ROLE OF CUCURBITACEOUS ROOTSTOCKS ON VEGETATIVE GROWTH, FRUIT YIELD AND QUALITY OF BITTER GOURD (*MOMORDICA CHARANTIA* L.) SCIONS THROUGH GRAFTING

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ABSTRACT

The aim of this study was to determine whether grafting could improve plant growth, yield and quality of bitter gourd through monitoring the changes induced by different rootstocks–scion combinations. Side grafting technique was followed in this experiment. The grafted and non-grafted plants were grown under pandal system. Among the 12 graft combinations, Palee F_1 scion grafted onto pumpkin (*Cucurbita moschata* Duch.ex Poir) rootstock recorded highest values for vegetative and flowering characters *viz.,* vine length at final harvest (856.6 cm), number of primary branches (13.1), days to first female flower appearance (68.3 days), node number to first female flower appearance (25.4) and sex ratio (17.2). The highest values for fruit yield (3.5 kg /per vine), fruit number (27.8) and weight (183.6 g) were also observed in Palee F_1 scion grafted onto pumpkin (*C. moschata* Duch.ex Poir) rootstock without changes in fruit quality parameters *viz., a*scorbic acid and total soluble solids content. Larger leaf area and total dry matter content of the aforementioned graft combination contributed mainly for highest vine length, fruit yield and higher total chlorophyll content. From this study, pumpkin (*C. moschata* Duch.ex Poir) followed by sponge gourd (*Luffa cylindrica* L.) rootstock could be identified as best rootstocks for grafting with bitter gourd scions due to characteristics like graft affinity, compatibility and vigorous root system which help to increase growth, yield and productivity without any quality defeat.

Key words: Grafting, Bitter gourd, Cucurbitaceous rootstocks, Growth, Yield, Quality.

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is one of the important cucurbitaceous vegetables grown in India. Bitter gourd has been identified as one of the potent vegetables for export by Agricultural Processed Food Products and Export Development Authority (APEDA). It is also known for its therapeutic properties and more attention is now being focused on its hypoglycemic properties (Meenakshi, 2002). The crop is cultivated over an area of 80990 ha in India with an annual production of 830450 tonnes and the productivity of 10.25 t ha^{-1}(Anon, 2015-16).

In the recent past, apart from other pathogens and pests, root knot nematode *Meloidogyne incognita* and *Fusarium* wilt (*Fusarium oxysporum*) have become a major threat to bitter gourd cultivation especially in Tamil Nadu. By wounding the roots, root knot nematode also increases the severity of soil borne diseases such as *Fusarium* wilt in bitter gourd. In such cases; chemical pest control is expensive, not always effective and can even harm the environment (Tamilselvi, 2014). The causal organisms may also develop resistance to a particular chemical or they may emerge as new races which may be resistant to chemical control measures. Although alternative pesticides and other physical treatments are being tested and developed, grafting with resistant rootstocks is part of an integrated approach to avoid soil borne diseases (Tamilselvi and Pugalendhi, 2015).

Grafting is a nonchemical alternative approach to reduce the crop damage resulting from soil borne pathogens and to increase plant biotic stress tolerance, which in turn increases crop production. In addition to this, grafted plants tend to give more yields by increasing the economic harvest duration (Mohamed *et al*., 2012). Several studies reported that grafting influenced the plant growth and fruiting characteristics of cucurbitaceous vegetables under normal as well as stress conditions (Mohamed *et al.,* 2012). However to our knowledge, there is no recent research on the effects of grafting on improving yield and yield related characters in bitter gourd. Therefore, the objective of this investigation was to determine the effect of grafting bitter gourd cv. Palee F_1 and CO 1 onto different cucurbitaceous rootstocks and ascertaining the plant growth, flowering characteristics, fruit yield and quality.

MATERIALS AND METHODS

Experimental site and growing conditions: The experiments were conducted at the experimental farm of the Department of Vegetable Crops, Tamil Nadu Agricultural University, Coimbatore, India (11^0 N latitude, 77^0 E longitudes and an altitude of 426.26 m above mean sea level) during the period June 2011 to May 2013.

Scion and rootstocks: The hybrid, Palee F_1 from East West Seed Company, Philippines which is popularly cultivated F_1 hybrid in Tamil Nadu and the other one is CO 1, a cultivar from Tamil Nadu Agricultural University (TNAU) that were used as scions and the rootstocks *viz.,* Wild bitter gourd (*Momordica charantia* var. *muricata)*, colocynth (*Citrullus colocynthis),* African horned cucumber *(Cucumis metuliferous),* fig leaf gourd (*Cucurbita ficifolia)*, pumpkin (*Cucurbita moschata* Duch.ex Poir*)*, zucchini squash *(Cucurbita pepo* L.*),* bottle gourd *(Lagenaria siceraria* Standl.*)*, ash gourd *(Benincasa hispida* Cogn.*),* ridge gourd *(Luffa acutangula* Roxb.*)* and sponge gourd *(Luffa cylindrical* L.*)* were collected from different parts of Tamil Nadu and India. These seeds were used for evaluation and seed production during June, 2011. The produced seeds were used for grafting study.

Grafting: Grafting experiment was done during November 2011 to June 2012. Grafting was performed under shade net house allowing only 25 per cent sunlight. In this structure relatively low temperature with high humidity was maintained in comparison with the outside environment. The relative humidity inside the shade net house ranged between 60 and 70 per cent and temperature between 25 and 27°C. The grafting method adopted in this study was side grafting. Immediately after grafting, the plants were transferred to a healing chamber or mist chamber and kept for seven days at RH >95%, 29ºC and darkness (shaded conditions) for graft union healing. Relative humidity was reduced gradually for acclimatization. Seven days after grafting, the plants were transferred to shade net house for primary hardening and acclimatization. Then seven days later, the grafted seedlings were transplanted in the main field. The graft success percentage was assessed at 15, 30 and 45 days after grafting (DAG).

Performance evaluation of grafted and non-grafted plants: Preliminary evaluation of grafted and non-grafted plants was done during July 2012- February 2013. The soil was a sandy loam with pH 7.5. Prior to planting the soil was ploughed three times. Manures, Fertilizers and bio-fertilizers were added to the soil before the last plough as follows. 1) Farm Yard Manure (FYM) at the rate of 500 g per pit. 2) Azospirillum and Phosphobacteria at 2 kg/ha^{-1} each, were mixed with 50 kg of FYM. 3) Commercial fertilizers *viz.,* Urea, Super phosphate and Muriate of potash were used as sources of N, P and K, respectively. Half dose of nitrogen (50 kg ha^{-1}) along with entire quantity of P and K (50 kg ha^{-1}) were incorporated well at the time of last ploughing. Remaining dose of nitrogen (50 kg ha^{-1}) was applied in splits on 30 and 45 days after planting (DAP). Thirty days old seedlings (scions) and grafted seedlings (15 days after grafting) of two cultivars (Palee F_1 and CO 1) were transplanted at 2 x 1 square meter apart under pandal system.

Plants were trained over the pandal by following single line trellis system after the development of lateral branches. The main stem were vertically supported by jute threads 10 cm from the ground level and tied to iron wires distributed along each row. The shoots that rose below the pandal were eliminated. Recommended package of practices of TNAU was followed to grow a successful crop of bitter gourd (Anon, 2009). During the growing season the parameters *viz.,* vine length (cm) at 30 and 60 days after grafting and at the time of final harvest, number of primary branches, days to first female flower appearance, node number to first female flower appearance, sex ratio, days to first harvest, fruit number per vine, individual fruit weight(g), flesh thickness (mm), fruit yield per vine (kg/vine), ascorbic acid of fruit (mg100 g^{-1}), total soluble solids of fruit samples (ºBrix) and total chlorophyll content (mg100 g^{-1}) were recorded in five plants and fruits for each treatment per replication during growing season.

Statistical analysis: Treatments were defined by randomized block design with three replicates per treatment, each consisting of 10 plants for field evaluation. The data were statistically analyzed using the IRRISTAT version 4.0 (1997) developed by the International Rice Research Institute Biometrics Unit, the Philippines (Gomez and Gomez, 1984). Data were subjected to statistical analysis and means were compared by Duncan's Multiple Range Test (DMRT).

RESULTS

Graft success per cent: Success per cent of the bitter gourd scions grafted onto different rootstocks is presented in Fig. 1. Among the ten rootstocks used in this study, the stem thickness of *C. colocynthis* and *C. metuliferous* rootstocks did not match with the thickness of bitter gourd scions. Moreover, the germination and growth of these rootstocks had been found too slow and these were discarded. In the case of *B. hispida* and *C. pepo*, quick wilting occurred immediately after grafting. Hence, graft success per cent was assessed on six rootstocks employing two scions *viz.,* Palee F_1 and CO 1 at 15, 30 and 45 days after grafting (DAG). Among the six rootstocks used, *C. moschata* Duch.ex Poir recorded the highest success per cent of 89.0 at 15 DAG, 78.9 at 30 DAG and 71.7 at 45 DAG followed by *L. cylindrica* which recorded 85.35 at 15 DAG, 74.35 at 30 DAG and 68.26 at 45 DAG. The lowest graft success (50.9, 25.4 and 12.1) was observed in *M. charantia* var. *muricata* rootstock followed by bitter gourd scion with *C. ficifolia* (45.0, 33.4 and 15.0) at 15, 30 and 45 days after grafting.

Evaluation of grafted plants under field condition: The result of the present study revealed that the biometric traits of the grafted plants were significantly affected by rootstock-scion combinations (Table 1). Vine length was significantly differed with respect to rootstocks and scions used in this study. There was gradual increase in vine length from 30 days after planting to final harvest. Among the twelve graft combinations, the highest vine length (856.6 cm) was recorded by Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock followed by CO 1 scion grafted onto *C. moschata* Duch.ex Poir rootstock (622.4 cm).

The number of primary branches per plant is yet another yield contributing trait in bitter gourd which differed significantly among the grafted and non-grafted plants. Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock recorded the highest number of primary branches (13.1) than the other grafted and non-grafted plants. Mean comparison of days to flowering showed that higher values for this trait were observed in grafted plants and least in non-grafted plants which was statistically identical. The scion Palee F_1 recorded the lowest number of days to produce female flower (62.3 days) than that of grafted and non-grafted plants. However, among the graft combination Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock was the earliest to produce female flower (68.3 days) whereas CO 1 scion grafted onto *L. siceraria* rootstock took more number of days (91.9 days). Node at which first female flower appearance is also considered as important biometric trait to measure the earliness in cucurbits. The graft Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock produced female flowers at the early nodes (24.4) than the other grafted plants and scions (Table 1).

Grafted bitter gourd plants tend to give higher female and lower male flowers when compared to non-grafted plants. In the present investigation, the graft combinations, Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock had the narrow sex ratio (17.2) than that of other grafted and non-grafted plants. Non-grafted plants or scions recorded lowest value for days to first harvest than grafted plants. However, among the twelve graft combinations, Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock showed earliness in the first harvest (81.9 days) which recorded high fruit yield (Table 2). Delayed harvesting in grafted plants was mainly due to delayed flowering because of heavy stress during graft union process.

The fruit yield and yield attributes varied significantly among the grafted and non-grafted (scion) plants (Table 3). The graft Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock recorded highest fruit number (27.8) and yield per vine (3.62 kg) which is significantly differed from the non-grafted plants or scions (3.04 kg). In the present study, fruit number and yield per vine of Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock were increased by 32 per cent and 22 per cent than that of Palee F_1 scion (Table 2, Figure 2). The highest mean fruit weight (183.6 g) and flesh thickness (0.83 cm) were obtained by Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock. The fruit weight recorded by this graft combination was 33 per cent higher than Palee F_1 scions. The quality characters *viz.,* ascorbic acid and total soluble solids content were not significantly affected when grafting bitter gourd scions onto *C. moschata* Duch.ex Poir rootstock. But the highest level of ascorbic acid content (106.3 mg/100 g) was observed in Palee F_1 scion grafted on to *C. moschata* Duch.ex Poir rootstock. The total soluble solid content found to be high in Palee F_1 scion compared to grafted plants. But the differences were not statistically different between the grafted and non-grafted (intact) plants. In case of total chlorophyll contents of leaf, significant differences were observed among the graft combinations and scions. The highest total chlorophyll content was recorded by Palee F_1 scion grafted onto *C. moschata* Duch.ex Poir rootstock.

Table 1. Growth and flowering behaviour of grafted and non grafted bitter gourd plants.

Bitter gourd Scions and Graft combinations (Scion / Rootstock)	Vine length at final Harvest (cm)	Number of primary branches	Days to first female flower appearances	Node no. to first female flower appearances	Sex ratio (No. of Male/ female flower)
Palee F1 bitter gourd					
T1-Palee F1 non-grafted (intact)	550.2 ^{c}	11.7 ^{b}	62.3n	28.6 m	19.6 m
T2- Palee F1 grafted onto Mithipakal *M.charantia* var. *muricata*	278.6 l	9.70 g	75.9j	30.7 k	29.9 ^{e}
T3- Palee F1 grafted onto Fig leaf	264.7 m	7.70 n	82.3h	32.2 h	31.0 ^{d}

gourd *(C. ficifolia)*					
T4- Palee F1 grafted onto Pumpkin *(C. moschata)*	856.6 a	13.1a	68.3l	24.4 n	17.2 n
T5- Palee F1 grafted onto Sponge gourd *(L. cylindrica)*	512.2 e	11.2 c	75.7k	32.0 i	19.7 l
T6- Palee F1 grafted onto Ridge gourd *(L. acutangula)*	363.8 g	8.30 k	86.9d	33.1e	33.2 c
T7- Palee F1 grafted onto Bottle gourd *(L.siceraria)*	349.0 i	8.40 j	86.4e	33.1d	27.5 h
CO 1 bitter gourd					
T8- CO 1 non-grafted (intact)	536.1d	10.1 e	67.3 m	32.9 f	22.6 j
T9- CO 1 grafted onto Mithipakal *M.charantia* var. *muricata*	281.6 k	8.60 h	84.6 g	31.3 j	34.2 b
T10- CO 1 grafted onto Fig leaf gourd *(C. ficifolia)*	260.6 n	8.50 i	91.3 c	34.6 c	27.1 i
T11- CO 1 grafted onto Pumpkin *(C. moschata)*	622.4 b	10.8 d	79.8 i	30.0 l	21.8 k
T12- CO 1 grafted onto Sponge gourd *(L. cylindrica)*	394.8 f	9.80 f	85.3 f	32.3 g	27.8 g
T13- CO 1 grafted onto Ridge gourd *(L. acutangula)*	342.5 j	7.80 m	91.4 b	35.1b	29.1f
T14- CO 1 grafted onto Bottle gourd *(L.siceraria)*	362.81h	8.26 l	91.9 a	35.5a	34.9 a
SEd	33.84	0.69	1.15	1.27	0.84
CD (P=0.05)	69.57	1.42	2.36	2.62	1.73

Values are mean of three replications; Means followed by a common letter are not significantly different at 5% level by DMRT

Table 2. Performance of bitter gourd grafts and scions for yield and quality parameters.

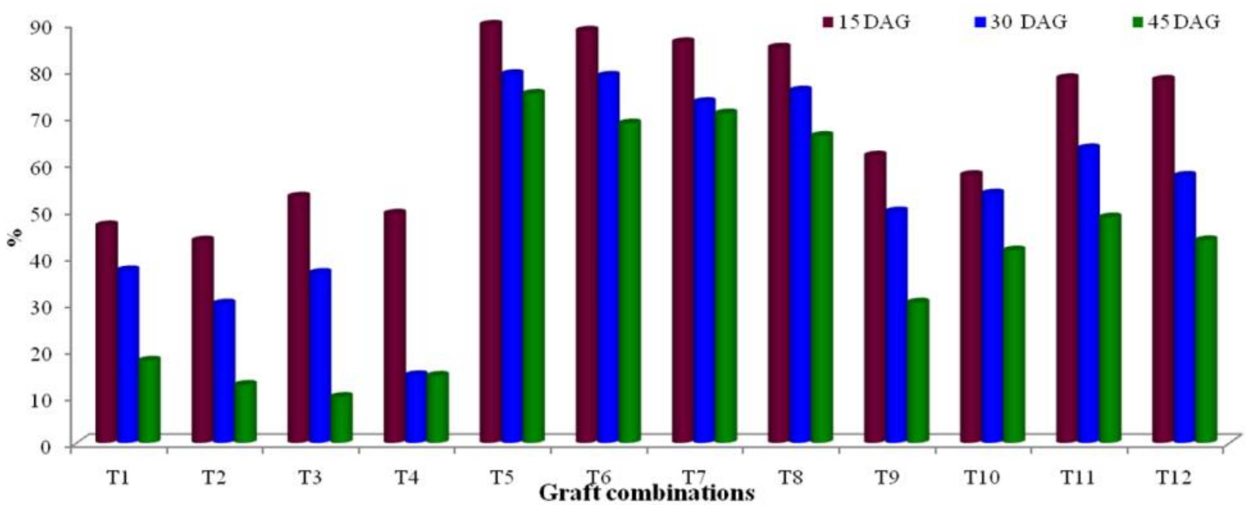
Bitter gourd Scions & Graft combinations (Scion / Rootstock)	Days to first harvest	Fruit number per vine	Individual fruit weight (g)	Flesh thickness (cm)	Fruit yield per vine (kg)	Ascorbic acid (mg/100 g)	Total soluble solids (ºBrix)	Total chlorophyll content (mg g-1)
Palee F1 bitter gourd								
T1-Palee F1 non-grafted (intact)	76.2 a	21.5 c	166.6 b	0.72 d	3.04 b	104.5 b	5.16a	2.16 b
T2- Palee F1 grafted onto Mithipakal *M.charantia* var. *muricata*	91.3e	12.6 k	98.3 g	0.51 k	1.36 g	54.4 k	2.47 i	1.33 f
T3- Palee F1 grafted onto Fig leaf gourd *(C. ficifolia)*	100.4 g	13.9 h	77.2 k	0.46 n	1.23 i	47.1 m	2.10 m	1.15 i
T4- Palee F1 grafted onto Pumpkin *(C. moschata)*	81.9 c	27.8 a	183.6 a	0.83 a	3.62 a	106.3 a	5.14 b	2.23 a
T5- Palee F1 grafted onto Sponge gourd *(L. cylindrica)*	90.0 d	20.2d	136.7c	0.76 b	2.35 c	102.6 c	4.71c	1.93 c
T6- Palee F1 grafted onto Ridge gourd *(L. acutangula)*	102.5 j	14.2 g	101.4f	0.66 f	1.24 h	57.3 h	2.75 g	1.04 l
T7- Palee F1 grafted onto Bottle gourd	103.7 k	13.1i	83.8 j	0.55 j	1.14 j	55.7 j	2.51 g	1.03 m

(L.siceraria)								
CO 1 bitter gourd								
T8- CO 1 non-grafted (intact)	80.9 ^{b}	19.7 ^{e}	89.2^{i}	0.69 ^{e}	1.86 ^{e}	97.9 ^{e}	4.70 ^{d}	1.64 ^{e}
T9- CO 1 grafted onto Mithipakal *M.charantia* var. *muricata*	101.8 ^{i}	10.7 ^{m}	73.9^{m}	0.49 ^{m}	0.94 ^{n}	52.6 ^{l}	2.21 ^{l}	1.10 ^{j}
T10- CO 1 grafted onto Fig leaf gourd *(C. ficifolia)*	106.2 ^{l}	10.6 ^{n}	75.8^{l}	0.50 ^{l}	0.98 ^{l}	45.1 ^{n}	1.98 ^{n}	1.06 ^{k}
T11- CO 1 grafted onto Pumpkin *(C. moschata)*	94.4 ^{f}	21.5 ^{b}	135.6^{d}	0.73 ^{c}	2.15 ^{d}	98.8 ^{d}	3.59 ^{e}	1.65 ^{d}
T12- CO 1 grafted onto Sponge gourd *(L. cylindrica)*	100.9 ^{h}	18.4 ^{f}	103.8^{e}	0.65 ^{g}	1.61^{f}	89.5 ^{f}	3.44 ^{f}	1.21 ^{g}
T13- CO 1 grafted onto Ridge gourd *(L. acutangula)*	106.6 ^{n}	12.8 ^{j}	98.2^{h}	0.62 ^{h}	1.07 ^{k}	63.1 ^{g}	2.41 ^{j}	1.16 ^{h}
T14- CO 1 grafted onto Bottle gourd *(L.siceraria)*	106.3 ^{m}	11.4 ^{l}	62.0^{n}	0.57 ^{i}	0.95 ^{m}	56.9 ^{i}	2.25 ^{k}	0.92 ^{n}
SEd	1.67	1.39	4.40	0.01	0.17	1.42	0.08	0.13
CD (P=0.05)	3.44	2.87	9.05	0.03	0.36	2.93	0.17	0.28

Values are mean of three replications; Means followed by a common letter are not significantly different at 5% level by DMRT

Table 3.Climatic data prevailed during growing cycle of bitter gourd.

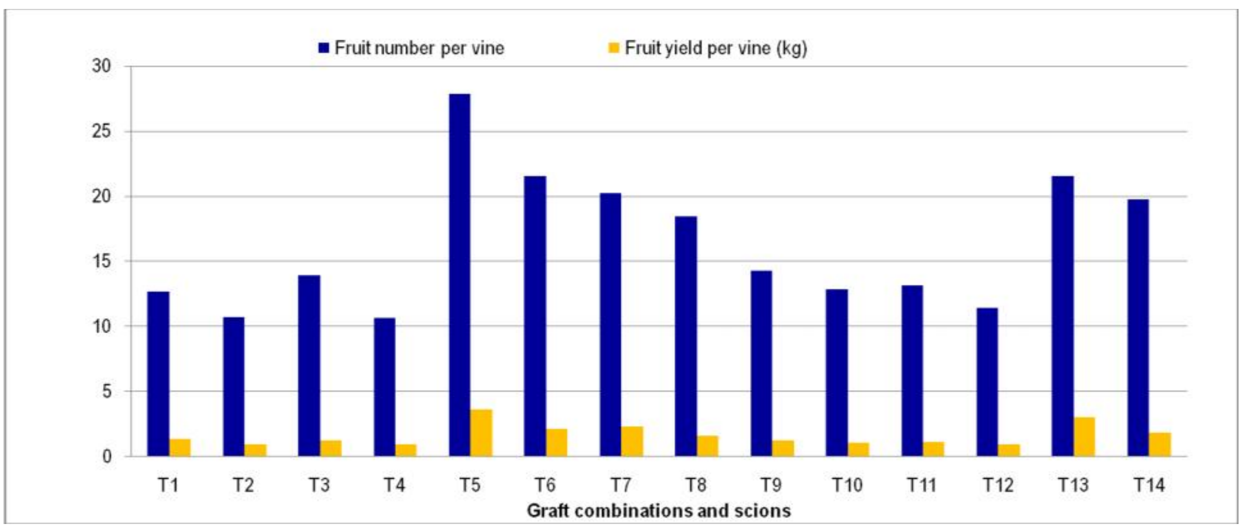
Month	Mean temperature (^{0}C)	Relative Humidity (M) (%)	Relative Humidity (E) (%)	Rain Fall (mm)
June ,2011	26.6	83.5	57.8	93.0
July, 2011	27.0	82.0	55.6	32.3
August, 2011	27.0	89.0	56.5	7.1
September, 2011	26.4	87.4	58.2	67.9
October, 2011	26.8	91.0	61.5	305.3
November 2011	24.9	89.5	59.3	243.1
December 2011	24.1	89.4	52.2	11.6
January 2012	24.4	88.5	46.0	1.0
February, 2012	25.9	83.0	35.0	0.0
March, 2012	28.7	84.0	36.0	1.2
April, 2012	29.7	86.0	43.0	78.4
May, 2012	29.3	87.0	49.0	25.6
June, 2012	28.1	76.8	49.2	11.1
July, 2012	27.5	77.8	51.1	27.5
August, 2012	27.2	83.3	54.0	28.3
September, 2012	27.4	84.8	52.0	6.1
October, 2012	26.5	87.3	58.0	165.2
November, 2012	25.7	89.3	49.8	22.4
December,2012	25.3	84.8	44.2	6.9
January, 2013	25.2	86.0	35.3	0.0
February, 2013	27.8	68.3	38.3	99.8
March, 2013	30.2	80.4	38.2	0.0
13-Apr	30.2	85.5	40.3	46.8
13-May	29.8	81.8	44.0	14.8



T_1- Palee F_1/ *M.charantia* var. *muricata*	T_2 – CO 1/ *M.charantia* var. *muricata*	T_3- Palee F_1/*C. ficifolia*	T_4- Palee F_1/*C. ficifolia*
T_5 – Palee F_1/*C. moschata*	T_6 – CO 1/*C. moschata*	T_7 – Palee F_1/*L. cylindrica*	T_8 –CO 1/*L. cylindrica*
T_9 – Palee F_1/*L. acutangula*	T_{10} – CO 1 / *L.acutangula*	T_{11} – Palee F_1/*L. siceraria*	T_{12} - CO 1 / *L. siceraria*

Number of individuals per sample is 50; Number of individuals observed per sample is 50; number of replicates -3; DAG – Days after grafting

Figure 1. Effect of rootstocks on grafting success with bitter gourd scions at 15, 30 and 45 days after grafting (DAG)



T_1- Palee F_1/ *M.charantia* var. *muricata*	T_2 – CO 1/ *M.charantia* var. *muricata*	T_3- Palee F_1/*C. ficifolia*	T_4- Palee F_1/*C. ficifolia*
T_5 – Palee F_1/*C. moschata*	T_6 – CO 1/*C. moschata*	T_7 – Palee F_1/*L. cylindrica*	T_8 –CO 1/*L. cylindrica*
T_9 – Palee F_1/*L. acutangula*	T_{10} – CO 1 / *L. acutangula*	T_{11} – Palee F_1/*L.siceraria*	T_{12} - CO 1 / *L.siceraria*
T_{13} – Palee F_1	T_{14} - CO 1		

Figure.2. Performance of bitter gourd grafts and scions for fruit number and fruit yield per vine (Kg).

DISCUSSION

The results on grafting success per cent revealed that the highest and lowest success per cent belonged to *C. moschata* (89.70 %) and *C. ficifolia* (43.40%) respectively. Petran and Hoover (2014) reported that *S. torvum* rootstock had the highest average days to fusion (12.3 days) with 'Celebrity', scion compared to any other graft combination and had the lowest survival percentage (50%). Similar trends of results were obtained by

Punithaveni (2015) who reported that 'Green long' cucumber grafted onto bottle gourd rootstock took least average number of days (6.75) for graft union fusion and recorded highest success percentage (85%) with hole insertion grafting and Dhivya (2014) reported that grafting TNAU Tomato hybrid CO-3 on *S. torvum* registered the least number of days for graft union fusion (9.10) and highest success percentage (90.67) with cleft grafting.

In case of *B. hispida* and C. *pepo*, quick wilting occurs immediately after grafting. This is a characteristic of graft incompatibility, which contributes to poor vascular connection with poor connecting sieve tubes, cambium and xylem in the heterograft *Cucumis*/*Cucurbita* (Salehi *et al*., 2008). Sudden wilting is also due to physiological incompatibility as a result of lack of cellular recognition, wounding responses, presences of growth regulators or incompatible toxins. In the incompatible combinations, the leaves turned yellow and plants withered (Davis *et al.,* 2008). This study is in agreement with other studies performed with melon scions onto *L.* s*iceraria, C. ficifolia* and *C. moschata* rootstocks (Morra, 1997; Miguel, 2004).

Grafted plants had better growth and development throughout the growing period than that of non grafted plants. In previous reports, similar differences in vine length were also obtained by Salam *et al*. (2002) and Mohamed *et al.* (2012) who stated that grafted watermelon plants were more vigorous than self-rooted ones and had a larger central stem diameter and recorded 32 per cent higher main vine length than that of non-grafted counterpart. Similarly, Shahidul Islam *et al*. (2013) also observed 32 and 53.7 per cent of higher main vine length in grafted watermelon plant than that of non-grafted counterpart. Alan *et al.* (2007) reported that the grafted watermelon plants produced more lateral vines (9 lateral vines / vine) than non-grafted plants (4 lateral vines/vine). Improved plant growth in grafted plants may attributed to the interaction of some or all of the following phenomena: increased water and plant nutrient uptake, stronger and more extensive root growth of the rootstock, augmented endogenous hormone production, enhanced scion vigor (Mohamed *et al.,* 2012; Shahidul Islam *et al*., 2013**).**

Earliness is one of the main attributes which is measured in terms of days to female flower appearance and is preferred for commercial cultivation when high yield is coupled with earliness. The results of this study indicated that grafted plants showed seven to ten days delay in flowering (both male and female) than non-grafted plants due to heavy stress during graft union process. Similar trend of delayed flowering in grafted plants were reported by Sakata *et al.* (2007) and Hamed *et al.* (2012) in watermelon who stated a delayed flowering up to one week in grafted watermelons, resulting in an equal delay in fruit maturity. Narrow sex ratio is favorable trait in cucurbits. This result is of the present investigation was in agreement with the finding of Shahidul Islam *et al.* (2013) in watermelon. Days to first harvest are an indicator of the earliness of any crop especially in vegetables which could fetch premium price and catch the early market. It is directly influenced by earliness in flowering. However, earliness in flowering is indirectly proportional to number of harvests. Delayed harvesting in grafted plants was mainly due to delayed flowering tends to extent the crop duration with more number of harvest days.

Grafted plants recorded higher values for yield and yield contributing traits than non-grafted plants. The effect of grafting on watermelon growth and yield with 72 and 21 *L. siceraria* genotypes was studied by Yetisir *et al.* (2007) and Karaca *et al.* (2012) and stated that grafted plants had longer roots and main stems, higher dry weight, more leaves and higher yield. Similar trends of increased fruit number and yield in grafted plants were also reported by Mohamed *et al.* (2012) and Shahidul Islam *et al.* (2013) in watermelon. In cucumber, Kohatsu *et al.* (2013) reported that 'Shelper' rootstock provided 31.2 and 43.2% increase in the number of marketable fruits and 35.5% and 39.5% increases in yield, compared to non-grafted plants and cucumber grafted onto Green-stripped cushaw squash rootstock respectively. Regarding the quality parameters such as ascorbic acid and total soluble solids content were not affected by rootstock – scion combination as previously reported by Miguel *et al.*(2004); Colla *et al.*(2006) and Huitron- Ramirez *et al.*(2009) on fruit total sugar content of watermelon.

Conclusions: It could be concluded that the rootstock-scion combination and compatibility play a major role in growth, development and yield of bitter gourd. Therefore, the choice of the scion and rootstock could be of major importance for the achievement of high yields with good quality. From this study it could be finalised that bitter gourd scion 'Palee F_1' grafted onto '*C. moschata* Duch.ex Poir*'* rootstock had positive effects on vegetative growth, earliness, and yield and fruits production with equal quality to that of the intact plants. Therefore, 'Palee F_1' grafted onto '*C. moschata* Duch.ex Poir*'* rootstock would enable the farmer to produce sustainable crop with higher fruit yield.

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