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Influential exploration of rootstocks and grafting techniques on horticultural traits of parthenocarpic cucumber

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Abstract
Grafting has a potential for higher yield and disease control in the cultivation of cucurbitaceous crops. The investigation was conducted to study the effect of rootstocks and grafting techniques on yield and quality attributes in cucumber. The seeds of local varieties of different rootstocks i.e. summer squash, bottle gourd, pumpkin, ash gourd, luffa, cucumber, and bitter gourd were procured from the local farmers. The experiment was laid out in a Randomized Block Design with three replications and data were recorded on various horticultural and quality traits of grafted plants viz. Days to first flowering, Days to first fruit set, Days to first harvest, Number of marketable fruits per plant, Marketable fruit yield per plant (kg), Average fruit weight (g), Marketable fruit yield per square meter (kg/m2), Fruit length (cm), Fruit diameter (cm), Harvest duration (days), Vine length (cm), Internodal length (cm),. Most of the characters under investigation were significantly influenced by the grafting techniques except average fruit weight, fruit length and width, length of vine and harvest duration. Therefore, it is inferred from the study that bottle gourd is the best compatible rootstock along with splice grafting technique for securing high yield in parthenocarpic cucumber under protected conditions.

Keywords: Rootstocks and grafting techniques, horticultural traits, parthenocarpic cucumber

Introduction
Vegetable grafting is a new concept in India, whereas it is very old technique in other countries like Japan, South Korea, Spain, China and Italy. It is defined as an art of joining together two plant parts (a rootstock and a scion) by means of tissue regeneration, in which the resulting combination of plant parts achieves physical reunion and grows as a single plant (Janick, 1986). Grafting occurs commonly in nature, and the observation of natural grafts may have inspired human use of this technique in horticulture thousands of years ago. It also acts as a site-specific management tool for soil and seed borne diseases. Parthenocarpic cucumber (*Cucumis sativus* L.) is one of the most important commercial vegetable crops being grown on a large scale under protected environment. It is popular throughout the world due to its crisp texture and taste. At present, in India cucumber is being cultivated in open field conditions, over an area of about 82,000 hectares with an annual production of 12,60,000 metric tonnes (Anonymous, 2018a) [1, 2]. In Himachal Pradesh area under cucurbits in open fields is 2578 hectares with a total production of 69,298 metric tonnes (Anonymous, 2018b) [1, 2]` whereas, in Himachal Pradesh the area and production statistics for cucumber are not available. Polyhouse technology is becoming popular in Himachal Pradesh due to concerted efforts of state and central governments through sponsored schemes like HTM, MIDH, RKVY, Pt Deen Dyal Kisan Rozgar Samridhi Yojna, Dr Y.S. Parmar Kisan Swarozgar Yojna and Chief Minister Greenhouse Technology Scheme. Due to these reasons Himachal Pradesh occupies a prime place in protected cultivation in the country. Parthenocarpic cucumber is the most popular crop grown under protected conditions due to its short life cycle. Under protected environment, parthenocarpic type of cucumber is preferred over open pollinated or hybrid due to cross pollination nature of the cucumber as open pollinated varieties need cross pollination which is not possible under protected structures as well as for higher yield per unit area. Parthenocarpic and gynoecious cucumber cultivars increase the potential yield to high fruit load in controlled environments resulting in a high harvest index (Sharma *et al.*, 2015) [4].

Material and Methods

The present study was carried out in a modified naturally ventilated polyhouse (25 m x 10 m) during off-season in 2018 at the "Experimental Farm of Department of Vegetable Science and Floriculture". It is an ideal polyhouse with essential features like double door, side and top ventilation, drip and fogging facilities and internal shading with 50% green agro UV stabilized shade net. The climate of the area is generally sub-temperate and semi-humid with mild summers (March to June) and cool winters (October to February) with high rainfall mainly during rainy season (June to September). Twenty-two treatments in total, comprising of seven rootstocks and three grafting techniques and control were laid out in a Randomized Block Design (Factorial) with three replications. The experimental material used comprised of seven Cucurbit rootstocks of local varieties namely Summer squash (*Cucurbita pepo*), Bottle gourd (*Lagenaria siceraria*), Pumpkin (*Cucurbita moschata*), Cucumber (*Cucumis sativus*), Bitter gourd (*Momordica charantia*), Luffa (*Luffa acutangula*), ash gourd (*Benincasa hispida*) and parthenocarpic cucumber hybrid Kian as scion. The nursery of the rootstock and scion varieties were raised in plug trays by using soil-less media having mixture of Cocopeat: Perlite: Vermiculite in the ratio of 3:1:1 in growth chamber. To obtain an equal stem-diameter in scion and the rootstock, rootstock seeds were planted 7 days earlier than scion variety. Five plants were randomly selected from each treatment in each replication from the experimental plots to assess the effect of treatments on both qualitative and quantitative characters.

Result and Discussion

Phenological traits

The number of days taken to first female flower appearance in cucumber under-protected as well as under open field conditions is an imperative character. It is an indicator of getting early and uniform fruit yield of cucumber. Rootstock (RS2) Bottle gourd produced significantly early flowers than other rootstocks used. It took a minimum number of days to first flowering. Though, rootstock Bottle gourd (RS2) took a minimum number of days to first fruit set; however, these were statistically at par with rootstocks Bitter gourd (RS5) and Summer squash (RS1).

Table 1: Effect of rootstocks and grafting techniques on days to first flowering, days to first fruit set and days to first harvest

Treatment	Days to first flowering	Days to first fruit set	Days to first harvest
A. Rootstocks			
Summer squash (RS_1)	20.04	27.12	37.81
Bottle gourd (RS_2)	18.82	26.59	34.78
Pumpkin (RS_3)	21.20	28.58	38.16
Cucumber (RS_4)	21.13	28.54	36.10
Bitter gourd (RS_5)	19.01	26.66	35.74
Luffa (RS_6)	21.06	28.41	38.04
Ash gourd (RS_7)	21.37	29.01	35.26
CD (P=0.05)	1.07	1.42	1.49
B. Grafting techniques			
Approach (GT_1)	20.55	28.32	36.31
Hole insertion (GT_2)	20.73	28.10	37.35
Splice (GT_3)	19.85	27.11	36.01
CD (P=0.05)	0.70	0.93	1.0
C. Control vs Others			
Control (Non-grafted)	21.80	30.00	39.00
Others	20.38	27.84	36.55
CD (P=0.05)	1.34	1.78	1.86

Rootstock Bottle gourd (RS2) grafted with popular parthenocarpic hybrid Kian as scion took a considerably lesser number of days to first harvest which were, statistically at par with rootstocks Ash gourd, Bitter gourd, and Cucumber. Splice grafting technique (GT3) took minimum number of days to first flower and days to first fruits set which was significantly superior w.r.t earliness than other grafting techniques i.e. approach (GT1) and hole insertion (GT2). Meanwhile, grafted plants (others) took significantly lesser number of days to first flowering and days to first fruits set than control. In addition to this, Splice grafting technique (GT3) took minimum number of days to first harvest which was statistically at par with approach grafting technique (GT1).

Yield and its horticultural traits

Rootstock Bottle gourd (RS2) produced a significantly higher number of marketable fruits per plant than all other rootstocks. Maximum fruit yield per plant was observed in plants grafted on rootstock Bottle gourd (RS2), which was notably superior to all other rootstocks utilized in the experiment. Among the various rootstocks used, plants grafted on rootstock Summer squash ensued in the highest average fruit weight per fruit which was statistically at par with rootstock Bottle gourd (RS2). The highest fruit yield per square meter area was found in cucumber plants grafted on rootstock Bottle gourd which was considerably higher than plants grafted on all other rootstocks. Maximum fruit length (16.10cm) was observed when plants were grafted on Summer squash rootstock (RS_1), whereas minimum length (13.74 cm) was reported in plants grafted on rootstock Bitter gourd (RS_5). It is to be mention here that the difference between the lengths of these two rootstocks was 2.36 cm. Plants grafted on rootstock (RS_2) Bottle gourd resulted in maximum fruit width (4.31 cm) which was statistically at par with rootstock (RS_7)Ash gourd with fruit width of 4.12 cm. On a meanwhile, longer fruits were observed when cucumber plants grafted onto Summer squash rootstock (RS1) as compared to other rootstocks. Rootstock Bottle gourd (RS2) was reported with long harvest duration has been statistically at par with rootstock Pumpkin (RS3) and Bitter gourd (RS5).

Table 2: Effect of rootstocks and grafting techniques on number of marketable fruits per plant, marketable fruit yield per plant (kg), average fruit weight (g) and marketable fruit yield per square meter (kg/m^2)

Treatment	No of marketable fruits per plant	Marketable fruit yield per plant (kg)	Average fruit weight (g)	Marketable fruit yield per square meter (kg/m$^{2)}$
A. Rootstocks				
Summer squash ($RS_{1)}$)	13.53	2.02	149.08	10.08
Bottle gourd (RS_2)	15.38	2.28	148.05	11.39
Pumpkin (RS_3)	12.98	1.83	141.07	9.17
Cucumber (RS_4)	14.29	1.97	138.13	9.87
Bitter gourd (RS_5)	12.31	1.72	139.68	8.61
Luffa (RS_6)	13.16	1.83	139.00	9.14
Ash gourd (RS_7)	13.36	1.84	137.30	9.19
CD (P=0.05)	0.91	0.14	5.53	0.70
B. Grafting techniques				
Approach (GT_1)	13.55	1.90	140.13	9.49
Hole insertion (GT_2)	12.95	1.83	140.87	9.15
Splice (GT_3)	14.22	2.05	144.28	10.26
CD (P=0.05)	0.59	0.09	NS	0.46
C. Control vs Others				
Control (Non-grafted)	15.00	2.13	133.87	10.67
Others	13.57	1.93	141.76	9.63
CD (P=0.05)	1.14	0.18	6.92	0.88

Various grafting techniques such as hole insertion, approach and splice, used in the present investigation, affected the number of fruits per plant significantly. Splice grafting technique (GT3) found with highest number of marketable fruits per plant, fruit yield per plant and marketable fruit yield per square meter. Besides this, Non-grafted plants (control) significantly produced higher number of marketable fruits per plant, marketable fruit yield per plant and higher marketable fruit yield per square meter. While, with other treatment combinations (grafted plants) on an average produced (13.57) number of marketable fruits per plant, 1.93 kg of yield per plant and produced on an average 9.63 kg/m2 of yield, respectively. In case of average fruit weight grafting techniques had no significant effect on average fruit weight. But, grafted plants produced fruits with considerably higher average fruit weight compared to non-grafted (control).

Plate 1: Evaluation of rootstocks for *Didymella bryoniae* disease reaction

General view of the research trial at Vegetable Research Farm

Table 3: Effect of rootstocks and grafting techniques on fruit length (cm), fruit width (cm) and harvest duration (days)

Treatment	Fruit length (cm)	Fruit width (cm)	Harvest duration (days)
A. Rootstocks			
Summer squash (RS_1)	16.10	4.07	46.02
Bottle gourd (RS_2)	14.53	4.31	48.38
Pumpkin (RS_3)	14.61	4.05	47.54
Cucumber (RS_4)	14.37	4.08	46.98
Bitter gourd (RS_5)	13.74	4.02	47.75
Luffa (RS_6)	13.87	4.03	47.01
Ash gourd (RS_7)	14.69	4.12	46.83
CD (P=0.05)	0.79	0.19	1.16
B. Grafting techniques			
Approach (GT_1)	14.56	4.07	46.82
Hole insertion (GT_2)	14.32	4.13	47.63
Splice (GT_3)	14.79	4.09	47.20
CD (P=0.05)	NS	NS	NS
C. Control vs Others			
Control (Non-grafted)	15.83	4.53	46.80
Others	14.56	4.10	47.22
CD (P=0.05)	0.98	0.23	NS

Different grafting techniques used in the study did not show any significant effect on fruit length, width and harvest duration. Moreover on that, grafted plants found to be more prominent as compared to control as it could be correlated with variation in intervals of fruit maturity. Non-grafted plants (control) recorded significantly higher for fruit length of 15.83 cm and fruit width of 4.53 cm as compared to average of other treatments (grafted plants) (14.56 cm) length wise and in fruit width of 4.10 cm, correspondingly.

Structural traits

The data on inter-nodal length as influenced by innumerable rootstocks, grafting techniques and their interactions, respectively. The internodal length determines the height and number of nodes per plant. Minimum Internodal length was accounted for when cucumber plants were grafted on rootstock Bitter gourd (RS5) and were statistically at par with rootstocks Ash gourd (RS7), Luffa (RS6), Cucumber (RS4) and Summer squash (RS1). Mean comparison of the vine length exhibited that the longest vine was observed in cucumber plants grafted on rootstock Bottle gourd (RS2) which was statistically at par with plants grafted on rootstocks Pumpkin (RS3) and Cucumber (RS4).

Grafting techniques also affected internodal length significantly. Minimum internodal length of 10.47 cm was observed when plants were grafted using approach grafting technique (GT1). Meanwhile, grafting techniques did not affect the vine length (cm) considerably. In general grafted plants had noticeably longer vines as compared to non-grafted (control).

Table 4: Effect of rootstocks and grafting techniques on internodal length (cm) and vine length (cm)

Treatment	Internodal length (cm)	Vine length (cm)
A. Rootstocks		
Summer squash (RS_1)	11.12	303.33
Bottle gourd (RS_2)	11.63	327.89
Pumpkin (RS_3)	11.34	327.22
Cucumber (RS_4)	11.05	324.56
Bitter gourd (RS_5)	10.23	297.56
Luffa (RS_6)	10.60	289.44
Ash gourd (RS_7)	10.30	288.33
CD (P=0.05)	0.92	15.71
B. Grafting techniques		
Approach (GT_1)	10.47	310.8
Hole insertion (GT_2)	11.27	305.0
Splice (GT_3)	10.95	309.2
CD (P=0.05)	0.60	NS
C. Control vs Others		
Control (Non-grafted)	10.57	286.33
Others	10.90	308.81
CD (P=0.05)	NS	19.67

Conclusion

The present investigation confirms that the rootstocks and grafting techniques play a remarkable role in affecting growth and development of the cucumber. Rootstock and scion compatibility is crucial for getting desired results in grafted plants. Local varieties of different cucurbits were used for grafting a popular parthenocarpic cucumber hybrid Kian. Bottle gourd rootstock was found as one of the best rootstocks for grafting and it recorded higher plant growth and yield. Evaluation of characters based on grafting techniques revealed that splice grafting technique was the easiest method to be utilized with positive significant outcomes. Therefore, on the basis of outcome obtained from the analysis of various growth and yield attributes, resulted that bottle gourd is best compatible rootstock along with splice grafting technique for securing high yield under protected conditions.

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