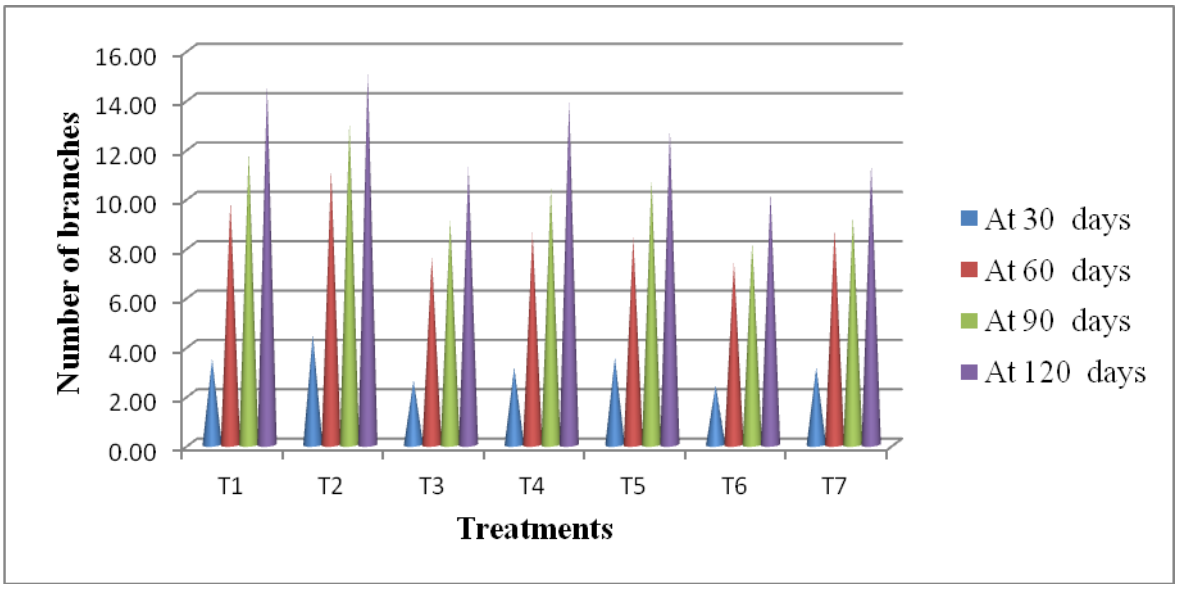

Figure 4.3 Number of branches of hybrid varieties in grafted and non grafted conditions

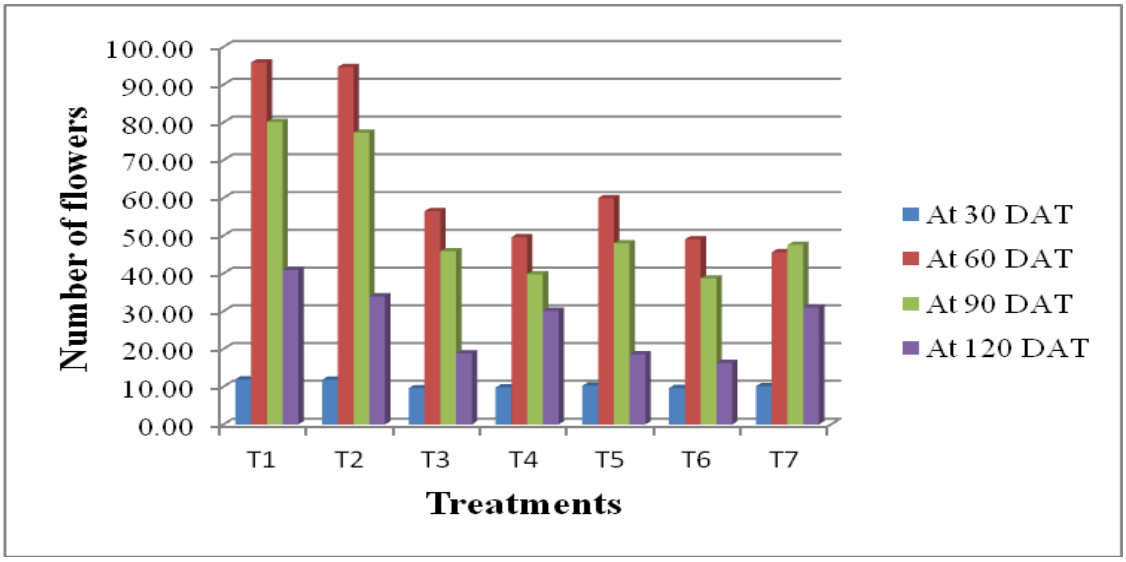

Figure 4.4 Number of flowers of hybrid varieties in grafted and non grafted conditions

self rooted Lalitha (T_5) (9.80) and self rooted Sharpova (T_6) (9.67) were on par with one another.

At 60 DAT grafted Mahyco-9 (T_1) recorded the highest number of flowers (95.87) followed by grafted Lalitha (T_2) (94.67) and were found on par to one another whereas, in self rooted Arka Anand (T_7) the lowest number of flowers (45.60) was recorded (Figure 4.4). Further self rooted Mahyco-9 (T_4) (49.60) was on par with self rooted Sharpova (T_6) (49.00).

At 90 DAT grafted Mahyco-9 (T_1) recorded the highest number of flowers (80.13) followed by grafted Lalitha (T_2) (77.27) whereas, in self rooted Sharpova (T_6) the lowest no. of flowers (38.67) was recorded which showed on par results with self rooted Mahyco-9 (T_4) (39.80).

At 120 DAT grafted Mahyco-9 (T_1) recorded the highest number of flowers (40.87) followed by grafted Lalitha (T_2) (33.93) whereas, the lowest number of flowers (16.27) was recorded in self rooted Sharpova (T_6). Further, grafted Sharpova (T_3) (18.80) shown on par results with self rooted Lalitha (T5) (18.60). These results agreed with the findings of Mohamed *et al*. (2012).

Sex expression and flowering are controlled by plant hormones. The rootstock-scion combination may alter amount of hormones produced in grafted plants which resulted in maximum number of flowers in grafted plants than self rooted ones (Salehi-Mohammadi *et al*., 2009).

4.3.5 Days taken for 50% flowering and full flowering

In days taken for 50 per cent flowering, the differences among the treatments were not significant (Table 4.5) however, an average of 43 to 48 days were recorded for 50% flowering after transplanting whereas, Lalitha grafted (T_2) and own rooted (T_5) took the lowest number of days (43.33) and Arka Anand (T_7) took the highest number of days (48.49). However on an average all the treatments took 45 days after transplanting for 50 per cent flowering.

For 100 per cent flowering the treatments were significantly different whereas, self rooted Lalitha (T_5) recorded the lowest (54.33) number of days to full bloom followed by Lalitha grafted (T_2) (55.67) whereas, self rooted Arka Anand (T_7) took the highest number of days (68.67) for 100% flowering. Further,

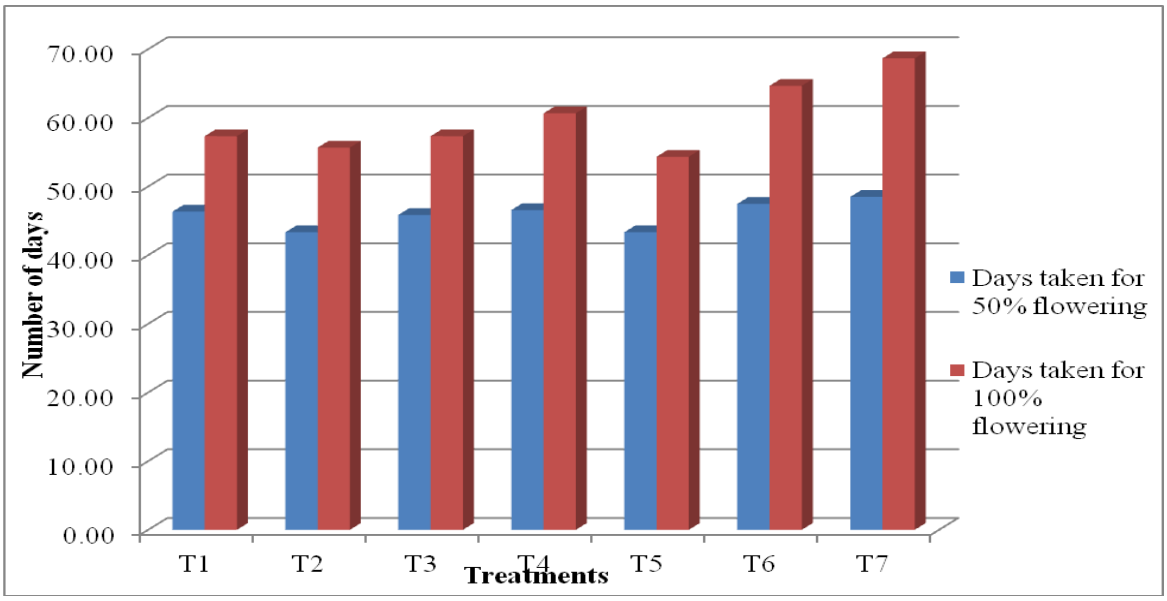

Figure 4.5 Days taken for 50 % and 100 % flowering of hybrid varieties in grafted and non grafted conditions

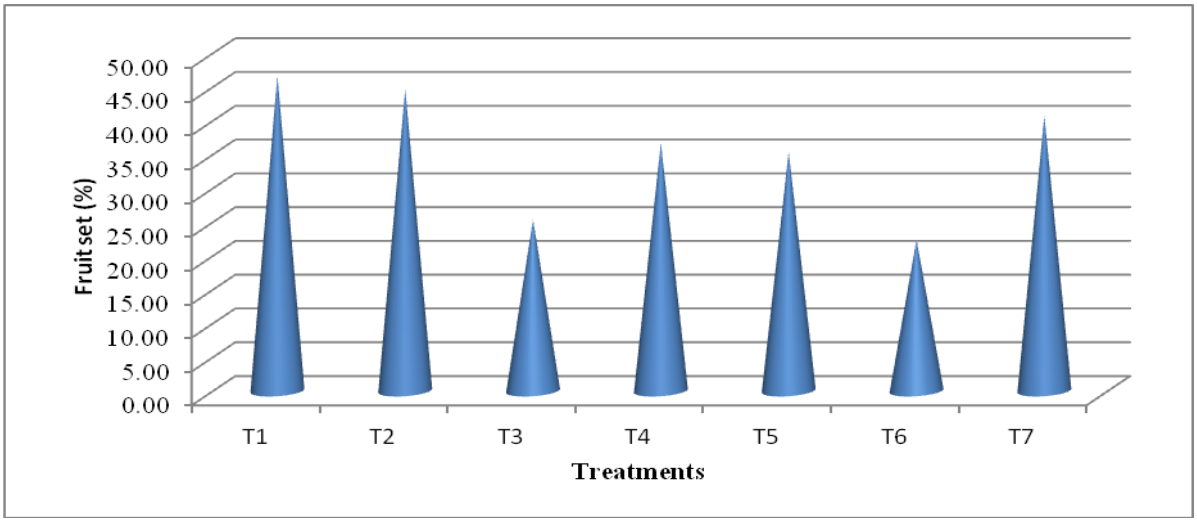

Figure 4.6 Fruit set (%)hybrid varieties in grafted and non grafted conditions

Table 4.5. Effect of rootstock and hybrid varieties on flowering characters and fruit set (%) in grafted and non grafted conditions

Treatments	Number of Flowers				Days taken for 50 % flowering	Days taken for 100% Flowering	Fruit set percentage
	30	60	90	120			
T_1	11.93	95.87	80.13	40.87	46.33	57.33	46.67
T_2	11.80	94.67	77.27	33.93	43.33	55.67	44.67
T_3	9.60	56.47	45.87	18.80	45.87	57.33	25.33
T_4	9.80	49.60	39.80	30.13	46.57	60.67	36.67
T_5	10.27	59.93	48.00	18.60	43.33	54.33	35.33
T_6	9.67	49.00	38.67	16.27	47.47	64.67	22.33
T_7	10.13	45.60	47.53	31.00	48.49	68.67	40.67
SEm±	0.17	0.67	0.68	0.51	0.65	51.00	0.79
CD at 5%	0.38	1.46	1.47	1.11	NS	1.12	1.72
CV %	7.04	4.42	5.32	7.98	5.87	3.64	9.30

T_1 : Mahyco-9 on *Solanum torvum* Swartz, **T_2** : Lalitha on *Solanum torvum* Swartz, **T_3** : Sharpova on *Solanum torvum* Swartz, **T_4** : Mahyco-9 own root, **T_5** : Lalitha own root, **T_6** : Sharpova own root, **T_7** : Arka Anand own root (BWR)

DAT : Days after transplanting, **CV** : Co-efficient of variance, **CD @ 5%** : Critical difference at 0.05 level of significance, **SEm±** : Standard error of mean

grafted Mahyco-9 and Sharpova (T_3) showed on par results with each other *i.e.*, 57.33 days for full blooming (Figure 4.5).

Flowering is earlier in the self rooted plants as compared to grafted plants which might be due to the fact that grafting caused stress and delayed flower formation. As grafted plants needs time to acclimatize in field condition where formation of graft union delays the early establishment of plant which may affect the reproductive organs without effecting vegetative growth in the grafted plants at early stages, later, grafted plants significantly influenced the flowering because of wild habit and vigorous root system of rootstock as wild cultivars have gregarious flowering nature (Madhur *et al*., 2009). Vigorous plants by grafting extended the growth period and luxurious growth and delayed flowering.

4.3.6 Fruit set percentage

Significant differences were found among the treatments (Table 4.5). Brinjal has heterostyly flowering behavior (Long style, medium style, short style and pseudo short style) and fifty flowers were tagged randomly to get set percentage. Among all the treatments, the highest fruit set (46.67 %) was recorded in grafted Mahyco-9 (T_1) followed by grafted Lalitha (T_2) (44.67 %) whereas, self rooted Sharpova (T_6) recorded the lowest fruit set percentage (22.33 %). Further, self rooted Mahyco-9 (T_4) (36.67 %) was on par with self rooted Lalitha (T_5) (35.33 %) (Figure 4.6). These results are in line with the findings of Sanjeev *et al*. (2016).

It might be due to hormonal signalling in rootstock-scion interactions which have a greater impact on flowering and fruit setting. Flower inducing substances were controlled by photoperiod and the graft union facilitates the early movement of flower inducing substances thereby enhanced the fruit set percentage. Similar findings were observed by Sanjeev *et al*., 2016 in grafted brinjal.

4.3.7 Leaf area (cm^2)

All the treatments were significantly different (Table 4.6) whereas, grafted Mahyco-9 (T_1) recorded the highest leaf area (166.29 cm^2) followed by grafted Lalitha (T_2) (157.04 cm^2) and the lowest leaf area (109.19 cm^2) was recorded in

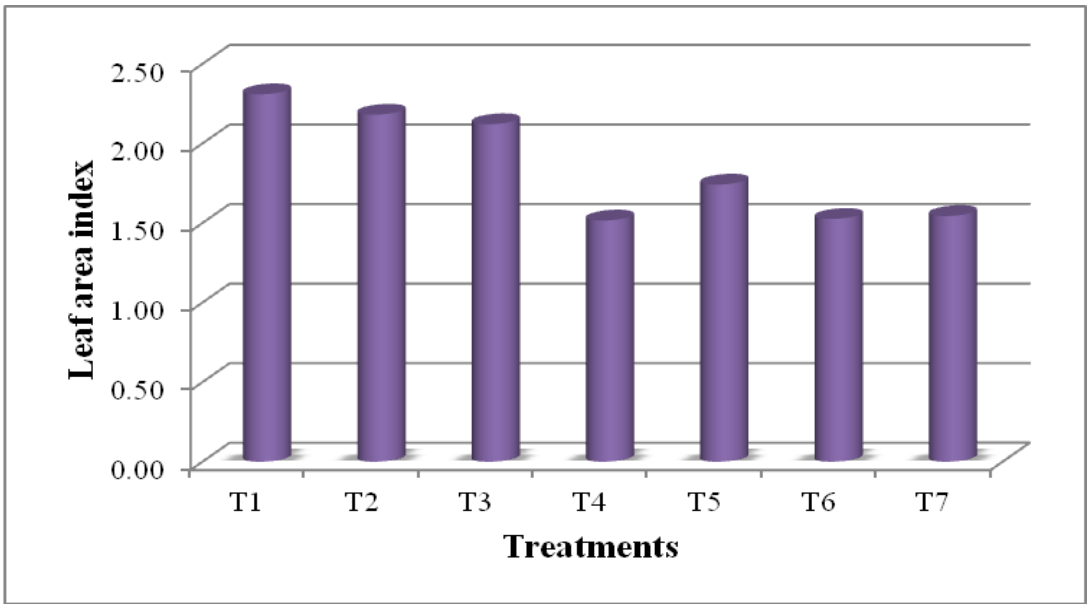

Figure 4.7 Leaf area index of hybrid varieties in grafted and non grafted conditions

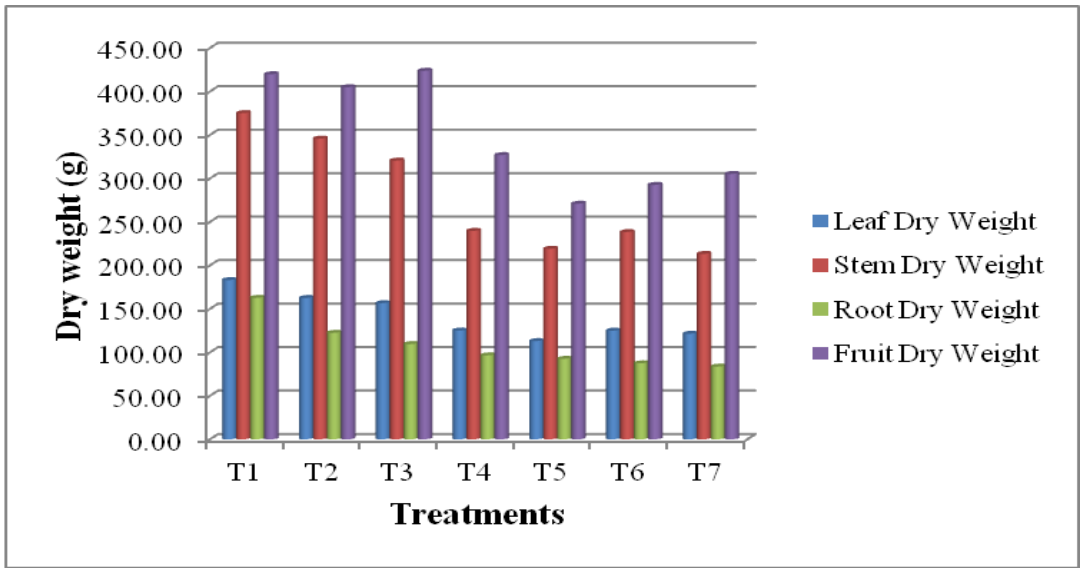

Figure 4.8 Dry weight of leaf, stem, root and fruit (g) of hybrid varieties in grafted and non grafted conditions

Table 4.6. Effect of rootstock and hybrid varieties leaf area (cm^2), LAI, leaf dry weight (g), stem dry weight (g), root dry weight (g) and fruit dry weight (g) in grafted and non grafted conditions

Treatments	Leaf Area (cm^2)	LAI	Leaf Dry Weight (g)	Stem Dry Weight (g)	Root Dry Weight (g)	Fruit Dry Weight (g)
T1	166.29	2.31	183.27	375.33	162.80	420.00
T2	157.04	2.18	162.63	345.90	122.60	405.00
T3	152.74	2.12	156.73	320.67	109.67	424.00
T4	109.19	1.52	125.20	239.87	96.65	327.00
T5	125.42	1.74	113.07	219.20	92.73	271.00
T6	109.89	1.53	125.07	238.57	87.53	292.67
T7	111.18	1.54	121.47	213.33	83.73	305.33
SEm±	2.82	0.04	2.81	11.23	3.16	8.35
CD @ 5%	6.15	0.09	6.12	24.48	6.88	18.18
CV %	9.39	9.39	8.44	17.08	12.41	7.22

T_1 : Mahyco-9 on *Solanum torvum* Swartz, **T_2** : Lalitha on *Solanum torvum* Swartz, **T_3** : Sharpova on *Solanum torvum* Swartz, **T_4** : Mahyco-9 own root, **T_5** : Lalitha own root, **T_6** : Sharpova own root, **T_7** : Arka Anand own root (BWR)
DAT : Days after transplanting, **CV** : Co-efficient of variance, **CD @ 5%** : Critical difference at 0.05 level of significance, **SEm±** : Standard error of mean

self rooted Mahyco-9 (T_4). Further, self rooted Mahyco-9 (T_4) (109.19 cm^2), Sharpova (T_6) (109.89 cm^2) and Arka Anand (T_7) (111.18 cm^2) were on par with one another. Khah (2005) concluded that the highest leaf area was recorded in Rima grafted tomato rootstocks Primavera and the lowest was recorded in control.

Similarly, grafted Mahyco-9 (T_1) recorded the highest leaf area index (2.31) followed by grafted Lalitha (T_2) (2.18) and the lowest leaf area (1.52) was recorded in self rooted Mahyco-9 (T_4) (Figure 4.7).

It has been reported that grafting promotes vegetative growth at different levels dependent on rootstock characteristics (Yetisir and Sari, 2003). Promoted vigor and vegetative growth was explained by the resistance to soilborne diseases (Lee 1994). Grafting caused an increase in leaf area and leaf number. The vigorous root system of rootstocks is often capable of absorbing water and plant nutrients more efficiently than scion roots and serves as a good supplier of endogenous hormones (Heo, 1991; Jang, 1992; Kato and Lou, 1989). Grafted plants on vigorous rootstocks can uptake more plant nutrients and utilize them more efficiently than non grafted plants (Ruiz and Romero, 1999).

4.3.8 Dry matter accumulation and partitioning at final harvest

All the treatments of dry matter partitioning were significantly different (Table 4.6). Overall performance was better in grafted plants whereas, leaf dry weight grafted Mahyco-9 (T_1) gave highest dry matter of 183.27 g per plant followed by grafted Lalitha (T_2) (162.63 g) and the lowest leaf dry weight (113.07 g) was recorded in self rooted Lalitha (T_5) which was on par with self rooted Arka Anand (T_7) (121.47). Further, self rooted Arka Anand (T_7) (121.47), self rooted Mahyco-9 (T_4) (125.20) and Sharpova (T_6) (125.07) showed on par results (Figure 4.8).

For stem dry weight all treatments shown significant difference whereas, grafted Mahyco-9 (T_1) recorded the highest dry matter of 375.33 g per plant followed by grafted Lalitha (T_2) (345.90 g) which was on par with grafted Sharpova (T_3) (320.67 g) whereas, the lowest stem dry weight (213.33 g) was recorded in self rooted Arka Anand (T_7). Further, all the self rooted treatments did not show any significant differences.

For root dry weight treatments shown significant difference wherein, grafted Mahyco-9 (T_1) recorded the highest dry matter of 162.80 g per plant followed by grafted Lalitha (T_2) (122.60 g) whereas the lowest root dry weight (83.73 g) was recorded in self rooted Arka Anand (T_7). Further, self rooted Mahyco-9 (T_4) (96.65 g), self rooted Lalitha (T_5) (92.73 g) and self rooted Sharpova (T_6) (87.53 g) were on par with one another whereas, self rooted Lalitha (T_5) (92.73 g), self rooted Sharpova (T_6) (87.53 g) and self rooted Arka Anand (T_7) (83.73 g) showed on par with one another in root dry matter.

For fruit dry weight treatments shown significant difference whereas, grafted Sharpova (T_3) recorded the highest dry matter of 424.00 g per plant followed by grafted Mahyco-9 (T_1) (420.00 g) and these were on par with grafted Lalitha (T_2) (405.00 g) whereas, the lowest dry weight was recorded (271.00 g) in self rooted Lalitha. Self rooted Arka Anand (T_7) (305.33 g) was on par with self rooted Sharpova (T_6) (292.67 g).

Grafted plants had a higher accumulation of dry matter as compared to non grafted plants. As the vigorous root system of rootstock influenced on the scion by absorbing the water and nutrient uptake, thereby increased the photosynthetic efficiency of plants which lead to increased vegetative growth thereby increased the biomass production. These findings are in close conformity with Romano and Paratore (2001), Khah (2005) and Khah *et al*. (2006).

4.4 YIELD PARAMETERS

The major yield contributing traits observed in grafted plants of all the three cultivars were production of higher number of fruits per plant and enhancement of cropping period to take more number of harvests from these plants as compared to non-grafted plants.

4.4.1 Number of fruits per plant

Treatments had significantly effect on number of fruits per plant (Table 4.7). However, grafted Mahyco-9 (T_1) recorded maximum number of fruits per plant (39.33) followed by grafted Lalitha (T_2) (32.67) and minimum number of fruits (12.67) was recorded in self rooted Sharpova (T_6) (Figure 4.9).

The differences in plant development and fruit yield could be attributed mainly to the root system functionality, which is better for grafted than non

grafted plants, especially when soil problems are present, allowing for better water and nutrient uptake and consequently, higher photosynthetic and growth rates compared to non grafted plants (Ruiz *et al*., 1997).

4.4.2 Average fruit weight (g)

Treatments showed significant differences for average fruit weight. Among various treatments (Table 4.7), grafted Sharpova (T_3) recorded the highest average fruit weight (260.00 g) per fruit followed by self rooted Sharpova (T_6) (233.33 g) whereas, the lowest fruit weight was recorded in Arka Anand (T_7) (91.33 g) (Figure 4.10).

Eggplant hybrids grafted onto rootstock *Solanum torvum* Swartz showed maximum number of fruits and higher fruit weight which might be due to increase in the xylem sap and hormone concentrations in eggplants grafted onto vigorous rootstock which are capable of absorbing water and nutrients more efficiently than scion roots which influenced the fruit quality in terms of number, shape *etc*. Further, the same treatments resulted with highest plant height, number of fruits and number of leaves ultimately resulted in maximum fruit production and enhanced the quality of fruit. Uptake of macronutrients such as phosphorous and nitrogen was enhanced by grafting (Ruiz and Romeo, 1999). Similar results were observed by Bletsos *et al*. (2003), Sabatino *et al*. (2016) and Ruiz *et al*. (1997).

4.4.3 Per plant yield (kg/plant) and fruit yield (t/ha)

All the treatments shown significant differences (Table 4.7). Among the treatments grafted Mahyco-9 (T_1) recorded the highest yield per plant (4.23 kg) followed by grafted Lalitha (T_2) (3.97 kg) which were on par with each other and the lowest yield (2.73 kg per plant) was recorded in Self rooted Lalitha (T_5) (Figure 4.11).

Similar trend was observed with respect to fruit yield per hectare (Table 4.7). Among the treatments, grafted Mahyco-9 (T_1) recorded significantly highest yield per hectare (58.67 t/ha) followed by grafted Lalitha (T_2) (54.12 t/ha) and the lowest yield was recorded (37.33 t/ha) in self rooted Lalitha (T_3).

The higher yield obtained from grafted plants may be the result of improvement in the nutritional status and higher CO_2 and soil water assimilation.

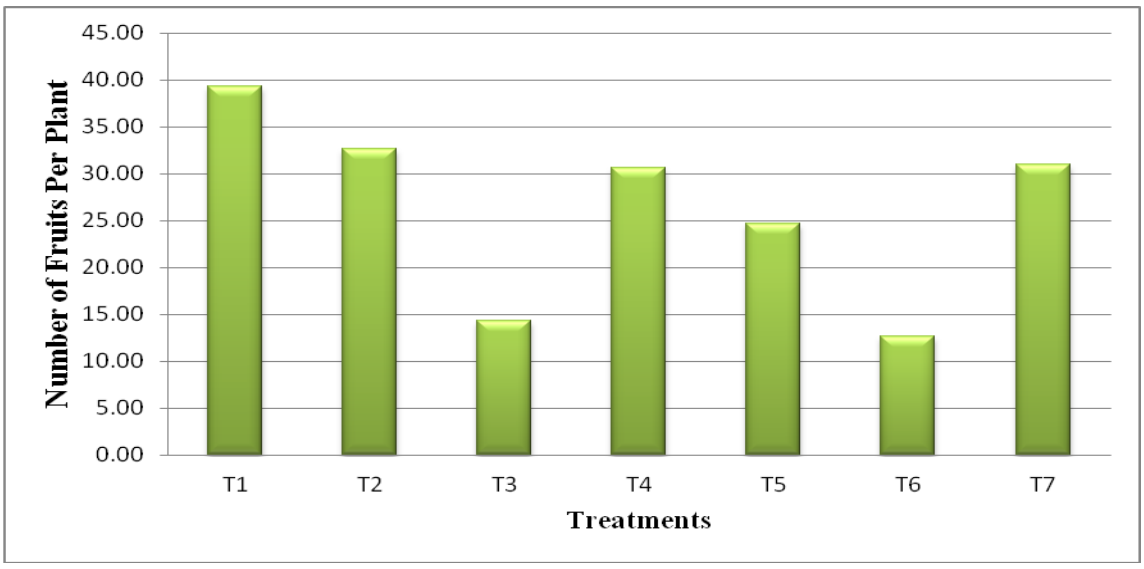

Figure 4.9 Number of fruits per plant of hybrid varieties in grafted and non grafted conditions

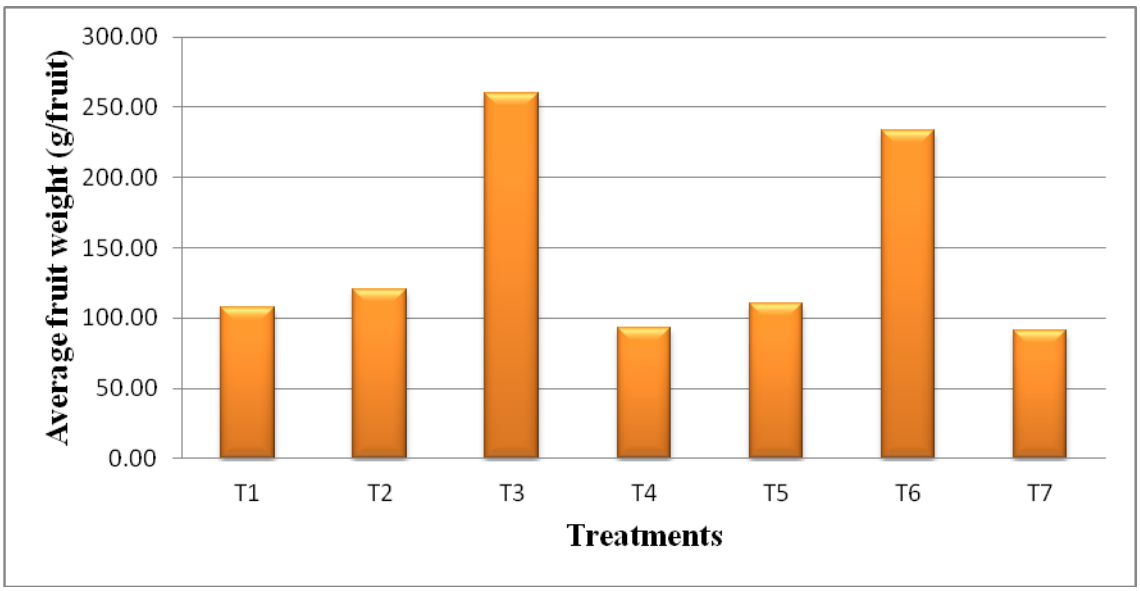

Figure 4.10 Average fruit weight (g/fruit) of hybrid varieties in grafted and non grafted conditions

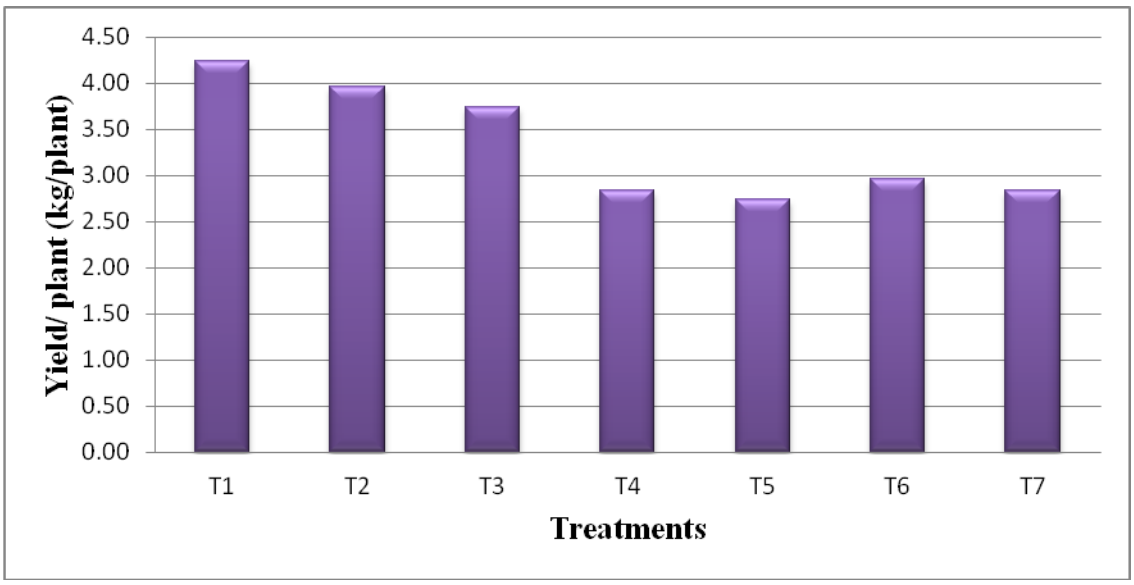

Figure 4.11 Yield per plant (kg) of hybrid varieties in grafted and non grafted conditions

(Colla *et al*., 2008; Prioetti *et al*., 2008), which result in increase in the production of endogenous hormones (Zijlstra *et al*., 1994) which enhanced water and nutrient uptake (Bletsos, 2003; Yetisir and Sari, 2004).

4.5 FRUIT CHARACTER

4.5.1 Fruit shape and colour

There were no changes in fruit shape and colour of fruits obtained from grafted plants when compared to the fruits obtained from non grafted plants. As the traits *viz*., shape and colour predominantly governed by scion genotype and little alerted by environmental or cultural factors. Hence, the effect of grafting there upon has been circumstantial and mostly minimal (Marios *et al*. 2017). Owing to the utilization of vigorous root system of the rootstock grafted plants usually showed increased uptake of water and minerals when compared to self rooted plants but does not affected the shape and colour of fruits as it is controlled by genotype of scion but not the genotype of rootstock (Turhan *et al*., 2011).

4.5.2 Fruit diameter (cm)

Treatments differed significantly for fruit diameter (Table 4.7). Among the treatments, grafted Sharpova (T_3) recorded maximum fruit diameter of about 7.00 cm followed by self rooted Sharpova (T_6) (5.33) and minimum (3.27 cm) was recorded in Self rooted Arka Anand (T_7). Similar results were reported by Turhan *et al*. (2011) and Lee (1994).

4.5.3 Fruit length (cm)

All the treatments were significant differed for fruit length (Table 4.7). The highest fruit length was recorded (23.33 cm) by grafted Mahyco-9 (T_1) followed by self rooted Mahyco-9 (T_4) (20.70 cm) and the lowest fruit length (8.17 cm) was recorded in Self rooted Lalitha (T_5). Further grafted Lalitha (T_2) (9.47 cm) was on par with self rooted Lalitha (T_5) (8.17 cm) and grafted Sharpova (T_3) (20.70 cm), self rooted Mahyco-9 (T_4) (20.27 cm) and Arka Anand (T_7) (19.07 cm). It may be due to changes in the concentration of growth regulators induced by the brinjal rootstock which lead to increased length of the fruit. The results are in line with Francisco *et al*. (2014) and Pardeep *et al*. (2016).

4.5.4 Fruit volume (ml)

All the treatments were significantly differed (Table 4.7). The highest fruit volume (210 ml) was recorded by grafted Sharpova (T_3) followed by self rooted Sharpova (T_6) (205 ml) whereas, the lowest volume was recorded in self rooted Arka Anand (T_7) and self rooted Mahyco-9 (T_4) (65 ml).

The characteristics of the scion influence the size, quality and yield of the grafted plants. Genetically the fruit volume of Sharpova is higher as reported the highest volume in grafted condition. Similar results were reported by Davis *et al*. (2008).

4.6 COST OF GRAFT PLANT PRODUCTION

Cost of graft production including polyhouse construction and labour charges for sowing, grafting and maintenance of individual grafts for Mahyco-9 and Lalitha was Rs. 3.75/- and for Sharpova graft it took Rs. 9.35/- per graft and data is presented in Appendix-IV. The higher cost of Sharpova graft was because of high cost of seed.

4.7 PER CENT OF BACTERIAL WILT (%)

There was no pathogenic infection found in the experiment during the period of study.

Table 4.7. Effect of rootstock and hybrid varieties on yield parameters and fruit characters in grafted and non grafted conditions

	Yield parameters				Fruit Characters		
Treatments	**Number of Fruits Per Plant**	**Average Fruit Weight (g/fruit)**	**Yield per hectare (t/ha)**	**Yield per plant (kg/plant**	**Fruit Length**	**Fruit Diameter**	**Fruit Volume**
T_1	39.33	107.33	58.67	4.23	23.33	3.40	70.00
T_2	32.67	120.33	54.12	3.97	9.47	5.33	80.00
T_3	14.33	260.00	51.33	3.73	20.27	7.00	210.00
T_4	30.67	92.67	39.25	2.83	20.70	3.30	65.00
T_5	24.67	110.33	37.33	2.73	8.17	4.83	75.00
T_6	12.67	233.33	41.10	2.97	16.73	6.61	205.00
T_7	31.00	91.33	39.50	2.83	19.07	3.27	65.00
SEm±	0.55	1.88	0.81	0.08	0.20	0.07	1.91
CD at 5%	1.21	4.09	1.76	0.18	0.44	0.14	4.16
CV %	8.86	5.50	7.47	10.27	5.12	5.78	7.36

T_1 : Mahyco-9 on *Solanum torvum* Swartz, **T_2** : Lalitha on *Solanum torvum* Swartz, **T_3** : Sharpova on *Solanum torvum* Swartz, **T_4** : Mahyco-9 own root, **T_5** : Lalitha own root, **T_6** : Sharpova own root, **T_7** : Arka Anand own root (BWR)

DAT : Days after transplanting, **CV** : Co-efficient of variance, **CD @ 5%** : Critical difference at 0.05 level of significance, **SEm±** : Standard error of mean

Chapter V

Summary and Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

Grafting increases yield since plants have strong root system and increased photosynthesis. It was believed that grafting is an effective horticultural approach to improve fruit yield and quality under adequate growth conditions. The positive effect of the rootstock on fruit yield and quality may be dependent on both the shoot and root genotypes making it a difficult task to select the optimum rootstocks. So considering the advantages of grafted plants, study was conducted on "Evaluation of rootstock and scion in brinjal (*Solanum melongena* L.) for growth, yield and fruit quality".

Graft success was recorded about 85 to 87% in all the rootstocks and scion combinations, on an average it was reported 85%. Overall vegetative growth was highest in grafted mahyco-9 followed by Lalitha. Plant height (91.47 cm) was maximum in grafted Mahyco-9 (T_1) further, minimum plant height (70.80 cm) was observed in self rooted Lalitha. The highest number of branches was recorded with grafted Lalitha (15.07) whereas, in self rooted Sharpova the lowest (10.20) were recorded. Number of leaves was maximum in grafted Lalitha (T_2) (541.93) whereas, self rooted Sharpova it was minimum number of branches (273.20). Leaf area was recorded maximum (166.29 cm^2) in grafted Mahyco-9 (T_1) and minimum leaf area (109.19 cm^2) was recorded in self rooted Mahyco-9 (T_4).

Flowering behaviour was good in grafted Mahyco-9 followed by grafted Lalitha. Days taken for 50% flowering self rooted and grafted Lalitha (T_2) took minimum number of days (43.33) whereas, Arka Anand (T_7) took maximum number of days (48.79) for 50% flowering. Further, for 100% flowering self rooted Lalitha (T_5) took minimum number of days (54.33) and Arka Anand took maximum number of days (68.67) to full bloom. Fruit set was recorded maximum (46.67%) in grafted Mahyco-9 and minimum fruit set (22.33%) was observed in self rooted Sharpova.

In overall yield, grafted mahyco-9 was recorded maximum yield followed by grafted Lalitha, whereas, self rooted treatments were recorded lower yield as

compared to grafted cultivars. Grafted mahyco-9 (T_1) had the highest number of fruits per plant (39.33) whereas, the lowest fruit number (12.67) was recorded in self rooted Sharpova (T_6). Further, grafted Sharpova (T_3) recorded the highest fruit weight (260.00 g) and the lowest (91.33 g) was recorded in self rooted Arka Anand (T_7). Further, grafted mahyco-9 (T_1) recorded the maximum yield (4.23 kg/plant) whereas, the minimum (2.73 kg/plant) was recorded in self rooted Lalitha (T_5). Similar trend was observed with respect to fruit yield per hectare. Among the treatments, grafted Mahyco-9 (T_1) recorded significantly highest yield per hectare (58.67 t/ha) followed by grafted Lalitha (T_2) (54.12 t/ha) and the lowest yield was recorded (37.33 t/ha) in self rooted Lalitha (T_3).

In overall fruit characters grafted Mahyco-9 was recorded good compared to other grafted combinations. The highest fruit length was recorded (23.33 cm) in grafted Mahyco-9 (T_1) and the lowest fruit length (8.17 cm) was recorded with self rooted Lalitha. Fruit diameter was maximum in grafted Sharpova (7.00 cm) (T_3) and minimum fruit diameter was recorded in (3.27 cm) self rooted Arka Anand (T_7). Fruit volume was maximum (210 ml) in grafted Sharpova (T_3) whereas, minimum fruit volume (65 ml) was recorded in self rooted Arka Anand (T_7) and self rooted Mahyco-9 (T_4).

Leaf, stem and root dry weight was maximum in Mahyco-9 (T_1) (122.27 g, 249.60 g and 162.80 g respectively) whereas, minimum Leaf and stem dry weight (30.07 g and 83.53 g respectively) was recorded in self rooted Sharpova (T_6) and root dry weight (40.40 g) was recorded in Arka Anand (T_7). The highest fruit dry weight (128.67 g) was recorded in grafted Sharpova (T_3) and self rooted Lalitha (T_5) recorded the lowest fruit dry weight (32.67 g).

CONCLUSIONS

Grafting technology has a potential in promotion of cultivation in non-traditional and fragile agro-eco system. Grafting is a rapid alternative tool to increase biotic and abiotic stress tolerance of fruit vegetables. Since grafting gives increased vigour to crops, it will be useful in the low input sustainable horticulture of the future.

In India, where the vegetable cultivation is still carried out mostly by traditional methods and modern cultivated techniques are limited, the grafting technique could help in solving many problems.

Overall the fruit character (fruit index) was recorded the highest in scion sharpova when grafted on *Solanum torvum* Swartz. Economic yield was obtained in grafted Mahyco-9 followed by grafted Lalitha.

The effect of rootstock on the agronomic characteristics of the three brinjal cultivars, allow a series of considerations on the feasibility of this technique in the cultivars tested. The grafted plants produced maximum yield than non-grafted ones when grown for the potential economic value. Wild rootstock varieties if used in combination with good agricultural practices and field hygiene can greatly reduce effect of the disease and disease spread.

FUTURE LINE OF WORK

- To evaluate more scions and rootstocks so as to determine the effect of grafting technique on fruit quality and yield and propose specific combinations of scions and rootstocks according to market demands and soil deterioration and pathogens problems
- To study the effect of different grafting methods to get high rate of graft success
- Studies on costs benefit analysis of using rootstock varieties should be done to compare it with the use of resistant varieties
- Studies to map distribution and occurrence of bacterial wilt strains in the country should be carried to predict tolerance of varieties when their strain tolerance range is known
- Further study on the use of wild brinjal as a rootstock but also a source of resistance genes for bacterial wilt as the variety is more adapted to local conditions is recommended

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Appendices

Appendix I: Monthly meteorological data recorded at ICAR-IIHR, Hesaraghatta, Bengaluru during August 2016 to February

Month and year	Temperature (^{o}C)		Relative Humidity (%)		Evaporation(mm)	Wind speed (km/hr)	Rainfall (mm)	Rainy days
	Maximum	Minimum	Average at 7:30 AM	Average at 1:30 PM				
August, 2016	27.00	20.60	80.60	58.10	3.00	3.90	16.50	5
September, 2016	25.20	21.70	80.50	54.50	2.90	4.40	58.00	11
October, 2016	26.00	19.00	58.00	38.00	5.00	2.00	15.00	3
November, 2016	27.00	18.00	64.00	28.00	4.00	2.00	9.00	1
December, 2016	28.00	17.00	73.00	37.00	4.00	2.00	62.00	4
January, 2017	20.80	16.30	72.60	37.60	3.90	2.70	0	0
February, 2017	28.70	15.10	54.62	18.31	6.34	0.83	0	0
Total	**-**	**-**	**-**	**-**	**-**	**-**	**160.50**	**24**
Mean	**26.10**	**18.24**	**69.04**	**38.78**	**4.16**	**2.54**		

Appendices II. Physical and chemical properties of experimental plot soil at (ICAR-IIHR) Bengaluru during 2016 and 2017.

S. No.	Parameter	Values
1	Particle size distribution (%)	
	Sand	62.85
	Silt	10.90
	Clay	26.25
	Textural class	Red sandy loam
2	pH (1: 2.5)	6.10
3	EC (1:2.5) (dSm $^{-1}$)	0.31
4	Organic carbon (g kg $^{-1}$)	1.59
5	Available nitrogen (kg ha^{-1})	257.58
6	Available phosphorus (kg ha^{-1})	59.74
7	Available potassium (kg ha^{-1})	231.5
8	Exch. Ca (c mol (P +) kg $^{-1}$)	12.85
9	Exch. Mg (c mol (P +) kg $^{-1}$)	2.95
10	Sulphur (kg ha^{-1})	12.50
11	DTPA extractable Fe (mg kg^{-1})	9.85
12	DTPA extractable Mn (mg kg^{-1})	2.85
13	DTPA extractable Zn (mg kg^{-1})	1.65
14	DTPA extractable Cu (mg kg^{-1})	1.28

Appendix III: Observation on RH, Temperature & Light inside the graft chamber

	1st Day		2nd Day		3rd Day		4th Day	
Time	**RH (%)**	**T (°C)**	**RH (%)**	**T (°C)**	**RH (%)**	**T (°C)**	**RH (%)**	**T (°C)**
09:30	92.7	22.1	91	24.1	90.2	24	88.8	24.2
10:45	89.2	24	90.2	25.9	82.8	26.4	83.6	28.4
12:00	88.6	26.2	91.1	29.7	80.8	30	83.2	29.8
01:15	86.2	29.7	89.1	30.9	80	32.2	83.2	29.8
02:30	84.5	31.1	89.9	31	80.1	31.7	80.2	32.3
03:45	85.6	31.4	89.1	31.2	82.5	32	82.2	31.9
05:00	85.8	31.1	88.7	31.1	83.1	31.9	81.2	31.6

Light was maintained about 50 L during the healing period.

Appendix-IV: Cost of graft plant production

S.No	Item	Rate (Rs.)	Cost/plant (Paisa)
A	**Construction and labour cost**		
1	Net house structure	Rs.300/sq.m	9
2	Acclimatization chamber construction	Rs.200/sq.m	6
3	Poly propylene seedling trays for scion	10/tray	10
4	Poly propylene seedling trays for stock	10/tray	10
5	Cocopeat for scion tray	Rs.4/kg	5
6	Cocopeat for stock tray	Rs.4/kg	5
7	Labour for Media filling & sowing (scion)	Rs.200/man day. 100trays/day	2
8	Labour for Media filling & sowing (stock)	Rs.250/man day. Rs.250/man day	3
9	Labour for Grafting	Rs.500/man day. 360 grafting/day	140
	Cost of grafting clips	Rs.4/-(10 cycles)	10
10	Labour for acclimatization	Rs.250/man day.	10
11	Labour for maintainance	Rs.250/man day.	10
12	PP chemicals & nutrients	-	5
13	Others		10
	Sub-Total (A)		**235**
B	**Plant material cost (Mahyco 9 & Lalitha)**		
	Cost of brinjal stock seed		5
	Cost of brinjal scion seed (Mahyco 9 & Lalitha) (accounted germination % as 75%)		8
	Cost due to graft failure (15%)		37
	Return to investment and management (30%)		86
	Sub – Total (B)		**136**
	Grand total cost per graft of Mahyco-9 and Lalitha	**A+B**	**371**
C	**Planting cost of Sharpova**		
	Cost of brinjal hybrid Sharapova seed		440

	(accounted germination % as 90%)		
	Cost due to graft failure (15%)		102
	Return to investment and management (20%)		156
	Sub-Total (C)		**698**
	Sub-Total (A)		**235**
	Grand total cost per graft of Sharpova	**A+C**	**935**

Summary: Cost of Mahyco-9 & Lalitha grafts: Rs.3.75/graft & Sharapova grafts: Rs.9.35/graft