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Effect of different environmental conditions on performance of sapota softwood grafts worked on invigorated khirni rootstock on days required for bud sprouting, sprout length and branches per graft

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Abstract
An experiment entitled **"**Effect of different environmental conditions on performance of sapota softwood grafts worked on invigorated khirni rootstock." Experiment was laid out in Factorial Randomized Block Design with eight treatment combinations comprising factor A four different environmental conditions C_1 (Open condition), C_2 (Partial shade condition), C_3 (Partial shade (tree shade) condition), C_4 (Poly house condition) and factor B comprised of two decaping height of invigorated khirni rootstock viz., 10 cm and 15 cm from ground level and these were replicated five times. The treatment combination of poly tunnel and decaping height at 15 cm from ground level took minimum days for bud sprouting (15.80) days which was at par with treatment combination green shade net tunnel 50% and decaping height at 15 cm from ground level (16.12) days. Whereas, open condition and decaping height at 10 cm from ground level took maximum days for sprouting (22.46) days.

Keywords: Sapota, Khirni, Rootstock, Grafting and Bud sprouting

Introduction
Sapota (*Manilkara achras L.*) is one of the important fruit crop of tropical and subtropical regions of India. It is popularly known as ''Chiku'' or Sapodilla in India. It is a delicious fruit and eaten as dessert fruit.

Sapota belongs to family Sapotaceae and introduced from Tropical America. Sapota is a native of Mexico and Central America and now widely cultivated throughout tropics. Sapota cultivation was taken up for the first time in Maharashtra in 1898 in a village named Gholwad (Cheema *et al*. 1954). The states that are growing sapota on a commercial scale in India are Maharashtra, Gujrat, Andhra Pradesh, West Bengal, Punjab and Haryana. Total area under sapota in India is about 177.0 Lakh ha with production of 17.44.3 lakh MT. In Maharashtra, area under sapota is about 56,896 Lakh ha with production of 2, 05,360 MT and productivity of 9.9 MT/ha (Anonymous NHB, 2014) [1]

Sapota plants are evergreen in nature. The tree canopy has four kinds, viz., erect growing, with drooping branches ,spreading branches with inferior fruits and spreading branches with sweet fruits. It has strong trunk on which scaffolds develop at regular intervals. Fruit bearing is on new growth in axils of leaves. Flowers have 6 sepals, 6 stamens which are petaloid.

Sapota is mainly valued for its sweet and delicious fruits. It has a high sugar content (20%) from a total of 21.4% carbohydrate, 1.1 % in addition to vitamins A, B_1, B_2, B_6, C, protein 0.7% and also rich in useful minerals such as 27.0 mg phosphorous, 28.0 mg calcium, potash, 2.0 mg iron, 6.0 mg ascorbic acid magnesium and sodium per 100 gm of fruit . Sapota is also grown for its edible milky latex known as gutta- percha from which chewing gum is manufactured. A number of processed products such as jam, jelly, marmalade, toffee, preserve,fruit bar and flakes are prepared. Another feature of this crop is the ease in post-harvest handling. Of late, sapota cultivation has attaracted many farmers of this region on account of its better adoption to diversified soil and climatic conditions. Hence, there is scope for increasing the area under this crop.

Material and method
1. Days required for bud sprouting
The numbers of days required for sprouting of grafts were observed from the day of grafting

operation. From randomly selected five observational plants and after computing the means average period for sprouting was worked out as days required for bud sprouting.

2. Sprout length (cm)
In each graft, the sprout length of grafts was measured by measuring scale at monthly interval up to 180 days after grafting operation and after computing the mean, it was expressed as sprout length of scion in centimeter.

3.Branches per graft
Number of branches produced per graft was recorded at 180 days after grafting operations. After computing the mean, it was expressed as number of branches per graft.

Result and discussion
1.Effect of different environmental conditions and decaping height of invigorated khirni rootstock on days required for bud sprouting
The data regarding days required for bud sprouting as influenced by environmental conditions and decaping height of invigorated khirni rootstock were recorded and presented in Table 1 and depicted in fig. 1.

1.1 Effect of environmental conditions
From the Table 1, it is clearly indicated that, different environmental conditions influenced significantly on days required for bud sprouting of grafts. Among different environmental conditions minimum days required for bud sprouting in poly tunnel (16.32) days, followed by green shade net tunnel - 50% (17.28) days. Whereas maximum days required for bud sprouting under open condition (21.70) days.

Table 1: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on days required for bud sprouting

Treatments Environmental conditions	Days required for bud sprouting
C_1 (Open condition)	21.70
C_2 (Partial shade (Tree shade)	20.09
C_3 (Green shade net tunnel 50%)	17.28
C_4 (poly tunnel)	16.32
F-Test	Sig
SE(m) ±	0.16
CD at 5%	0.48
Decaping height	
H_1 (10 cm from ground level)	19.60
H_2 (15 cm from ground level)	18.09
F-Test	Sig
SE(m) ±	0.11
CD at 5%	0.34
Treatment combinations	
C_1 x H_1	22.46
C_1 X H_2	20.94
C_2 X H_1	20.66
C_2 X H_2	19.52
C_3 X H_1	18.44
C_3 X H_2	16.12
C_4 X H_1	16.84
C_4 X H_2	15.80
F-Test	Sig
SE(m) ±	0.23
CD at 5%	0.69

The difference in days to sprouting due to a built in mechanism and inherent potential or physiological condition of the root stock for initial success and early sprouting and storage of more metabolites for survival and growth of the sprout as reported by Dubey *et al.* (2002) [8]. This is perhaps due to fact that sprouting is influenced by the prevailing temperatures during the period availability of active buds and the higher temperatures during July and August in poly tunnels helped in early sprouting, while lower temperatures during the preceding winter months may have inhibited sprouting as reported in some fruit crops by Pathak (1991) [19] and Awasthi *et al.* (2005) [4] in tamarind. These results are in line with the finding of Nair *et al.* (2002) [15] in mango. Patel *et al.* (2007) [18] in mandarin, Mir and Kumar (2011) [13] in walnut and Raghavendra *et al.* (2011) [20] in wood apple who reported that minimum days to sprouting was recorded in softwood grafting under poly house conditions. This may be due to rapid formation of callus tissues allows translocation of vital biochemical compounds between stock and scion might be the reason for minimum days to sprouting Syamal *et al.* (2012) [24]. Results obtained are in accordance with the results of Mulla *et al*. (2011) [14] in Jamun.

1.2. Effect of decaping height of invigorated khirni rootstock.
The data presented in the Table 1, revealed that, the effect of decaping height of invigorated khirni rootstock on days required for bud sprouting was found to be significant. The minimum days required for bud sprouting (18.09) days required in decaping height at 15 cm from ground level. However, maximum (19.60) days required for bud sprouting was observed in decaping height at 10 cm from ground level grafted on invigorated khirni rootstock seedlings. This results are corroborated with Srinivas (2007) [27] in sapota, Kumar *et al.* (2000) [12] in mango, Aboutalebi *et al*. (2012) [5] in ber.

1.3. Interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock
The interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock was found to be significant in days required for bud sprouting. However, minimum days required for sprouting (15.80) days was recorded in poly tunnel and decaping height at 15 cm from ground level, which was at par with (16.12) treatment combination green shade net tunnel 50% and decaping height at 15 cm from ground level and maximum (22.46) days required for bud sprouting was recorded in the treatment combination open condition and decaping height at 10 cm from ground level.
Days required for bud sprouting of grafts early come and increased significantly when kept under the poly tunnel with decaping height at 15 cm from ground level. This might be due to the higher cambial activity at 15 cm height for sprouting inside the polyhouse could be attributed to congenial environment condition owing to rapid callusing and early contact to cambium layers, thus enabling the graft to heal quickly and make a strong union. Ultimately results into more vegetative growth of grafts which might be helpful in early sprouting in sapota grafts. These results are in close agreement with the finding of Patel *et al.* (2007) in mandarin, Tandel and Patel (2009) [25] in sapota, Islam *et al.* (2003) [16] in Jackfruit, Panchabhai *et al.* (2005) [17] and Roshan *et al.* (2008) in anola.

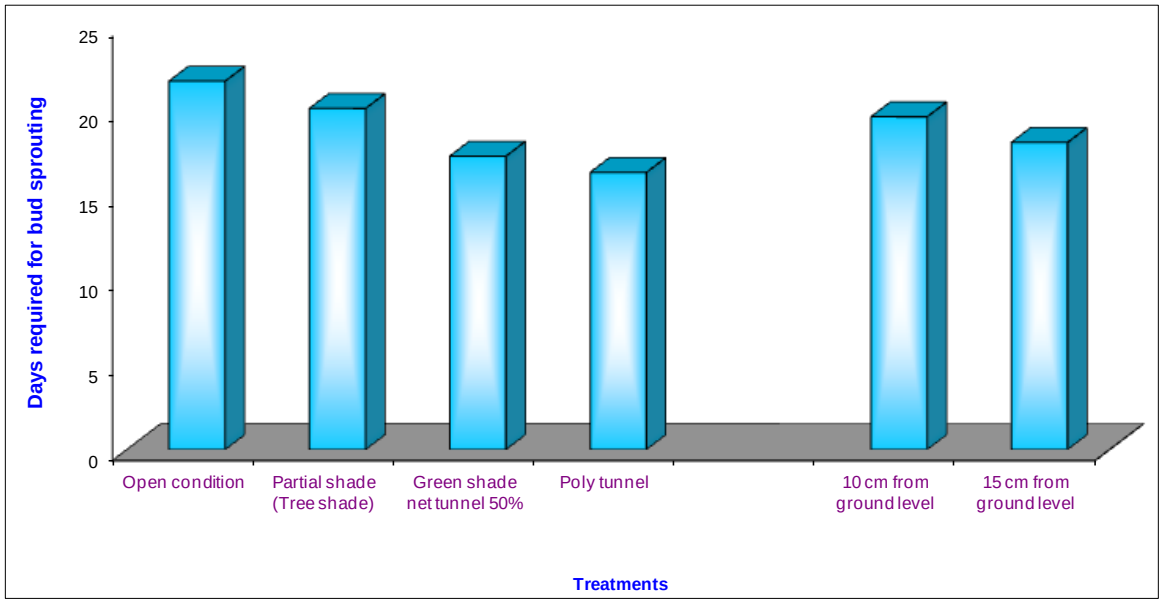

Fig 1: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on days required for bud sprouting

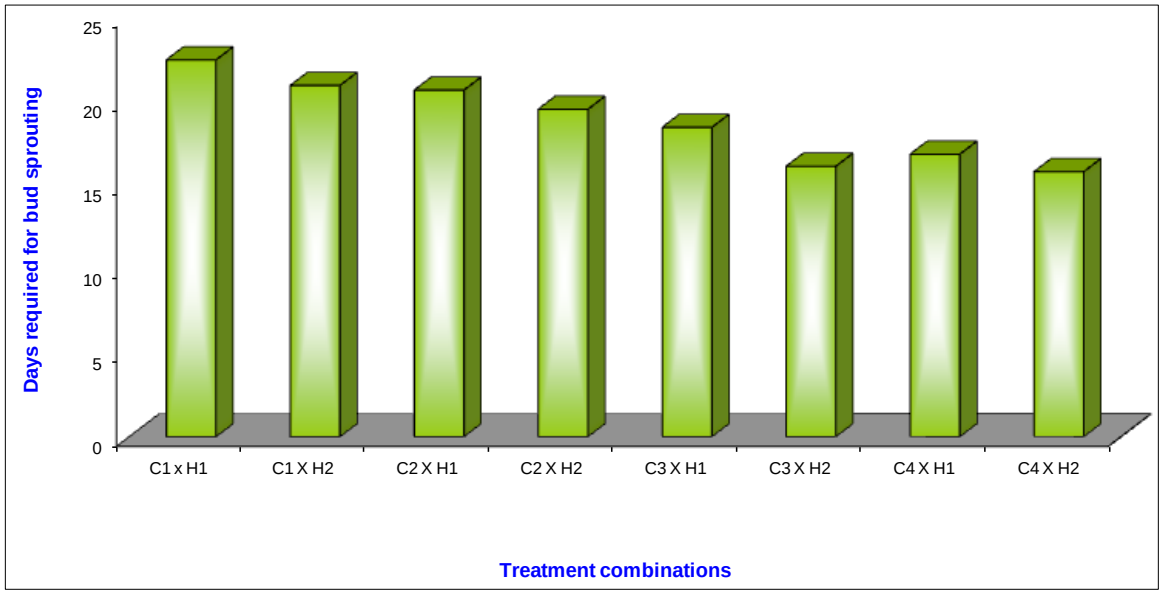

Fig 2: Interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock on days required for bud sprouting

2. Effect of different environmental conditions and decaping height of invigorated khirni rootstock on sprout length

Perusal of data regarding sprout length as influenced by the different environmental conditions and decaping height of invigorated khirni rootstock were recorded at 30 days of interval and are presented in Table 2 and depicted in fig. 4.

Table 2: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on sprout length

Treatments	Sprout length (cm)					
	30 DAG	60 DAG	90 DAG	120 DAG	150 DAG	180 DAG
Environmental conditions						
C_1 (Open condition)	2.29	3.67	4.94	6.84	9.06	11.60
C_2 (Partial shade (Tree shade)	2.75	4.89	6.23	7.73	10.73	13.13
C_3 (Green shade net tunnel 50%)	4.07	6.54	8.07	9.72	13.74	16.57
C_4 (poly tunnel)	4.84	7.37	8.91	10.86	14.70	17.59
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) ±	0.13	0.14	0.20	0.22	0.25	0.18
CD at 5%	0.38	0.41	0.59	0.65	0.73	0.52
Decaping height						
H_1 (10 cm from ground level)	3.00	5.02	6.33	8.12	10.87	13.41
H_2 (15 cm from ground level)	3.97	6.21	7.74	9.45	13.24	16.03
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) ±	0.09	0.10	0.14	0.16	0.18	0.12

CD at 5%	0.27	0.29	0.41	0.46	0.52	0.36
Treatment combinations						
C_1 x H_1	2.08	3.34	4.74	6.52	8.60	11.04
C_1 X H_2	2.50	4.00	5.14	7.16	9.52	12.16
C_2 X H_1	2.34	4.12	5.48	7.40	9.26	12.26
C_2 X H_2	3.16	5.66	6.98	8.06	12.20	14.00
C_3 X H_1	3.36	6.02	7.18	8.82	12.34	14.92
C_3 X H_2	4.78	7.06	8.96	10.62	15.14	18.22
C_4 X H_1	4.22	6.60	7.92	9.76	13.30	15.42
C_4 X H_2	5.46	8.14	9.90	11.96	16.10	19.76
F-Test	N S	N S	Sig	Sig	Sig	Sig
SE(m) ±	0.18	0.20	0.28	0.32	0.36	0.25
CD at 5%	-	-	0.83	0.92	1.04	0.73

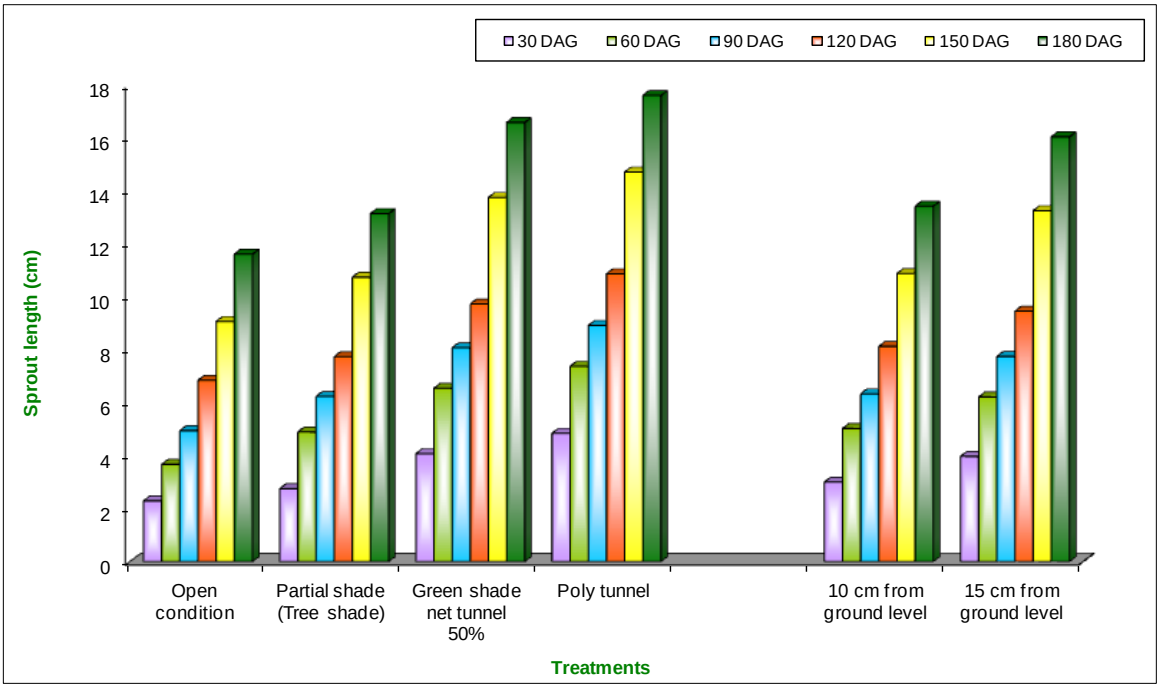

Fig 3: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on sprout length (cm)

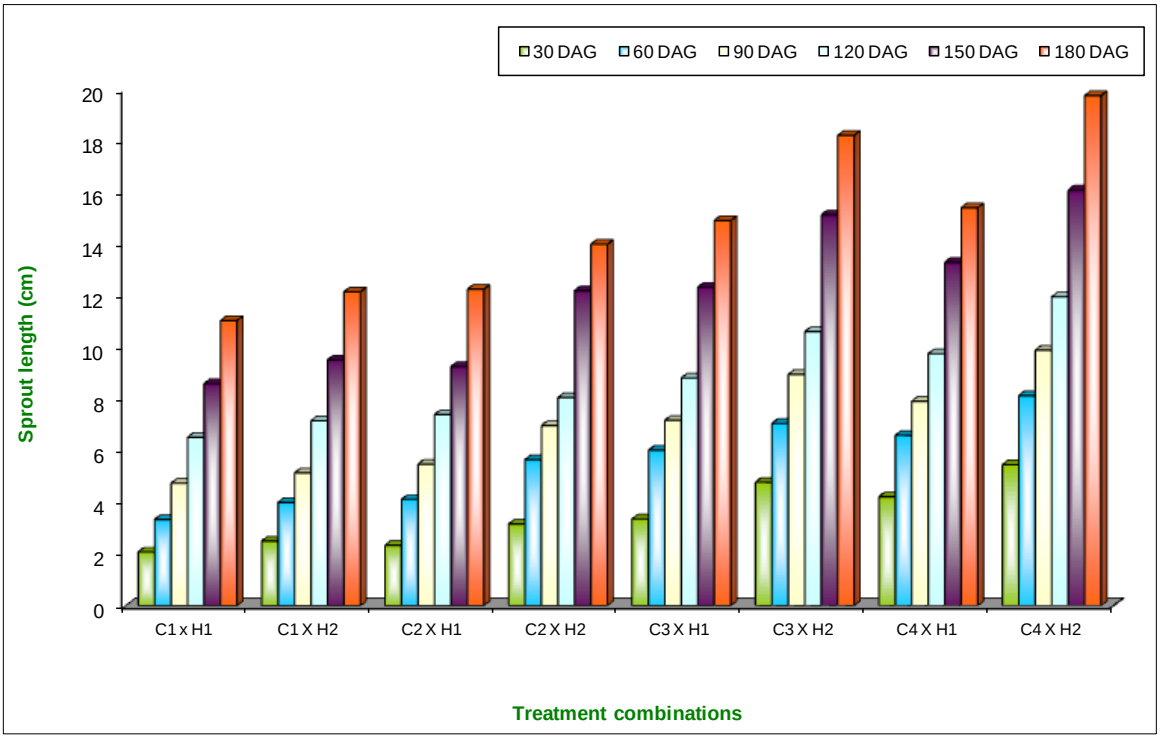

Fig 4: Interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock on sprout length (cm)

2.1 Effect of different environmental conditions

From the data in the Table 2. revealed that, sprout length were differ significantly due to different environmental conditions during the all stage of growth.

At the stage 30 days after grafting, the poly tunnel recorded significantly maximum sprout length (4.84 cm), followed by green shade net tunnel - 50%. However, minimum sprout length was noticed in open condition (2.29 cm).

Similar trend of results were noticed at 60, 90, 120, 150 and 180 days after grafting.

These observations are in conformity with those of Mir & Kumar *(*2011) [13] who reported that maximum length of sprout (cm) was recorded in wedge grafting of walnut under poly house condition. Ghafoor *et al.* (2001) [10] in pecan nut. Shinde *et al.* (2010) [21], Kalalbandi *et al.* (2014) in sapota.

2.2. Effect of decaping height of invigorated khirni rootstock

Data in the Table 2, it is clearly indicated that, sprout length was significantly influenced by the decaping height of invigorated khirni rootstock. Increasing trend was observed regarding sprout length.

At the stage 30 days after grafting, decaping height at 15 cm from ground level recorded significantly maximum sprout length ((3.97 cm). whereas, minimum length of scion was recorded in decaping height at 10 cm from ground level (3.00 cm)

Similar trend of results were noticed at 60, 90, 120, 150 and 180 days after grafting.

The number of lateral shoots increased significantly with increased grafting height. These results are corroborated with Srinivas (2007) [27] in sapota, Kumar *et al.* (2000) [12] in mango and Aboutalebi *et al.* (2012) [5] in ber, Karlidag *et al.* (2012) [11] in apple.

2.3 Interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock on sprout length

An interaction effect of environmental conditions and different decaping height of invigorated khirni rootstock were found to be significant for length of scion of sapota grafts at all stages of growth i.e. 90, 120, 150 and 180 DAG except 30 and 60 DAG.

At the stage 90 and 120 days after grafting, maximum sprout length was exhibited by the poly tunnel and decaping height at 15 cm from ground level (9.90 and 11.96 cm respectively), followed by green shade tunnel – 50% and decaping height at 15 cm from ground level (8.96 and 10.62 cm respectively). Whereas, minimum sprout length was recorded in open condition and decaping height at 10 cm from ground level (4.74 and 6.52 cm).

At the stage 150 days after grafting. Maximum sprout length (16.10 cm) obtained by the poly tunnel and decaping height at 15 cm from ground level, which was at par with treatment combination green shade tunnel – 50% and decaping height at 15 cm from ground level. However, minimum length (8.60 cm) was obtained by open condition and decaping height at 10 cm from ground level.

Similar trend of results were noticed at 180 days after grafting.

Length of sprout increased significantly with when kept under the poly tunnel with decaping height at 15 cm from ground level. This might be due to the fact that, the better growth of grafts and weather condition like temperature and humidity, which played important role in growth of grafts. Yelleshkumar *et al.* (2008). This could be attributed to the vigorous growth of stock, which increased the growth and loads to maximum accumulation of stored metabolites at the time of grafting. (Devechandra, 2006) [9]. Ultimately results into more vegetative growth of plants which might be helpful in length of sprout in sapota grafts. This result is line with the finding of Singh (1977), Dewangan and Raut (2014), Patel *et al.* (2007) [18].

2.4. Effect of different environmental conditions and decaping height of invigorated khirni rootstock on branches per graft at 180 DAG

Data regarding branches per graft as influenced by the different environmental conditions and decaping height of invigorated khirni rootstock at 180 days after grafting is presented in Table 3 and depicted in fig. 5.

Table 3: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on branches per graft at 180 DAG

Treatments Environmental conditions	Branches per graft at 180 DAG
C_1 (Open condition)	2.30
C_2 (Partial shade (Tree shade)	2.98
C_3 (Green shade net tunnel 50%)	4.54
C_4 (poly tunnel)	5.08
F-Test	Sig
SE(m) ±	0.11
CD at 5%	0.31
Decaping height	
H_1 (10 cm from ground level)	2.88
H_2 (15 cm from ground level)	4.57
F-Test	Sig
SE(m) ±	0.07
CD at 5%	0.22
Treatment combinations	
C_1 x H_1	1.84
C_1 X H_2	2.76
C_2 X H_1	2.16
C_2 X H_2	3.80
C_3 X H_1	3.28
C_3 X H_2	5.80
C_4 X H_1	4.24
C_4 X H_2	5.92
F-Test	Sig
SE(m) ±	0.15
CD at 5%	0.45

3.1. Effect of different environmental conditions

The data regarding the branches per graft arise from scion presented in Table 14 revealed that, the different environmental conditions showed significant effect on branches per graft at 180 days after grafting. Maximum numbers of branches (5.08) were produced in poly tunnel, followed by (4.54) green shade net tunnel - 50%. Whereas, open condition showed minimum branches per graft (2.30).

Branches per graft increased significantly when grafts were kept under poly tunnel. This might be due to congenial environment condition owing to rapid callusing and early contact to cambial layers, thus enabling the graft to heal quickly and make a strong union. These results are in line with the finding of Patel *et al.* (2007) [18] in mandarin, Anushma *et al.* (2014) [14] in jamun and Sivudu *et al.* (2014) [22] in mango.

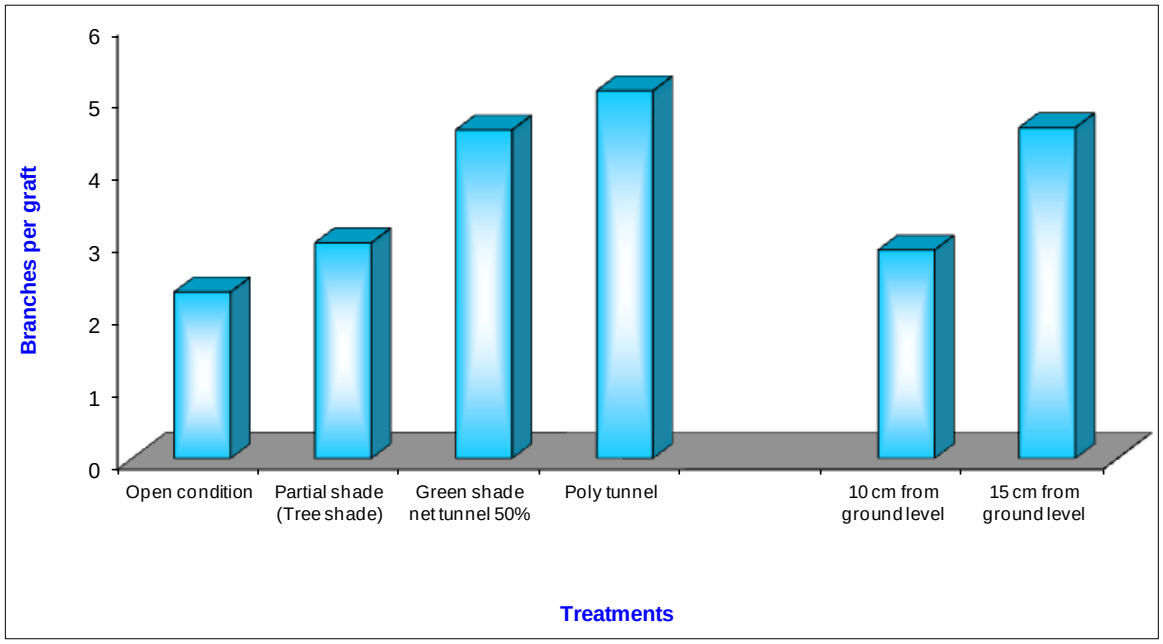

Fig 5: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on branches per graft at 180 DAG

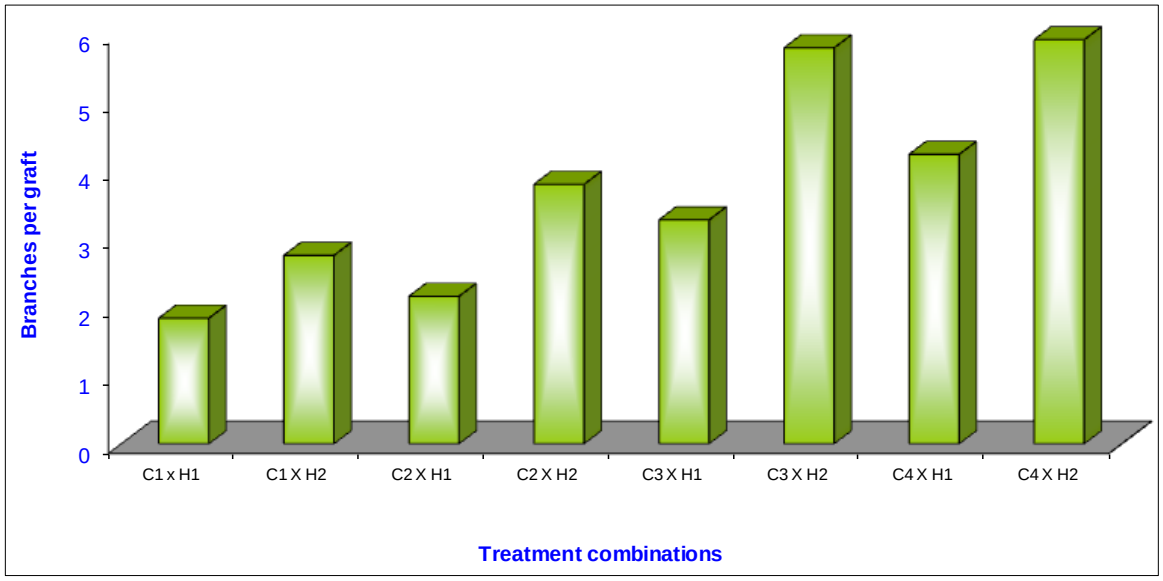

Fig 6: Interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock on branches per graft at 180 DAG

3.2. Effect of decaping height of invigorated khirni rootstock

From the Table 3, it is observed that, the decaping height of invigorated khirni rootstock showed significant effect on branches per graft at 180 days after grafting. The maximum branches per graft (4.57) were observed in decaping height at 15 cm from ground level. While, minimum branches per graft (2.88) noticed in decaping height at 10 cm from ground level.

More quantity of food material stored in invigorated rootstocks which help in boosting the growth of young scion this might be the reason for production of more number of branches. The results are in corroborated with findings of the scientists Shwetha *et al.* (2015) in mango. Pampanna and Sulikeri (1995) in sapota, and Patil *et al*. (2012) in sapota.

3.3. Interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock on branches per graft

The data presented in the Table 3, revealed that, the interaction effect of different environmental conditions and decaping height of invigorated khirni rootstock showed significant effect on branches per graft. The maximum branches per graft produced (5.92) in poly tunnel and decaping height at 15 cm from ground level, which is at par with treatment combination green shade tunnel – 50% and decaping height at 15 cm from ground level. However, minimum branches per graft (1.84) obtained from treatment combination open condition and decaping height at 10 cm from ground level.

Branches per graft increased significantly with when kept under the poly tunnel with 15 cm from ground level. This might be due to the fact that wide variation in the temperature and humidity under the different conditions. These factors influence the branches per plant, sprouting, grafts success and plant growth. Patel *et al*. (2007) [18]. This result are in line with the finding of Singh (1977), Anon. 1993 [2], Reddy and Kohli (1985), Chattopadhyay (1994).

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