Study on Graft Compatibility of Plants among three Selected Cucurbits

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Abstract

The research was conducted using three selected cucurbits such as cucumber (*Cucumis sativus* L.), bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) and bitter gourd (*Mormodica charantia* L.), to evaluate on the yield of grafted and non-grafted cultivated plants in completely randomized design (CRD). The seeds of cucumber, bottle gourd and bitter gourd were suggested to use in this experiment owing to the germination rate of above 70 %. In grafting, the graft compatibility of bottle gourd as a stock was the most exceptional for cucurbits and the survival rate is 26.5%. When compare the vegetative and reproductive growth of grafted and non-grafted of three cucurbits: cucumber, bottle gourd and bitter gourd. The grafted plants had maximum leaf area, female and male flowers, and fruit yield. The fruit weight of grafted plants was also superior to non-grafted plants. It was therefore suggested to use the grafted cucurbits for yield improvement.

Introduction

Cucurbits including in the family Cucurbitaceae had 118 genera and 825 species, and these plants are distributed in tropical and subtropical regions of the world (Jeffery *et al.*, 1990). Among 118 genera, four have been recognized as of great economic importance: *Citrullus, Cucumis, Cucurbita* and *Lagenaria.* Cucumber (*Cucumis sativus*) is of Asiatic origin and probably of Indian origin and was domesticated around 1500 BC (Pitrat *et al*., 1999). Cucurbits are an important part of the human diet (FAO, 2006). The germination of typical dicot, the cucurbits, is epigeal and require relatively high temperature for germination. Generally cucurbits will not germinate in soil temperature below 17 - 19 °C. Cucumber, bottle gourd and bitter gourd may be grown on trellised, if it is not they tend to vine and sprawl out vigorously in the garden. Moreover, the use of trellises is to overcome the space problem (The Gardener, 1996).

The main advantage of grafting is disease-resistant (Core, 2005). Grafting is the joining the two plant parts together such that they will unite and continue their growth as one plant. Grafting with detached scions has been practiced for thousands of years. It was used by the Chinese before 2000 B.C and spread to the rest of Eurasia and the practice was almost common in ancient Greece (Garner, 1988). Grafting of cucurbits is practiced to acquire the disease and drought resistant plants, and yield improvement of such crops. Grafting has become a routine technique in continuous cropping systems in many parts of the world.

It was the first introduced in Korea and Japan during the late 1920s by grafting watermelon onto bottle gourd rootstocks to address the problems of declining yield due to soil borne disease in plants (Garner, 1988). It is estimated that more than half of the world's watermelons and cucumbers are produced in China and more than 90% of these are grafted. In grafting, the rootstock is important effects in plant growth, yield, and fruit quality (Garner, 1988). Grafting, which does not require major adaptations in farming practices, has been rapidly adopted y the cucurbits growers in many countries. Grafting of cucurbits for the local market is also rapidly developing (Lee, 1994). In many countries, yield increase has been reported. The average yields of grafted plants were much higher than the yields of the non-grafted plants (Lee, 1994). Regarding to the above facts, the study is aimed to record the seed germination rate of three selected cucurbits, to study the process of grafting, to examine the graft compatibility of cucurbits based on the survival rate of plants and to observe the growth of grafted cucurbits.

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Materials and Methods

Germination, grafting of curcurbits such as local and F1 varieties of *Lagenaria siceraria* L., *Cucumis sativus* L. and *Momordica charantia* L. and field performance of grafted plants was carried out in Vegetable and Fruit Research Development Centre (VFRDC).

Table 1. Name, definition and source of rootstocks and scions

Plant Species	Definition	Source
Rootstocks		
L. siceraria (Mol.) Standl.	Local	VFRDC
L. siceraria	F_1	VFRDC
Scions		
C. sativus L.	Local	VFRDC
C. sativus	F_1	VFRDC
L. siceraria (Mol.) Standl.	Local	VFRDC
M. charantia L.	Local	VFRDC

Grafting Methods

Peg (or) hole insertion grafting technique (HIGT), and splice grafting technique (SGT) were used in this experiment.

Preparation of Seedbed and Seed Germination

In this experiment, 22.2 cm x 24.75 cm size polyethylene bags and the plastic trays with 104 plots were used for growing of stock and scion plants. The polyethylene bags and plastic trays containing the mixture of sand and vermicompost (10: 1) was prepared before sowing the seeds. One seed was sown in one polyethylene bag and also in a plot of tray. The bags and trays were set up under the shade.

Peg (or) Hole Insertion Grafting Technique (HIGT)

The stem of stout, straight and big diameter of the stock plants was chosen from the germinated plants. The first node between the cotyledons was straight cut by using a razor blade. Then the bamboo stick was inserted at the middle of the node to make a small hole for inserting the scion. The diameter of scions must be smaller than the stock. The slant cut was made 1 cm above cotyledons of straight and smaller diameter of scions. The cut end of scion was carefully inserted into prepared stock.

Splice Grafting Method (SGT)

This method was applied for the rootstock and scion of nearly the same diameter. The stem of the stock with one cotyledon was slant cut using a razor blade. The hypocotyl of the scion was also slant cut and then the cut ends of the stock and scion were grafted and the grafted union was firmly sealed with tape.

Grafting of Three Cucurbits

In this experiment, seven treatments with 60 replicates were set up in Completely Ramdomized Design (CRD). The distance between individual bag and between rows is 2.5 cm.

The treatments are as follows.

T_1 - *Lagenaria siceraria* (F_1) x *Cucumis sativus* L. (Local)
T_2 - *Lagenaria siceraria* (F_1) x *C. sativus* (F_1)
T_3 - *Lagenaria siceraria* (Mol.) Standl. (Local) x *C. sativus* L.. (Local)
T_4 - *Lagenaria siceraria* (Mol.) Standl. (Local) x *C. sativus* (F_1)
T_5 - *Lagenaria siceraria* (Mol.) Standl. (Local) x *L. siceraria* (Mol.) Standl. (Local)

T_6 - *Lagenaria siceraria* (Mol.) Standl. (Local) x *M. charantia* L.(Local)

Data Collection

The experimental data were recorded once a week. The germination rate, survived and dead plants were recorded by Soupe (2009) and the leaf area method were recorded by Blanco and Folegatti (2005). The recorded data were analyzed using the following the formula:

$$\text{Germination Rate (\%)} = \frac{\text{Germinated Seeds}}{\text{Total Sown Seeds}} \times 100$$

$$A = \frac{L \times a}{P}$$

where: A = area of leaves (cm^2)
L = weight of leaf blade figure of hard paper
p = weight of 20 × 20 cm hard paper
a = area of hard paper (20 × 20 cm)

Field Performance of Three Grafted Cucurbits

The soil of the cultivation field was thoroughly crushed and removed the debris and weeds. Carbofuran (3 g $plant^{-1}$), biofungicide (Trigold) (5 g $plant^{-1}$) were added to the soil for suspress the soil born bacteria and fungi. Then the soil was wet by water and cover with plastic sheet for a week. But turning up was done in every 2 days interval.

Experimental Layout

In this experiment four treatments with seven replicates were set up in CRD (Completely Randomized Design). The area of the field was 460 x 870 cm^2. The distance between rows and plants were 124.28 cm. The treatments were as follows:

T1 Non-grafted scion
T2 Grafted plants using peg method
T3 Grafted plants using splice method

Growing of the Grafted and Non-Grafted Cucurbits

One week after soil preparation, the grafted and non grafted plants were transplanted to the prepared soil beds. The age of grafted and non grafted plants was about 3 weeks.

Fertistart solution (10 ml $gallon^{-1}$) was added to the root zone for the growth of roots. Two weeks after cultivation, the mixture of T-Super, potash and urea (1: 1: 1) were fed to the plant and daily watering was done in growing of cucurbits. The bamboo trellises were provided to climb up and straighten up the plants.

Data Collection

The survived male and female flowers, total leaf areas, yield were collected. The collected data were statistically analyzed using IRRISTAT software developed by International Rice Research Institute (IRRI), the Philippines. The treatment mean separation was expressed by 5 % LSD.

Results

Germination of Three Selected Cucurbits

The germination of cucurbits was set up under the shade. The mean temperature of the place was 25 ºC and relative humidity of 80 % during germination.

The germination of both local and F1 cultivars of *L. siceraria* (Mol) Standl. started at 7 days after sowing (DAS) and it was continued to 9 DAS. The total number of germinated seedlings of local cultivar was 74 and that of F1 cultivar was 87. The germination of both local and F1 cultivars of *C. sativus* stated at 2 DAS and it was completed at 3 DAS. The total number of germinated seedlings of local cultivar was 81 and that of F1 cultivar was 75. For *M. charantia* L., only local variety was used for grafting owing to its high potent in medicinal value but F_1 was less. The germination of *M. charantia* L. started at 5 DAS and it was continued to 8 DAS and the germinated seedling of it was 97.The germination of F1 cultivar started at 6 DAS and it was continued to 10 DAS and the germinated seedling of it was 40 (Table 2 and Figure 1).

Table 2. Daily Recorded Germination Rate of Cucumber, Bottle Gourd and Bitter Gourd

Treatment	Germinated seedlings (Number)										Germination Rate (%)
	2 DAS	3 DAS	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS	9 DAS	10 DAS	Total	
Bottle gourd (Local)	-	-	-	-	-	3	21	50	-	74	74
Bottle gourd (F1)	-	-	-	-	-	3	8	26	50	87	87
Cucumber (Local)	32	49	-	-	-	-	-	-	-	81	81
Cucumber (F1)	28	47	-	-	-	-	-	-	-	75	75
Bitter gourd (Local)	-	-	-	8	21	38	30	-	-	97	97
Bitter gourd (F1)	-	-	-	-	2	10	8	10	10	40	40

DAS = Days after sowing

Grafting of Three Cucurbits

The survival plants are recognized by its new leaf emergence. The result of the experiment showed that the highest survival rate (25 %) were observed in T_4 (*Lagenaria siceraria* (Mol.) Standl. (Local) x Cucumber 112 Pothong [FC 37-112] (F_1) followed by 20 % in T_3 (*Lagenaria siceraria* (Mol.) Standl. (Local) x *Cucumis sativus* (Local) then 18.3 % in T_1 (Bottle gourd [FR-Twist] (F_1) x *Cucumis sativus* (Local)) and 16.7 % in T_2 (Bottle gourd [FR-Twist] (F_1) x Cucumber 112 Pothong [FC 37-112] (F_1). It was noted that the use of bottle gourd (Local) rootstock gave the highest survival rate than F1 stock (Table 3 and Figure 2).

Field Performance of Three Grafted Cucurbits

Thee stock of the graftage was bottle gourd and there were 3 different scions such as bottle gourd, cucumber and bitter gourd. Two grafting techniques are used in grafting plants that is peg and splice grafting.

Grafting of Bottle Gourd vs Cucumber

The results showed that the plants from splice grafting method possessed the largest leaf areas (16119.30 cm^2). It also possessed more female (12.10) and male (10.74) flowers than those of peg grafting as well as scion plants. The statistical analyzed results revealed that the treatments on leaf area were significant at 0.05 % level whereas those on number of female and male flowers were significant at 0.01 % level (Table 4 and Figure 3).

Table 3. Effect of grafting methods on survival and dead rates of cucurbits

Treatment	Stock Plant	Scion Plant	Survival rate(%)	Dead rate(%)
T_1	*Lagenaria siceraria* (Mol.) Standl. [FR-Twist]	*Cucumis sativus* L. (Local)	18.3	81.7
T_2	*Lagenaria siceraria* (Mol.) Standl. [FR-Twist]	*Cucumis sativus* L. (112 Pothong, FC-37-112)	16.7	83.3
T_3	*Lagenaria siceraria* (Mol.) Standl. (Local)	*Cucumis sativus* L. (Local)	20.0	80.0
T_4	*Lagenaria siceraria* (Mol.) Standl. (Local)	*Cucumis sativus* L. (112 Pothong, FC-37-112)	25.0	75.0
T_5	*Lagenaria siceraria* (Mol.) Standl. (Local)	*L. siceraria* (Mol.) Standl. (Local)	26.5	73.5
T6	*Lagenaria siceraria* (Mol.) Standl. (Local)	*M. charantia* L. (Local)	21.9	80.1

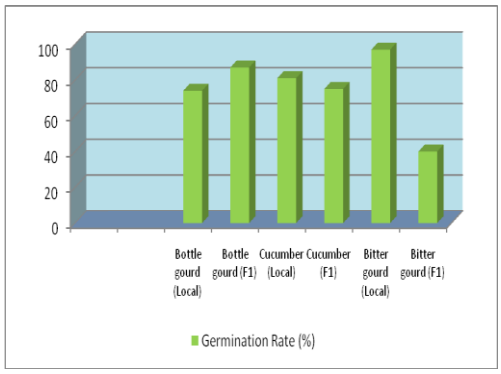


Figure 1. Germination rate of bottle gourd, cucumber and bitter gourd

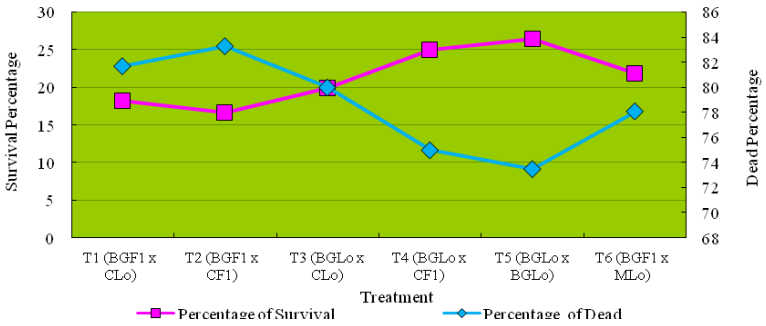


Figure 2. Survival and dead rate of grafted plants

Table 4. Vegetative and Reproductive Growth of Grafted Cucumber

Treatment	Total Leaf Area (cm^2) per Plant	No. of Female Flower per Plant	No. of Male Flower per Plant
T_1 (Scion)	5173.10	4.00	4.49
T_2 (Peg Grafting)	15674.60	12.00	10.53
T_3 (Splice Grafting)	**16119.30**	**12.10**	**10.74**
F-test	*	**	**
5% LSD	9897.87	0.4984	2.236
cv%	34.8	17.7	16.7

** = highly significant * = significant No. = number

The yield of a splice grafted plant was 6.11 and it was higher than that of peg grafting and scion plants. However, the marketable yield of peg grafted plants (4.17) was higher than that of splice grafted plants. The fruit weight of splice grafted plants (2924.78 g) was higher than splice grafted plants. The statistical analyzed results showed that the treatments on total and marketable yield were significant at 0.01 % level and those on non-marketable yield were not significant (Table 5 and Figure 4).

Table 5. Effect of Grafting Methods on Yield of Cucumber

Treatment	TFY	MFY	NMFY	TFWt (g)	MFWt (g)	NMFWt (g)
T_1 (Scion)	434.60	234.32	200.28	1322.67	1142.67	180
T_2 (Peg Grafting)	570.79	417.58	150.21	2509.23	2359.23	**150**
T_3 (Splice Grafting)	611.84	409.56	200.28	**2924.78**	**2704.78**	220
F-test	**	**	ns	**	**	ns
5% LSD	1.2428	0.7886	0.64	610.021	524.939	117.825
cv%	23.5	23.4	33.8	22.8	21.5	48.7

TFY = Total fruit yield MFY = Marketable fruit yield NMFY = Non-marketable fruit yield
TFWt = Total fruit weight MFWt = Marketable fruit weight NMFWt = N0n-marketable fruit weight
** = highly significant ns = non-significant

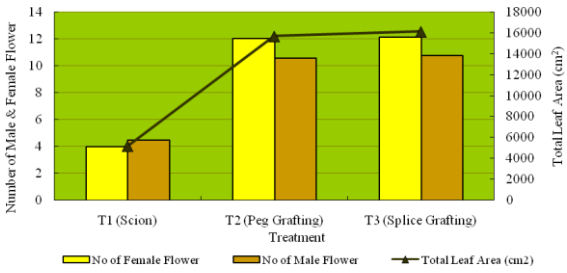


Figure 3. Total leaf area and number of male and female flowers of cucumber resulted in response to different grafting methods

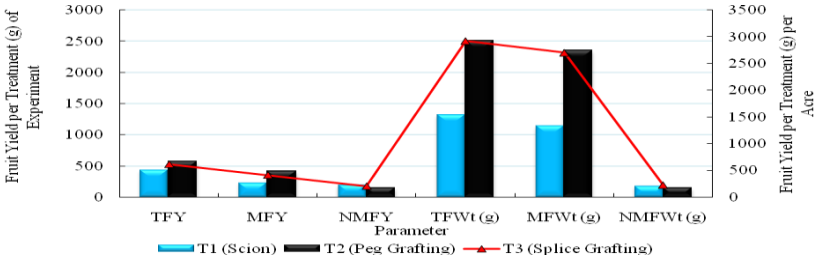


Figure 4. Total, marketable and non-marketable fruit yield of grafted cucumber

Grafting of Bottle Gourd *vs* Bottle Gourd

The results showed that the plants from splice grafting method possessed the largest leaf areas (66198.0 cm^2). It also possessed more female (4.2) and male (17.7) flowers than those of peg grafting as well as of scion plants. The statistical results expressed that the treatments on leaf area was significant at 0.05 % level whereas those on number of female and male flowers were significant at 0.01 % level (Table 6 and Figure 5).

Table 6. Vegetative and Reproductive Growth of Grafted Bottle Gourd

Treatment	Total Leaf Area (cm^2) per Plant	No. of Female Flower per Plant	No. of Male Flower per Plant
T_1 (Stock & Scion)	44496.8	1.2	7.4
T_2 (Peg Grafting)	64198.0	3.6	17.6
T_3 (Splice Grafting)	**66536.5**	**4.2**	**17.7**
F-test	*	**	**
5 % LSD	11966.9	0.4984	2.236
cv %	9.1	17.7	16.7

** = highly significant * = significant No. = number

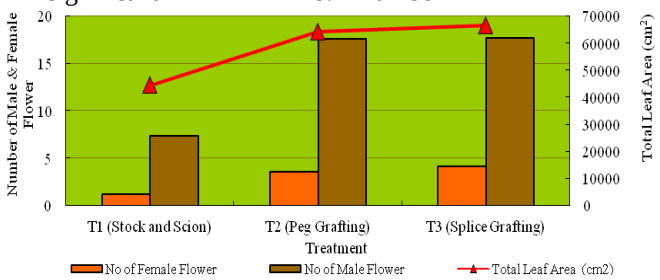


Figure 5. Total leaf area and number of male and female flowers of bottle gourd resulted in response to different grafting methods

The yield of a splice grafted plant was 5.56 and it was higher than that of peg grafting, stock and scion plants. The marketable yield of splice grafted plants (227) was higher than that of peg grafted plants. The fruit weight such as total, marketable and non-marketable of splice grafted plants (3338.07 g, 2957.29 g and 218.0 g) was higher than peg grafted plants. The statistical analyzed results also revealed that the treatments on each parameter were significant at 0.01 % level (Table 7 and Figure 6).

Table 7. Effect of Grafting Methods on Yield of Bottle Gourd

Treatment	TFY	MFY	NMFY	TFWt (g)	MFWt (g)	NMFWt (g)
T_1 (Stock & Scion)	200.28	124.17	76.10	1365.57	1303.29	**62.20**
T_2 (Peg Grafting)	399.55	193.27	207.29	3109.50	2937.17	136.66
T_3 (Splice Grafting)	556.77	227.31	329.45	**3338.07**	**2957.29**	218.00
F-test	**	**	**	**	**	**
5% LSD	0.7596	477.623	0.5723	0.518	474.641	47.2674
cv%	26.4	24.5	37.5	26.4	38.2	45.5

TFY = Total fruit yield MFY = Marketable fruit yield NMFY = Non-marketable fruit yield
TFWt = Total fruit weight MFWt = Marketable fruit weight NMFWt = N0n-marketable fruit weight
** = highly significant

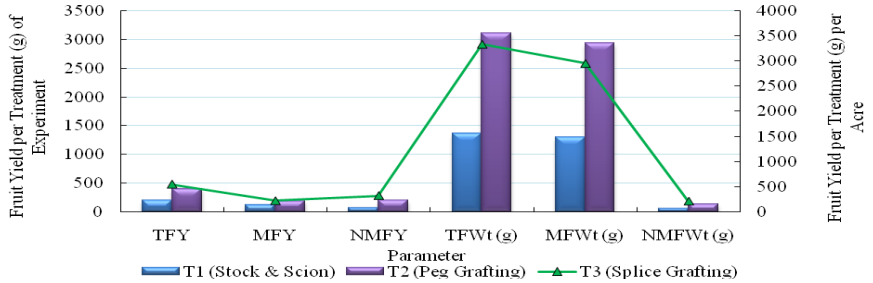


Figure 6. Total, marketable and non-marketable fruit yield of grafted bottle gourd

Grafting of Bottle Gourd vs Bitter Gourd

The results showed that the plants from peg grafting method possessed the largest leaf areas (5406.60 cm^2). However the plants from the splice grafted plants had more female (22.46) and male (34.61) flowers than those of peg grafting as well as scion plants. The statistical analyzed results expressed that the treatments on leaf area, number of female and male flowers were significant at 0.01 % level (Table 8 and Figure 7).

Table 8. Vegetative and Reproductive Growth of Bitter Gourd

Treatment	Total Leaf Area (cm^2) per Plant	No. of Female Flower per Plant	No. of Male Flower per Plant
T_1 (Scion)	2211.40	9.74	21.10
T_2 (Peg Grafting)	**5406.60**	21.61	33.75
T_3 (Splice Grafting)	4852.50	**22.46**	**34.61**
F-test	**	**	**
5% LSD	4670.2	1.1465	2.3512
cv%	34.8	5.2	6.7

** = highly significant No. = number

The yield of a peg grafted plant was 6.07 and it was higher than that of splice grafted and scion plants. The marketable yield of peg grafted plants (4.35) was higher than that of splice grafted plants. The total and marketable fruit weights of peg grafted plants (727.33 g and 572.27 g) were higher than that of splice grafted plants. But yield and fruit weight of splice grafted plants were higher than that those of scion plants. The statistical analyzed results

revealed that the treatments on each parameter were significant at 0.01 % level except non-marketable yield which was non-significant (Table 9 and Figure 8).

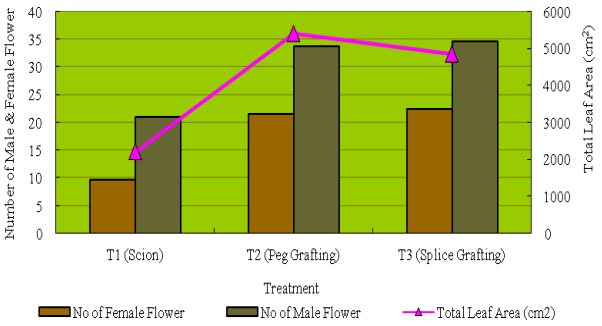


Figure 7. Total leaf area and number of male and female flowers of bitter gourd resulted in response to different grafting methods

Table 9. Effect of grafting methods on yield of bitter gourd

Treatment	TFY	MFY	NMFY	TFWt (g)	MFWt (g)	NMFWt (g)
T_1 (Scion)	381.53	238.33	143.20	340.27	179.88	160.39
T_2 (Peg Grafting)	607.84	435.60	172.24	**727.33**	**572.27**	**155.06**
T_3 (Splice Grafting)	571.79	368.51	204.28	610.80	407.22	203.57
F-test	**	**	ns	**	**	*
5% LSD	0.9638	0.5909	0.8705	517.954	438.025	115.638
cv%	18.8	17.90%	47.9	41.3	42.9	49.6

TFY = Total fruit yield MFY = Marketable fruit yield NMFY = Non-marketable fruit yield
TFWt = Total fruit weight MFWt = Marketable fruit weight NMFWt = N0n-marketable fruit weight
** = highly significant * = significant ns = non-significant

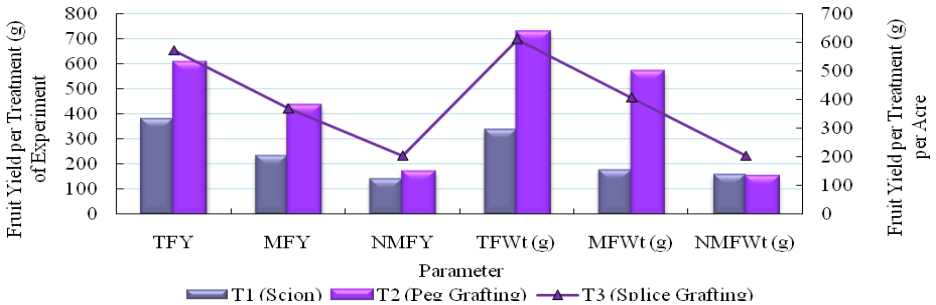


Figure 8. Total, marketable and non-marketable fruit yield of grafted bitter gourd

Discussion and Conclusion

The germination treatment was set up under shade and the result showed that most of the seeds in all treatments could germinate at the mean temperature of 25 ºC. The seeds of (bitter gourd) T_5 were germinated at 5 days after sowing. It was in agreement with Reyes *et al*. (1994) who reported that the seedlings of bitter gourd were emerged at 5-7 days after sowing. However, the seeds of bottle gourd (T_1 and T_2) were germinated at 7 days after sowingat the mean temperature of 25 ºC. The results of this experiment was in agreement with Hazra and Som (2005) and Suteks shinohara (1984) who reported the optimum soil temperature for germination in most of the vegetables is 20-30 ºC. For cucumber, it germination started 2 days after sowing and complete germination was observed at 3 days after sowing at the mean temperature of 25 ºC. It was agreement with Simon et al. (1976) who reported that cucumber seeds germinate rapidly between 20-30 ºC.

The main purpose of grafted seedlings is to increase the yield and quality of fruits by combining a disease resistant rootstock with a genetically superior scion. In this experiment, the highest survival rate was observed by the use of bottle gourd as a stock. This finding was consistent with Edelstein (2004) who reported that bottle gourd (*L. siceraria* (Mol.) Standl.) is the main rootstocks available for grafting. Yetisir (2003) also reported that in general, *Lagenaria* rootstock had a higher survival rate than did other rootstocks. Lin *et al*. (1998) reported that Luffa (bottle gourd) provides an excellent root stock for bitter gourd, and grafting can increase yields substantially mainly through the control of *Fusarium* wilt. The results of the male and female flowers emergence and number of grafted bottle gourd, cucumber and bitter gourd were earlier as well as higher than those of non-grafted plants. This may be due to the flowering time which is controlled by plant hormones. The stock-scion combination may alter amounts of hormones produced and their influence on grafted plants organ (Satoh, 1996). Yetisir (2003) reported that the flowering date of grafted plants in earlier than the non-grafted one. Marukawa (1979) also reported that the grafted seedlings had the first female flower at 36 to 43 days after grafting which is 10 to 17 days earlier as compared to directly sown, non grafted bitter gourds.

The yield of the grafted plants was superior than that of non grafted plants. The findings of this experiment was agreed with Lee (1994) and Oda (1994) who reported that the interaction between rootstocks and scions resulting the vigorous roots system that leading to the increased yield and fruit enhancement.

The seeds used in this experiment were accepted for commercial use as well as technical uses owing their germination rate were over 70 %. The grafted plants had higher vegetative and reproductive growth (yield) than non-grafted normal plant. Among two grafted technique, splice technique is suitable for bottle gourd and cucumber but the peg grafting method for bitter gourd owing to their high productivity. The application of trellis for bottle gourd, cucumber and bitter gourd enhanced the fruit yield. Trellis also provided the fruits not to touch to the soil which can develop fruit decay. The advantages of grafting are that disease resistant, plant growth, yield and fruit quality, to create the high yield varieties for farmers. Grafting of vegetable is also rapidly developing for our local market and to fulfill the required fruit production.

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***Lagenaria siceraria* (Mol.) Standl.: Local and F_1**




***Cucumis sativus* L.: Local and F_1**

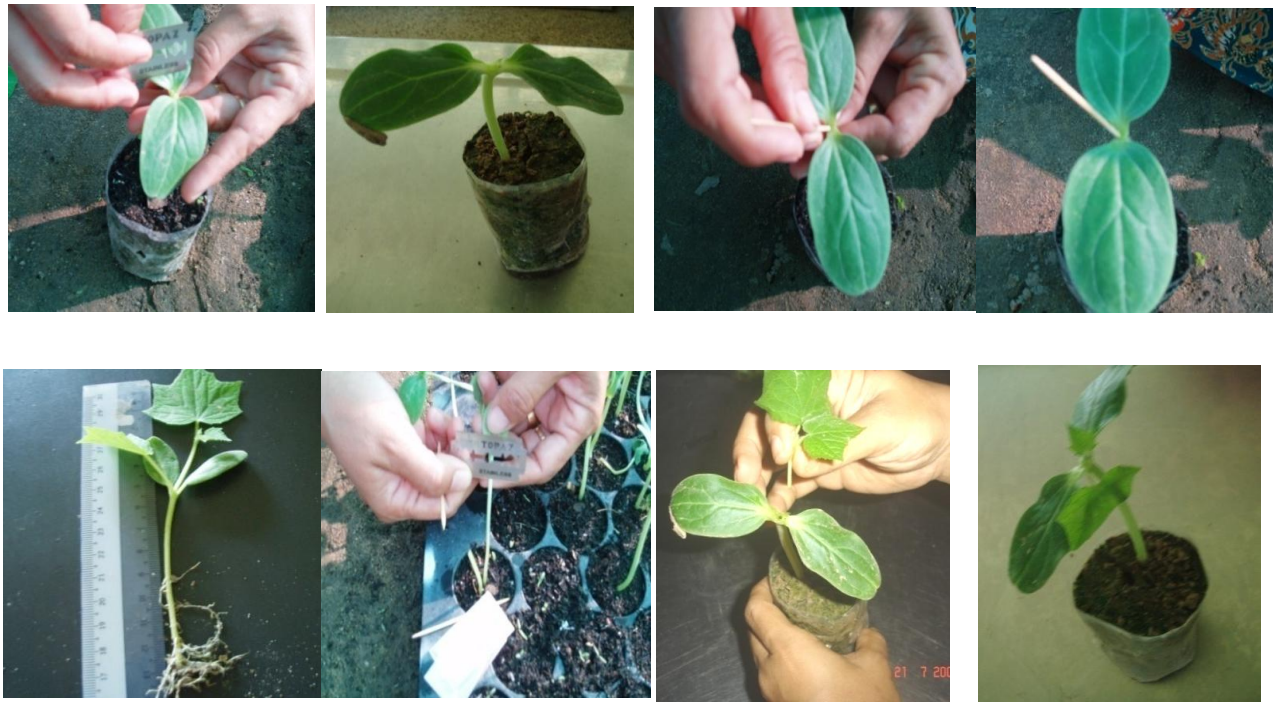



***Momordica charantia* L.: Local and F_1**





Vermicompost and Plastic Tray



Preparation of peg grafting technique



Preparation of splice grafting technique



Set up grafting experiment



Germination of cucumber, bottle gourd and bitter gourd



Cultivation



Yield of non-grafted cucumber



Yield of grafted cucumber



Cultivation



Yield of non-grafted bottle gourd



Yield of grafted bottle gourd



Cultivation



Yield of non-grafted bitter gourd



Yield of grafted bitter gourd

Cultivation and yield of cucumber, bottle gourd and bitter gourd