



E-ISSN: 2278-4136

P-ISSN: 2349-8234

www.phytojournal.com

JPP 2020; 9(2): 2340-2347

Received: 03-01-2020

Accepted: 06-02-2020

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Effect of different environmental conditions on performance of sapota softwood grafts worked on invigorated Khirni rootstock on length of scion Shoot, number of leaves per graft and leaf area

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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 C₁ (Open condition), C₂ (Partial shade condition), C₃ (Partial shade (tree shade) condition), C₄ (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. Maximum length of scion shoot (20.20 cm) was observed in poly tunnel and decaping height at 15 cm from ground level, whereas minimum length of scion shoot (12.16 cm) exhibited by open condition and decaping height at 10 cm from ground level.

Keywords: Sapota, Khirni, rootstock, grafting, scion, shoot and length

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 through out 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, B₁, B₂, B₆, 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 attracted 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. Length of scion (cm)**

In each graft, the scion length of grafts was measured at monthly interval upto 180 days after grafting operation and after computing the mean it was expressed as length of scion in centimeter.

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2. Number of leaves per graft

Number of leaves produced per graft was recorded at monthly interval up to 180 days after grafting operations. After computing the mean, it was expressed as number of leave per graft.

3. Leaf area (cm²)

In sprouted grafts the leaf area was estimated at monthly interval up to 180 days from grafting operation with the help of leaf area meter and computing the mean, it was expressed in square centimeter.

Result and Discussion

1. Effect of different environmental conditions and decaping height of invigorated khirni rootstock on length of scion shoot

The data regarding length of scion shoot was significantly influenced by different environmental conditions and

decaping height of invigorated khirni rootstock were recorded at 30 days of interval and are presented in Table 1. and depicted in fig. 1.

1.1. Effect of different environmental conditions

The data presented in Table 1, indicated that the effect of different environmental conditions on length of scion were found to be significant at the all stages of growth. Under different environmental conditions increasing trend was observed regarding length of scion shoot.

From Table 1, it is clearly indicated, the significant results with respect to the effect of different environmental conditions on length of scion at 30 days after grafting. Among different environmental conditions maximum length of scion shoot was obtained from the poly tunnel (8.98cm), followed by green shade net tunnel -50% (8.52cm). However, minimum length of scion was observed in open condition (7.36cm).

Table 1: Effect of different environmental conditions and decaping height of invigorated khirni rootstock on length of scion shoot

Treatments	Length of scion shoot (cm)					
	30 DAG	60 DAG	90 DAG	120 DAG	150 DAG	180 DAG
Environmental conditions						
C ₁ (Open condition)	7.36	8.66	9.28	10.36	11.21	13.23
C ₂ (Partial shade (Tree shade))	7.98	9.53	10.38	11.28	12.75	14.81
C ₃ (Green shade net tunnel 50%)	8.52	10.52	12.12	13.77	15.44	17.84
C ₄ (poly tunnel)	8.98	10.88	12.47	14.03	16.28	18.77
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.12	0.14	0.16	0.18	0.20	0.17
CD at 5%	0.36	0.41	0.46	0.53	0.58	0.51
Decaping height						
H ₁ (10 cm from ground level)	7.9	8.48	10.47	11.41	12.84	15.02
H ₂ (15 cm from ground level)	8.51	8.84	11.65	13.30	14.99	17.30
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.08	0.10	0.11	0.13	0.14	0.12
CD at 5%	0.25	0.29	0.32	0.37	0.41	0.36
Treatment combinations						
C ₁ x H ₁	7.12	8.48	8.92	9.80	10.84	12.68
C ₁ X H ₂	7.60	8.84	9.64	10.92	11.58	13.78
C ₂ X H ₁	7.88	9.04	9.44	10.98	11.72	13.70
C ₂ X H ₂	8.08	10.02	11.32	11.58	13.78	15.92
C ₃ X H ₁	7.98	9.66	11.74	12.22	14.04	16.36
C ₃ X H ₂	9.06	11.38	12.50	15.32	16.84	19.32
C ₄ X H ₁	8.64	10.16	11.78	12.66	14.78	17.34
C ₄ X H ₂	9.32	11.60	13.16	15.40	17.78	20.20
F-Test	NS	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.17	0.20	0.22	0.26	0.28	0.25
CD at 5%	-	0.59	0.65	0.75	0.82	0.73

At the 60, 90 and 120 days after grafting, in poly tunnel recorded significantly maximum length of scion (10.88, 12.47 and 14.03 cm respectively), which was at par with green shade net tunnel 50% (10.52, 12.12 and 13.77 cm respectively). Whereas, minimum length of scion shoot was recorded in open condition (8.66, 9.28 and 10.36 cm respectively).

At the stage of 150 and 180 days after grafting, in poly tunnel observed maximum length of scion (16.28 and 18.77 cm), followed by green shade net tunnel – 50 % (15.44 and 17.84 cm respectively) was observed. However, minimum length of scion (11.21 and 13.23 cm respectively) was recorded under open condition.

Length of scion increased significantly when kept under the poly tunnel, this might be due to the fact that, relatively increased in height of graft inside the poly tunnel could be attributed 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. Ultimately results into more vegetative growth of sapota grafts which might be helpful in increasing the height of sapota grafts. Patel *et al.* (2007) [20]. Nair *et al.* (2002) [16], who reported that maximum height of graft scion was recorded in epicotyl grafting of mango under colored poly house condition and Gurjar & Singh (2012) [11] reported that the maximum length of scion stick in wedge grafting of aonla at poly house condition. Hadli and Raijadhav (2010) [12] in lime. Dewangan and Raut (2014) [10] in mango.

1.2. Effect of decaping height of invigorated khirni rootstock

From the data in the Table 1. it is evident that, decaping height of invigorated khirni rootstock on length of scion was found to be significant during the all stage of growth. Among

the different decapating heights of invigorated khirni rootstock increasing trend was observed regarding the length of scion shoot.

At the stage 30 days after grafting, decapating height at 15 cm from ground level recorded significantly maximum length of scion shoot (8.51 cm). However, minimum length of scion was recorded in decapating height at 10 cm from ground level (7.90 cm).

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

Length of scion shoot increases when rootstock were decapitated at 15 cm from ground level. Due to fact that the height of grafting had an important effect on the accumulation of sugars and dry matter. Caulet *et al.* (2009) ^[6], Srinivas (2007) ^[26] in sapota, Kumar *et al.* (2000) ^[13] in mango, Aboutalebi *et al.* (2012) ^[5] in ber.

1.3 Interaction effect of different environmental conditions and decapating height of invigorated khirni rootstock on length of scion shoot

The interaction effect of different environmental conditions and decapating height of invigorated Khirni rootstock influenced significantly on length of scion shoot at the all stages of growth i.e. 60, 90, 120, 150, and DAG except 30 DAG.

The data regarding the different environmental conditions and decapating height of invigorated khirni rootstock on length of scion shoot at the stage of 30 days after grafting was found to be statistically non-significant.

At the stage 60 days after grafting, the maximum length of scion (11.60 cm) was exhibited by the poly tunnel and decapating height at 15 cm from ground level, which was at par with (11.68 cm) green shade net tunnel – 50% and decapating height at 15 cm from ground level. Whereas, minimum length of scion (8.48 cm) was recorded in open condition and decapating height at 10 cm from ground level.

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

Length of scion increased significantly when kept under the poly tunnel with decapating height at 15 cm decapating height. This might be due to the fact that, it promotes the rate of transpiration, keeps the guard cells turgid and the stomata open which may have resulted in earlier production and accumulation of carbohydrate, protein and earlier completion of other physiological process involved in development of rapid growth between the stock and scion. Dhungana (1989) ^[10] in mango, The difference in days to sprouting, graft success, plant survival and scion growth seems to be due to a built in mechanism and inherent potential or physiological condition of the rootstock 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) ^[9]. Ultimately results into more vegetative growth of plants which might be helpful in the length of scion in sapota graft. This lines are corroborated with the finding of the scientist Singh (1977) ^[25], Pampanna and Sulikheri (2000) in sapota, Nair *et al.* (2002) ^[16] in mango. Hadli and Rajadhar (2010) ^[12] in lime.

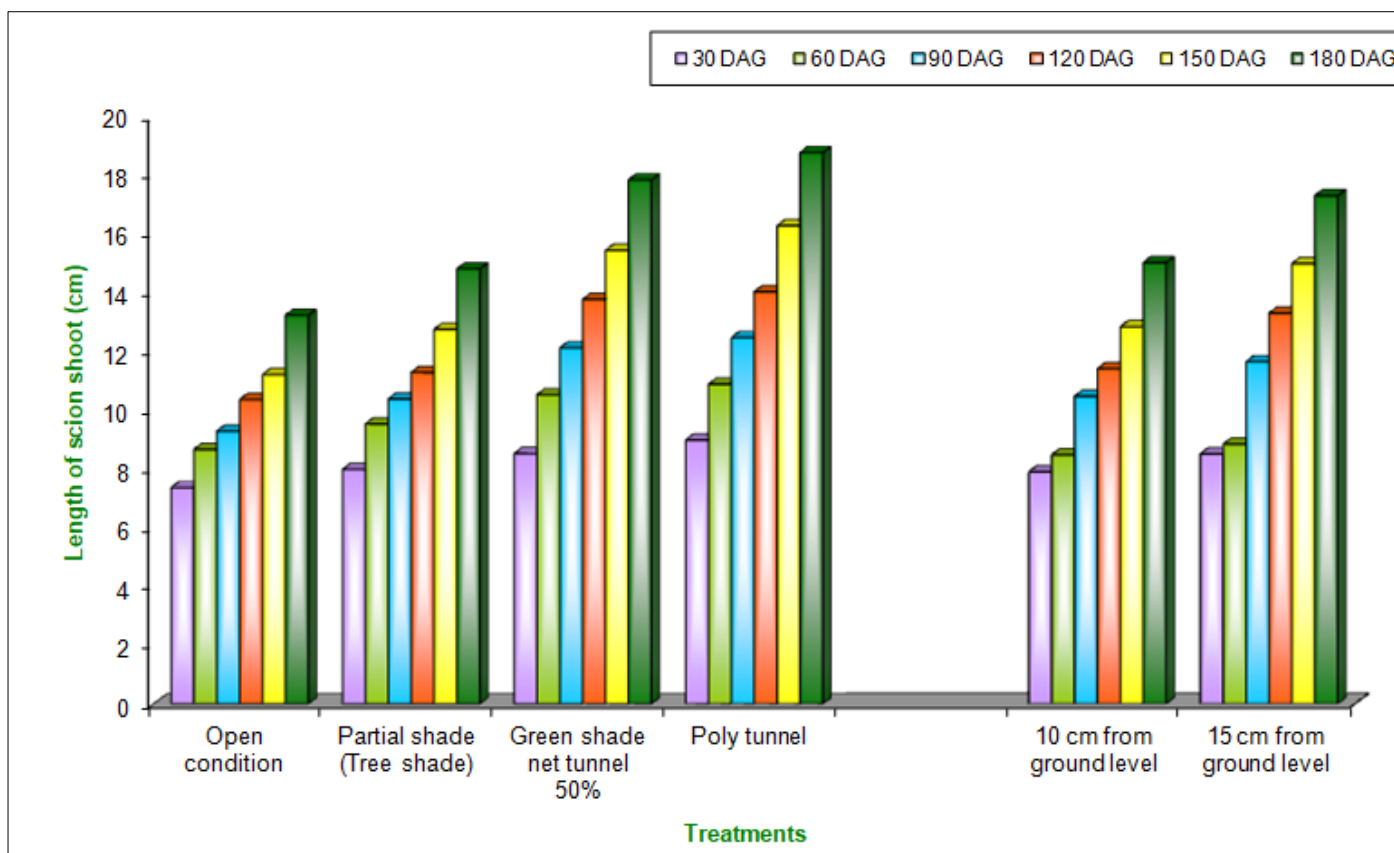


Fig 1: Effect of different environmental conditions and decapating height of invigorated khirni rootstock on length of scion shoot (cm)

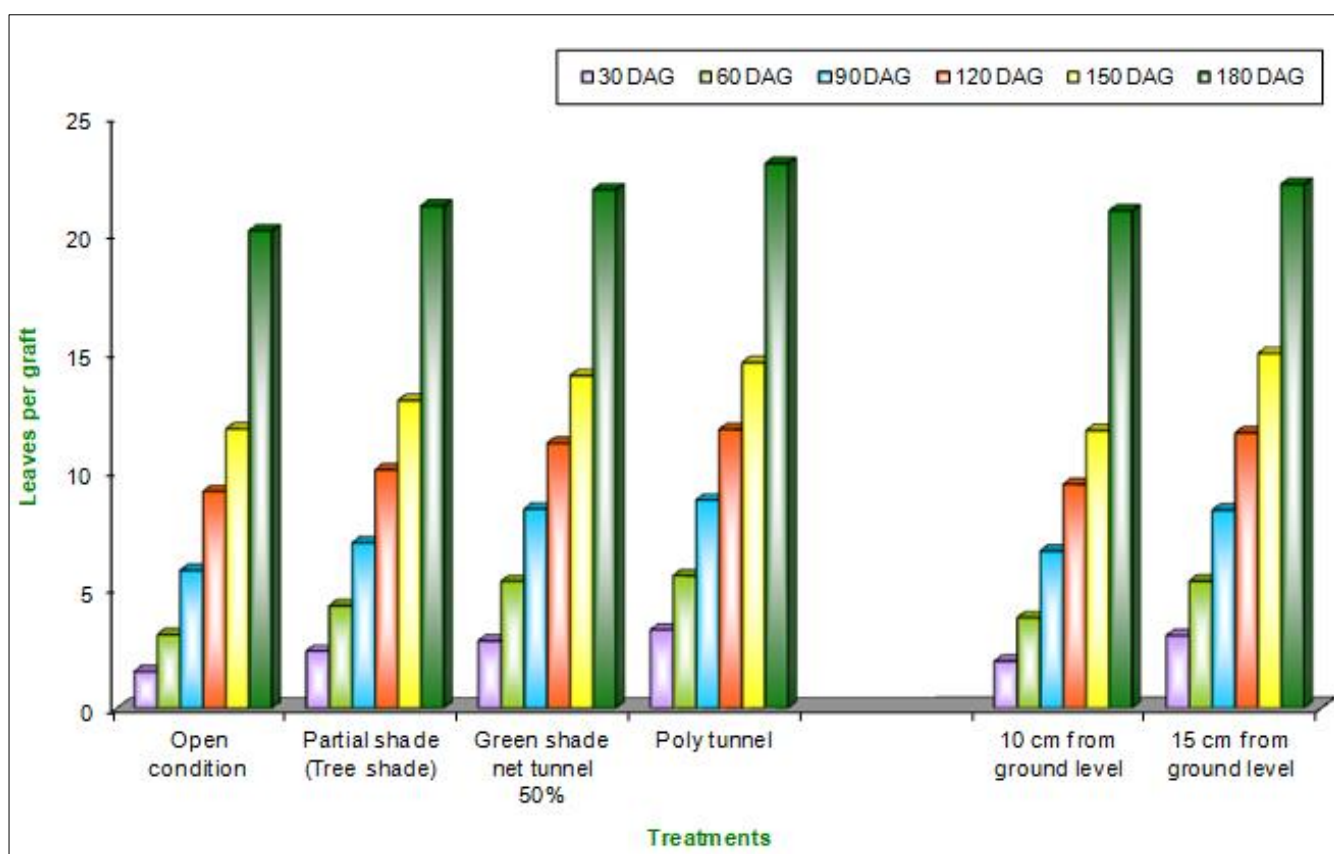
2. Effect of different environmental conditions and decapating height of invigorated khirni rootstock on leaves per graft

Perusal of data regarding Lea per graft as influenced by the

different environmental conditions and decapating height of invigorated khirni rootstock were recorded periodically at 30 days of interval and are presented in Table 2 and depicted in fig. 2.

Table 2: Effect of different environmental conditions and decaping height of invigorated khirmi rootstock on leaves per graft

Treatments	leaves per graft					
	30 DAG	60 DAG	90 DAG	120 DAG	150 DAG	180 DAG
Environmental conditions						
C ₁ (Open condition)	1.54	3.10	5.82	9.16	11.81	20.19
C ₂ (Partial shade (Tree shade)	2.41	4.32	6.99	10.08	13.01	21.24
C ₃ (Green shade net tunnel 50%)	2.84	5.36	8.42	11.20	14.06	21.92
C ₄ (poly tunnel)	3.30	5.60	8.80	11.78	14.61	23.03
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.07	0.09	0.13	0.14	0.15	0.34
CD at 5%	0.22	0.27	0.38	0.42	0.45	1.00
Decaping height						
H ₁ (10 cm from ground level)	1.98	3.82	6.64	9.46	11.74	21.03
H ₂ (15 cm from ground level)	3.06	5.37	8.37	11.64	15.00	22.15
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.05	0.06	0.09	0.10	0.11	0.24
CD at 5%	0.15	0.19	0.27	0.30	0.32	0.71
Treatment combinations						
C ₁ X H ₁	1.20	2.48	4.76	8.32	10.32	20.16
C ₁ X H ₂	1.88	3.72	6.88	10.00	13.30	20.22
C ₂ X H ₁	1.80	3.32	5.92	9.24	11.80	21.04
C ₂ X H ₂	3.02	5.32	8.06	10.92	14.22	21.44
C ₃ X H ₁	2.16	4.52	7.76	9.92	12.08	21.28
C ₃ X H ₂	3.52	6.20	9.08	12.48	16.04	22.56
C ₄ X H ₁	2.76	4.96	8.12	10.38	12.78	21.66
C ₄ X H ₂	3.84	6.24	9.48	13.18	16.44	24.40
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.10	0.13	0.18	0.20	0.22	0.49
CD at 5%	0.31	0.39	0.54	0.60	0.64	1.42

**Fig 2:** Effect of different environmental conditions and decaping height of invigorated Khirmi rootstock on leaves per graft

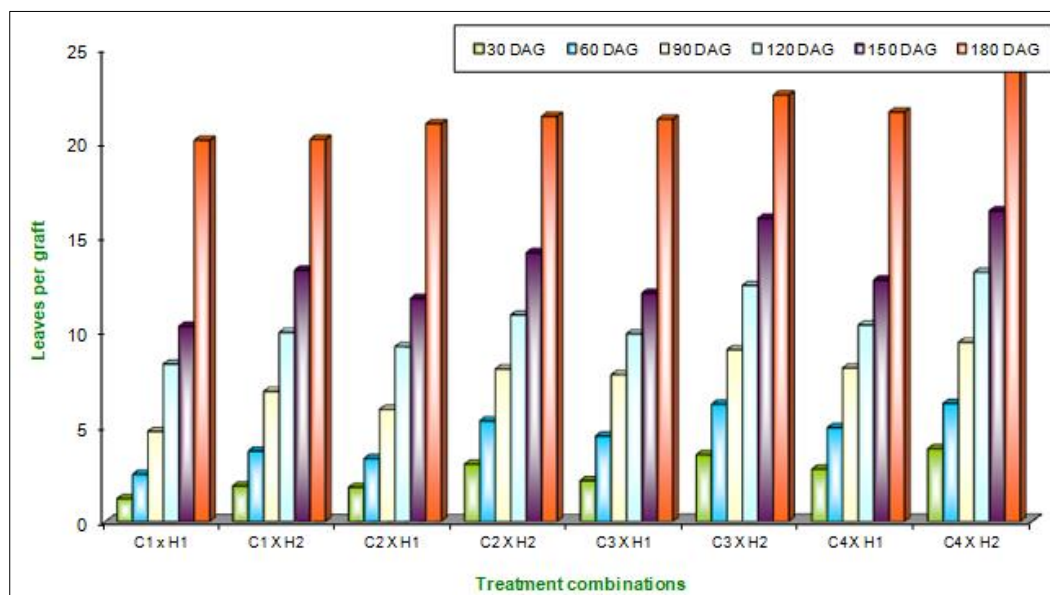


Fig 3: Interaction effect of different environmental conditions and decaying height of invigorated khirni rootstock on leaves per graft

2 Effect of different environmental conditions

The data presented in Table 2, indicated that, leaves per graft influenced by different environmental conditions was found to be significant at the all stages of growth i.e. 30, 60, 90, 120, 150 and 180 DAG

The data regarding the different environmental conditions significantly influenced on leaves per grafts at 30 days after grafting. Maximum leaves per graft (3.30) were observed by poly tunnel, Followed by (2.84) green shade net tunnel - 50%. While, minimum leaves per graft (1.54) noticed in open condition.

At the stage 60 and 90 days after grafting, maximum sprout length was exhibited by the poly tunnel (5.60 and 8.80 respectively), which was at par with green shade net tunnel – 50% (5.36 and 8.42 respectively). Whereas, minimum sprout length was recorded in open condition (3.10 and 5.82 respectively).

At the stage 120 days after grafting, maximum sprout length was exhibited by the poly tunnel (11.78), followed by green shade net tunnel – 50% (11.20). Whereas, minimum sprout length was recorded in open condition (9.16) and similar trend of results were noticed at 150 and 180 days after grafting.

These observations are in conformity with Mir and Kumar (2011) [14], who reported that maximum number of leaves per graft was recorded in wedge grafting of walnut under poly house condition. Similar results were observed by Nair *et al.* (2002) [16] in mango, Raghavendra *et al.* (2011) [23] in wood apple, Patel *et al.* (2007) [20] in mandarin when treated with poly house condition.

2.1 Effect of decaying height of invigorated khirni rootstock

Data in the Table 2, revealed that, leaves per graft was significantly influenced by the decaying height of invigorated khirni rootstock. The increasing trend was observed in decaying height from ground level.

At the stage 30 days after grafting, decaying height at 15 cm from ground level recorded significantly maximum leaves per graft (3.06). While, minimum leave per graft was recorded in decaying height at 10 cm from ground level (1.98).

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

It could be attributed to the fact that numbers of leaves increased significantly in trees grafted 15 cm above ground level, compared with trees grafted 7.5 cm above ground level. Singh *et al.* (2005) in apple. The similar findings have also been reported by Kumar *et al.* (2000) in mango, Srinivas (2007) [26] in sapota, Aboutalebi *et al.* (2012) [5] in ber.

42.3 Interaction effect of different environmental conditions and decaying height of invigorated khirni rootstock on leaves per graft

An interaction effect of different environmental conditions and decaying height of invigorated khirni rootstock on leaves per graft were found to be significant at the all stages of growth i.e. 30, 60, 90, 120, 150 and 180 DAG.

At stage 30 days after grafting. The maximum leaves per graft were observed (3.84) on poly tunnel and decaying height at 15 cm from ground level, followed by (3.52) green shade tunnel – 50% and decaying height at 15 cm from ground level. However, minimum leaves per graft (1.20) obtained from open condition and decaying height at 10 cm from ground level.

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

The leaves per graft increased significantly when kept under the poly tunnel with 15 cm from ground level. This might be due to the fact that, the vigorous growth of grafts includes by stimulative organs and also influenced by maximum number of sprout leading to maximum number of leaves. Yelleshkumar *et al.* (2008) [29] due to the better environmental condition in side polyhouse ultimately results into more vegetative growth of plants which might be helpful in leaves per grafts in sapota. This result are in agreement with Singh (1977) [25], Reddy and Kohli (1985) [24], Chattopadhyay (1994), Pampanna *et al.* (1995), Pampanna and Sulikheri (2000) [18].

3. Effect of different environmental conditions and decaying height of invigorated khirni rootstock on leaf area

The data regarding leaf area was significantly influenced by different environmental conditions and decaying height of invigorated khirni rootstock was recorded at 30 days of interval and are presented in Table 3. and depicted in fig. 4.

3.1 Effect of different environmental conditions

The data regarding the different environmental conditions significantly influenced on leaf area at 30 days after grafting. Maximum leaf area was observed in poly tunnel (10.41 cm²), followed by green shade net tunnel - 50% (9.80 cm²). While, minimum leaf area noticed in open condition (8.85 cm²). Similar trend of results were noticed at 60, 90, 120, 150 and 180 days after grafting.

Grafts kept under the protected structure are having more leaf area. The favorable condition prevailing inside the structure stimulating rapid callusing and early contact of cambial

layers, which enables the graft to heal quickly and make a strong union ultimately leading to better strength and faster growth. Nair *et al.* (2002) [16], they recorded the maximum leaf area under red polyhouse which was significantly superior to open conditions in epicotyls mango. Harshavardhan (2011) obtained maximum leaf area under polyhouse condition during the month of October in jack fruit. Sivudu *et al.* (2014) recorded maximum leaf area in the natural ventilated poly house in mango. Similar finding was observed by Anushma *et al.* (2014), Mulla *et al.* (2011) [15] and Angadi and Karadi (2012) in jamun.

Table 3: Effect of different environmental conditions and decaping height of invigorated khirmi rootstock on leaf area

Treatments	Leaf area (cm ²)					
	30 DAG	60 DAG	90 DAG	120 DAG	150 DAG	180 DAG
Environmental conditions						
C ₁ (Open condition)	8.85	11.83	15.84	21.74	28.79	38.72
C ₂ (Partial shade (Tree shade))	8.51	10.92	15.28	20.59	27.56	37.59
C ₃ (Green shade net tunnel 50%)	9.80	13.21	19.72	26.32	33.81	47.19
C ₄ (Poly tunnel)	10.41	13.98	20.48	27.14	34.99	48.46
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.10	0.13	0.20	0.26	0.30	0.40
CD at 5%	0.29	0.39	0.60	0.76	0.89	1.18
Decaping height						
H ₁ (10 cm from ground level)	8.95	11.87	15.82	22.22	29.99	40.80
H ₂ (15 cm from ground level)	9.83	13.10	19.84	25.67	32.58	45.18
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.07	0.09	0.14	0.18	0.21	0.28
CD at 5%	0.20	0.28	0.42	0.53	0.63	0.83
Treatment combinations						
C ₁ x H ₁	8.67	11.46	15.34	20.50	27.92	37.28
C ₁ X H ₂	9.02	12.21	16.34	22.98	29.66	40.16
C ₂ X H ₁	8.37	10.53	14.52	19.42	26.76	36.14
C ₂ X H ₂	8.64	11.31	16.04	21.76	28.36	39.04
C ₃ X H ₁	9.12	12.43	16.36	24.22	32.02	44.26
C ₃ X H ₂	10.48	13.98	23.08	28.42	35.60	50.12
C ₄ X H ₁	9.64	13.08	17.06	24.77	33.26	45.52
C ₄ X H ₂	11.18	14.89	23.90	29.52	36.72	51.40
F-Test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.14	0.19	0.29	0.37	0.43	0.57
CD at 5%	0.41	0.56	0.85	1.07	1.26	1.67

3.2 Effect of decaping height of invigorated Khirmi rootstock: The data presented in Table 3, indicated that, leaf area influenced by decaping height of invigorated khirmi rootstock were found to be significant at the all observations. In 15 cm from ground level, the increasing trend was observed in leaf area.

From the Table 3 it is observed that, decaping height of invigorated khirmi rootstock significantly influenced by leaf area at 30 days after grafting. The maximum leaf area (9.83 cm²) was observed in decaping height at 15 cm from ground level. While, minimum leaf area (8.95 cm²) noticed in decaping height at 10 cm from ground level.

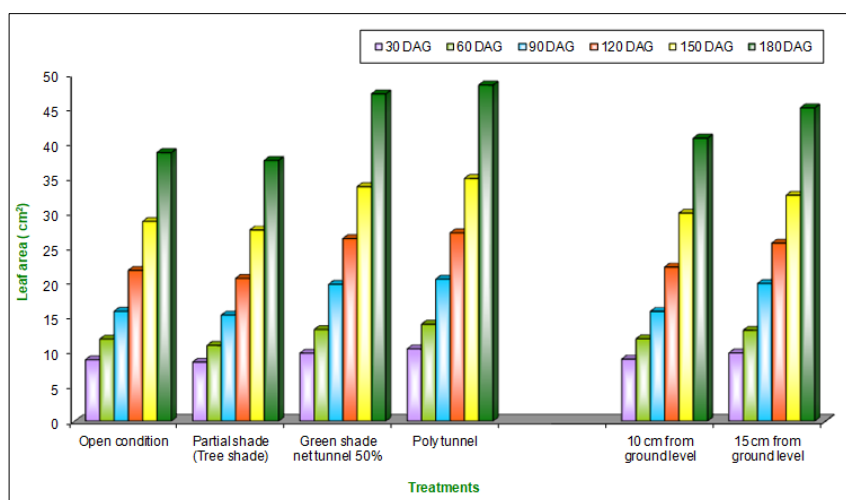


Fig 4: Effect of different environmental conditions and decaping height of invigorated khirmi rootstock on leaf area (cm²)

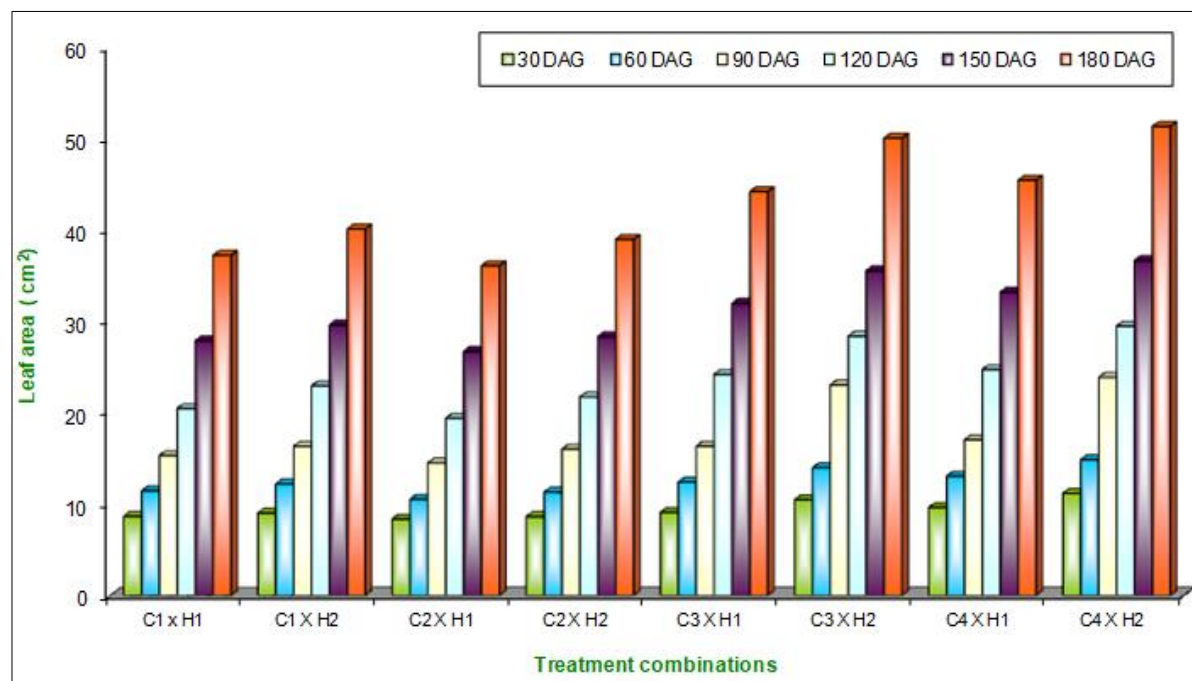


Fig 5: Interaction effect of different environmental conditions and decapting height of invigorated Khirmi rootstock on leaf area (cm²)

Similar trend of results were noticed at 60, 90, 120, 150 and 180 days after grafting. Similar increased result was observed by Srinivas (2007) [26] in sapota when grafted at different height, Kumar *et al.* (2000) in mango, Aboutalebi *et al.* (2012) [51] in ber.

3.3 Interaction effect of different environmental conditions and decapting height of invigorated khirmi rootstock on leaf area

An interaction effect of different environmental conditions and decapting height of invigorated khirmi rootstock on leaf area were found to be significant at the all stages of growth.

Interaction effect at the stage 30 and 60 days after grafting, showed maximum leaf area in the poly tunnel and decapting height at 15 cm from ground level (11.18 and 14.89 cm² respectively), followed by green shade tunnel – 50% and decapting height at 15 cm from ground level (10.48 and 13.98 cm²). However, minimum leaf area obtained in treatment combination partial shade (tree shade) and decapting height at 10 cm from ground level (8.37 and 11.46 cm²).

At the stage of 90 days after grafting, maximum leaf area was recorded in poly tunnel and decapting height at 15 cm from ground level (23.90 cm²), which was at par with green shade tunnel – 50% and decapting height at 15 cm from ground level with (23.08 cm²). However, the treatment combination partial tree shade and decapting height at 10 cm from ground level, showed minimum leaf area (14.52 cm²).

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

Leaf area increased significantly when kept under the poly tunnel with decapting height at 15 cm from ground level. This might be due to the fact that, the production and accumulation of more food material in the grafts as well as increased hormonal activities in polyhouse, which resulted in quick cell division and enlargement of already existing cells. These results are line with the findings of Chattopadhyay (1994) and Kamachuk and Golovatkaya (1998) due to the better environmental condition under polyhouse ultimately results into more vegetative growth of grafts which might be helpful in increasing the leaf area of sapota grafts. These observations

are in conformity with those of Mir and Kumar (2011) [14], who reported that maximum Leaf area (cm²) was recorded in wedge grafting of walnut under poly house condition. Angadi (2012) in Jamun, when treated with poly mist house condition and Nair *et al.* (2002) [16] in mango under red polyhouse condition.

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