“Studies on different method and times of grafting in Walnut (*Juglans regia* L.) under different growing condition”

Thesis

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Place: Bharsar, Pauri Garhwal. *(Kaushal Upadhyay)*

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CERTIFICATE

This is to certify that the thesis entitled **"Studies on different methods and times of grafting in walnut (*Juglans regia* L .) under different growing condition"** submitted in partial fulfillment of the requirements for the degree of **Master of Science (Horticulture)** with major in **Fruit science** of the College of Horticulture, VCSG Uttarakhand University of Horticulture & Forestry, Bharsar, is a record of ***bona fide*** research carried out by **Mr. Kaushal Upadhyay, Id. No. 13105** under my supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the course of this investigation have been acknowledged.

(Dr. B. P. Nautiyal)
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of **Mr. Kaushal Upadhyay, Id. No 13105** a candidate for the degree of **Master of Science (Horticulture),** with major in **Fruit Science** agree that the thesis entitled **"Studies on different methods and times of grafting in walnut (*Juglans regia* L .) under different growing condition."** may be submitted in partial fulfillment of the requirements for the degree.

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CONTENTS

Chapter	Title	Page no.
1	INTRODUCTION	1-5
2	REVIEW OF LITERATURE	6-15
3	MATERIAL AND METHODS	16-23
4	EXPERIMENTAL RESULTS	24-43
5	DISCUSSION	44-51
6	SUMMARY AND CONCLUSION	52-57
7	LITERATURE CITED	58-63
	ABSTRACT	64-65
	APPENDICES	I-III
	CURRICULUM VITAE	

LIST OF TABLES

SI. No.	Title	Page no.
1	Effect of various methods of grafting under different growing conditions on days taken to sprouting	24
2	Effect of various methods of grafting and grafting time on days taken to sprouting	24
3	Effect of different growing conditions and grafting time on days taken to sprouting	25
4	Effect of various methods of grafting and grafting time on days taken to sprouting under different growing conditions	25
3	Effect of various methods of grafting under different growing conditions on shoots length	26
4	Effect of various methods of grafting and grafting time on shoots length	26
5	Effect of different growing conditions and grafting time one shoots length	27
6	Effect of various methods of grafting and grafting time on shoots length under different growing conditions	27
7	Effect of various methods of grafting under different growing conditions on average shoots diameter	28
8	Effect of various methods of grafting and grafting time on average shoots diameter	28
9	Effect of different growing conditions and grafting time on average shoots diameter	29
10	Effect of various methods of grafting and grafting time on average shoots diameter under different growing conditions.	29
11	Effect of various methods of grafting under different growing conditions on number of leaves	32
12	Effect of various methods of grafting and grafting time on number of leaves	32
13	Effect of different growing conditions and grafting time on number of leaves	33
14	Effect of various methods of grafting and grafting time on number of leaves under different growing conditions	33
15	Effect of various methods of grafting under different growing conditions on leaf area	34
16	Effect of various methods of grafting and grafting time on leaf area	34
17	Effect of different growing conditions and grafting time on leaf area	35

18	Effect of various methods of grafting and grafting time on leaf area under different growing conditions	35
19	Effect of various methods of grafting under different growing conditions on percentage of dead grafted plants	36
20	Effect of various methods of grafting and grafting time on percentage of dead grafted plants	36
21	Effect of different growing conditions and grafting time on percentage of dead grafted plants	37
22	Effect of various methods and time of grafting on percentage of dead grafted plants under different growing conditions	37
23	Effect of various methods of grafting under different growing conditions on percentage of dead graft after sprouts	38
24	Effect of various methods of grafting and grafting time on percentage of dead graft after sprouts	38
25	Effect of different growing conditions and grafting time on percentage of dead graft after sprouts	39
26	Effect of various methods of grafting and grafting time on percentage of dead graft after sprouts under different growing conditions	39
27	Effect of various methods of grafting under different growing conditions on percentage of survival grafted plants	40
28	Effect of various methods of grafting and grafting time on percentage of survival grafted plants	40
29	Effect of different growing conditions and grafting time on percentage of survival grafted plants	41
30	Effect of various methods of grafting and grafting time on percentage of survival grafted plants under different growing conditions	41
31	Effect of various methods of grafting under different growing conditions on percentage of saleable grafted plants	42
32	Effect of various methods of grafting and grafting time on percentage of saleable grafted plants	42
33	Effect of different growing conditions and grafting time on percentage of saleable grafted plants	43
34	Effect of various methods of grafting and grafting time on percentage of saleable grafted plants under different growing conditions	43

ABBREVIATIONS

%	Percent
/	Per
±	Positive Negative
^{0}C	Degree in Celsius or Centigrade
^{0}E	Degree East
^{0}N	Degree North
C.D.	Critical difference
Cm	Centimeter
cm^2	Square centimeter
d.f.	Degree of freedom
EMS	Error mean of square
et al.	et alia (Co workers)
Fig.	Figure
FRBD	Factorial randomised block design
Ha	Hectare
i.e.	that is
M	Meter
m^2	Square meter
Max.	Maximum
Min.	Minimum
Mm	Millimeter
Ms	Mean Square
MSL	Mean sea level
MT	Matric tone
No.	Number
N/S	Non-significant
SE (m)	Standard error of mean
SE. (d)	Standard error of deviation
S.S.	Sum of square
Viz	Namely

CHAPTER-1

INTERODUCTION

CHAPTER 1

INTRODUCTION

Walnut (*Juglans regia* L.) is an important temperate nut crop with delicious kernel. It belongs to the family Juglandaceae, and genus *Juglans* L. The genus *Juglans* has 21 species of which *Juglans regia* is the most important. Its chromosome number is 2n = 32. Walnut is believed to have originated in Iran and the areas surroundings it. The major walnut growing countries are China, USA, Iran, Ukrain, Turkey and Mexico. In India, walnut production was earlier confined to Jammu & Kashmir and it appears that it spread to Himachal Pradesh and Uttarakhand. Some limited variability also exists in eastern and north-eastern regions, *viz*. Darjeeling, Sikkim and Arunachal Pradesh. The most common vernacular name for walnut in the region is *akhrot*, but other names are also known, such as *dun* in Kashmir and *khod* in parts of Himachal Pradesh and Uttarakhand.

In India the total area and production of walnut is estimated to 121.87 ha and 240.63 MT (NHB, 2014). The productivity of walnut in India is about 1.2 MT/ha. Jammu & Kashmir occupy the largest share in total area and production (2.61 lakh MT) of walnut. Uttarakhand rank second in the country in production of walnut (0.21 lakh MT). In Uttarakhand major walnut producing districts are Almora, Dehradun, Chamoli, Pauri, Tehri and Uttarkashi. The important varieties of walnut are Chakrata selections and Govind are grown in Uttarakhand. The walnut is highly sensitive to extremes in winter and summer temperature as well as to its duration. The plant can tolerate as low as -11^{0}C during deep dormancy without serious damage. An annual rainfall of about 80 cm is considered sufficient for the cultivation of walnut. Walnut requires soil of neutral range as compared to other temperate fruits which generally do well in a slightly lower pH (Stephens, 1969).The suitability of a soil for walnut cultivation is examined on the basis of top soil, sub soil, aeration, drainage, chemical reaction (pH) and availability of various nutrients. The top soil should be fertile and well drained.

Walnuts are rich in proteins, fats and minerals and are a concentrated source of energy. Oil is rich in omega fatty acid. These contain a good amount of vitamin B group and are the richest in vitamin B6 among all the nuts. Walnut is having very high nutritive values

and good for curing heart diseases. Immature fruits of walnut can be utilized for preparing various products like pickles, chutneys, fresh juices and syrups. The fruit has excellent flavor and is mainly consumed as a dry fruit. Commercially, it is used for preparation of bakery products, chocolates, ice-creams, ornaments, oils, and confectionary and salad products. Shells are used in glue and plastics and for making solutions for cleaning and polishing surfaces. Walnut oil has a pleasant aroma and is used as edible oil and in varnish and soap manufacture.

Multiplication of any plant species is very essential. The plant can be multiplied either sexual or asexual means. In sexual propagation the plants are multiplied by seeds. The asexual propagation takes place due to mitosis division. The plants raised through asexual process are identical to mother plants. Cutting, budding and grafting, division and layering are main methods of asexual propagation. By using asexual methods, noble plants can be created. Sometimes on single plant of rose, two – three types of bloom flourishes. It becomes possible only through asexual propagation. The benefits of rootstock and scion are exploited through asexual propagation. By using asexual propagation a non – productive local variety can be converted into productive and improved type variety.

Among various methods of vegetative propagation grafting is more suitable and preferred by the nursery man. Grafting is a technique of propagation in which scion stick and rootstock is connected in a manner such as that they may unite and subsequently grow and develop as a successful plant. The scion become the new shoots system of the graft .It is composed of a short piece of detached shoot containing several dormant buds which, when united with the rootstock, comprises the upper portion of the graft and from which, will grow the stem or branches, or both, of the grafted plant. The scion should be of desired cultivar and free from disease. The rootstock is the lower portion of graft, which develop into the root system of the grafted plant. It may be a seedling, adopted cutting, a layered or micro-propagated plants.

Grafting has many advantages i.e. grafted trees produce fruit quicker. A tree grown from seed may take 8-10 years to fruit, but a grafted tree will only take 2-4 years. A tree grown from seed may produce poor quality fruit. Grafting is done to improve the taste and

size of the fruit, tree grown from seed may not produce same type fruit as the mother tree. But a grafted tree will be just as good as the tree the cutting (scion) of mother plant. Grafted tree will continue to give the same quality fruit for many years and Grafted fruit trees can be sold to give an income to the household.

For a long time in the past, propagation through seed was only method available for walnut multiplication though this practice resulted into plants of great variability (Sharma et al 2003). Generally, walnut does not respond favorably to the vegetative propagation techniques under normal conditions. Various methods of vegetative propagation in walnut have been reported to give varying degree of success under different climatic conditions in India and abroad. The variations are dependent on different environmental conditions to which the plants are subjected before and after propagation (Chase 1947, Awasthi *et al.* 1982, Qureshi and Dalal 1985). In fact, there is an urgent need to standardize the suitable technique for clonal multiplication of walnut in order to ensure supply of quality plant material for expansion of area, achieve increase in production and productivity of superior nuts and meeting the international standards of quality characters of nut and kernel.

The vegetative propagation of walnut can be accomplished by grafting, rooting of cuttings, layering and micro-propagation. However, grafting has proved to be a more successful and feasible method for asexual propagation. In this type of vegetative propagation, different budding and grafting methods are used. In order to perform these methods, one- or two-year-old rootstocks are needed. But it increases the nursery period and production costs. The percent success in grafting in walnut is lower than the pome and stone fruits. Better survival of grafts is obtained when grafting operation is carried out in the middle of January rather than in the last week of December or in the middle of February. The most common method of grafting practice in walnut is cleft grafting. Walnut seedlings are generally used as seedling rootstock. The seedling of more than pencil thickness should be grafted in late winter, the 10-12 months old scion should be used, and they must be defoliated 10-15 days earlier. Only the scion with well-developed vegetative bud should be used to obtain good success for walnut grafting.

Grafting in walnuts is more difficult than in other fruit trees. Temperature and humidity have major effects on the process of walnut graft union. Specially changing in temperature among the uniting period has direct effect on callus development and successful grafting. Best temperature for walnut grafting is 27°C. In this temperature, callus formation occurs five days after grafting but at 22°C callus formation begins in seven days after grafting, and at temperatures lower than 20°C, no callus formation occurs. Low temperature in winters is the most important limiting factor for walnut grafting. To avoid low temperature in winter in walnut, 27°C condition has to be provided for 3-4 weeks for successful grafting. Also high environmental moisture is needed for winter grafting, because the parenchymal cells of callus have soft walls and they lose their moisture in dry places. Covering the graft point with moist sawdust might increase graft success up to 93.3%, but in dry condition as occurs in the cleft method, the graft success was zero. So only the environments having with proper moisture, is required for callus formation and growth. Grafting method also influences graft success. Comparison of different grafting methods showed that modified bark grafting had 100% graft success and 85% survival while, other grafting (whip and cleft) resulted in poor success and survival.

Grafting success in walnut depends on the correct timing for collection of scion material. Porebski *et al*. (2002) advised that scion wood be cut in late autumn before severe frost is experienced. Özkan and Zunus (2001) collected scion material 48 hours prior to grafting, while Mitrović (1997) collected scion material only on the day when grafting was performed. According to Erdogan (2006) scion material can be collected on the same day of grafting or cold stored for several days. To ensure grafting success, the conservation of scion moisture after grafting was just as vital as before grafting and various approaches were followed to prevent scion desiccation after grafting. The lower critical level of scion moisture (38%) determined by Rongting and Pinghai (1993) and it was reached within seven days after grafting if the scion was uncoated. By coating the scion with grafting wax, this period was extended to 23 days.

Although walnut is a very popular nut fruit crop, yet its cultivation in our country has remained continedifew state or in neglected state. The non-availability of the quality planting

materials (rootstock and scion) and lack of efficient propagation techniques and other information on the performance of cultivars under different agro-climatic condition of temperate hilly region are the major constraints in the expansion of walnut cultivation in India. In walnut no systematic work has so far been done on their survivability and morphological performance in relation to propagation method (grafting) with suitable time of propagation under the hilly conditions of Uttarakhand. Therefore, keeping in view the above points into consideration, the present investigation was under taken on **"Studies on different methods and time of grafting in walnut (*Juglans regia* L.) under different growing conditions"** with following objectives:

1. To standardize the appropriate grafting methods in walnut propagation,
2. To find out suitable time of grafting
3. To standardize appropriate conditions for successful grafting.

Chapter- 2

Review of literature

CHAPTER 2

REVIEW OF LITRATURE

A brief literature related to investigation on grafting methods, time of grafting, and appropriate conditions in walnut (*Juglans regia* L.) is reviewed here as under –

Thapar and Rana (1961) while working on vegetative propagation of walnut under Himanchal conditions, obtained a relatively high percentage of success (22.50) with whip or tongue grafting method in comparison to other methods.

Mittempergher (1963) obtained 63 to 73 per cent success in cleft grafting in walnut under glass house conditions using 1 or 2 year old seedlings as root stocks and scions of the same thickness. Komanic (1967) reported saddle, cleft and bark saddle grafting as the suitable methods for walnut propagation. The optimum condition for callus formation and union were found to be a temperature of 25 to 27 ^{0}C and relative humidity of 70 to 80 per cent.

Pathak and Srivastva (1975), Lal and Shrama (1986) reported 80 per cent success with cleft grafting of walnut, when the grafting was done in situ in the month of March by taking the bud sticks in January.Avanzato and Tamuri (1988) reported 73.00 per cent success in cleft grafting *Juglans regia* with scion by heating the graft union at a temperature of 27^{0} C for 24 days in comparison to the unheated graft unions which produced only 6.00 percent success.

Zachej (1976) grafted two walnuts cultivars and several selections on walnut seedling in November-December, January or March and the grafts were stored upright in peat in boxes heated to 24-26^{0}C. They observed that the most suitable time for grafting was March followed by November and heated storage for three weeks was better than for 4 weeks. Two bud scion and PVC ties were used and scions from the apical part of the shoot made less extension growth than from lower down. Dhuria *et al.,* (1976) obtained as high as 71.7 per cent success with cleft grafting by keeping the grafts in incubator for 3 weeks at a temperature of 25 ± 1 ^{0}C and relative humidity of 75 ± 2 percent.

Awasthi *et al.*, (1982) conducted an experiment at Chaubattia (India) on walnut for evaluation of epicotyl grafting in relation to success using different methods of grafting from 1st May to 1st July and observed that cleft grafting gave the highest success (83.3%) followed by saddle grafting (73.3%).

Lal and Sharma (1986) reported that when walnut grafting was done on the side in the month of March by taking bud sticks in January and storing in the soil for two months, the best result was obtained as high as 80.00 percent with cleft grafting. Kantari and Jacob (1988) studied that soft wood grafting gave 75-100 percent success in walnut when performed in the month of May.

Gautam (1990) conducted an experiment for several winter vegetative propagation methods of Walnut (*J. regia* L.) and recorded 5.0 to 45.0 per cent of grafting success. Modified cleft grafting technique at or above crown portion gave 45.0 and 25.0 per cent success respectively. Tongue grafting method though resulted in poor success (15.0 per cent) but the growth of grafted plants was better. In the summer propagation techniques, the veneer grafting method during mid- July resulted in highest success 90.0 per cent and also better growth of the grafted plants.

Sharma (1990) studies on Walnut propagation by using Five methods viz. tongue, cleft, cleft at collar level, veneer grafting and patch budding were tried in three local thin shelled selection and in Govind, Kashmir budded and Kashmir seedling. The first three methods were attempted in first week of April, whereas, veneer grafting and patch budding in the 1st week of July. The seedling of one year old age of local walnut (*Juglans regia* L.) was used as rootstock for studies. Patch budding gave best result as highest mean value for bud take (45.98%) was obtained in Kashmir seedling.

Rongting and Pinghal (1993) reported that 90.3% with survival rate of bark tongue grafting using paraffin wax gave best result. In another study on the healing process of walnut grafts inberred that scion moisture content was the main factor responsible for callus formation and graft survival.

Effect of grafting method and surrounding of the graft union with moist sawdust were investigated for walnut (*juglans regia*) by Unal (1995).The Scion material was taken 1.5 months prior to grafting, which was done at the end of March and beginning of April, the highest success rate (85 percent) was obtained with bark grafting and saw dust. Other grafting technique with saw dust had success rates of 70 percent, without sawdust, top cleft grafting, gave the best results (45%) and whip grafting the poorest (10%).

Dwivedi *et al.*, (2000) reported tongue grafting gave the highest mean sprouting (98.7 %) and bud take (94%). Maximum linear (167 cm) and radial (0.85 cm) growth under ladakh condition had been observed. It have been reported that the plant raised by tongue grafting and chip budding methods showed higher growth, which could be attributed to the successful union and with tongue grafting followed by chip budding in apple cultivars.Barut (2001) observed 20 % and 32% successwith spring whip grafting over a two year period in walnut under uncontrolled field conditions.

Achim and Betu (2001) found the best result in grafting by tongue and whip with more than 85%grafting success out of four methods of propagation viz. tongue, chip, shield and angular budding tried in spur type apple cultivar Number and length of internode were influenced significantly by different methods.

Ozkan and Zunus *(*2001) studiedrate of grafting success under controlled conditions of walnut. In the study three different grafting seasons (January, February and March), three grafting methods (cleft, whip-tongue and chip budding) and two walnut varieties were used (Tokat and Yalova 1). The rates of highest graft-take success of Tokat variety were determined from grafts of February season with 60 % with cleft grafting, 66 % with whip-tongue grafting and 53 % with chip budding. On the other hand, the rates of highest graft-take of Yalova 1 variety were obtained from February season as being in Tokat variety with 63 % with cleft grafting, 70 % with whip tongue grafting and 43 % with chip budding. But the survival rates of grafted plants were rather low. The best survival rate (50 %) was obtained from the chip budding of Tokat variety in March period. The lowest survival rate (22 %) was determined from whip tongue grafting of Tokat variety in January period. The highest shoot lengths were obtained from the grafts of March period. In March grafting period, while the

highest shoot length (23.99 cm) was obtained from chip budding of Tokat variety, the lowest shoot length (13.59 cm) was determined from cleft grafting of Yalova 1. When three grafting periods were appraised together, the shoot lengths of January period were lower than the other periods.

Reil *et al*., (1998) reported that the bark grafting has been employed with excellent success on walnut gave highest graft-take rate about more than 80%.Chauhan (2007) reported that persimmon plants grafted on 10th and 20^{th}febrauary gave the highest percent of success (72.35 and 74.57). In the March the percent of successful grafting was 49.38 and 34.38 per cent. Baniyal (2003) recorded 60.00 percent success in top working of walnut by bark tongue grafting.

Kumar and Ananda (2004) conducted experiment on the effect of propagation method in spur type cultivars of apple viz., Red spurand well spur for comparing performance of tongue grafting, chip budding, shied budding, annular budding and reported that tongue grafting gave maximum linear growth (30.60 and 87.38 cm) and radial growth of scion (2.77 and 2.68 cm) and rootstock (3.12 and 2.88 cm) in Redspur and Wellspur, cultivars respectively. They also found that tongue grafting also produced maximum number feathers (1.33 and 1.77) and length of feathers (928.54 and 17.67cm). The height of feather emergence (30.36 and 14.67 cm) from union in both cultivars, respectively these finding are in line with the results obtained by Kumar and Ananda (2004) in the same cultivar of apple.

Singh *et al*., (2007) an experiment on Kiwi fruit grafting technique was undertaken to find out the optimum time and environmental conditions for maximum grafting success and satisfactory growth of prepared grafted plants. Tongue grafting was performed at 15 days interval starting from 30th December to 15th February under two environments viz., open field and controlled polyhouse under Chaubattia climatic conditions. The maximum grafting success 66.0 percent and survival of grafts 87.2 percent were observed under polyhouse on 30th January, 2005. The success was 33.4 percent more under polyhouse than the open field condition. Date of grafting and environment had significant effect on shoot growth. The shoot growth and number of leaf size were 31.3 cm, 10.0 and 5.6cm more, respectively, under polyhouse as compared to open field.

Sharma *et al*., (2006) observed that the graft success in walnut was maximum in polyhouse environment followed by hot callusing cable system. The maximum graft success was recorded on thick rootstocks followed by medium and thin rootstock. Hard shell and soft shell rootstocks were found statistically at par in respect to graft success. Shoot length, rootstock girth at crown level and scion girth above union were found significantly superior under polyhouse over thehot callusing cable (HCC) system. Similar results were obtained when thick rootstocks were used for grafting. Soft shell rootstockswere found significantly superior over hard shells ones in respect of scion length, rootstock girth and scion girth. Maximum graft success was obtained under polyhouse from medium rootstocks. The open field conditions proved inferior to polyhouse and hot callusing cable (HCC) system.

Gandev (2007) investigated new methods for the production of inoculated walnut trees, two of which – hot callus and hypocotyls grafting were tested and adapted. Heating techniques were described as well – local heating on the graft union withhot water and hot callusing cable. According to the results of the most recent studies on hypocotyl grafting in temperature controlled greenhouses, the method is 83% successful and can be implemented in the production of grafted young Walnut trees.

Ebrahimi *et al*., (2008) compared different budding methods (patch, shield and chip) under controlled and field conditions using different native varieties of Persian walnut (*Juglans regia* L.) and they obtained the best results in a greenhouse condition considerably in all grafting methods compared under field conditions. The highest success rate was obtained with patch (91.0%) followed by shield (31.1%) and chip (19.1%) budding under greenhouse conditions versus 25.0, 15.0 and 10.0% under field conditions, respectively. Similar trends were also observed for callus formation and scion growth. Patch budding showed the highest callus formation and scion growth followed by shield and chip budding under both conditions. The genotype used did not affect grafting take using shield and patch budding excluding the N3 selection which had the highest graft success using the shield budding under greenhouse conditions. The best results were obtained by patch budding, under greenhouse conditions in all of the tested genotype.

Hassani *et al*., (2008) observed the effects of five kinds of grafting covers including sawdust, perlite, vermiculite, coco peat and no covering (control) on callus quality, number of callused grafts, graft take, graft survival and scions growth. 'Pedro' and 'Chandler' were used as scion cultivars and modified bark grafting method was used to graft the main branches in the scaffolds of 10 to 15 years old walnut trees before mid-April, 2008 and 2009. According to the results of first year experiment, among sawdust, perlite and no covering, the highest graft take (75.00%) and survival (66.04%) and the lowest graft take (10.00%) and survival (8.33%) was observed with sawdust cover and no covering, respectively. The results of second year experiment, among sawdust, coco peat and vermiculite showed the highest graft take (88.00%) and graft survival (84.67%) in sawdust cover treatment. Also the lowest graft takes (38.33%) and survival (54.44%) was observed with vermiculite cover.

Gandev *et al*., (2009) studied that the grafted plants when grown in the open in the nursery during the years with low winter temperatures or spring frosts the survival rate is low. In the two years of the experiment at the end of March the tested grafted plants were placed under controlled temperature of 27 ^{0}c for callus formation. Four weeks after grafting the plants were transferred to a room temperature of 15-18 ^{0}c for twenty days, after which the percentage of graft take was recorded. The lowest percentage of successfully grafted plants was reported for the classical Omega bench grafting method (control) 40.8 % in both years of the experiment. For the new propagation techniques, close percentages of successfully grafted plants were obtained 74.2 % in average for the method hot callus and 77.5 % for the method of Epicotyl grafting.

Asghar *et al.*, (2008) conducted an experiment in which two hot callusing systems including hot callusing in room (HCR) and modified hot callusing cable (MHCC), and two grafting methods (omega and saddle) were used for table grafting of four walnut cultivars and native genotypes (Hartley, Chandler, Z63 and Z30). Grafting was carried out on two years Old Persian walnut rootstocks and the grafted plants were kept at 27ºC temperature and 95% RH. Graft success and scion growth were recorded for each treatments one month after grafting and the succeeded grafts were potted. Percentage of loss in the succeeded grafts was also recorded at the end of growth season. The results showed that application of MHCC system resulted in

the highest graft success (63.3%) and lower graft losses (28.1%) comparing with HCR system with 56.7% success and 36.4% losses. Based on the results, graft success was higher using saddle method than omega method (87.7% and 38.3%, respectively). Also, graft loss was lower with saddle method than omega method (19% and 45.5%, respectively). The interaction of hot callusing system and grafting method were statistically different for graft success and losses. Highest grafting success (87.52%) and lowest loss (13.4%) was obtained using MHCC system with saddle method. Comparison of grafting success in different cultivars showed that the highest graft success and the lowest losses (70.8% and 22.2%, respectively) were detected in Chandler cultivar.

Dehgan *et al*., (2010) evaluated different bench grafting methods (side stub, omega and whip tongue) in four walnut varieties (‘Z53’, ‘Hartley’, ‘Pedro’ and ‘Serr’). In addition, the effect of forcing pre-treatment on grafting components (placing of grafting components in a forcing room at a temperature of 26-28°C and relative humidity of 80-90% for two weeks (rootstocks) or 3 days (scions) before grafting) was assessed using the side stub grafting method in two varieties (‘Hartley’ and ‘Pedro’). All experiments were repeated twice during 2006 and 2007. The grafted plants were covered with moist sawdust, providing a relative humidity of 85-90%, and stored in a humid room with a temperature of 26-28°C for 21 days. The omega grafting method had the highest average callus score (2.61 out of 4), number of callused grafts (82.22%), graft take (71.11%) and graft survival (81.03%). In the second experiment, the effect of stocks and scions pretreatment (forcing) were significant on the callus rate, graft take and graft survival characters. In this experiment, grafted plants treated with the forcing pre-treatments showed the highest callused grafts (82.7%), graft take (73.8%) and grafting survival (71.9%). Treating of grafting components with forcing pre-treatments under controlled conditions increase grafting success considerably.

Gandev and Arnaudov (2011) conducted an experiment on epicotyl grafting in walnut. The following practices were determined: the methods of rootstock production, choosing the cuttings, the grafting methods and the time of grafting, the conditions for callus formation, etc. The results showed that the successfully propagated walnut plants obtained in the different years were from 56.6 % to 63.35 % in average. It was established that the time of grafting

exerted an effect on the percentage of survival rate, grafting at the end of March leading to obtaining a higher percentage in comparison with grafting performed at the end of April. The conclusion was drawn that the developed method of walnut epicotyl grafting under production conditions resulted in successful tree propagation and it could applied in be practice.

Mujaffar and Kumar (2011) conducted an experimental during 2005-2006 to study the effect of different of grafting *viz*. tongue, wedge and veneer with three different timings *viz*. 2nd, 3rd and 4th week of February under poly house condition in walnut .The same experiment was repeated in field conditions with same methods of grafting with three different timing *viz*. 4th week of February, 1st and 2nd week of march. The results indicated that under polyhouse, the maximum grafting success (76.66 %) was obtain through wedge method grafting followed by (70.00%) through tongue grafting when done in 4th week of February. When the grafting was done in 3rd week, maximum success (66.66%) was achieved using wedge grafting followed by tongue grafting (63.33%). Veneer grafting resulted in maximum (53.33%) success when performed in 4th week of February. The grafting success was comparatively quite low in case of field conditions. In this case only 20.00 per cent success was obtained through wedge grafting done in 1st and 2nd week of March. The higher grafting success in wedge and tongue grafting recorded could be due to the favorable temperature and relative humidity at the time of grafting and rapid flow of sap in stock and scion that might have favored the healing process and established the continuity of cambial and vascular tissues for the graft take. Significant effects were also noticed on shoot length, number of leaves, number of leaflets, leaf area and days to leaf fall.

According to Paunovic *et al*., (2012) the production of walnut nursery plants is a complex process, being dependent upon a range of factors that affect graft-take success and behavior of walnut plants in the nursery. The experiment included two parts, three different treatments were used in the heated room under controlled air temperature and humidity conditions: Treatment 1-grafting without paraffin treatment of the scion and graft union, coupled with covering the graft with sawdust up to the top of the scion; Treatment 2-grafting involving paraffin treatment of the scion and graft union, coupled with covering the graft with sawdust up to the top of the scion; and Treatment 3-grafting involving paraffin treatment of the scion and graft union, coupled with

covering the graft with both sawdust up to the top of the scion and polyethylene foil. The treatments were evaluated for their effect on graft-take success. Graft planting in the nursery was followed by two treatments: treatment without foliar fertilization and treatment with foliar fertilization. Under controlled conditions, treatment 3 induced a higher graft-take success as compared to the other two treatments, whereas foliar fertilization in the nursery had a positive effect on the survival, production of class 1 plants and vegetative growth of walnut plants.

Vahdati (2012) evaluated three methods of grafting for pecanut. Cleft grafting with hot cable system five times from late October till mid -February, cleft graft with polyethylene bag and side –stub five times from early November till early march. For each grafting methods, scion wood of GraTex,Wichita, Choctaw, 10 J and Graking, Pecan cultivars were grafted on two year old seedling rootstocks 1-1.5 cm in diameter. The best graft time was from late January till late February using the cleft graft with hot cable system graft method and from mid-February till late march using the cleft graft with polyethylene bag grafting method. Also the highest per cent of graft success was achieved using Wichita scion (92 %), while 10 J had the lower per cent.

Maliro *et al.,* (2013) observed that the four populations of Liwonde, Kaputu, Nkope and Chikwawa of cashewnut did not show any variation in grafting success due to minimal differences in environmental and elevation of the sites. Cashew scions can be collected from 12 and 20 year old trees but period or season of collection and grafting of scions is crucial in the success of the grafting exercise. The success rate for October (58 and 72%) for immature and mature scions suggests that October may be a suitable month for grafting Cashew in Malawi. Higher temperatures at the end of the dry season in October would be suitable for increased growth of leaves to coincide with the onset of rains in November and December. Mature scions demonstrated superiority over the immature scions due to their ability to withstand adverse weather conditions. The findings therefore suggest that type of cashew scions, period of grafting affect graft take while source of the scion and age of tree do not affect grafting.

Zia *et al*., (2014) studied effect of different budding methods and times on grafting success of walnut. They applied the three methods of grafting (patch, shield, and chip) at

various periods of walnut growth with different timings of grafting in walnut. Early May was the best time for grafting, at which time the highest success rate was obtained by the patch method (96%), followed by chip-budding (75%), and while shield-grafting showed the lowest efficiency (10%). Patch-grafting was also successful (75-80%) in early August and moderately successful in mid-June (51-55%), while the shield and chip methods had no success during these two times (0.00%). Patch-grafting was more efficient and also induced better callus formation and scion growth than the other two methods. The genotypes used did not affect grafting efficiency. The best results were obtained by patch-budding in both tested genotypes.

Chapter -3

Materials and Methods

CHAPTER- 3
MATERIALS AND METHODS

The present investigation entitled **"Studies on different method and times of grafting in walnut (*Juglans regia* L.) under different growing condition"** was conducted at field conditions of Fruit Nursery, Department of Fruit Science, VCSG, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri, Garhwal, Uttarakhand, India, during the year 2015. The experiment was conducted to find out appropriate grafting methods in walnut, suitable time of grafting and to evaluate appropriate condition for successful grafting in hilly regions of Garhwal. The detail of materials used and methods followed during the course of present investigation are described in this chapter:

3.1 Location of experimental site

The present investigation was carried out in the field condition of Fruit Nursery, Department of Fruit Science, VCSG, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal. The site is located at an altitude of 1950 meters above mean sea level at a longitude of 78.99 ºE and latitude of 30.056ºN. (IMD, 2014).

3.2 Climate

The climatic condition of Bharsar region is mild-summer, higher precipitation and cold or severe cold prolonged winter. The South-east monsoon commences towards the end of June, while the North-east monsoon causes occasional winter showers during November to February. During winter, snow fall is common in this region, during summer months, the valley has hot climate prevailing for few hours in a day, the maximum temperature during May - June is recorded between 30ºC - 35ºC, however nights are cool. Last week of December to first week of January are the coldest days, the minimum temperature reaches to 1ºC to -4ºC. Relative humidity is normally highest during rainy season (July –August), often recorded near to saturation point (92-97%).The experimental site received average rainfall of 1647.60 mm (January – December, 2015) with average minimum and maximum temperature of 14.38 ºC and 18.30 ºC respectively during the period of investigation. Minimum and maximum rainfall was received during the month of January 2015(345 mm) and July

2015(3125 mm), respectively. The minimum and maximum temperature was recorded during the first week of January2015 (0-5ºC) and June 2015(30ºC) respectively.

3.3 Experimental details -:

The experiment was laid out in RBD (Factorial) with three replications. The experimental plan is given below:-

Scion wood used for grafting	:	Govind Walnut
Rootstock	:	Local seedling of Walnut
Grafting methods	:	3
Growing conditions	:	3
Time of grafting	:	2
Treatment combinations	:	18
Number of replications	:	03
Total Number of treatments	:	18
Plot size	:	90 cm ×90 cm
Spacing	:	15 cm × 15 cm
Total plots area	:	14.58 m^2
Number of grafted plants per replication	:	12
Number of grafted plants per plot	:	12×3 = 36
Total number of grafted plants	:	36 × 18 = 648

3.4. Treatment combinations

1	$G_1P_1T_1$	Tongue grafting + Polyhouse + January
2	$G_2P_1T_1$	Cleft grafting + Polyhouse + January
3	$G_3P_1T_1$	Veneer grafting + Polyhouse + January
4	$G_1P_2T_1$	Tongue grafting + Net House + January
5	$G_2P_2T_1$	Cleft grafting + Net House + January
6	$G_3P_2T_1$	Veneer grafting + Net House + January
7	$G_1P_3T_1$	Tongue grafting + Open Field + January
8	$G_2P_3T_1$	Cleft grafting + Open Field + January
9	$G_3P_3T_1$	Veneer grafting + Open Field + January
10	$G_1P_1T_2$	Tongue grafting + Polyhouse + February
11	$G_2P_1T_2$	Cleft grafting + Polyhouse + February
12	$G_3P_1T_2$	Veneer grafting + Polyhouse + February
13	$G_1P_2T_2$	Tongue grafting + Net House + February
14	$G_2P_2T_2$	Cleft grafting + Net House + February
15	$G_3P_2T_2$	Veneer grafting + Net House + February
16	$G_1P_3T_2$	Tongue grafting + Open Field + February
17	$G_2P_3T_2$	Cleft grafting + Open Field + February
18	$G_3P_3T_2$	Veneer grafting + Open Field + February

3.5 Rootstock selection

Seedling rootstock of uniform size and vigor were selected for experiments. Beds were prepared for planting and one year old pencil thickness rootstock were procured and planted in the bed having 0.90X0.90meter size at a spacing of 15 X15 centimeter leaving a space of 30 centimeter after every third row for grafting, than other cultural operations were similar in all the treatments.

3.6 Scion wood collection

The scion material used was taken from Govind variety of Walnut. The bud sticks used for dormant grafting were, one year old terminal shoots ranging from 0.6 to 0.8 cm in diameter. The scion used for January and February grafting were collected at the time of grafting. 10 to 12 months old terminal shoots of pencil thickness were used without giving any pre- treatment.

3.7 Time and methodology

Grafting was started in the January, 2015 as the standard practice for propagation of temperate fruits. For this purpose about 12 cm long scion wood of Walnut cv. Govind, having more than 3 buds from the previous season growth was collected. A piece of scion wood containing three to seven buds was used for grafting. Grafting operation was performed at one month interval using tongue, cleft and veneer grafting methods in poly-house, net-house and open field on January and February. These grafted plants were tied by an alkathene tape in order to avoid desiccation of the graft union. Regular pinching was done to control the unwanted growth of shoots from the seedlings, below graft union. Various cultural operations were followed in nursery bed like weeding, hoeing, control of insect- pest and disease time to time.

3.8 Propagation technique

All the propagation techniques were performed by a single skilled grafter and 1.0 - 1.5 cm wide strips of 400 gauge alkathene tape were used as tying material in all the techniques. The different techniques of propagation followed under present studies are described as under:

3.8.1 Grafting techniques

3.8.1.1 Tongue grafting

The top of the stock was remove by giving a slanting cut about 3cm long at a height of about 20cm from the ground lavel. A corresponding cut of the same size was given on the lower portion of the scion, having 3-4 buds. Reverse cut about 1.5 cm long each on the stock

and scion was made at about one third distance from the terminals of the slanting cut and stock and scion were than inserted into each other the tongues inter-locking. The cambial layer of stock and scion were brought into close contact and the grafts were then wrapped carefully with the alkathene strip in usual way.

3.8.1.2 Cleft grafting-:

The stock seedling was transversely cut at a height of 15- 20 cm above the ground level. The stub of the stock was then vertically splitted down for a distance of about 5 cm with a sharp knife. The scion containing 3-4 buds was prepared like a wedge by a giving two slanting cut about 3 to 4 cm. long opposite to each other at the basal end. The scion was than insertion the split of the stock. The cambial layers of stock and scion were then brought into close contact and graft was tied with alkathene strip.

3.8.1.3 Veneer grafting-:

In this method, a shallow, inward slant cut, 3 – 4 cm long is made in a healthy rootstock. The scion 8.5 cm long is selected from the terminal of a healthy, bearing parent plant. The leaves were removed and the cut portion of scion was trimmed to long and short cut to fit in the root stocks. After insertion of the scion into the cut in the root stock, the whole scion was bound tightly to the root stock with grafting tape. About 3-4 weeks later the terminal portion of root stock 3-4 cm above the union, is cut away and the grafting is removed from the scion just above the union to encourage the scion to sprout.

3.8 Observations recorded

Observations were recorded during the first growing season in 2015 of the various grafted plants started from the month of March to December, 2015 for tongue, cleft and veneer grafting on various parameters *viz*. days taken to first sprouting, average length of sprout (cm), average diameter of sprout (cm), average number of branch, average number of leaves, average leaf area (cm^2), dead graft percentage, dead graft after sprouting percentage, survival percentage, and number of saleable plants. Eight representative plants were taken for the purpose and mean were recorded for each parameters.

During the year of study, the final observations were recorded at the end of December, 2015, pertaining to tongue, cleft and veneer grafted plants. The grafted plants got the desired saleable height and were; therefore, ready to sell in market for planting in the subsequent winter or onwards. The grafted plants showing the undersized height in the year was needed heading back about 5cm to 10 cm above the graft union. The procedures used and methodology followed for taking the various observations are described below:

The following observations of the grafting were recorded at 30 days intervals with the following characters.

3.8.1 Days taken to first sprouting

The days taken to first sprouting in each treatment was recorded from the date of grafting to date of first sprout.

3.8.2 Shoot length (cm)

The Length of sprouts(cm) was measured in each treatment with the help of scale in each previously tagged grafted plants at 30 days interval and the mean length of sprouts were calculated.

3.8.3 Shoot diameter (cm)

The diameter of randomly selected sprout was measured in centimeter by Vernier Calipers or micro meter at 30 days interval and average was worked out.

3.8.4 Number of branch

Number of branches was counted on the grafting in each treatment and average number of branches per plant was worked out.

3.8.5 Number of leaves

The total number of leaves was counted on newly emerged shoots of graft at 30 days interval and average number of leaves on sprouted graft was calculated.

3.8.6 Leaf area (cm^2)

The leaf area was recorded by means with a digital leaf area meter, ten leaves were selected randomly from each of the tagged grafted plants and their average leaf area was calculated and multiplied with average number of leaves per plants to obtain the total leaf area.

3.8.7 Percentage of dead grafted plants (%)

The percentage of dead graft was recorded in each treatment at 4 to 5 months after grafting. It was calculated with the help of following formula:

$$\text{Dead graft percentage} = \frac{\text{Number of dead graft}}{\text{Total grafted plants}} \text{ X } 100$$

3.8.8 Percentage of dead graft after sprouting (%)

The percentage of dead graft after sprouting observed in each treatment at about 4 to 5 months after grafting was calculated with the help of following formula:

$$\text{Percentage of dead graft after sprouting} = \frac{\text{Number of dead graft after sprout}}{\text{Total grafted plants}} \text{X100}$$

3.8.9 Percentage of survival grafted plants (%)

The survival of graft was recorded in each treatment after 8 to 10 months at the termination of experiments and the survival percentage of graft was calculated by following formula:

$$\text{Total survival percent} = \frac{\text{Number of survived grafts}}{\text{Total grafted plants}} \text{X100}$$

3.8.10 Total percentage of saleable grafted plants (%)

The plants attaining good height and vigor in growth were considered as saleable plants. The number of such saleable plants were recorded at the end of growing season and expressed under:

$$\text{Saleable plants percentage} = \frac{\text{Number of saleable plants}}{\text{Number of succesfull graft}} \text{ X } 100$$

3.9 Statistical analysis

The data obtained for different season during the investigation were analysed by using standard statistical procedure in the Factorial Randomized Block Design (FRBD). Standard errors of mean's (S.Em ±) were computed in each case and the critical differences (C.D.) at 5 percent level of significance were calculated only for significance results **(Cochran and Snedecor 1987).** The experimental results are presented with the help of tables, diagrams, and photographs wherever found.

PRACTICES OF CLEFT AND TONGUE GRAFTING

DATA RECORDED FROM GRAFTED PLANTS

CHAPTER-4

EXPERIMENTAL RESULTS

CHAPTER- 4

EXPERIMENTAL RESULTS

The present investigation entitled **"Studies on different methods and time of grafting in walnut (*Juglans regia* L.) under different growing conditions"** was conducted under the field conditions at Fruit nursery and Department of Fruit Science, VCSG, Uttarakhand University of Horticulture and Forestry Bharsar, Pauri Garhwal, Uttarakhand, India, during the year 2015-16. The findings of the present study are presented in this chapter under the following headings

4.1 Days taken to sprouting

Table4.1 Effect of various methods of grafting under different growing conditions on days taken to sprouting

Methodsof grafting	**Growing conditions ±SE(m)**			
	P_1 polyhouse	**P_2 net house**	**P_3 open**	**Mean**
G_1tongue	48.34 ± 0.02	46.27 ± 0.03	51.72 ± 0.01	48.78
G_2 cleft	47.31 ± 0.03	56.11 ±0.01	51.55 ± 0.01	51.65
G_3veneer	54.12 ± 0.03	53.46 ± 0.02	56.66 ± 0.02	54.75
Mean	49.92	51.94	53.31	
	A	**B**	**A x B**	
SE (d)	**0.04**	**0.04**	**0.07**	
C.D. (0.05)	**0.09**	**0.09**	**0.16**	

A close perusal of the observations presented in Table 4.1 and Appendix II. Pertaining to days taken to sprouting showed significant effect of different methods and different growing conditions. Among all treatment combinations G_1P_2 (tongue grafting in net house conditions) showed the earliest sprout (46.27 days) followed by (cleft grafting in polyhouse) G_2P_1 treatment combination. While G_3P_3 (veneer grafting in open condition) treatment combination took longest period (56.66 days) to sprout.

Table 4.2 Effect of various methods of grafting and grafting time on days taken to sprouting

Methods of grafting)	**Grafting time ±SE(m)**		
	T_1January	**T_2February**	**Mean**
G_1tongue	51.09 ± 0.01	46.46 ± 0.04	48.78
G_2 cleft	50.06 ± 0.02	53.25 ± 0.02	51.65
G_3 veneer	56.92 ± 0.03	52.57 ± 0.03	54.75
Mean	52.69	50.76	
	C	**A X C**	
SE (d)	**0.03**	**0.06**	
C.D. (0.05)	**0.07**	**0.13**	

A close perusal of the observation presented in Table 4.2 and Appendix. II, pertaining to days taken to sprout showed significant effect for different methods and time among all treatment combination G_1T_2 (tongue grafting during February) treatment combination showed the earliest bud sprout (46.46 days) followed by (cleft grafting during January) G_2T_1 treatment combination. While G_3T_1(veneer grafting during January) treatment combination took longest period (56.92 days) to sprout.

Table 4.3 Effect of different growing conditions and grafting time on days taken to sprouting

Growing conditions	**Grafting time ±SE(m)**		
	T_1January	**T_2February**	**Mean**
P_1 polyhouse	49.23 ± 0.02	50.62 ± 0.02	49.92
P_2 Net house	54.77 ± 0.01	49.12 ± 0.01	51.94
P_3 Open field	54.07 ± 0.03	52.54 ± 0.04	53.31
Mean	52.69	50.76	
SE (d)	**0.06**		
C.D.(0.05)	**0.13**		

The effect of interaction between different conditions and time of grafting were also found significant with respect to days taken to sprouting (Table.4.3 and Appendix. II). The earliest days taken to sprout (49.12 days) were recorded in net house conditions during February (P_2T_2 treatment combination) which was followed by (P_1T_1) treatment combination (January with polyhouse conditions). While (P_2T_1) treatment combination was showed maximum days to sprout (54.77days).

Table 4.4 Effect of various methods of grafting and grafting time on days taken to sprouting under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**Mean**
T_1 January	50.32 ±0.07	52.17 ±0.01	50.80 ±0.01	44.77 ±0.01	53.66 ±0.09	51.75 ±0.02	52.60 ±0.01	58.50 ±0.02	59.68 ±0.01	52.69
T_2 February	46.37 ±0.13	40.38 ±0.02	52.64 ±0.03	49.85 ±0.09	58.56 ±0.04	51.35 ±0.03	55.65 ±0.03	48.41 ±0.01	53.65 ±0.04	50.76
Mean	48.34	46.27	51.72	47.31	56.11	51.55	54.12	53.40	56.66	
SE. (d)	**0.11**									
CD.(0.05)	**0.22**									

The interaction between different methods, condition and time of grafting was also found significant with respect to days taken to sprouting (Table.4.4 and Appendix II). Among all treatment combination $G_2P_1T_2$ (cleft grafting under polyhouse during February) treatment combination showed the earliest bud sprout (40.38 days) followed by $G_1P_2T_1$ (44.77 days) treatment combination (tongue grafting under net house during January). While $G_3P_3T_1$ (veneer grafting under open condition during January) treatment combination took longest period (59.68days) to sprout.

4.2 Shoot length

Table 4.5 Effect of various methods of grafting under different growing conditions on average shoot length of grafted plant

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3 open**	**Mean**
G_1 tongue	57.08 ± 0.01	65.46 ± 0.03	51.50 ± 0.02	58.01
G_2 cleft	50.58 ± 0.05	46.04 ± 0.03	58.46 ± 0.01	51.69
G_3 veneer	44.58 ± 0.03	48.37 ± 0.02	42.10 ± 0.03	45.01
Mean	50.75	53.29	50.69	
	A		**B**	**A X B**
SE (d)	**0.02**		**0.02**	**0.05**
C.D.(0.05)	**0.05**		**0.05**	**0.10**

The interaction between different methods and conditions was also found significant on the shoot length (Table.4.5 and Appendix II). The longest shoot length (65.46 cm) were determined with tongue grafting in net house (G_1P_2 treatment combination) followed by cleft grafting in open conditions (G_2P_3 treatment combination) while the shortest shoot length (42.10 cm) was recorded with (veneer grafting in open condition) G_3P_3 treatment combination.

Table 4.6 Effect of various methods of grafting and grafting time on shoot length of plant

Methods of grafting	Grafting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
G_1 tongue	59.52 ± 0.01	56.50 ± 0.02	58.01
G_2 cleft	54.49 ± 0.03	48.90 ± 0.04	51.69
G_3 veneer	40.88 ±0.04	49.15 ± 0.03	45.01
Mean	51.63	51.51	
	C	**A X C**	
SE (d)	**0.02**	**0.04**	
C.D.(0.05)	**0.04**	**0.08**	

Data on present investigation revealed that the interaction between different methods and time of grafting had significant effect on the shoot length (Table. 4.6 and Appendix. II). Tongue grafting during January (G_1T_1 treatment combination) was found to longest shoot length (59.52 cm) followed by tongue grafting during February (G_1T_2 treatment combination). The shortest shoot length (40.88 cm) was observed with veneer grafting which was practiced during January (G_3T_1 treatment combination).

Table 4.7 Effect of different growing conditions and grafting time on shoot length of grafted plant

Growing conditions	Grafting time ±SE(m)		
	T_1 January	**T_2 February**	**Mean**
P_1 polyhouse	52.20 ± 0.01	49.30 ± 0.04	50.75
P_2 net house	47.64 ± 0.03	58.94 ± 0.01	53.29
P_3 open field	55.06 ± 0.04	46.31 ± 0.02	50.69
Mean	51.63	51.51	
SE (d)	**0.04**		
C.D.(0.05)	**0.08**		

Data on present investigation revealed that the interaction between different conditions and time of grafting had significant effect on the shoot length of grafted plants (Table.7and Appendix. II). Net house conditions during February (P_2T_2 treatment combination) was found to record the longest length of shoots (58.94 cm) followed by open conditions during January (P_3T_1treatment combination). The shortest length of shoots (46.31 cm) was observed in open condition during February (P_3T_2 treatment combination).

Table 4.8 Effect of various methods of grafting and grafting time on shoot length under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			**Mean**
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	
T_1 January	53.71 ±0.01	62.43 ±0.01	62.43 ±0.02	55.55 ±0.01	39.56 ±0.01	68.38 ±0.02	47.34 ±0.01	40.94 ±0.02	34.38 ±0.02	51.63
T_2 February	60.45 ±0.02	68.49 ±0.02	40.58 ±0.03	45.62 ±0.03	52.53 ±0.03	48.55 ±0.03	41.83 ±0.02	55.80 ±0.01	49.82 ±0.04	51.51
Mean	57.08	65.46	51.50	50.58	46.04	58.46	44.58	48.37	42.1	
SE. (d)	**0.07**									
CD.(0.05)	**0.14**									

The interaction between different methods, conditions and time of grafting was also found to be significant with respect to average shoot length of grafted plants (Table. 4.8and Appendix II). Among all treatment combination $G_2P_1T_2$ (cleft grafting under polyhouse in February) treatment combination showed the longest shoot length (68.49cm) followed by (veneer grafting under net house in January) $G_3P_2T_1$ treatment combination. While $G_3P_3T_1$ (veneer grafting under open condition in January) treatment combination showed the shortest length (34.38 cm) of shoots.

4.3 Shoot diameter (cm)

Table 4.9 Effect of various methods of grafting under different growing conditions on average shoot diameter of grafted plant

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	P_2 net house	P_3open	Mean
G_1 tongue	0.85 ± 0.01	0.92 ± 0.03	0.89 ± 0.01	0.89
G_2 cleft	0.86 ± 0.03	0.82 ± 0.03	0.82 ± 0.03	0.83
G_3 veneer	0.90 ± 0.01	0.82 ± 0.02	0.79 ± 0.01	0.84
Mean	0.87	0.85	0.83	
	A	B	A X B	
SE (d)	0.00	0.00	0.00	
C.D.(0.05)	0.01	0.01	0.01	

The interaction between different methods and conditions of grafting were significant on the average diameter of shoot (Table 4.9and Appendix II). The tongue grafting under net house (G_1P_2 treatment combination) was found to have maximum average diameter of shoot (0.92 cm), followed by veneer grafting in polyhouse condition treatment combination. The minimum average diameter of shoots (0.79cm) was observed under open condition with veneer grafting (G_3P_3) treatment combination.

Table 4.10 Effect of various methods of grafting and grafting time on shoot diameter of plant

Methods of grafting	Grafting time ±SE(m)		
	T_1January	T_2February	Mean
G_1 tongue	0.88± 0.02	0.89 ± 0.04	0.89
G_2 cleft	0.85 ± 0.01	0.82 ± 0.03	0.83
G_3 veneer	0.81 ± 0.05	0.87 ±0.02	0.84
Mean	0.85	0.86	
	C	A X C	
SE (d)	0.00	0.00	
C.D.(0.05)	N/A	0.01	

It was again observed that the interaction between different methods and time of grafting found significant affect with respect to the shoot diameter (Table. 4.10 and Appendix. II). February with tongue grafting was found to record maximum shoot diameter (0.89 cm) followed by January with tongue grafting (G_1T_1 treatment combination).While veneer grafting practiced during January was recorded to have minimum (0.81 cm) average shoot diameter.

Table 4.11 Effect of different growing conditions and grafting time on shoot diameter of grafted plant

Growing conditions	Planting time ±SE(m)		
	T_1january	T_2February	Mean
P_1 polyhouse	0.88 ± 0.01	0.85 ± 0.02	0.87
P_2 net house	0.81 ± 0.03	0.89 ± 0.01	0.85
P_3 open field	0.85 ± 0.02	0.82 ± 0.02	0.83
Mean	0.85	0.86	
SE (d)	0.00		
C.D.(0.05)	0.01		

Data on present investigation revealed that the interaction between different conditions and time of grafting had significant effect on the shoot diameter of grafted plants (Table. 4.11 and Appendix. II). (P_2T_2) net house conditions during February was found maximum diameter of shoots (0.89cm) followed by polyhouse in January (P_1T_1treatment combination). The minimum diameter of shoots (0.81 cm) was observed in net house condition during January (P_2T_1 treatment combination).

Table 4.12 Effect of various methods of grafting and grafting time on shoot diameter under different growing conditions

	P_1Polyhouse± SE(m)			P_2Net house± SE(m)			P_3 Open± SE(m)			
	G_1 Tongue	G_2 Cleft	G_3 Veneer	G_1 Tongue	G_2 Cleft	G_3 Veneer	G_1 Tongue	G_2 Cleft	G_3 Veneer	Mean
T_1 January	0.85 ±0.02	0.88 ±0.01	0.94 ±0.01	0.89 ±0.03	0.79 ±0.01	0.88 ±0.03	0.93 ±0.01	0.77 ±0.02	0.73 ±0.02	0.85
T_2 February	0.85 ±0.03	0.97 ±0.03	0.84 ±0.02	0.84 ±0.02	0.85 ±0.02	0.76 ±0.02	0.88 ±0.02	0.87 ±0.02	0.86 ±0.01	0.85
Mean	0.85	0.92	0.89	0.86	0.82	0.82	0.90	0.82	0.79	
SE. (d)	0.01									
CD.(0.05)	0.02									

The interaction between different methods, conditions and time of grafting was also found to be significant with respect to shoot diameter (Table 4.12). Among all treatment combination, $G_2P_1T_2$ (cleft grafting under Polyhouse condition during February) treatment combination showed the maximum shoot diameter (0.97 cm) followed by (veneer grafting under polyhouse in February) $G_1P_1T_2$ (0.94 cm) treatment combination. While $G_3P_3T_2$ (veneer grafting under net house condition in January) treatment combination resulted in minimum (0.73 cm) shoot diameter.

4.4 Total number of branches

Table 4.13 Effect of various methods of grafting under different growing conditions on total number of branch per grafted plants

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3 open**	**Mean**
G_1 tongue	12.55 ± 0.01	14.08 ± 0.03	15.66 ± 0.01	14.10
G_2 cleft	11.58 ± 0.04	12.67 ± 0.02	12.16 ± 0.03	12.14
G_3veneer	11.71 ± 0.02	12.16 ± 0.02	9.70 ± 0.03	11.19
Mean	11.95	12.97	12.50	
	A	**B**	**A X B**	
SE (d)	**0.04**	**0.04**	**0.07**	
C.D.(0.05)	**0.09**	**0.09**	**0.14**	

In the present study, the interaction between different methods and conditions of grafting was found to have significant effect on average number of branches per grafted plant (Table. 4.13 and Appendix II). The maximum number of branches (15.66) was recorded with G_1P_3treatment combination (tongue grafting in open conditions). The minimum number of branches per grafted plant (9.70) was produced by (veneer grafting in open conditions) G_3P_3treatment combination.

Table 4.14Effect of various methods of grafting and grafting time on total number of branch per grafted plant

Methods of grafting	Planting time±SE(m)		
	T_1January	**T_2 February**	**Mean**
G_1 tongue	13.92 ± 0.01	14.28 ± 0.03	14.10
G_2 cleft	12.00 ± 0.02	12.27 ± 0.02	12.14
G_3 veneer	10.70 ± 0.03	11.67 ± 0.01	11.19
Mean	12.20	12.74	
	C	**A X C**	
SE (d)	**0.03**	**0.06**	
C.D.(0.05)	**0.07**	**0.12**	

It was again observed that the interaction between different methods and time of budding significantly affected the average number of branches on new sprout (Table.14 and Appendix. II).

February with tongue grafting (G_1T_2treatment combination) was found to have maximum number of branches (14.28) followed by January with tongue grafting (G_1T_1 treatment combination).While veneer grafting practiced during January was recorded to have minimum (10.70) number of branches per grafted plants.

Table 4.15 Effect of different growing conditions and grafting time on total number of branches per grafted plant

Growing conditions	Planting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
P_1 polyhouse	12.26 ± 0.02	11.64 ± 0.02	11.95
P_2 net house	11.65 ± 0.01	14.29 ± 0.05	12.97
P_3 open field	12.71 ± 0.02	12.30 ± 0.01	12.50
Mean	12.20	12.74	
SE (d)	**0.06**		
C.D.(0.05)	**0.12**		

Data on present investigation revealed that the interaction between different condition and time of grafting had significant effect on the average number of branch per grafted plants (Table. 4.15 and Appendix. II). Net house conditions in February (P_2T_2 treatment combination) were found to have maximum number of branches (14.29) followed by open conditions in January (P_3T_1 treatment combination). The minimum number of branches (11.64) was observed in poly house condition during February (P_1T_2 treatment combination).

Table 4.16 Effect of various methods of grafting and planting time on total number of branches per grafted plants under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**Mean**
T_1 January	14.55 ±0.01	11.56 ±0.02	15.65 ±0.02	10.53 ±0.02	12.66 ±0.01	12.81 ±0.02	11.70 ± 0.01	10.73 ±0.01	9.69 ±0.04	12.20
T_2 February	10.56 ±0.01	16.60 ±0.02	15.68 ±0.01	12.64 ±0.01	12.68 ±0.04	11.51 ±0.03	11.72 ± 0.02	13.60 ±0.02	9.71 ±0.02	12.74
Mean	12.55	14.08	15.66	11.58	12.67	12.61	11.71	12.61	9.7	
SE. (d)	**0.10**									
CD.(0.05)	**0.22**									

The interaction between different methods, condition and time of grafting was also found significant with respect to average number of branches (Table 4.16 and Appendix II). Among all treatment combinations $G_2P_1T_2$ (cleft grafting under polyhouse in February) treatment combination showed the maximum number of branches (16.60) followed by (veneer grafting under polyhouse in February) G_3P_1T2 (15.68) treatment combination. While $G_3P_3T_1$ (veneer grafting under open in January) treatment combination obtained (9.69) minimum number of branches per grafted plants.

4.5 Number of leaves

Table 4.17 Effect of various methods of grafting under different growing conditions on average number of leaves per grafted plants

Methods of grafting	Growing conditions±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3 open**	**Mean**
G_1 tongue	87.19 ± 0.01	91.08 ± 0.01	95.68 ± 0.01	91.32
G_2 cleft	76.82 ± 0.01	74.73 ± 0.01	89.59 ± 0.01	80.38
G_3veneer	65.62 ± 0.01	63.74 ± 0.01	60.13 ± 0.01	63.16
Mean	76.54	76.52	81.80	
	A	**B**	**A x B**	
SE (d)	**0.01**	**0.01**	**0.02**	
C.D.(0.05)	**0.03**	**0.03**	**0.05**	

Data on present investigation revealed that the interaction between different methods and conditions had no significant effect on the number of leaves per grafted plants (Table.17 and Appendix.II). Tongue grafting with open conditions (G_1P_3 treatment combination) was found to recorded maximum number of leaves (95.68) followed by tongue grafting in net house conditions (G_1P_2treatment combination). The minimum average number of leaves (60.13) was observed when veneer grafting was practiced under open conditions (G_3P_3 treatment combination).

Table4.18 Effect of various methods of grafting and grafting time on average number of leaves per grafted plants

Methods of grafting	Planting time±SE(m)		
	T_1January	**T_2February**	**Mean**
G_1 tongue	83.99 ± 0.01	98.64 ± 0.01	91.32
G_2 cleft	77.06 ±0.03	83.69 ± 0.02	80.38
G_3 veneer	52.58 ± 0.03	73.74 ± 0.03	63.16
Mean	71.21	85.36	
	C	**A x C**	
SE (d)	**0.01**	**0.02**	
C.D.(0.05)	**0.02**	**0.04**	

It was again observed that the interaction between different methods and time of grafting had no significantly effect on the average number of leaves (Table. 4.18and Appendix. II). Tongue grafting in February (G_1T_2treatment combination) was found to recorded maximum number of leaves (98.64) followed by tongue grafting in January (G_1T_1treatment combination).While veneer grafting during January was recorded to have minimum (52.58) number of leaves.

Table4.19 Effect of different growing conditions and grafting time on average number of leaves per grafted plants

Growing conditions	Planting time ±SE(m)		
	T_1 January	T_2February	Mean
P_1 polyhouse	70.67 ± 0.01	82.41 ± 0.03	76.54
P_2 net house	56.72 ± 0.02	96.31 ± 0.02	76.52
P_3 open field	86.24 ± 0.06	77.35 ± 0.01	81.80
Mean	71.21	85.36	
SE (d)	0.02		
C.D.(0.05)	0.04		

Data of present investigation revealed that the interaction between different condition and time of grafting had significant effect on the average number of leaves of grafted plants (Table. 4.19 and Appendix. II). Net house condition during February (P_2T_2 treatment combination) was found to record maximum number of leaves (96.31) followed by open conditions during January (P_3T_1 treatment combination). The minimum number of leaves (56.72) was observed in net house condition which was practiced during January (P_2T_1 treatment combination).

Table4.20 Effect of various methods of grafting and grafting time on average number of leaves per grafted plants under different growing conditions

	P_1Polyhouse± SE(m)			P_2Net house± SE(m)			P_3 Open± SE(m)			Mean
	G_1 Tongue	G_2 Cleft	G_3 Veneer	G_1 Tongue	G_2 Cleft	G_3 Veneer	G_1 Tongue	G_2 Cleft	G_3 Veneer	
T_1 January	81.68 ±0.01	67.70 ±0.02	102.60 ±0.01	70.80 ±0.01	56.77 ±0.01	103.62± 0.04	59.54 ±0.01	45.71 ±0.01	52.51 ±0.02	71.21
T_2 February	92.71 ±0.06	114.47 ±0.02	88.76 ±0.03	82.84 ±0.02	92.69 ±0.02	75.56 ±0.02	71.70 ±0.01	81.78 ±0.01	67.75 ±0.02	85.36
Mean	87.19	91.08	95.68	76.82	74.73	89.59	65.62	63.74	60.13	
SE. (d)	0.03									
CD.(0.05)	0.07									

The interaction between different methods, conditions and time of grafting was also not found significant with respect to average number leaves on grafted plants (Table 4.20 and Appendix. II). Among all treatment combination $G_2P_1T_2$ (cleft grafting under polyhouse in February) treatment combination showed the maximum number of leaves (114.47) followed by (veneer grafting under poly house during January) $G_3P_1T_1$ treatment combination. While $G_2P_3T_1$ (cleft grafting under open condition in January) treatment combination showed minimum number of leaves (45.71).

4.6 Leaf area (cm)^2

Table 4.21 Effect of various methods of grafting under different growing conditions on average leaf area

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3 open**	**Mean**
G_1 tongue	23.60 ± 0.03	30.37 ± 0.03	28.70 ± 0.02	27.55
G_2 cleft	25.22 ± 0.02	26.77 ±0.04	26.39 ± 0.04	26.13
G_3 veneer	24.35 ± 0.01	24.64 ± 0.02	26.04 ± 0.01	25.01
Mean	24.39	27.26	27.04	
	A	**B**	**A X B**	
SE (d)	**0.04**	**0.04**	**0.07**	
C.D.(0.05)	**0.09**	**0.09**	**0.16**	

Data of present investigation revealed that the interaction between different method and condition of grafting had significant effect on the leaf area per grafted plants (Table. 4.21 and Appendix.III). Tongue grafting in net house condition (G_1P_2 treatment combination) was found to record maximum leaf area (30.37 cm^2) followed by tongue grafting in open condition (G_1P_3 treatment combination). The minimum average of leaf area (23.60 cm^2) was observed when tongue grafting was practiced on polyhouse (G_1P_1 treatment combination).

Table 4.22 Effect of various methods of grafting and grafting time on average leaf area

Methods of grafting	Planting time ±SE(m)		
	T_1January	**T_2 February**	**Mean**
G_1 tongue	28.42 ± 0.01	26.69 ± 0.01	27.55
G_2 cleft	26.01 ± 0.03	26.25 ± 0.04	26.13
G_3 veneer	25.49 ± 0.02	24.53 ± 0.03	25.01
Mean	26.64	25.82	
	C	**A x C**	
SE (d)	**0.03**	**0.06**	
C.D.(0.05)	**0.07**	**0.13**	

It was again observed that the interaction between different method and time of grafting was found to significantly affect the average leaf area (Table. 4.22and Appendix. III). Tongue grafting in January (G_1T_1 treatment combination) was found to have maximum leaf area (28.42 cm^2) followed by tongue grafting during February (G_1T_2 treatment combination).While veneer grafting during February was recorded to have minimum (24.53cm^2) leaf area.

Table4.23 Effect of different growing conditions and grafting time on average leaf area (cm)

Growing conditions	Grafting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
P_1 polyhouse	27.84 ± 0.03	20.94 ± 0.05	24.39
P_2 net house	26.44 ± 0.02	28.08 ± 0.04	27.26
P_3 open field	25.64 ± 0.01	28.45± 0.03	27.04
Mean	26.64	25.82	
SE (d)	**0.06**		
C.D.(0.05)	**0.13**		

Data presented in Table 23 revealed that there was a significant effect of interaction between growing conditions and time of grafting on average leaf area. With a maximum leaf area (28.45 cm^2) in P_3T_2open condition during February), followed by the treatment P_2T_2 (net house conditions during February) while, P_1T_2 (poly house conditions house in February) treatment combination exhibited minimum (20.94 cm^2) leaf area.

Table 4.24 Effect of various methods of grafting and grafting time average Leaf area under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**Mean**
T_1 January	28.63 ±0.02	28.99 ±0.04	27.65 ±0.03	26.74 ±0.01	25.66 ±0.02	25.63 ±0.01	28.15 ±0.03	24.69 ±0.01	23.64 ±0.02	26.64
T_2 February	18.58 ±0.03	31.75 ±0.01	29.75 ±0.01	23.71 ±0.04	27.89 ±0.01	27.16 ±0.02	20.55 ±0.02	24.60 ±0.02	28.45 ±0.03	25.82
Mean	23.60	30.37	28.7	25.22	26.77	26.39	24.35	24.64	26.04	
SE. (d)	**0.11**									
CD.(0.05)	**0.22**									

In the present investigation, it has been observed that the interactions among grafting methods, growing conditions and time of grafting were found to be significant with respect to leaf area (Table 4.24). Among all the treatment combinations $G_2P_1T_2$ (cleft grafting under polyhouse during February) treatment combinations showed the maximum leaf area (31.75 cm^2) followed by $G_1P_1T_1$ (tongue under poly house in January). The minimum leaf area (18.58cm^2) was obtained under $G_1P_1T_2$ (tongue grafted in polyhouse during February) treatment combination.

4.7 Percent of dead grafted plant (%)

Table 4.25 Effect of various methods of grafting under different growing conditions on percentage of dead grafted plants

Methods of grafting	Growing conditions ±SE(m)			
	P_1polyhouse	P_2 net house	P_3 open	Mean
G_1 tongue	46.41 ± 0.02	44.22 ± 0.03	44.93 ± 0.4	45.18
G_2 cleft	43.41 ± 0.01	44.44 ± 0.02	41.79 ± 0.02	43.21
G_3 veneer	54.38 ± 0.03	47.73 ± 0.01	55.84 ± 0.03	52.65
Mean	48.06	45.46	47.52	
	A	B	A X B	
SE(d)	0.01	0.01	0.02	
C.D.(0.0 5)	0.03	0.03	0.05	

The data presented in Table. 4.25 and Appendix.III, indicated that the different methods and conditions significantly affect the percentage of dead grafted plants. It is evident from the data that the minimum percentage of dead grafted plants (41.79%) was produced with cleft grafting under open conditions (G_2P_3) treatment combination followed by G_2P_1(cleft grafting under polyhouse conditions) treatment. While the maximum percentage of dead grafted plants (55.84%) was produced by G_3P_3 treatment combination (veneer grafting under open condition).

Table 4.26 Effect of various methods of grafting and grafting time on percentage of dead grafted plants

Methods of grafting	Grafting time ±SE(m)		
	T_1January	T_2February	Mean
G_1 tongue	46.44 ± 0.02	43.93 ± 0.02	45.18
G_2 cleft	44.17 ± 0.01	42.25 ± 0.04	43.21
G_3 veneer	52.34 ± 0.03	52.96 ± 0.05	52.65
Mean	47.65	46.38	
	C	A X C	
SE (d)	0.01	0.02	
C.D.(0.05)	0.02	0.04	

It was again observed that the interaction between different methods and time of grafting significantly affected the dead grafted plant (Table 26 and Appendix. III). cleft grafting during February (G_2T_2 treatment combination) was recorded to have minimum number of dead grafted plant (42.25%). While Veneer grafting during February (G_3T_1treatment combination) was found to record maximum number of dead grafted plant (52.96 %).

Table 4.27 Effect of different growing conditions and grafting time on percentage of dead grafted plants

Growing conditions	Grafting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
P_1 polyhouse	49.32 ± 0.01	46.80 ± 0.03	48.06
P_2 net house	46.35 ± 0.02	44.57 ± 0.02	45.46
P_3 open field	47.27 ±0.06	47.76 ± 0.05	47.52
Mean	47.65	46.38	
SE(d)	**0.02**		
C.D.(0.05)	**0.04**		

Data presented in Table 4.27 revealed that there was a significant effect of interaction between growing conditions and time of grafting on the percentage of dead grafted plants P_2T_2 (net house conditions during February) treatment combination exhibited the lowest survival percentage of dead grafts (44.57%).The highest percentage of dead grafted plant (49.32%) was obtained with P_1T_1 (polyhouse condition during January).

Table 4.28 Effect of various methods of grafting and planting time on percentage of dead graft under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**Mean**
T_1 January	47.78 ±0.02	48.07 ±0.02	43.48 ±0.02	44.42 ±0.01	47.21 ±0.02	40.90 ±0.02	55.78 ±0.01	43.79 ±0.02	57.45 ±0.01	47.65
T_2 February	45.04 ±0.02	40.38 ±0.01	46.38 ±0.07	42.40 ±0.01	41.67 ±0.01	42.68 ±0.01	52.98 ±0.02	51.67 ±0.02	54.24 ±0.04	46.38
Mean	46.41	44.22	44.93	43.41	44.44	41.79	54.38	47.73	55.84	
SE. (d)	**0.03**									
CD.(0.05)	**0.07**									

In the present investigation, it has been observed that the interactions among grafting methods, growing conditions and time of grafting were found to be significant effect the percentage of dead grafted plants (Table. 4.28). Among all the treatment combinations the minimum percentage of dead grafted plant (40.38%) was obtained under $G_2P_1T_2$ (cleft grafting under polyhouse conditions during February). While $G_3P_3T_1$ (veneer grafting under open condition in January) showed the maximum percentage of dead grafted plant (57.45%).

4.8 Percentage of dead grafted plants after sprouting (%)

Table 4.29 Effect of various methods of grafting under different growing conditions on percentage of dead graft after sprout

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3open**	**Mean**
G_1 tongue	19.07 ± 0.02	19.72 ± 0.03	16.24 ± 0.03	18.34
G_2 cleft	26.27 ± 0.04	24.55 ± 0.02	21.92 ± 0.01	24.24
G_3 veneer	18.44 ± 0.02	18.24 ± 0.01	21.33 ± 0.01	19.34
Mean	21.26	20.84	19.83	
	A	**B**	**A X B**	
SE (d)	**0.02**	**0.02**	**0.04**	
C.D.(0.05)	**0.04**	**0.04**	**0.08**	

The interaction between various grafting methods and conditions of grafting was found to be significant with respect to percentage of dead graft after sprout (Table.4.29). The lowest dead grafts after sprout (16.24%) was recorded with G_1P_3 (tongue grafting under open condition) treatment combination, during the present investigations. The highest percentage of dead graft (26.27%) was produced under G_2P_1 (cleft grafting under polyhouse condition) treatment combination.

Table 4.30Effect of various methods of grafting and grafting time on percentage of dead graft after sprout

Methods of grafting	Planting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
G1 tongue	19.34 ± 0.03	17.34 ± 0.01	18.34
G2 cleft	24.49 ± 0.02	24.00 ± 0.02	24.24
G_3 veneer	20.55 ± 0.04	18.13 ± 0.05	19.34
	21.46	19.82	
	C	**A X C**	
SE(d)	**0.01**	**0.03**	
C.D.(0.05)	**0.02**	**0.07**	

The percentage of dead grafted plants after sprout was affected significantly by the interaction between different methods and time of grafting (Table 4.31 and Appendix.III). The minimum percentage of dead grafted plants after sprout (17.34%) was recorded with (G_1T_2) tongue grafting practiced during February followed by veneer grafting during February. Under the treatment combinationG_2T_1 (cleft grafting during January) maximum number (24.49%) of plants became dead after sprout.

Table 4.31Effect of different growing conditions and grafting time on percentage of dead graft after sprout

Growing conditions	Planting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
P_1 polyhouse	21.37 ± 0.01	21.15 ± 0.05	21.26
P_2 net house	22.75 ± 0.02	18.93 ± 0.02	20.84
P_3 open field	20.27 ± 0.03	19.39 ± 0.02	19.83
Mean	21.46	19.82	
SE (d)	**0.03**		
C.D.(0.05)	**0.06**		

Data presented in Table. 4.31, revealed that there was a significant effect of interaction between growing conditions and time of grafting on the dead graft after sprout. Treatment P_2T_2 (net house during February) treatment combination exhibited the lowest percentage of dead graft after sprout (18.93%) followed by open condition during February (P_3T_2). While net house conditions during January showed (22.75%) the maximum percentage of dead graft after sprout.

Table 4.32Effect of various methods of grafting and planting time on percentage of dead grafts after sprout under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**Mean**
T_1 January	18.56 ±0.01	22.46 ±0.04	17.02 ±0.03	27.22 ±0.02	26.38 ±0.06	19.88 ±0.02	18.34 ±0.04	19.41 ±0.04	23.91 ±0.01	21.46
T_2 February	19.58 ±0.03	16.99 ±0.01	15.46 ±0.01	25.33 ±0.01	22.72 ±0.04	23.96 ±0.01	18.55 ±0.01	17.08 ±0.02	18.76 ±0.03	19.82
Mean	19.07	19.72	16.24	26.27	24.55	21.92	18.44	18.24	21.33	
SE. (d)	**0.05**									
CD.(0.05)	**0.11**									

In the present investigation, it has been observed that the interactions among grafting methods, growing conditions and time of grafting were found to be significant with respect to dead graft after sprout (Table. 4.32). Among all the treatment combinations, the minimum dead graft after sprout (15.46%) was obtained under $G_3P_1T_2$ (veneer grafting under polyhouse condition during February) treatment combination. While $G_1P_2T_1$ (tongue under net house during January) treatment combinations showed the maximum dead graft after sprout (27.22%).

4.9 Survival percentage of grafting

Table 4.33 Effect of different methods of grafting under different growing conditions on survival percentage of grafting

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3 open**	**Mean**
G_1 tongue	34.52 ± 0.01	36.05 ± 0.01	38.87 ± 0.01	36.48
G_2 cleft	30.31 ± 0.02	31.01 ± 0.02	36.29 ± 0.02	32.53
G_3 veneer	27.19 ± 0.06	34.02 ±0.02	22.85 ± 0.04	28.02
Mean	30.67	33.69	32.67	
	A	**B**	**A X B**	
SE (d)	**0.00**	**0.00**	**0.00**	
C.D.(0.05)	**0.01**	**0.01**	**0.01**	

A close analytical of data indicates that the survival percentage were influence significantly by different methods and condition of grafting Table. 4.33 and Appendix.III. The maximum survival percentage (38.87%) was obtained with tongue grafting under open condition(G_1P_3 treatment combination) followed by tongue grafting under net house condition(G_1P_2 treatment combination).While the minimum survival plants (22.85%) was recorded with veneer grafting under open condition (G_3P_3 treatment combination).

Table 4.34 Effect of various methods of grafting and grafting time on survival percentage of grafting

Methods of grafting	Grafting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
G_1 tongue	34.23 ± 0.02	38.72 ± 0.01	36.48
G_2 cleft	31.33 ± 0.02	33.74 ± 0.02	32.53
G_3 veneer	27.11 ± 0.03	28.93 ± 0.4	28.02
Mean	30.89	33.80	
	C	**A X C**	
SE (d)	**0.00**	**0.00**	
C.D.(0.05)	**0.01**	**0.01**	

Data presented in Table.4.34reveals that there was a significant effect of interaction between type of grafting method and grafting time on the survival percentage of grafting. The highest survival percentage (38.72%) of grafting were obtained from G_1T_2 (tongue grafting during February) followed by the treatment combination G_1T_1 (tongue grafting during January) (34.23 %) while, G_3T_1 (veneer grafting during January) treatment combination exhibited the lowest survival percentage of grafting (27.11%).

Table 4.35 Effect of different growing conditions and grafting time on survival percentage of grafting

Growing conditions	Planting time ±SE(m)		
	T_1January	**T_2February**	**Mean**
P_1 polyhouse	29.30 ± 0.01	32.05 ± 0.01	30.67
P_2 net house	30.89 ± 0.04	36.49 ± 0.02	33.69
P_3 open field	32.48 ± 0.05	32.85 ± 0.03	32.67
Mean	30.89	33.80	
SE(d)	**0.00**		
C.D.(0.05)	**0.01**		

Data of present investigation reveals that the interaction between different conditions and time of grafting had significant effect on the survival percent of grafted plants (Table. 4.35 and Appendix.III). Net house conditions during February (P_2T_2 treatment combination) was found to record highest survival percent of grafting (39.49%) followed by open conditions during February 32.85% (P_3T_2 treatment combination). The lowest survival percent (29.30%) was observed in polyhouse condition practiced during January (P_1T_1) treatment combination.

Table 4.36 Effect of various methods of grafting and planting time on survival percentage of grafting under different growing conditions

	P_1Polyhouse± SE(m)			**P_2Net house± SE(m)**			**P_3 Open± SE(m)**			
	G_1 Tongue	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**G_1 Tongue**	**G_2 Cleft**	**G_3 Veneer**	**Mean**
T_1 January	33.66 ±0.03	29.47 ±0.01	39.58 ±0.03	28.36 ±0.01	26.41 ±0.05	39.22 ±0.03	25.88 ±0.01	36.80 ±0.02	18.66 ±0.04	30.89
T_2 February	35.38 ±0.06	42.63 ±0.02	38.16 ±0.02	32.27 ±0.03	35.61 ±0.02	33.36 ±0.01	28.50 ±0.05	31.25 ±0.01	27.05 ±0.01	33.80
Mean	34.52	36.05	38.87	30.31	31.01	36.29	27.19	34.02	22.85	
SE. (d)	**0.01**									
CD.(0.05)	**0.02**									

In the present investigation, it has been observed that the interactions among grafting methods, growing conditions and time of grafting were found to be significant with respect to survival percentage of grafting (Table4.36).Among all the treatment combinations (cleft grafting under polyhouse conditions during February) treatment combinations showed the maximum survival percentage of grafting (42.63%), followed by $G_3P_1T_1$ (veneer grafting under polyhouse conditions during January) (39.58%). The minimum survival percentage of grafting (18.66%) was obtained with $G_3P_3T_1$ (Veneer grafting under open conditions during January) treatment combination.

4.10 Saleable percentage

Table 4.37 Effect of various methods of grafting under different growing conditions on number of saleable grafted plants

Methods of grafting	Growing conditions ±SE(m)			
	P_1 polyhouse	**P_2 net house**	**P_3open**	**Mean**
G_1 tongue	87.01 ± 0.01	87.31 ± 0.14	88.27 ± 0.01	87.53
G_2 cleft	85.35± 0.03	85.86 ± 0.02	87.96± 0.03	86.39
G_3 veneer	83.41 ± 0.04	87.74 ± 0.03	82.42 ± 0.02	84.52
Mean	85.26	86.97	86.22	
	A	**B**	**A X B**	
SE(d)	**0.00**	**0.00**	**0.01**	
C.D.(0.05)	**0.01**	**0.01**	**0.02**	

Data pertaining to the percentage of saleable plant are represented Table.4.37 and Appendix.III). The effect of interaction between different methods and conditions of grafting on the saleable plant was found significant. The best result was obtained as high as (88.27 %) with tongue grafting practiced under open conditions (G_1P_3) followed cleft grafting under open conditions (G_2P_3 treatment combination) which were ready for sale at end of December. While the minimum saleable plants (82.42%) were recorded with veneer grafting under open conditions (G_3P_3 treatment combination).

Table4.38 Effect of various methods of grafting and grafting time on number of saleable grafted plants

Methods of grafting	Planting time±SE(m)		
	T_1January	**T_2February**	**Mean**
G_1 tongue	86.67 ± 0.03	88.39 ± 0.02	87.53
G_2 cleft	86.46 ± 0.02	86.32 ± 0.01	86.39
G_3 veneer	84.76 ± 0.02	84.28 ± 0.02	84.52
Mean	85.96	86.33	
	C	**A X C**	
SE (d)	**0.00**	**0.01**	
C.D.(0.05)	**0.01**	**0.02**	

Data presented in Table.4.38 revealed that there was a significant effect of interaction between type of grafting method and grafting time on saleable grafted plants. The maximum saleable grafted plant (88.39%) obtained with G_1T_2 (tongue grafting during February), followed by the treatment combination G_1T_1 (tongue grafting during January) while, G_3T_2 (veneer grafting during February) treatment combination showed the minimum saleable plant (84.28%).

Table 4.39 Effect of different growing conditions and grafting time on number of saleable grafted plants

Growing conditions	Planting time ±SE(m)		
	T_1January	T_2February	Mean
P_1 polyhouse	85.63 ± 0.02	84.88 ± 0.01	85.26
P_2 net house	84.78 ± 0.01	89.16 ± 0.04	86.97
P_3 open field	87.47 ± 0.02	84.96 ± 0.02	86.22
Mean	85.96	86.33	
SE(d)	0.01		
C.D.(0.05)	0.02		

Data presented in Table 4.39 revealed that there was a significant effect of interaction between growing conditions and time of grafting on the saleable percent of plants. The maximum saleable percent (89.16%) was recorded under the treatment combination of P_2T_2 (net house conditions during February), followed by the treatment combination P_3T_1 (open conditions during January) while P_2T_1 (net house condition in January) treatment combination exhibited minimum (84.78%) saleable plants.

Table 4.40 Effect of various methods of grafting and planting time on number of saleable grafted plants under different growing conditions

	P_1Polyhouse± SE(m)			P_2Net house± SE(m)			P_3 Open± SE(m)			
	G_1 Tongue	G_2 Cleft	G_3 Veneer	G_1 Tongue	G_2 Cleft	G_3 Veneer	G_1 Tongue	G_2 Cleft	G_3 Veneer	Mean
T_1 January	86.55 ±0.02	83.22 ±0.02	90.24 ±0.02	85.60 ±0.02	83.28 ±0.02	90.50 ±0.02	84.76 ±0.02	87.84 ±0.02	81.69 ±0.02	85.96
T_2 February	87.48 ±0.01	91.40 ±0.01	86.31 ±0.03	85.11 ±0.04	88.45 ±0.03	85.42 ±0.02	82.06 ±0.02	87.64 ±0.02	83.16 ±0.02	86.33
Mean	87.01	87.31	88.27	85.35	85.86	87.96	83.41	87.74	82.42	
SE. (d)	0.01									
CD.(0.05)	0.03									

The interaction between different methods, conditions and time of grafting was also found significant with respect to average saleable percent of grafted plants (Table 4.40 and Appendix. III). among all treatment combinations $G_2P_1T_2$ (cleft grafting under polyhouse during February) treatment combination showed the maximum percent of saleable plant (91.40%) followed by (veneer grafting under net house during January) $G_3P_2T_1$ (90.50%). While $G_3P_3T_1$ (veneer grafting under open condition during January) treatment combination showed minimum saleable percent of plants (81.69%).

CHAPTER-5

DISCUSSION

CHAPTER 5
DISCUSSION

The present investigation entitled **"Studies on different methods and time of grafting in walnut (*Juglans regia* L.) under different growing conditions"** was carried out to find out the best method of grafting, best growing condition and appropriate grafting time under different conditions of Fruit nursery at Department of Fruit Science, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, during the year 2015-16.

In this chapter the results obtained during the present investigation have been discussed critically under different leads.

5.1 Days taken to sprouting

The minimum number of days taken to first sprouts was recorded under tongue grafting under net house conditions (46.27 days) G_1P_2 treatment (Mujaffar and Kumar, 2011), The maximum days taken to bud sprouting (56.66 days) was recorded in veneer grafting under open conditions (G_3P_3). The reason for late bud bursting in veneer grafting might be due to lower temperature and humidity which delayed the callus formation and took more days for bud bursting. These findings are in conformity with those of (Joolkan *et al.*, 2001).The different methods and time had significant influence on days taken to sprout with minimum days to sprout was recorded in tongue grafting during February (G_1T_2) (46.46 days) (Dwivedi *et al.*, 2000) while the maximum days taken to sprout was recorded in veneer grafting during January (G_3T_1) 56.92 days. The interaction between different conditions and time for minimum days to sprout was recorded under P_2T_2 (net house during February) (49.12days), which may be due to suitable time for sprouting. The reason might be also due to presence of cell sap in root stock and scion during these dates which is important for the union between stock and scion. And the maximum days taken to sprouting (54.77 days) was recorded in net house conditions during January. The interactions among different growing conditions, methods and different time were also found significant with respect to number of days taken to first sprouting. The results showed that the minimum sprouting were recorded with cleft grafting under poly house condition in the month of February (40.38 days). Because

cleft grafting have very higher success percentage as compared to other grafting methods. It may be due to early and good contact of cambial layers of stock and scion, resulting in early callus formation. The data showed that the maximum days to bud sprouting was recorded with veneer grafting under field condition in month of January (59.68 days).Maximum days to bud sprouting using different methods, different time of grafting under different growing conditions has also been reported by several researcher (Mir and Kumar, 2011).

5.2 Shoot length (cm)

The interaction between different grafting methods under different growing conditions was found significant effect with respect to average shoot length. The maximum shoot length was found under tongue grafting under net house conditions (65.46cm). These findings are in conformity with those of (Kumar and Ananda, 2004). The minimum length of shoot was recorded in veneer grafting under open conditions (42.10 cm). Interaction between grafting method and time the maximum length of shoot was recorded under tongue grafting during January (59.52 cm) while minimum shoot length was resulted in veneer grafting during January (40.88 cm).When different conditions and time were studied under the present study, it was observed the maximum shoot length (58.94 cm) was recorded under P_2T_2 (net house conditions during February) treatment and minimum was recorded under open condition during February (P_3T_2) (46.31cm). The interactions among different growing conditions, methods and different time were also found significant with respect to shoot length. The resulted show that the maximum length of shoots was recorded in cleft grafting under poly house condition in the month of February (68.49 cm). In walnut cleft grafting is the commercial method of grafting. The data show that the minimum length of shoots was recorded in veneer grafting under open condition in month of January (34.38 cm).

5.3 Shoot diameter (cm)

The data shows that different grafting method and conditions show maximum shoot diameter was shows in (G_1P_2) tongue grafting under net house conditions (0.92cm) and minimum shoot diameter was recorded in veneer grafting under open conditions (0.79cm). In interaction between grafting methods and time was found to be significant with respect to average shoot diameter. The mean values for grafting time depicted that maximum shoot diameter (0.89 cm) were produced under tongue grafting when grafting was done in February.

It depends on species, favorable climatic conditions. While the minimum shoot diameter was recorded in veneer grafting during January (0.81cm). The interactions among different growing conditions and time the maximum shoot diameter was recorded in net house conditions during February (P_2T_2) (0.89 cm) while minimum shoot diameter was recorded in (0.81 cm) under net house during January. The interactions among different grafting methods, time under different growing conditions were also found significant with respect to average shoot diameter. The better shoot diameter with optimum time and methods under growing conditions might be due to better bud growth which augmented absorption and translocation of nutrients from soil which take active part in various plant metabolic processes (Singh, 2001). The maximum shoot diameter was recorded in cleft grafting under polyhouse condition in the month of February (0.97cm).These findings are in conformity with those of Singh *et al.*, 2007. The minimum shoot diameter was observed in veneer grafting under open condition during January (0.73cm).

5.4 Total number of branches

The maximum number of branch was found under (G_1P_3) tongue grafting under open conditions (15.66). Increase in number of branches may be due to better utilization of stored carbohydrates, nitrogen and other factors. In walnut cleft grafting is the commercial method of grafting (Ozkan and Zunus, 2001). The minimum total number of branch was recorded in veneer grafting under open conditions (9.70). In the interaction between method and time theG_1T_2treatment resulted in maximum number of branch (14.28) and minimum was recorded in veneer grafting during January(10.70). The results indicate that controlling temperature and humidity to around the optimum for callusing in polyhouse improves the grafting success (Fallahi, 2007). When different conditions and time were studied under the present study, it was observed the maximum number of branches (14.29) was recorded under P_2T_2 (net house conditions during February) treatment while minimum total number of branch (11.64) was recorded under poly house conditions during February (P_1T_2).The interactions among different growing conditions, methods and different time were also found significant with respect to total number of branch. The resulted show that the maximum total number of branch were recorded in cleft grafting under poly house condition in the month of February (16.60) followed by veneer grafting under poly house condition in February. The data show

that the minimum number of branch was recorded in veneer grafting under open condition in month of January (9.69).

5.5 Average number of leaves

The data shows that different grafting method and conditions show maximum number of leaves was shows in (G_1P_3) tongue grafting under open conditions (95.68). These result are corroborative with the findings of (Ahmed *et al.,* 2012) and minimum number of leaves was recorded in veneer grafting under open conditions (60.13).It may be due to wood maturity of grafting which probably reserves high starch and sugar. In interaction between grafting methods and time was found to be significant with respect to average number of leaves. The mean values for grafting time depicted that maximum number of leaves (98.64) were produced under (G_1T_2) tongue grafting when grafting was done in February. It depends on species, favorable climatic conditions. The minimum numbers of leaves were recorded in veneer grafting during January (52.58). The interactions among different growing conditions and time the maximum number of leaves was recorded in net house conditions during February (P_2T_2) (96.31) while minimum number of leaves was recorded in (56.72) under net house conditions during January. Environmental conditions influenced the number of leaves. It may be due to congenial temperature and humidity under polyhouse which help in proliferations of callus between rootstock and scion. Callus formation in walnut is temperature specific (Hartmann *et al.,* (1997). Ideal temperature for callus formation is 26^0C (Erdogan 2006) and no callus formation takes palace for the healing below the 20 ^{0}C (Wilbur *et al.,* 1998)..It may be due to favorable climatic conditions to the higher number of leaves. The interactions among different time and methods of grafting were also found to be significant with respect to average number of leaves. The better number of leaveswith optimum time and methods might be due to better bud growth and more number of branches. This augmented absorption and translocation of nutrients from soil which take active part in various plant metabolic processes. The interactions among different grafting method, different grafting times under different growing conditions were also not found significant. The maximum numbers of leaves were obtained from cleft grafting under poly house condition when grafting was done in February (114.47). These findings are in conformity with those of

(Pathak and Shrivastva, 1975). The minimum was recorded in cleft grafting under open condition during February (45.71).

5.6 Leaf area (cm^2)

The data recorded for average leaf area shows that different grafting, grafting time under different growing condition had significant effect on their average leaf area. The mean values for grafting method depicted that maximum leaf area (30.37 cm^2) were produced under tongue grafting under net house conditions (G_1P_2)treatment. It is due to vigorous growth of plant as it is capable of absorbing more nutrients and prepares more photosynthetic resulted in maximum leaf area. While the minimum leaf area was recorded under (23.60 cm^2) tongue grafting under poly house condition. The maximum average leaf area (28.42cm^2) was showed under tongue grafting during January (G_1T_1) treatment. It is due to stronger bud union and development of normal vascular tissues at the bud union which regulates the transport of water and nutrients and thereby increases the leaf area (Ronting and Pingai, 1993).And minimum leaf area (24.53cm^2) was recorded under veneer grafting during February. When the grafting was done in different time under different growing conditions, the results were found significant with respect to average leaf area. The maximum leaf area was recorded in month of February under open conditions (28.45cm^2) while, minimum was recorded under poly house conditions during February (20.94 cm^2). The interactions among different grafting method at different grafting under different growing conditions show significant effect on average leaf area. The maximum leaf area was recorded under cleft grafting under polyhouse condition in month of February (31.75cm^2). And minimum was recorded under tongue grafting under polyhouse conditions during February (18.58 cm^2).

5.7 Per cent of dead grafting (%)

The maximum percentage of dead grafting (41.79%) was observed under cleft grafting under open conditions (G_2P_3) treatment. The percentage of dead graft was maximum (55.84%) showed under veneer grafting open condition (G_3P_3) treatment. This may be due to unfavorable climatic conditions to the percentage of un-sprouted graft. High temperature also inhibits bud bursting and causes death of graft. The percentage of dead graft was recorded minimum (42.25%) under cleft grafting during February (G_2P_2) treatment. This may be due to

better union of the space between scion and rootstock in cleft grafting as compared to tongue grafting. This results are in conformity with the findings of (Singh *et al.,* 2008).The minimum number of dead graft was recorded under net house conditions during February (44.57%) while maximum was recorded under polyhouse conditions during January (49.32%).The interactions among different time and methods under different growing condition were found significant with respect to percentage of dead graft. The minimum percent of dead grafts (40.38%) was found in cleft grafting under poly house conditions during February ($G_2P_1T_2$). The maximum percent of dead grafting was recorded in veneer grafting open conditions in the month of January (57.45%).

5.8 Dead graft after sprouting (%)

The minimum percentage of dead graft after sprout (16.24%) was obtained in tongue grafting under open conditions (G_1P_3) treatment. The percentage of dead graft after sprouting (26.27%) was maximum in cleft grafting under polyhouse conditions (G_2P_1) treatment. This may be due to high temperature also inhibits shoot growth and causes even death of bud sprout. The lowest percentage of dead graft after sprouting (17.34%) was obtained under tongue grafting during February (G_1T_2) treatment. The minimum number of dead graft after sprout (18.93%) was recorded under net house conditions during February (P_2T_2). The maximum number (22.75%) of dead graft after sprout was recorded under net house conditions during January (P_2T_1). The presence of excess water reduces media aeration and can lead the anaerobic condition of death graft. The interactions among different time and methods under different growing condition of grafting were also found significant. The minimum percent of dead graft after sprout was found under veneer grafting under poly house condition during February (15.46%).While, maximum number of dead graft after sprout (27.22 %) was recorded under tongue grafting under net house conditions during January.

5.9 Survival percent of grafting (%)

Data regarding percent of plant survival showed that different time and methods of grafting under different growing condition had significant effect the plant survival. Maximum plant survival (38.87%) was recorded with tongue grafting under open conditions (G_1P_3) treatment, while minimum plant survival (22.85%) was observed in veneer grafting under

open conditions (G_3P_3). This may be due to affected by season and several factors such as temperature, light and nutrient availability to the survival percentage of graft. Significantly, highest survival percentage of graft (38.72%) was observed under tongue grafting during February (G_1T_2) treatment. While the minimum number of survival plants was recorded under veneer grafting during January (27.11%).The interaction among different conditions and time showed significant effect with respect to survival percent of grafting. The maximum survival (36.49%) was obtained from net house condition during February. While, minimum (29.30%) was obtained from polyhouse conditions during January (P_1T_1).The interaction between different time and methods under different growing condition had significant effect on percentage of plant survival. Maximum plant survival (42.63%) was recorded when the cleft grafting grafted under poly house condition during February. These findings are in conformity with those of Sharma *et al.*,2006. And the minimum plant survival (18.66%) was observed when veneer grafting was done under open condition in January. It is due to the fact that grafting under open condition produce minimum survival percent due to unfavorable climatic condition (Qian and Qian, 2000) and (Mittempergher, 1963) also observed the higher percentage of success in walnut, when cleft grafting was done during February.

5.10 Total percentage of saleable plant (%)

The percentage of saleable plant estimated (88.27%) was recorded tongue grafting under open conditions (G_1P_3) treatment. It is due to more attributed to proper and quick union formation, early bud sprouting. While minimum saleable grafted plant (82.42%) was recorded in veneer grafting under open conditions (G3P3). The maximum sealable plant percentage (88.39%) was recorded in tongue grafting during February (G_1T_2) treatment. While, minimum saleable plants was recorded in veneer grafting during February (84.28%). It is due to these plants required heading back for quality and good health growth of next year. The interactions between different conditions at different time were found significant with respect to percentage of saleable plants. The maximum percent of grafted plants was recorded under net house conditions during February (89.16%) while minimum was observed in net house conditions during January (84.78%).The interaction between different time and methods

under different growing condition has significant effect on percent of saleable plant. The maximum (91.40%) was found under cleft grafting under polyhouse condition when grafting was done in February. The interaction among different grafting methods under different condition show significant effect (Fallahi *et al.,* 2007).while the minimum (81.69%) was recorded in veneer grafting under open conditions during January ($G_3P_3T_1$).

CHAPTER-6

SUMMARY AND CONCLUSION

CHAPTER 6

SUMMARY AND CONCLUSION

The present investigation entitled **"Studies on different methods and time of grafting in walnut (*Juglans regia* L.) under different growing conditions"** was carried out at field conditions of Fruit nursery, department of fruit science VCSG, Uttarakhand University of horticulture and forestry, Bharsar, Pauri Garhwal, Uttarakhand, during the year 2015-16. The experiment was conducted to find out best method of grafting, best growing condition and appropriate grafting time, three methods of grafting (Tongue , cleft and veneer grafting) were grafted under different growing conditions and planted in two different time (Janurary and February) at Fruit nursery, department of fruit science VCSG, Uttarakhand University of horticulture and forestry, Bharsar. The experiment was conducted in Factorial Randomized Block Design with three replications. The salient findings of the present investigation are summarized below:

6.1 Days taken to sprouting

The minimum number of days taken to first sprouts was recorded under tongue grafting under net house conditions (46.27 days) G_1P_2 treatment .The maximum days taken to bud sprouting (56.66 days) was recorded in veneer grafting under open conditions (G_3P_3). The different methods and time had significant influence on days taken to sprout with minimum days to sprout was recorded in tongue grafting during February (G_1T_2) (46.46 days) while the maximum days taken to sprout was recorded in veneer grafting during January (G_3T_1) 56.92 days. The interaction between different conditions and time for minimum days to sprout was recorded under P_2T_2 (net house during February) (49.12days). And the maximum days taken to sprouting (54.77 days) was recorded in net house conditions during January. The interactions among different growing conditions, methods and different time were also found significant with respect to number of days taken to first sprouting. The results showed that the minimum sprouting were recorded with cleft grafting under poly house condition in the month of February (40.38 days. The data showed that the maximum days to bud sprouting was recorded with veneer grafting under field condition in month of January (59.68 days).

6.2 Shoot length (cm)

The interaction between different grafting methods under different growing conditions was found significant effect with respect to average shoot length. The maximum shoot length was found under tongue grafting under net house conditions (65.46cm). The minimum length of shoot was recorded in veneer grafting under open conditions (42.10 cm). Interaction between grafting method and time the maximum length of shoot was recorded under tongue grafting during January (59.52 cm) while minimum shoot length was resulted in veneer grafting during January (40.88 cm).When different conditions and time were studied under the present study, it was observed the maximum shoot length (58.94 cm) was recorded under P_2T_2 (net house conditions during February) treatment and minimum was recorded under open condition during February (P_3T_2) (46.31cm).The interactions among different growing conditions, methods and different time were also found significant with respect to shoot length. The resulted show that the maximum length of shoots was recorded in cleft grafting under poly house condition in the month of February (68.49 cm). The data show that the minimum length of shoots was recorded in veneer grafting under open condition in month of January (34.38 cm).

6.3 Shoot diameter (cm)

The data shows that different grafting method and conditions show maximum shoot diameter was shows in (G_1P_2) tongue grafting under net house conditions (0.92cm) and minimum shoot diameter was recorded in veneer grafting under open conditions (0.79cm). In interaction between grafting methods and time was found to be significant with respect to average shoot diameter. The mean values for grafting time depicted that maximum shoot diameter (0.89 cm) were produced under tongue grafting when grafting was done in February. While the minimum shoot diameter was recorded in veneer grafting during January (0.81cm). The interactions among different growing conditions and time the maximum shoot diameter was recorded in net house conditions during February (P_2T_2) (0.89 cm) while minimum shoot diameter was recorded in (0.81 cm) under net house during January. The interactions among different grafting methods, time under different growing conditions were also found

significant with respect to average shoot diameter. The maximum shoot diameter was recorded in cleft grafting under polyhouse condition in the month of February (0.97cm). The minimum shoot diameter was observed in veneer grafting under open condition during January (0.73cm).

6.4 Total number of branches

The maximum number of branch was found under (G_1P_3) tongue grafting under open conditions (15.66). The minimum total number of branch was recorded in veneer grafting under open conditions (9.70). In the interaction between method and time the (G_1T_2treatment) resulted maximum number of branch (14.28) and minimum was recorded in veneer grafting during January (10.70). When different conditions and time were studied under the present study, it was observed the maximum number of branches (14.29) was recorded under P_2T_2 (net house conditions during February) treatment while minimum total number of branch (11.64) was recorded under poly house conditions during February (P_1T_2).The interactions among different growing conditions, methods and different time were also found significant with respect to total number of branch. The resulted show that the maximum total number of branch were recorded in cleft grafting under poly house condition in the month of February (16.60) followed by veneer grafting under poly house condition in February. The data show that the minimum number of branch was recorded in veneer grafting under open condition in month of January (9.69).

6.5 Average number of leaves

The data shows that different grafting method and conditions show maximum number of leaves was shows in (G_1P_3) tongue grafting under open conditions (95.68). and minimum number of leaves was recorded in veneer grafting under open conditions (60.13). In interaction between grafting methods and time was found to be significant with respect to average number of leaves. The mean values for grafting time depicted that maximum number of leaves (98.64) were produced under (G_1T_2) tongue grafting when grafting was done in February. While the minimum number of leaves was recorded in veneer grafting during January (52.58). The interactions among different growing conditions and time the maximum number of leaves was recorded in net house conditions during February (P_2T_2) (96.31) while

minimum number of leaves was recorded in (56.72) under net house conditions during January. The interactions among different time and methods of grafting were also found to be significant with respect to average number of leaves. The interactions among different grafting method, different grafting time under different growing conditions was also found significant. The maximum number of leaves was obtained from cleft grafting under poly house condition when grafting was done in February (114.47). The minimum was recorded in cleft grafting under open condition during February (45.71).

6.6 Leaf area (cm^2)

The data recorded for average leaf area shows that different grafting; grafting time under different growing condition had significant effect on their average leaf area. The mean values for grafting method depicted that maximum leaf area (30.37 cm^2) were produced under tongue grafting under net house conditions (G_1P_2) treatment. While the minimum leaf area was recorded under (23.60 cm^2) tongue grafting under poly house condition. The maximum average leaf area (28.42cm^2) was showed under tongue grafting during January (G_1T_1) treatment. And minimum leaf area (24.53cm^2) was recorded under veneer grafting during February. When the grafting was done in different time under different growing conditions, the result was found significant with respect to average leaf area. The maximum leaf area was recorded in month of February under open conditions (28.45cm^2) while, minimum was recorded under poly house conditions during February (20.94 cm^2). The interactions among different grafting method at different grafting under different growing conditions show significant effect on average leaf area. The maximum leaf area was recorded under cleft grafting under polyhouse condition in month of February (31.75cm^2). And minimum was recorded under tongue grafting under polyhouse conditions during February (18.58 cm^2).

6.7 Per cent of dead grafting (%)

The maximum percentage of dead grafting (41.79%) was observed under cleft grafting under open conditions (G_2P_3) treatment. The percentage of dead graft was maximum (55.84%) showed under veneer grafting open condition (G_3P_3) treatment. The percentage of dead graft was recorded minimum (42.25%) under cleft grafting during February (G_2P_2) treatment. The minimum number of dead graft was recorded under net house conditions during February (44.57%) while maximum was recorded under polyhouse conditions during

January (49.32%).The interactions among different time and methods under different growing condition were found significant with respect to percentage of dead graft. The minimum percent of dead grafts (40.38%) was found in cleft grafting under poly house conditions during February ($G_2P_1T_2$). The maximum percent of dead grafting was recorded in veneer grafting open conditions in the month of January (57.45%).

6.8 Dead graft after sprouting (%)

The minimum percentage of dead graft after sprout (16.24%) was obtained in tongue grafting under open conditions (G_1P_3) treatment. The percentage of dead graft after sprouting (26.27%) was maximum in cleft grafting under polyhouse conditions (G_2P_1) treatment. The lowest percentage of dead graft after sprouting (17.34%) was obtained under tongue grafting during February (G_1T_2) treatment. The minimum number of dead graft after sprout (18.93%) was recorded under net house conditions during February (P_2T_2). The maximum number (22.75%) of dead graft after sprout was recorded under net house conditions during January (P_2T_1). The interactions among different time and methods under different growing condition of grafting were also found significant. The minimum percent of dead graft after sprout was found under veneer grafting under poly house condition during February (15.46%). While maximum number of dead graft after sprout (27.22 %) was recorded under tongue grafting under net house conditions during January.

6.9 Survival percent of grafting (%)

Data regarding percent of plant survival showed that different time and methods of grafting under different growing condition had significant effect the plant survival. Maximum plant survival (38.87%) was recorded with tongue grafting under open conditions (G_1P_3) treatment, while minimum plant survival (22.85%) was observed in veneer grafting under open conditions (G_3P_3). Significantly, highest survival percentage of graft (38.72%) was observed under tongue grafting during February (G_1T_2) treatment. While the minimum number of survival plants was recorded under veneer grafting during January (27.11%).The interaction among different conditions and time showed significant effect with respect to survival percent of grafting. The maximum survival (36.49%) was obtained from net house condition during February. While minimum (29.30%) was obtained from polyhouse conditions during January (P_1T_1). The interaction between different time and methods under

different growing condition had significant effect on percentage of plant survival. Maximum plant survival (42.63%) was recorded when the cleft grafting grafted under poly house condition during February and the minimum plant survival (18.66%) was observed when veneer grafting was done under open condition in January.

6.10 Total percentage of saleable plant (%)

The percentage of saleable plant estimated (88.27%) was recorded tongue grafting under open conditions (G_1P_3) treatment. While minimum saleable grafted plant (82.42%) was recorded in veneer grafting under open conditions (G3P3). The maximum sealable plant percentage (88.39%) was recorded in tongue grafting during February (G_1T_2) treatment. While minimum saleable plants was recorded in veneer grafting during February (84.28%). The interaction between different conditions at different time were found significant with respect to percentage of saleable plants. The maximum percent of grafted plants was recorded under net house conditions during February(89.16%) while minimum was observed in net house conditions during January (84.78%).The interaction between different time and methods under different growing condition has significant effect on percent of saleable plant. The maximum (91.40%) was found under cleft grafting under polyhouse condition when grafting was done in February. The interaction among different grafting methods under different condition show significant effect. While the minimum (81.69%) was recorded in veneer grafting under open conditions during January ($G_3P_3T_1$).

Conclusion

Among various methods of grafting, cleft grafting under polyhouse conditions during February showed the best performance in terms of days taken to bud sprouting, total number of branch, total number of leaves, average leaf area, percentage of survival plants, percentage of saleable plants and minimum dead grafted plants, shoot length, shoot diameter while, minimum dead graft after sprout was recorded in veneer grafting under poly house during February shown the best results in present study. It is suggested that cleft grafting under polyhouse conditions during February gave the overall best performance to produce healthy plants of walnut within a short time.

CHAPTER-7

LITERATURE CITED

CHAPTER 7

LITERATURE CITED

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APPENDICES

APPENDIX. I

Weekly data pertaining to the average temperature, relative humidity and rainfall

Week no.	Temp. (˚C) Max.	Temp. Min.	RH (%) Max.	RH Min.	Rainfall (cm)
Janurary	6	3	53	15	0
February	13.5	11.5	90	72	17
March	18.5	10	84	33	0
April	25	23.5	70	65	0
May	28	25.5	83.4	81.3	15.5
June	28.16	22.69	97	43	2
July	25.54	23.41	99	66	36.5
August	21.5	20.5	93	80	1.55
September	23.5	22	87	60	0.5
October	18.5	10	70	45	0
November	13	9.5	65	45	0
December	7	0.3	50	35	0

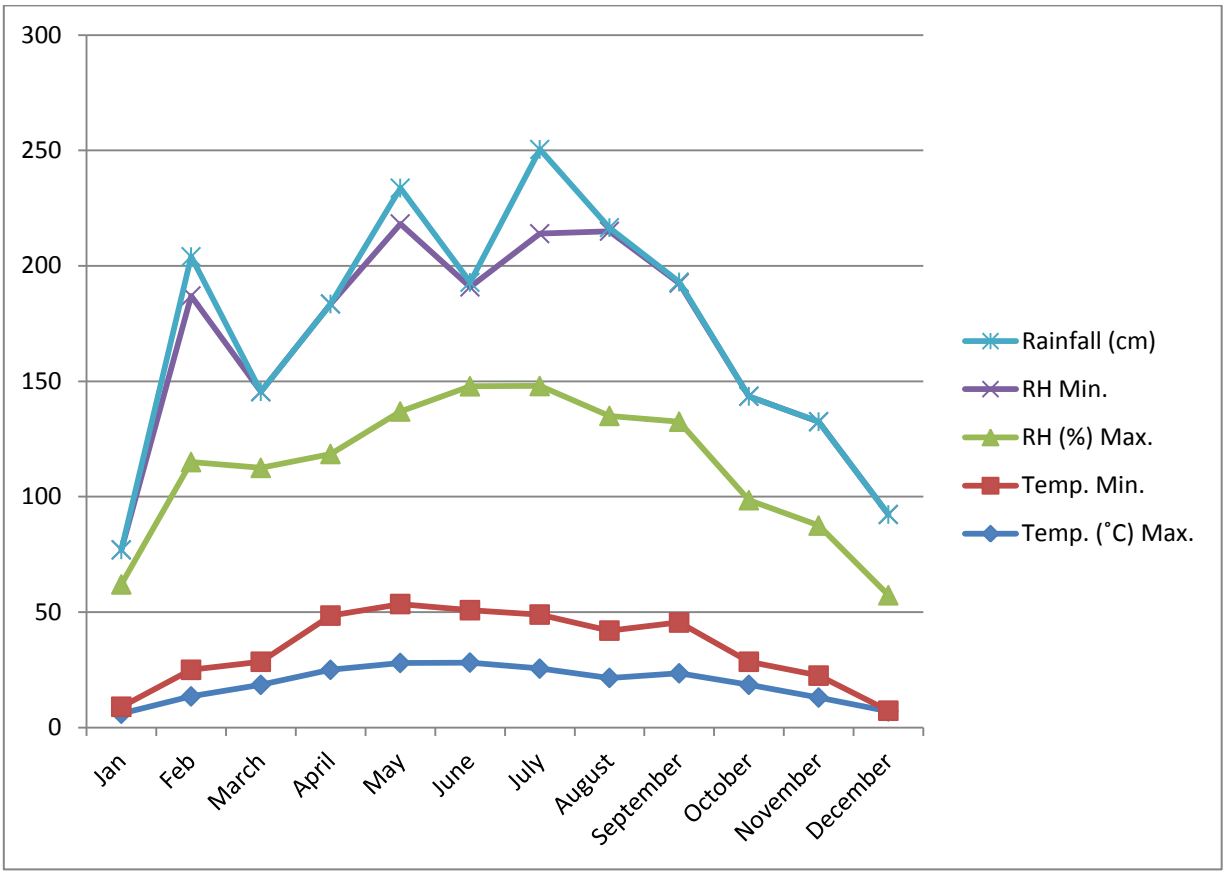

Figure 1. Graphical representation of weekly detaining to the average maximum and minimum temperature, relative humidity and rainfall.

APPENDIX. II

ANALYSIS OF VARIANCE FOR DIFFERENT CHARECTERS

Source of variance	Degree of Freedom	Mean sum of square (M.S.S.)				
		C1	C2	C3	C4	C5
Replication	2	0.03	0.01	0.00	0.00	0.00
Treatment (A)	2	320.92	79.22	1,520.59	0.03	7,252.42
(B)	2	104.41	9.45	79.36	0.01	332.92
(C)	4	252.87	43.77	1,106.28	0.05	753.51
(A×B)	1	50.37	3.87	0.15	0.00	2,702.11
(A×C)	2	177.53	1.28	489.01	0.02	476.34
(B×C)	2	113.04	30.11	956.23	0.04	5,325.80
(A×B×C)	4	192.32	48.23	1,118.39	0.04	1,102.30
Error	34	0.63	0.60	0.25	0.00	0.07

C_1-: Days taken to sprouting, C_2-:Total Number of branch per grafted plant, C_3-:Shoot Length,C_4-:Diameter of shoot (cm), C_5-: Average number of Leaf

APPENDIX. III

ANALYSIS OF VARIANCE FOR DIFFERENT CHARECTERS

Source of variance	Degree of freedom	Mean sum of square (M.S.S.)				
		C6	C7	C8	C9	C10
Replication	2	0.00	0.02	0.08	0.03	0.03
Treatment (A)	2	58.58	892.06	359.51	644.63	83.06
(B)	2	91.95	67.72	19.47	84.93	26.49
(C)	4	74.74	193.05	115.28	482.17	97.51
(A×B)	1	8.98	21.77	36.26	114.15	1.91
(A×C)	2	8.89	25.02	9.30	17.62	12.61
(B×C)	2	252.46	22.19	33.08	61.78	115.53
(A×B×C)	4	45.29	220.84	69.86	437.17	88.16
Error	34	0.63	0.06	0.17	0.00	0.01

C_6-: Average leaf area (cm^2) C_7-: Dead grafted plant (%), C_8-: Dead grafted plant after sprout (%), C_9-: Survival grafted plant (%). C_{10} -: Number of saleable plant (%),

ABSTRACT

ABSTRACT

Name of the student : Kaushal Upadhyay **ID No. :** 13105

Year of admission : 2013 **Degree** : M.Sc. Horticulture (Fruit Science)

Major Field : Fruit Science **Dept :** Fruit Science

Minor Field : Soil Science

Title of Thesis : "**Studies on different methods and time of grafting in walnut (*Juglans regia* L.) Under different growing condition"**

The present investigation entitled "Studies on different methods and time of grafting in walnut (*Juglans regia* L.) under different growing conditions" was carried out in Fruit Nursery, College of Horticulture, V. C. S. G. Uttarakhand University of Horticulture and Forestry, Bharsar, during 2015-2016. In this study the scion of Govind variety were grafted on walnut seedling with different methods and time of grafting under different growing conditions with Factorial Randomized Complete Block Design and three replications. The different parameters for this methods, conditions and time were recorded to evaluated the best methods of grafting under different growing conditions at different time. In the present study cleft grafting under polyhouse conditions during February ($G_2P_1T_2$) with minimum days taken to sprouting, maximum number of leaves per graft, total number of branch per grafted plants, minimum dead graft, maximum saleable plants, maximum survival plants, maximum shoot length, maximum shoot diameter and maximum leaf area (i.e., 40.38 days, 114.47, 16.60, 40.38%, 91.40%, 38.87%, 68.49cm and 31.75cm^2 respectively) show the best performance. The minimum dead graft after sprout 15.46% was recorded in veneer grafting under polyhouse during February ($G_3P_1T_2$).

Hence, the different methods of grafting under different growing conditions at different time varied in their growth characteristics. The cleft grafting under polyhouse conditions during February ($G_2P_1T_2$) was the best combination of methods, condition and time where healthy walnut plants with good growth were observed.

Prof. B.P. Nautiyal Chairman, Advisory commi	Dr. Manju Co – Advisor	Kaushal Upadhyay Author

सारांश

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प्रवेश का वर्ष : 2013 उपाधि :औद्यानिकी(फल विज्ञान)

मुख्य विषय : फल विज्ञान विभाग : फल विज्ञान

लधु विषय : मृदा विज्ञान

शोध का शीर्षक : ''अखरोट के प्रवर्धन पर विभिन्न विधियों, समय एवं स्थितियों के प्रभाव का अध्ययन''

वर्तमान शोध कार्य शीर्षक **''अखरोट के प्रवर्धन पर विभिन्न विधियों, समय एवं स्थितियों के प्रभाव का अध्ययन''** वर्ष 2015–16 के दौरान फल पौधशाला, वीर चन्द्र सिहं गढ़वाली, उत्तराखण्ड औधानिकी एवं वानिकी विश्व विद्यालय, भरसार में किया गया, जिसमें अखरोट के बीजू मूलवृन्त पर गोविन्द प्रजाति का प्रवर्धन विभिन्न विधियों द्वारा जैसेः जिह्वा प्रवर्धन, दीर्घ प्रवर्धन एवं विनियर प्रवर्धन अलग–अलग समय पर जैसेः जनवरी एवं फरवरी माह, पृथक परिस्थितियों में जैसेः पॉली हाउस स्थिति, नेट हाउस व खुली स्थिति में तीन अनुकरण के साथ भाज्य याहच्छिक ब्लॉक अभिकल्प में किया गया। शोध कार्य के दौरान उपचार $G_2P_1T_2$ (दीर्घ प्रवर्धन विधि द्वारा पॉली हाउस स्थिति में फरवरी माह) न्यूनतम कली अंकुरण समय, अधिकतम शाखा की लम्बाई, अधिकतम पत्तियॉ, न्यूनतम मृत पौधे, अधिकतम उत्तरजीवी पौधो की संख्या, अधिकतम शाखा की लम्बाई, अधिकतम शाखा व्यास, विक्रय योगय पौधों की संख्या एवं अधिकतम पत्तियों का क्षेत्रफल (क्रमशः 40.38 दिनों, 16.60, 114.47, 40.38 प्रतिशत, 38.87 प्रतिशत, 68. 49 सेमी, 0.97 सेमी, 91.40 प्रतिशत और 31.75 सेमी^{2}) के साथ सर्वोत्तम पाया गया जबकि अंकुरण के बाद न्यूनतम मृत पौधो की संख्या (15.46 प्रतिशत) फरवरी माह में विनियर विधि द्वारा, पॉली हाउस ($G_3P_1T_2$) में दर्ज की गयी ।

अतः वर्तमान शोध से यह निष्कर्ष निकाला गया कि दीर्घ प्रवर्धन विधि द्वारा पॉली हाउस में फरवरी माह में प्रवर्धन करने पर अखरोट की उत्तम एवं स्वस्थ पौध प्राप्त की जा सकती है।

(प्रो0 बी0 पी0 नौटियाल)	(डॉ0 मन्जू)	(कौशल उपाध्याय)
मुख्य सलाहकार	सह–सलाहकार	लेखक

CURRICULUM VITAE

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Intermediate	2010	G.I.C Devlikhet, Ranikhet	Second	U.K Board
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Scholarship/ Stipend/ Fellowship, any other financial assistance received during the study period	:	No

Kaushal Upadhyay