STUDIES ON PROPAGATION OF CHERRY ROOTSTOCKS THROUGH MOUND LAYERING

Thesis

by

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CERTIFICATE – I

This is to certify that the thesis titled **"Studies on propagation of cherry rootstocks through mound layering"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science (Horticulture) Fruit Science** in the discipline of **Horticultural Sciences** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) - 173 230 is a bonafide research work carried out by **Ms. Riya Chauhan (H-2022-25-M)** daughter of Shri Ravinder Chauhan under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

Place: Nauni, Solan
Dated:

Dr. NC Sharma
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CERTIFICATE – II

This is to certify that the thesis titled **"Studies on propagation of cherry rootstocks through mound layering"** submitted by **Ms. Riya Chauhan (H-2022-25-M)** daughter of Sh. RavinderChauhan to the Dr. Yashwant Singh Parmar University of Horticulture & Forestry, Nauni, Solan (HP) – 173 230, India in partial fulfilment of the requirements for the degree of **Master of Science (Horticulture) Fruit Science**in the discipline of **Horticultural Sciences** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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Dated: **(Riya Chauhan)**

CONTENTS

ABBREVIATIONS USED

Abbreviation		Description
%	:	Per cent
&	:	And
@	:	At the rate of
ANOVA	:	Analysis of variance
CD	:	Critical difference
cm	:	Centimetre
cm^2	:	Centimetre square
DF	:	Degree of freedom
EC	:	Electrical Conductivity
ed.	:	Editors
et al.	:	Co-workers
etc.	:	Et cetera
FYM	:	Farm yard manure
g	:	Gram
HP	:	Himachal Pradesh
J&K	:	Jammu and Kashmir
i.e.	:	That is
IBA	:	Indole-3-butyric acid
L	:	Litre
m	:	Meter (s)
mg	:	Milligram
ml	:	Milliliters
mm	:	Millimeters
MSS	:	Mean Sum of Square
NS	:	Non significant
^oC	:	Degree centigrade
^oN	:	Degree North
^oE	:	Degree East
pH	:	*Puissance de Hydrogen* (Potential of hydrogen)
p	:	Page
ppm	:	Parts per million
RBD	:	Randomized Block Design
S.E. (d)	:	Standard error of difference
S.E. (m)	:	Standard error of mean
SS	:	Sum of Square
var.	:	Variety
viz.	:	*Videlicet* (namely)

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

Chapter-1

INTRODUCTION

Cherry (*Prunus avium* L.) is one of the delicious and highly nutritious fruit belonging to family Rosaceae. Sweet cherries are believed to have originated between Black and Caspian Sea in Southern Europe and extensively grown in temperate countries of the world. Russia, USA, Italy, Germany and France are leading cherry producing countries of the world. In India, atmospheric inclination of cherry is towards temperate high hills in North Western Himalayan region. In the country, cherry is grown in Jammu & Kashmir, Himachal Pradesh and Uttarakhand at an altitude ranging between 2000-2700 m above the mean sea level, where its chilling requirement of 1000-1500 hours during winters is fulfilled. In Himachal Pradesh cherry occupies an area of 448 ha with an annual production of 981 MT fruits (Anonymous 2023). The major cherry growing areas in the state are Kullu and Shimla hills.

Cherry fruit is rich source of antioxidants, vitamin-C, vitamin-A and fibers. Besides, it has high medicinal and anti-inflammatory properties. Due to high nutritional value, fruit is in high demand for fresh consumption and processed products. Amongst the different fruits grown inhigh temperate region fruits, cherry is the earliest to reach market during May-June and fetches premium price. It is highly suitable fruit for crop diversification in high hill temperate region because of its better performance on slightly acidic, highly fertile, well drained, deep and sandy loam soils.

Plant propagation is one of the primary horticultural operations in fruit industry. Good quality planting material is the prerequisite for the development of healthy orchard. Temperate fruits are usually propagated by budding or grafting on seedling rootstock, hence, the plant raised are heterozygous in nature. Plants raised on seedling rootstock has long juvenile phase, inferior fruit quality and difficult to maintain due to their tall and spreading stature. To overcome these problems, propagation on clonal rootstocks is practiced and becoming popular. Plants raised on clonal propagation are true to type, precocious, high yielder of good quality fruits and resistant to specific pests/diseases. Since, demand for quality planting material raised on clonal rootstock is increasing, there is a need to increase the production of true to type and healthy rootstocks.

Paja (*Prunus cerasoides* var. *majestica*) has been a popular rootstock for cherry for many decades, but because of delayed graft incompatibility its usage as rootstock has now been ceased (Parmar and Bist 1992). Hence, clonal rootstocks are common in propagation of cherry. Among the clonal rootstocks, 'Colt' is most commonly used for cherry propagation. The plants raised on 'Colt' are semi vigorous in growth and produce a comparatively larger tree. With the modernization in orcharding, high density plantation is becoming popular among the temperate fruit growers for improving the productivity and quality of the produce. Dwarf trees suitable for high density plantations are raised on dwarfing or semi-dwarfing rootstocks. In Cherry, 'Gisela-5' and 'Gisela-6' are two newly introduced dwarf and semi-dwarf rootstocks, respectively, which can be used to produce short statured trees considered suitable for high density plantations (Sotirov and Dimitrova 2022). 'Gisela-6' (*P. cerasus* × *P. canescens*) is precocious, productive rootstock that can withstand harsh winter conditions and adapt to variety of soil types. It also has fair anchorage, good compatibility and suitablity for plantation at higher densities (Kappel 2005). 'Gisela-5' (*P. cerasus* × *P. canescens*) is rather early maturing and has good resistance to cold, requires well-fertile soils with additional watering.

Clonal propagation of rootstocks is mainly done through stooling/mound layering (Singh 2018). In stooling roots arise from the basal portion of the stool shoots after the process of mounding based on principle of etiolation. It is one of the means through which internal conditions of the developing shoots can be modified to stimulate rooting. The exclusion of light helps in successful rooting of layers by accumulating photosynthates and hormones from leaves and root tips.

In mound layering, certain treatments are given for better rooting in stool shoots. Auxin treatment is an effective way to promote the initiation and development of new roots in stool shoots. IBA (Indole Butyric Acid) is a synthetic auxin which is extensively utilized due is its high rooting capacity in comparison to others, however, optimum concentration varies with the species. IBA typically has clear advantages over other auxins since it is slowly degraded by auxin degrading enzymes and its stability enhances the root promoting action.

Rooting media is another crucial element for rooting in layers. It should be viewed as important aspect of propagation since the kind of media employed determines the rooting ability of plants. Root initiation and formation on layers is regulated by constant moisture, good aeration and moderate temperature in the rooting zone. Rooting media is responsible for

providing these conditions to the plants. After this rooting media needs to offer nutrients, water, allow gas exchange to and from the roots and support the plant for proper growth. Long dry spells coupled with compact and heavy media hinders the process of root development. The most ideal physical parameters for rooting media generally include 20-35% moisture content, 60% porosity, 30-40% aeration and a pH range of 6.0-6.8 (Nanda and Kochhar 1985). Various rooting media such as soil, sand, sawdust, vermiculite, perlite, sphagnum moss, peat and composts etc. can be used for rooting according to the response of the individual species.

The clonal propagation techniques for 'Gisela-5' and 'Gisela-6'rootstocks have not been standardized in Indian conditions. Keeping in view the importance of these cherry rootstocks, present studies on propagation of clonal rootstock of cherry through mound layering were carried out with the following objectives:

- To study the effect of propagation media and IBA treatment on rooting and growth of stool shoots in Gisela-5 and Gisela-6 rootstocks of cherry
- To find out the most suitable rooting medium and optimum concentration of IBA for propagation of Gisela-5 and Gisela-6 rootstocks of cherry

Chapter-2

REVIEW OF LITERATURE

Man's fascination with vegetative horticulture plant propagation for genetic composition preservation and continuation has truly taken hold. Vegetative propagation is the basis for maintaining the genetic purity of the plants, because of this benefit vegetative propagation has been used for a long time in horticulture to produce planting material of desired constitution. Vegetative propagation in fruit crops is usually done using various methods such as cutting, budding, layering and grafting. Clonal rootstocks are commonly propagated through stooling/mound layering. According to Hartmann et al. (2007) stooling is technique where roots are stimulated at the base of shoots by cutting them back to the ground and mounding soil or rooting media around them. Initiation and development of rooting in stooling is possible through manipulation of auxin treatments and rooting media. Comprehensive review of literature on various aspects related to impact of IBA and propagation media on rooting in stem cuttings or layers of temperate fruits in general and cherry in particular is presented in this chapter under appropriate heads:

2.1 EFFECT OF IBA ON ROOTING OF CUTTINGS AND LAYERS

Gulen et al. (2004) conducted a trail on propagation of cherry rootstock 'Gisela-5' by treating stem cuttings with two concentrations of IBA (5 and 10 mM) and planted them in perlite rooting medium. They obtained highest rooting percentage (80.00 %) in cuttings treated with 5 mM IBA. Aydin and Ercan (2023) studied the effect of different IBA treatments (500, 1000, and 2000 ppm) on soft wood cuttings of sweet cherry, sour cherry and mahaleb rootstocks and reported that cuttings treated with 1000 ppm IBA exhibited highest rooting of 59 per cent.

Mishra et al. (1984) treated stool shoots of behmi (local peach rootstock) with different concentrations of IBA (1250-10,000 ppm) and recorded highest rooting (48.30 and 51.00 %) and plant survival (75.90 and 78.30 %) with 5000 ppm IBA treatment during two consecutive years, respectively. Similarly, Shaltout et al. (1998) reported that treatment of peach rootstock 'Nemaguard' layers with 2000 ppm IBA produced 91.65 per cent rooting and 43.4 roots/plant, while 4000 ppm IBA treatment increased the rooting to 95.00 per cent and number of roots to 75.40 per plant. While working on multiplication of 'Nemaguard'

peach rootstock, Tewfik (2002) found significantly higher rooting percentage with 6000 ppm IBA treatment as compared with 4000 and 2000 ppm IBA treatments. Oliveira et al. (2018) applied various concentrations of IBA (0, 1000, 2000, 3000 and 4000 ppm) to hardwood cuttings of peach. They recorded highest adventitious rooting and root quality with the treatment of 2000 ppm IBA and suggest this as a best treatment for peach propagation during winters.

Srivastava et al. (2006) carried out experiment on multiplication of apple clonal rootstock 'MM106' through trench layering and reported that number of rooted shoots, average number of roots, length of longest root and rooted sprouts were significantly increased with 2500 ppm IBA. While working on clonal propagation of apple rootstock Merton 793 through mound layering, Khatik and Sharma (2013) reported that rooted stool shoots (84.57 %), number of rooted stool shoots (7.23/stool), number of adventitious roots per stool shoot (17.71) and total root length (4.80 m) were significantly increased with in stool shoots treated with 2500 ppm IBA. Verma and Chauhan (2015) propagated apple clonal rootstock 'Merton 793' through stem cuttings and reported that IBA 2500 ppm treatment significantly increased the rooting percentage (46.67 %), number of primary roots (4.60), length of primary roots (28.60 cm), diameter of primary roots (2.63 mm), fresh weight (2.89 g) and dry weight (1.83 g) of roots.

Ahmadi and Baglari (2016) while studying on clonal propagation of apple rootstock, applied IBA at different concentrations (0, 10, 100 and 500 mg/l) to the cuttings and mound layers. On the basis of performance of stem cuttings and layers, they suggested 100 mg/l as optimum concentration of IBA for treating stem cuttings and mound layers for propagation of apple rootstocks. Agaba et al. (2017) studied the effect of IBA on rooting in trench layers of four apple clonal rootstocks (M106, M109, M793 and Bitten-felder). They treated the layers with different IBA concentrations (0, 4000 and 8000 ppm) and recorded highest survival rates of 52.4 and 51.7 per cent in Bitten felder and M106 with IBA treatment @ 4000 and 8000 ppm, respectively. However, highest survival rate of 49.5 per cent (M109) and 51.7 per cent (Merton793) was recorded with 8000 ppm IBA treatment. Patial et al. (2021) carried out an experiment to study the effect of different concentrations of IBA (1500, 2000, 2500, 3000, 3500 and 4000 ppm) on stem cuttings of 'M 116' clonal rootstock of apple under mist chamber. They reported that cuttings treated with 3500 ppm IBA had exhibited significantly higher rooting (57.12 %), number of adventitious roots (7.33) and total root

length (4.16 m) as compared to cuttings treated with other IBA concentrations. Amandeep et al. (2022) studied the impact of different IBA concentrations (0, 2000 and 2500 ppm) on rooting in mound layers of Bud 9 clonal rootstock of apple and observed overall best performance of layers with 2500 ppm IBA.

Dhand et al. (2019) while working on pear cv. Patharnakh, treated stem cuttings with different IBA concentrations viz. 1000, 1500, 2000, 2500 and 3000 ppm. They reported that cuttings treated with IBA 2500 ppm performed best in terms of minimum days to first sprouting (23.15), maximum sprouting percentage (69.72 %), survival percentage (47.29 %), number of roots per cutting (5.00) and root length (11.50 cm). Kaviani et al. (2023) treated cuttings of pear with IBA using different concentrations and reported that IBA treatment of 2000 to 4000 ppm concentration had better rooting performance.

Rashid (1977) applied different combinations of auxin treatment to walnut for their rooting performance in stooling and observed maximum rooting with greater number and length of primary, secondary and tertiary roots in 5000 ppm IAA + 10,000 ppm IBA + 5000 ppm NAA treated layers. Wood (1989) carried out an experiment on mound layering in pecan nut and treated stools involving phloem girdling and IBA (3000 and 6000 ppm). They reported that rooting occurred in stools with combined treatment of girdling + IBA. Dunn and Col (1995) laid out trial on mound layering of pistachio nut with four treatments viz. wound, 17500 ppm IBA, wound + 17500 ppm IBA and no wound + no IBA. They observed significantly higher rooting in mound treated layers with wound + 17500 ppm IBA. Noori et al. (2019) while studying on air layering in pistachio nut, treated shoots with different IBA concentrations and recorded maximum rooting percentage (63 %), root number (4.6), root length (5.7 cm) and survival percentage (80 %) in 20000 ppm IBA treated layers.

In order to study the effect of IBA on stem cuttings of olive, Wiesman and Lavee (1994) treated cuttings with IBA in combination with urea-phosphate (UP) and paclobutrazol (PB). They reported that a triple combination of IBA, UP and PB was most effective treatment for improving the rooting percentage, whereas, IBA treatments was found to increase the number of roots per cutting. Prolingis et al. (1999) treated mound layers of olive with different concentrations of IBA in lanolin paste and reported that 4 per cent IBA significantly increased the rooting percentage and number as well as weight of roots. Similarly, Petridou and Voyiatzis (2002) treated olive cv. Kalamon stool shoots with different concentrations of IBA (0, 0.5, 1, 2 and 3 %) and observed a linear correlation

between IBA concentration and rooting percentages along with number and fresh weight of roots. Kurd et al. (2010) treated basal portion of olive stem cuttings with 3000, 4000 and 5000 ppm IBA solution for 3- 4 seconds and recorded highest rooting (60 %) in the cuttings treated with 3000 ppm IBA.

Haque et al. (2004) conducted an experiment on propagation of guava through mound layering. They treated stool shoots with different concentrations of IBA (2000, 2500 and 3000 ppm) and recorded highest rooting (84.23 %) and number of roots (40.00) per layers with 2500 ppm IBA treatment. Kakon et al. (2008) while studying in mound layering in guava, treated the layers with different concentrations of three plant growth regulators viz. IBA (300, 500, 800 and 1200 ppm), NAA (300, 500, 800 and 1200 ppm) and IAA (300, 500, 800 and 1200 ppm). They obtained the best rooting in layers treated with IBA @ 2000 ppm. Kurhe et al. (2022) studied the effect of IBA on air layers of pomegranate. They treated pomegranate shoots with different concentrations of IBA viz. 0, 300, 400 and 500 ppm and reported that shoots treated with IBA at 500 ppm took minimum days for rooting (32.25) and had maximum rooting (93.29 %), number of secondary roots (63.80) and number of primary roots (35.53).

2.2. EFFECT OF IBA ON GROWTH OF CUTTINGS AND LAYERS

Kaur (2014) while working on peach studied the effect of IBA on growth performance of hardwood cuttings. She treated cuttings with different doses of IBA viz. 0, 1000, 2000, 3000, 4000 and 5000 ppm and observed that cuttings treated with 3000 ppm IBA had maximum length of main root, root girth, root weight, plant height, plant girth, number of branches, number of leaves and leaf area. Similarly, Pathlan et al. (2022) treated hard wood stem cuttings of peach with different concentrations of IBA (0, 800, 1600, 2400, 3600, 4500 ppm). They reported that treatment of cuttings with 2400 ppm IBA significantly improved survival percentage, average number of branches, plant height, number of leaves and plant girth.

Casavela et al. (1977) experimented on mound layering of ‘MM106’, ‘M26’ rootstocks of apple and ‘Quince A’ rootstock of pear. They treated the stool shoots with different concentrations of IBA and found that 1500 ppm concentration of IBA produced the layers with higher diameter of at least 8 mm. Velickovic and Jovanovic (1987) treated hardwood stem cuttings of apple rootstock MM106 with IBA @ 500, 1500 and 2500 ppm.

They reported that all concentrations of IBA improved rooting as compared to control, however, IBA application @ 2500 ppm resulted in better rooting with highest percentage of well-rooted cuttings. Ersoy et al. (2010) treated softwood top cuttings of 'M9' apple rootstock with different concentrations viz. 0, 500, 1500, 2500 and 3500 ppm under humid conditions. They observed that cuttings treated with 1500 ppm exhibited highest surface length (0.53 cm) and highest root branching (0.88 number/cutting), whereas, longest root (2.03 cm) was reported under 500 ppm IBA.

Khatik and Sharma (2013) conducted studies on mound layering of apple rootstock Merton 793. They treated stools shoots with different concentration of IBA (1500 ppm, 2000 ppm and 2500 ppm) and concluded that stool shoots treated with IBA @ 2500 ppm had highest total root length (4.80 m), linear growth of stool shoot (127.76 cm), stool shoot diameter (12.03 mm), leaf area (11.31 cm2), root to shoot ratio (0.088), and total biomass in terms of fresh (110.38 g) and dry weight (67.08 g). Wani et al. (2016) while working on propagation of apple rootstock MM 106 through stem cuttings, reported that treatment of cuttings with 1000 ppm IBA significantly increased rooting percentage (45.37 %), survival percentage of rooted cuttings (60.00 %), number of leaves/cutting (2.27), number of secondary branches/cutting (1.87) and number of leaves/secondary branch (4.60). Verma et al. (2017) examined the effect of IBA treatment on stem cuttings of Merton 793 and reported that IBA 2500 ppm significantly increased length of main shoot (134.14 cm), diameter of main shoot (8.18 mm), fresh (30.40 g) and dry weight (22.60 g) of shoots in cuttings.

Haque et al. (2004) while propagating guava through mound layering, treated stool shoots with different concentrations of IBA (2000, 2500 and 3000 ppm) and recorded highest number of shoots per plant (5.75) and survival percentage (95.35 %) with 2500 ppm of IBA treatment. Lal et al. (2007) studied the effect of IBA on growth of guava cv. Sardar (Lucknow-49) in stool beds. They treated stool shoots with IBA @ 5000, 7500 and 10,000 ppm and reported that treatment with 7500 ppm IBA significantly increased the growth of stool shoots as compared to other concentrations. Naithani et al. (2018) laid out an experiment on propagation of guava through air layering. They treated shoots with various concentrations of IBA viz. 1500, 3000 and 4500 ppm and observed that shoots treated with 4500 ppm of IBA had significantly higher growth of layered shoot in terms of shoot length, diameter and leaf area.

2.3. EFFECT OF IBA ON PHYSIOLOGICAL TRAITS OF CUTTINGS AND LAYERS

Purohit and Shekharappa (1985) treated hardwood cuttings of pomegranate with different IBA concentrations and observed that cuttings treated with 5000 ppm IBA significantly increased C/N ratio and carbohydrate reserves in the rooted cuttings. Rao et al. (2020) treated stem cuttings of pomegranate with different concentrations of IBA viz. 2000, 3000, 4000, 5000 ppm and recorded highest chlorophyll content of 30.16 and 28.32 SPAD units in cvs. Kandhari Kabuli and Nabha, respectively with 5000 ppm IBA treatment.

Samim et al. (2021) treated stem cuttings of barbados cherry with different concentrations of IBA and analyzed the rooted plants for leaf chlorophyll contents. They reported that cuttings treated with 5000 ppm IBA accumulated highest Chlorophyll-a (1.26), Chlorophyll -b (0.55) and total chlorophyll content (1.82) in their leaves.

While working on propagation of guava, Gilani et al. (2019) applied different concentration of IBA (0, 50, 100, 150 and 200 ppm) to the air layers of guava and recorded higher concentration of chlorophyll-A (22.31 µg/ml), chlorophyll-B (23.41 µg/ml), total chlorophyll (45.72 µg/ml) and carotenoid (3.55 µg/ml) with 150 ppm IBA treatment. Dhatrikarani (2019) investigated the effect of IBA on cuttings of guava and analyzed the cuttings for chlorophyll content. They applied different concentrations of Indole-3-butyric acid i.e. 250 ppm, 500 ppm, 750 ppm in solution form and 1500 ppm, 3000 ppm and 6000 ppm in powdered form to the cuttings and reported that 3000 ppm treatment had highest value for total chlorophyll content.

Khandaker et al. (2022) experimented with wax apple in order to determine the effect of IBA on physiological parameters. They applied various concentrations of IBA (0, 1000, 1500 and 2000 mg L^{-1}) to the air layers and found that the highest chlorophyll content and stomatal aperture were recorded in 2000 mg L^{-1} of IBA treatment.

2.4 EFFECT OF PROPAGATION MEDIA ON ROOTING OF CUTTINGS AND LAYERS

While working on propagation of peach clonal rootstock 'GF677' (peach × almond hybrid), Tsipouridis and Thomidis (2004) planted hardwood stem cuttings in five rooting substrates viz. perlite (1-5 mm), peat, perlite + peat (50:50 %), sand, and perlite. They reported that cuttings planted in peat + perlite (50:50) growing media resulted in best rooting.

Similarly, Davarynejad et al. (2015) subjected stem cuttings of peach × almond hybrid to three rooting media like perlite, cocopeat and mixtures of perlite + cocopeat (2:1) and observed that cuttings treated with perlite had highest rooting percentage, maximum number of roots and root length.

Chand (1999) while working on propagation of different strains of apple rootstocks through mound layering, mounded mother stools with different rooting media. They observed significantly higher rooting percentage and total root length in stool shoots of M 9 and MM 111 mounded with sawdust, whereas, higher number of rooted suckers, number of main roots and higher total root length per sucker was recorded in stool shoots of M7 mounded with soil + FYM rooting medium. Koptowski (2001) subjected apple rootstocks (M9, M26, P60 and MM106) to different growing media viz. soil, peat, sawdust and bark. They reported that sawdust medium produced highest number of roots, total number of rooted shoots and longest roots. In order to determine the most suitable rooting media for propagation of apple clonal rootstock MM 111 through hardwood stem cuttings, Divin et al. (2011) planted cuttings in three rooting media i.e. cocopeat, perlite, cocopeat + perlite (1:1). They reported that cuttings treated with cocopeat + perlite (1:1) medium had significantly higher rooting percentage (37.03 %), root number (11.33) and root length (9.83 cm).

Provorchenko and Marinin (2010) investigated the effect of different propagation media on stool beds of apple rootstock MM 106. They used different media (sawdust, rice husk, sunflower husk and soil) and found that rice husk had the highest number of rooted layers. While multiplying apple clonal rootstock ‘Merton 793’ through mound layering, Khatik and Sharma (2013) mounded stool shoots with different rooting media like sand + soil, cocopeat + soil, vermicompost + soil, forest leaf compost + soil, vermicompost + forest leaf compost, cocopeat + vermicompost, cocopeat + forest leaf compost, vermicompost + sand, forest leaf compost + sand, cocopeat + sand and field soil. They reported that stools mounded up with cocopeat + Vermicompost produced highest proportion of rooted stool shoots (84.41 %), number of rooted shoots (7.40/stool) and number of adventitious roots per stool shoot (19.33). Akbari et al. (2015) subjected apple rootstock M 9 to different rooting media and advocated the use of rice seed coat (RSC) and smoked rice seed coat (SRSC) for efficient initiation of rooting.

Mehraj et al. (2022) while working on clonal propagation of apple rootstocks through layering, used 10 hilling materials viz. vermiculite, saw dust, FYM, vermicompost,

vermiculite + saw dust + Pseudomonas, vermiculite + saw dust + Azotobacter, FYM + vermicompost + Pseudomonas, FYM + vermicompost + Azotobacter, Pseudomonas + Azotobacter + soil and only soil. They recorded maximum production of rooted shoots per layer (8.62) under saw dust as a hilling media. Amandeep et al. (2022) tried different propagation media (soil, sawdust, crop residues and FYM) in stool beds while multiplying 'Bud 9' rootstock of apple. They recorded highest percentage of rooted shoots, number of roots, longest root, average root length, root diameter, fresh weight of roots, dry weight of roots and root shoot ratio under sawdust. Sachin (2022) used different rooting media mixtures like sand + vermicompost (1:1), sand + vermicompost + vermiculite (1:1:1), sand + vermicompost + perlite (1:1:1) and sand + vermicompost + cocopeat (1:1:1) in stem cuttings of apple clonal rootstocks (M7, M9 and MM106). They reported that rootstock MM106 performed best rooting behavior under sand + vermicompost + perlite (1:1:1) rooting media.

Baghel and Saraswat (1989) while propagating pomegranate through hardwood and semi hardwood stem cuttings used different rooting media viz. soil, soil + FYM, soil + FYM + sand, soil + sawdust, soil + FYM + sand, soil + FYM + sawdust, soil + FYM + sand + sawdust and river silt for planting of cuttings. They recorded maximum rooting (100 %) in semi-hardwood cuttings in river silt medium. Tryambake and Patil (2002) studied the effects of different rooting substrates on air layering of pomegranate and reported that sphagnum moss alone was the best substrate followed by the combination of sphagnum moss and cocopeat (1:1) for rooting and survival of air layers. Raut et al. (2015) found maximum root growth and survival percentage in cuttings subjected to soil + cocopeat medium. To propagate persimmon cv. Fuyu, Mehra et al. (2019) planted stem cuttings in rooting medium prepared by mixing of soil and FYM in different ratios (1:1, 1:2 and 2:1). They observed maximum proportion of rooted cuttings (61.10 %), length of roots (8.00 cm) and cost benefit (C: B) ratio (1:1.37) with mixture of soil and FYM prepared in the ratio of 1:2.

Naseer et al. (1991) while working on propagation of kiwifruit through hardwood stem cuttings found that cuttings grown in pure sand medium results in significantly higher rooting as compared to soil. Cladwell et al. (1988) advocated the use of vermiculite as compared to perlite or peat:perlite (1:1 v/v) rooting medium for higher rooting in cuttings of kiwifruit. Shylla et al. (2000) while studying the effect of various rooting media on kiwifruit cuttings under polyhouse conditions recorded highest rooting and root growth under sawdust + soil (2:1) medium. Kishore et al. (2001) used sand and saw dust rooting substrate for

hardwood stem cuttings of kiwifruit and reported that sawdust was superior rooting medium for root initiation and root development.

Rao (2004) studied the effect of different media on rooting in stem cuttings of grape rootstock and subjected cuttings to sand, sand + 10 % cocopeat, sand + 20 % cocopeat and sand + 30 % cocopeat. He reported significant increase in percentage of rooting and number of roots per cutting with sand + 10 % cocopeat. Chhukit (2009) studied the effect of different media on rooting of kiwifruit stem cuttings and recorded highest rooting (67.64 %), number of adventitious roots (16.67) length of longest root (30.63 m) and total root length (22.90 m) in cuttings planted in sand + forest leaf compost + cocopeat (1:1:1) rooting medium. Rana and Babita (2016) grown stem cuttings of kiwifruit (*Actinidia deliciosa* Chev.) in different rooting media and reported that rooting medium comprising forest soil + sand + soil (1:2:1) had maximum rooting (45.71 %), highest number of main roots (15.64), secondary roots (11.47) and total root length (183.75 cm).

While working on propagation of olive through air layering, Rehman et al. (2013) treated layers with different rooting media viz. sawdust, silt, garden soil and sawdust + silt + garden soil. They reported that silt resulted in maximum number of roots (8.27), root length (3.28 cm), root diameter (0.15 cm) and survival (67.22 %) took minimum days for initiation of rooting (27.11).

2.5 EFFECT OF PROPAGATION MEDIA ON GROWTH OF CUTTINGS AND LAYERS

Sangcheol et al. (1998) used different growing media (perlite, gravelly rock fragments, vermiculite, sawdust, compost and soil) in stool beds of apple rootstock M9 and found gravelly rock fragments alone or in combination with compost as most effective mounding material for stool shoots. They reported that vermiculite or perlite as mounding media reduced growth of underground parts. Koptowski (2001) while working on multiplication of apple rootstock reported that use of peat as growing media resulted in production of longest and thickest rootstocks. Khatik and Sharma (2013) subjected stool shoots of apple rootstock to different rooting media (sand + soil, cocopeat + soil, vermicompost + soil, forest leaf compost + soil, vermicompost + forest leaf compost, cocopeat + vermicompost, cocopeat + forest leaf compost, vermicompost + sand, forest leaf compost + sand, cocopeat + sand and field soil) and recorded maximum linear growth of

stool shoots (130.43 cm), number of leaves per stool shoot (79.16) and total biomass in terms of fresh (115.78g) and dry weight (62.75g) under vermicompost + forest leaf compost.

Kanu (2002) studied the effect of propagation media on multiplication of kiwifruit cultivars Hayward and Abbott through stem cuttings. They reported that growing medium comprising of forest soil + sand + soil (1:2:1) produced highest shoot length (7.85 cm) and leaf area (91.81 cm^2). Chhukit (2009) subjected stem cuttings of kiwifruit to different growing media viz. cocopeat, vermicompost, forest leaf compost, sand and soil. They recorded highest number of leaves per rooted cutting, leaf area, shoot length and total biomass with sand + forest leaf compost + cocopeat (1:1:1).

Baghel and Saraswat (1989) while propagationg pomegranate through hardwood and semi-hardwood stem cuttings subjected cuttings to different rooting media viz. soil, soil + FYM, soil + FYM + sand, soil + sawdust, soil + FYM + sand, soil + FYM + sawdust, soil + FYM + sand + sawdust and river silt. They reported that cuttings treated with river silt and soil + FYM (1:1) significantly increased shoot length, number of leaves and leaf area. Raut et al. (2015) planted stem cuttings of pomegranate in different growing media and recorded maximum sprouting percentage, length and number of sprouts and shoot dry matter in cuttings planted in soil + cocopeat medium. Mehra et al. (2019) planted stem cuttings of persimmon cv. Fuyu in rooting medium prepared by mixing soil and FYM in different ratios (1:1, 1:2 and 2:1) and recorded maximum number of sprouting (7.57), length of shoot (11.27 cm), diameter of sprouted cuttings (4.85 mm), number of leaves (11.80), leaf area (8.86 cm^2) and survival of cuttings (64.40 %), with mixture of soil and FYM prepared in the ratio of 1:2.

While propagating guava through air layering, Singh et al. (2007) used different rooting media and reported that layers subjected to poultry media had significantly higher number of leaves (12.04) and length of shoot (6.06 cm). Sardoei (2014) studied the impact of growing media on stem cuttings of guava (*Psidium guajava* L.) under greenhouse and subjected cuttings to different growing media viz. Soil loam, silt, sawdust, perlite, sand, sand + cocopeat (1:1), sand + perlite (1:1) and perlite + silt (1:1). They recorded highest shoot length and shoot dry weight in cuttings treated with perlite + silt (1:1). Rani et al. (2015) while studying the response of different growing media in stem cuttings of guava, reported that growing media comprising vermiculite + sand + FYM (1:1:1) significantly increased number of new shoots (10.42), plant height (26.49 cm), number of leaves per plant (25.08) and stem thickness (1.14 cm). Ali (2016) performed air layering in litchi using different

media (silt, silt + sawdust and sawdust) and observed that silt significantly increased the number of shoots per layer, number of leaves and survival percentage as compared to other media.

Kashyap et al. (2016) performed air layering in acid lime using various rooting media viz. soil, soil + vermicompost, soil + cocopeat, soil + leaf mould, soil + vermicompost + cocopeat, soil + vermicompost + leaf mould and soil + cocopeat + leaf mould and observed that number of leaves, number of new sprout/layer and survival percentage (73.61 %) increased significantly using soil + vermicompost + cocopeat as rooting medium.

2.6 EFFECT OF PROPAGATION MEDIA ON PHYSIOLOGICAL TRAITS OF CUTTINGS AND LAYERS

Yadav et al. (2012) subjected stem cuttings of acid lime to different rooting media and recorded maximum nitrogen (1.86 %) and chlorophyll content (5.44 mg/g) in the leaves under soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) rooting media. Al-Zebari and Al-Brifkany (2014) reported that chlorophyll content in leaves increased significantly by planting the stem cuttings of citron in peatmoss + sand (1:2) growing medium. Dhatrikarani (2019) subjected stem cuttings of guava to different rooting media (cocopeat, vermiculite and sawdust) and reported that cuttings planted in cocopeat synthesized highest total leaf chlorophyll content. while propagating apple rootstock Bud 9, Amandeep et al. (2022) planted stem cuttings in different rooting media (soil, sawdust, crop residue and FYM) and recorded maximum leaf chlorophyll content in cuttings subjected to sawdust medium.

Chapter-3

MATERIALS AND METHODS

The present investigation entitled **"Studies on propagation of cherry rootstocks through mound layering"** was conducted at Nursery Block of the Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during the year 2022-23. The details of materials used and methodology adopted in carrying out the experiment is given below under the appropriate headings:

3.1 EXPERIMENTAL SITE

3.1.1 Location and Climate

The trial was carried out in the Experimental Nursery Block of the Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni. The area is located in the hilly regions of the Western Himalayas at an elevation of 1193 meters above mean sea level with latitude 30°51'23" North and longitude 77°09'36" East. The annual rainfall of area ranges between 800-1500 mm, the major amount of which is received during July to September. The summers are mild with May-June the hottest months and winters are harsh with December-January the coldest months.

3.2 EXPERIMENTAL DETAILS

The entire programme of study was conducted under two different experiments with a view to elucidate the studies on propagation of cherry rootstocks through mound layering. The detailed technical programme of present investigation was as under:

3.2.1 TECHNICAL PROGRAMME

3.2.1.1 EXPERIMENT-1: Effect of IBA treatments on rooting and growth of mother stool shoots of cherry rootstock.

Treatment details

T_1 : IBA@2500 ppm

T_2 : IBA@3500 ppm

T_3 : IBA@4500 ppm

T_4 : IBA@5500 ppm

T_5 : IBA@6500 ppm

Number of treatments	:	5
Replications	:	5
Unit per replication	:	5
Experimental Design	:	Randomized Block Design
Rootstock	:	Gisela-5
Method of layering	:	Mound layering (Stooling)

3.2.1.2 EXPERIMENT-2: Effect of propagation media on rooting and growth of mother stool shoots of cherry rootstock

Treatments combination

T_1	:	Sawdust
T_2	:	Cocopeat
T_3	:	Soil+ FYM
T_4	:	Vermicompost + Cocopeat
T_5	:	Sawdust + Sand + Vermicompost

Number of treatments	:	5
Replications	:	5
Unit per replication	:	5
Experimental Design	:	Randomized Block Design
Rootstock	:	Gisela-6
Method of layering	:	Mound layering (Stooling)

3.3 METHODOLOGY

One-year-old mother stool shoots of cherry rootstock ‘Gisela-5’ and ‘Gisela-6’ were cut back to 2 inch above the ground level during January, 2022. In spring season, the new stool shoots emerged from the mother stool when attained a height of 10-15 cm, they were treated with different concentrations of IBA and propagation media as per respective treatments under both the experiments.

3.3.1 Preparation of IBA solution

In order to prepare 2500, 3500, 4500, 5500 and 6500 ppm IBA solutions, a stock solution of 10000 ppm was prepared by dissolving 10 g of IBA in little quantity of 90 per

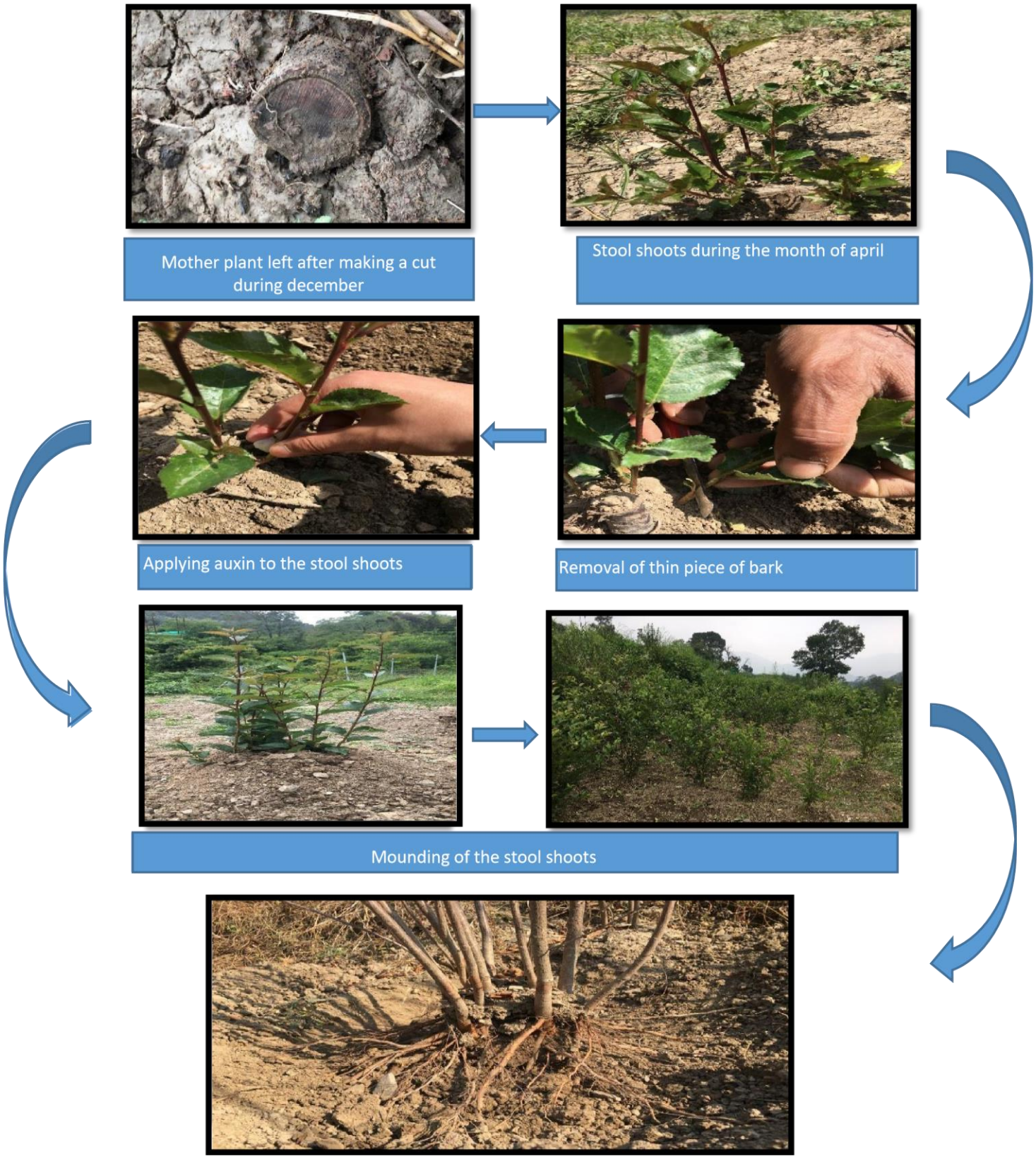

Plate 1. Process of mound layering

Preparation of propagation media

Mixing of propagation media

Mounding of stool shoots

Plate 2. Preparation of propagation media and mounding of stool shoots of ‘Gisela-6’

cent ethanol and making the final volume to 1000 ml with 50 per cent ethanol. Then quantity of stock solution required to further preparation of working IBA solutions of 2500, 3500, 4500, 5500 and 6500 ppm concentration was calculated using formula $N_1V_1=N_2V_2$. Thus 62.5, 87.5, 112.5, 137.5 and 162.5 ml of stock solution was diluted with distilled water and final volume was made 250 ml for preparing 2500, 3500, 4500, 5500 and 6500 ppm working solutions, respectively.

3.3.2 Application of IBA treatments

The prepared concentrations of IBA solution were applied to base of the stool shoots in the month of April when shoots attained 10-15 cm height. The small portion of bark was removed from the base of the stool shoots and then IBA solution was applied at the point where the bark was removed as per respective treatment. In Experiment-1, the base of stool shoots was mounded up with propagation media i.e. soil + FYM (1:1) after applying IBA solution.

3.3.3 Preparation and application of propagation media:

Five mounding media *viz*. sawdust, cocopeat, soil + FYM (1:1), vermicompost + Cocopeat (1:1) and sawdust + sand + vermicompost (1:1:1) were prepared by mixing the media in volume wise specific ratio as per treatments. The cocopeat bricks were soaked in water for easy breaking and making it into coir dust. All the stool shoots under experiment-2 were treated with 4000 ppm IBA solution after girdling and before mounding. The mixture of propagation media was prepared after through mixing of the ingredients at the experimental site. Under both the experiments, the stool beds were irrigated at frequent intervals to maintain adequate moisture in mounded beds so as to favors rooting. The intercultural operations like weeding, spray of insecticides and fungicides were performed at regular intervals to keep stool shoots healthy and free from pests and diseases.

3.4 OBSERVATIONS RECORDED

3.4.1 Morphological parameters

Observations on root and shoot systems of stool shoots were recorded at the end of season (December). The propagation media used for mounding was removed carefully

from each mother stool for exposing the root system of daughter stools. Each daughter stool was then detached from the mother stool along with its complete root system.

3.4.1.1 Rooting percentage

The number of total and rooted daughter stools per mother stool was counted after detaching them from mother stools. The rooting percentage was calculated using the following formula:

$$\text{Percentage of rooting} = \frac{\text{Rooted stool shoots}}{\text{Total number of stool shoots}} \times 100$$

3.4.1.2 Number of rooted shoots per mother stool

The data on the number of rooted shoots per mother stool was recorded by counting all the rooted stool shoots produced from each mother stool and data was expressed as average number of rooted shoots per mother stool.

3.4.1.3 Number of main roots per stool shoot

The roots emerging directly from the mounded portion of the stool shoot were designated as main roots. The number of main roots in individual stool shoot was counted and data was expressed as average number of main roots per stool shoot.

3.4.1.4 Length of longest root (cm)

The length of longest root was recorded by measuring the length of longest adventitious root with the help of measuring tape and expressed in centimeter (cm).

3.4.1.5 Diameter of main roots (mm)

The diameter of main roots was measured using digital Vernier calipers. The diameter was measured at central positions of each main root which was then averaged and expressed in millimeters (mm).

3.4.1.6 Total root length (m)

The entire root system of each plant was washed with tap water under pressure and then cut into small pieces. The total length of roots was measured with the help of root length scanner (Comair root length scanner) and expressed in meters (m).

3.4.1.7 Height of stool shoot (cm)

The height of the main shoot was measured with a measuring tape at the end of growing season during December from the ground level to the tip of the shoot and expressed in centimetres (cm).

3.4.1.8 Diameter of stool shoot (mm)

The diameter of stool shoots was recorded with the help of Digital Vernier Callipers (Mitutoyo Corporation-Digimatic Callipers) at a height of 6 inches above the root initiation zone and the average was expressed in mm per shoot.

3.4.1.9 Internodal length (mm)

Total number of nodes were counted and height of the stool shoot was measured at the end of season. The internodal length was then calculated by dividing the height of stool shoot by total number of nodes and expressed as average internodal length in millimeters (mm).

3.4.1.10 Number of leaves per stool shoot

The data on leaf number was recorded during the month of November before the onset of leaf fall. All the leaves, irrespective of their size on each stool shoot were counted and average number of leaves per shool shoot was calculated.

3.4.1.11 Leaf area (cm^2)

The observation on the leaf area was recorded in the month of September when the leaves were fully developed. Ten leaves were collected at random from middle of the stool shoots under each replication. The leaf area was measured with the help of an Automatic Leaf Area Meter (Licor Model-3100) and was expressed in square centimeter (cm^2).

3.4.1.12 Fresh and dry weight of roots (g)

After separation of stool shoots from the mother stool, root and shoot systems were separated by cutting at collar portion. To record the fresh and dry weight of roots, entire root system of each layer was cut into small pieces and weighed on a topane electronic balance for fresh weight and expressed in gram (g). The cut root pieces of entire roots were then

dried in an oven at a temperature of 65±5˚C for about 72 hours until the constant weight of sample was obtained and dry weight was expressed in gram (g).

3.4.1.12 Fresh and dry weight of shoots (g)

The separated entire shoot system of each stool shoot was cut into small pieces and weighed on a topane electronic balance for fresh weight and expressed in gram (g). To record dry weight of shoots, the pieces of entire shoot system were dried in an oven at a temperature of 65±5˚C for about 72 hours until the constant weight of sample was obtained and expressed in gram (g).

3.4.1.13 Proportion of graftable rootstocks

The number of daughter stools per mound was counted at the end of season. The stool shoots which had attained a well-developed root system and diameter of >8 mm were considered as graftable rootstocks. The proportion of graftable rootstock per mound was then calculated by using the following formula:

$$\text{Proportion of graftable rootstocks} = \frac{\text{Number of graftable stools}}{\text{Total number of stool shoots}} \times 100$$

3.2.4.14 Total plant biomass (dry weight basis)

The observations on total plant biomass were recorded on the basis of dry weight of each randomly selected rooted stool shoots. To calculate the total plant biomass the dry weight of each shoot was added to the dry weight of respective root system and the total of both shoot and root dry weight was considered as total plant biomass. The total plant biomass was expressed in gram (g).

3.4.2 Physiological parameters

3.4.2.1 Leaf chlorophyll content

Five fully expanded and mature leaves were collected from each replicated bed during morning hours (Halfacre et al. 1968), immediately placed in ice box and brought to the laboratory. The leaves from each sample were then chopped into fine pieces under

subdued light and 100 mg chopped leaf samples were placed in vials containing 7 ml of dimethyl sulphoxide.

A. Extraction

The 100 mg of chopped material was placed in vial containing 7 ml of dimethyl sulphoxide (DMSO). The contents of the vials were incubated at 65˚C temperature for 30 minutes and then extract was transferred to graduated test tube and final volume was made to 10 ml with dimethyl sulphoxide (Hiscox and Israelstam 1979).

B. Estimation

The optical density (OD) values of the extract were recorded on Spectrophotometer (T8DS Double beam spectrophotometer) at 645 and 663 nm wavelength against a dimethyl sulphoxide blank. The total chlorophyll content was calculated by using the following formula:

$$\text{Total Chlorophyll (mg/g)} = \frac{20.2\ A_{645} + 8.02\ A_{663} \times V}{A \times 1000 \times W}$$

Where,

V = Volume of extract used (ml)

A = Length of light path in cell (1cm)

W = Weight of the sample (g)

A_{645} = Absorbance at 645 nm wavelength

A_{663} = Absorbance at 663 nm wavelength

The results were expressed as chlorophyll content in mg g^{-1} of fresh weight.

3.4.2.2 Carbon partitioning

Total carbohydrate content in roots, shoots and leaves was estimated by Anthrone reagent method (Hodge and Hofreiter 1962). A dried sample of 100 mg was taken in a beaker and 5 ml of 2.5 N HCl was added and then hydrolyzed for 3 hours on a boiling water bath. After cooling, to neutralize the acid, sodium carbonate was added until the effervescence

stopped. Final volume was made to 100 ml with distilled water followed by centrifugation. One milliliter aliquot from the supernatant was taken in a test tube to which 4 ml of anthrone reagent was added. The test tube was placed in a boiling water bath for 8 minutes and then cooled rapidly. The absorbance of green to dark green colour developed was recorded at 630 nm on Spectrophotometer (T8DS Double beam spectrophotometer).

Carbohydrate content was expressed as mg/g on dry weight basis.

3.4.2.3 Photosynthetic rate (μmol CO_2 m^{-2} s^{-1})

Photosynthetic rate was recorded during the month of June. The observations were recorded between 9:00 am to 12:00 noon with the help of LICOR-6200 portable system. The results were expressed in μmol CO_2 m^{-2} s^{-1} photosynthetic rate.

3.4.2.4 Stomatal conductance (mol H_2O m^{-2} s^{-1})

Stomatal conductance was recorded during the month of June. The observations were recorded between 9:00 am to 12:00 noon with the help of LICOR-6200 portable system. The results were expressed in mol H_2O m^{-2} s^{-1} stomatal conductance.

3.4.2.5 Transpiration rate (mmol H_2O m^{-2} s^{-1})

Transpiration rate was recorded during the month of June. The observations were recorded between 9:00 am to 12:00 noon with the help of LICOR-6200 portable system. The results were expressed in mmol H_2O m^{-2} s^{-1} for transpiration rate.

3.4.3 Physico-chemical properties of propagation media

After preparation of propagation media as per treatments and before its use for mounding the stool beds, media was analyzed for physico-chemical properties such as pH, electrical conductivity, organic matter, water retention, water holding capacity, bulk density, particle density and porosity (Table 3.1).

Table 3.1: Physico-chemical properties of propagation media used for mounding the stool beds

S.No.	Physico-chemical property	Propagation media	Value	Method of estimation
1.	pH	Sawdust (T_1)	5.22	Water suspension (1:2.5) method (Jackson,1973).
		Cocopeat (T_2)	6.12	
		Soil + FYM (T_3)	6.85	
		Vermicompost + Cocopeat (T_4)	6.62	
		Sawdust + Sand + Vermicompost (T_5)	7.02	
2.	Electrical conductivity (dSm^{-1})	Sawdust (T_1)	0.78	Water suspension (1:2.5) method (Jackson, 1973).
		Cocopeat (T_2)	0.65	
		Soil + FYM (T_3)	0.14	
		Vermicompost + Cocopeat (T_4)	0.24	
		Sawdust + Sand + Vermicompost (T_5)	1.54	
3.	Organic matter content (%)	Sawdust (T_1)	10.08	Walkely and Black Wet oxidation method (Walkely and Black, 1934).
		Cocopeat (T_2)	24.17	
		Soil + FYM (T_3)	3.34	
		Vermicompost + Cocopeat (T_4)	21.14	
		Sawdust + Sand + Vermicompost (T_5)	17.84	
4.	Water retention (%)	Sawdust (T_1)	7	Porous plate apparatus by (Richard, 1948).
		Cocopeat (T_2)	242	
		Soil + FYM (T_3)	47	
		Vermicompost + Cocopeat (T_4)	123	
		Sawdust + Sand + Vermicompost (T_5)	26	
5.	Water holding capacity (%)	Sawdust (T_1)	98.50	Keen box method (Keen and Raczkowski, 1921).
		Cocopeat (T_2)	324.00	
		Soil + FYM (T_3)	36.44	
		Vermicompost + Cocopeat (T_4)	61.84	
		Sawdust + Sand + Vermicompost (T_5)	10.67	
6.	Bulk density (gcm^{-3})	Sawdust (T_1)	0.24	Pycnometer method (Singh, 1980).
		Cocopeat (T_2)	0.12	
		Soil + FYM (T_3)	1.37	
		Vermicompost + Cocopeat (T_4)	0.42	
		Sawdust + Sand + Vermicompost (T_5)	1.03	
7.	Particle density (gcm^{-3})	Sawdust (T_1)	0.84	Pycnometer method (Singh, 1980).
		Cocopeat (T_2)	0.61	
		Soil + FYM (T_3)	2.06	
		Vermicompost + Cocopeat (T_4)	0.82	
		Sawdust + Sand + Vermicompost (T_5)	2.52	
8.	Porosity (%)	Sawdust (T_1)	72.00	Calculated from bulk and particle density using formula: Porosity = 1- (BD/PD)× 100
		Cocopeat (T_2)	80.00	
		Soil + FYM (T_3)	39.60	
		Vermicompost + Cocopeat (T_4)	47.00	
		Sawdust + Sand + Vermicompost (T_5)	57.00	

3.5 Statistical analysis

The data recorded were analyzed following procedure suggested by Gomez and Gomez (1984) for Randomized Block Design (RBD) and using OPSTAT.

Analysis of variance (ANOVA)

Sources of variation	Degree of freedom	Sum of square	Mean sum of square	Fcal
Replication	r-1	Sr	$\frac{\text{Sr}}{(\text{r}-1)} = \text{Mr}$	$\frac{\text{Mr}}{\text{Me}}$
Treatment	t-1	St	$\frac{\text{St}}{(\text{t}-1)} = \text{Mt}$	$\frac{\text{Mt}}{\text{Me}}$
Error	(r-1) (t-1)	Se	$\frac{\text{Se}}{(r-t)(t-1)} = \text{Me}$	
Total	(rt-1)	ST		

Where

r = Number of replications

t = Number of treatments

Sr = Sum of squares due to replications

S_t = Sum of squares due to treatments

S_e = Sum of squares due to error

S_T = Total sum of squares

Mr = Mean sum of squares due to replications

M_t = Mean sum of squares due to treatments

M_e = Mean sum of squares due to error

The treatment mean sum of square was tested against mean sum of square due to error by 'F-test' for (r-1), (r-1) (t-1) and (t-1), (r-1) (t-1) degree of freedom at 0.05 level of significance.

The calculated F-values were compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one treatment over the others. The standard error and critical differences were calculated as follows:

SE (m) ± = $\pm\sqrt{\frac{Me}{r}}$

SE (d) ± = $\pm\sqrt{\frac{2Me}{r}}$

$CD_{0.05}$	=	SE (d) × $t_{0.05}$(r-1) (t-1) df
SE (m) ±	=	Standard error of mean
SE (d) ±	=	Standard error of differences
$CD_{0.05}$	=	Critical difference at 5% level of significance

Chapter-4

RESULTS AND DISCUSSION

The present investigation entitled **"Studies on propagation of cherry rootstocks through mound layering"** was carried in Nursery Block of the Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, under open field conditions during the year 2022-2023. The results obtained in the present study have been presented below and discussed under suitable headings:

4.1 EXPERIMENT-1: Effect of IBA treatments on rooting and growth of mother stool shoots of cherry rootstock

4.1.1 MORPHOLOGICAL CHARACTERS

Morphological characters include rooting percentage, number of rooted shoots per stool, number of main roots per stool shoot, length of longest root, diameter of the main root, total root length, height of the stool shoots, diameter of the stool shoots, proportion of graftable rootstocks, leaf area, number of leaves, internodal length, fresh and dry weight of roots & shoots and total plant biomass. The data pertaining to morphological parameters are presented in Table 4.1 to 4.6.

4.1.1.1 Rooting percentage

The data pertaining to the effect of IBA treatments on percentage of rooting in stool shoots of 'Gisela -5' rootstock is depicted in Table 4.1 and Fig.1.

It is pertinent from the data (Table 4.1) that percentage of rooting was significantly affected by different concentrations of IBA. The maximum rooting (97.50 %) was recorded under 4500 ppm IBA treatment (T_3) which was statistically at par with all the treatments except T_5 (IBA @ 6500 ppm). However, minimum rooting (69.99 %) was registered by 6500 ppm IBA treatment (T_5) which was significantly lower than all other treatments under study. It is worthy to be noticed from Fig.1 that an increase of 9.08, 13.38, 5.20 and -18.60 per cent in rooting was observed under IBA treatments of 3500 ppm, 4500 ppm, 5500 ppm and 6500 ppm, respectively over T_1 (IBA @ 2500 ppm).

Table 4.1: Effect of different IBA concentrations on rooting, number of rooted shoots and main roots in stool shoots of cherry rootstock 'Gisela-5'

Treatment	Rooting percentage*	No. of rooted shoots/stool	No. of main roots/ stool shoot
IBA @ 2500 ppm (T_1)	85.99 (72.79)	4.60	6.80
IBA @ 3500 ppm (T_2)	93.80 (80.72)	5.00	7.40
IBA @ 4500 ppm (T_3)	97.50 (85.85)	6.60	8.00
IBA @ 5500 ppm (T_4)	90.47 (75.90)	5.80	6.00
IBA @ 6500 ppm (T_5)	69.99 (56.81)	3.40	2.80
CD $_{0.05}$	15.61	1.40	1.40

*Values in the parenthesis are angular transformed

4.1.1.2 Number of rooted shoots per stool

The data presented in Table 4.1 reveals that application of IBA had significantly influenced the numbers of rooted shoots per stool in cherry rootstock Gisela-5. The maximum number of rooted shoots (6.60) was recorded in layers treated with IBA @ 4500 ppm (T_3). This treatment was statistically at par with T_4 (IBA @ 5500 ppm) and significantly superior to all other treatments under study. Whereas, minimum number of rooted shoots (3.40) was observed under 6500 ppm IBA treatment (T_5) which was statistically at par with T_1 (IBA @ 2500 ppm) and significantly lower than all other treatments under study.

4.1.1.3 Number of main roots per stool shoot

The is evident from the data presented in Table 4.1 that application of IBA to the stool shoots significantly influenced the number of main roots per stool shoot. The maximum number of main roots (8.00) was observed in stool shoots treated with 4500 ppm IBA (T_3) which was statistically at par with those of T_1 (IBA @ 2500 ppm) and T_2 (IBA @ 3500 ppm). The minimum number of main roots per stool shoot (2.80) was noticed under 6500 ppm IBA treatment (T_5) which was significantly lower than all other treatments under study.

4.1.1.4 Length of longest root

The data pertaining to length of longest root presented in Table 4.2 reveals that IBA treatments had a significant effect on root length. The stool shoots treated with 4500 ppm IBA (T_3) attained the maximum length of longest of root (53.40 cm), closely followed by T_4 i.e. IBA @ 5500 ppm (47.20 cm). Both these treatments were statistically at par with each

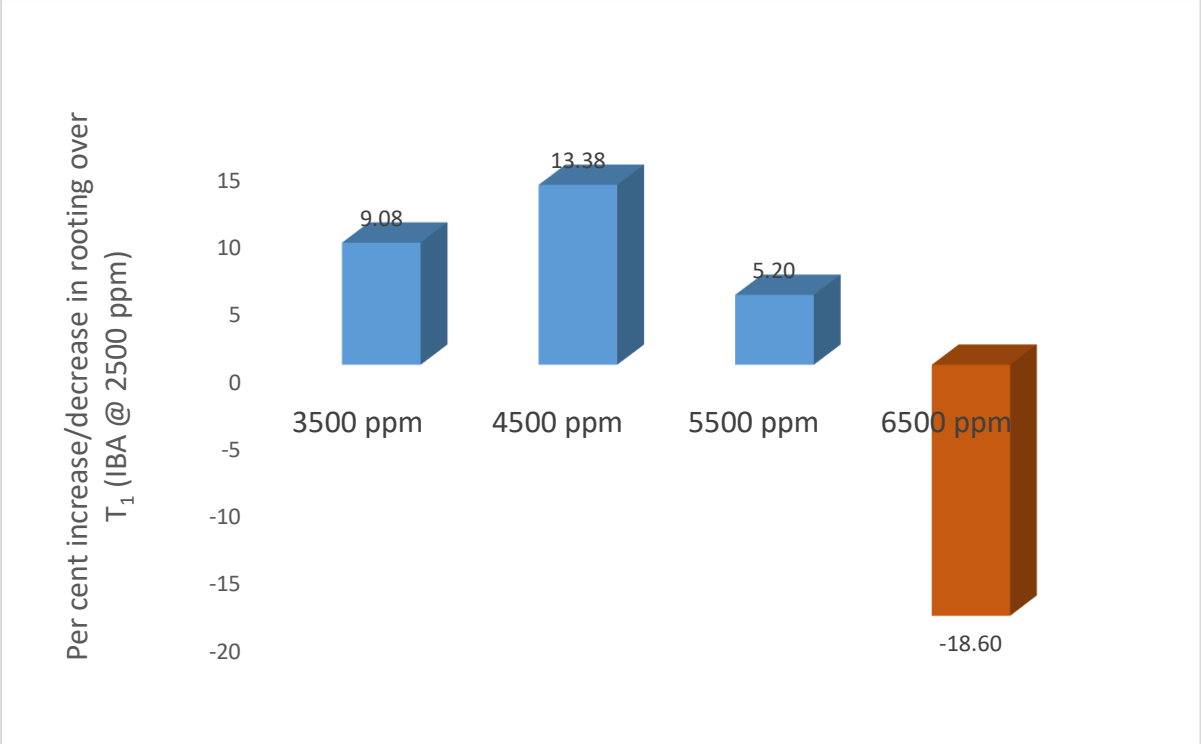

Fig. 1: Per cent increase/decrease in rooting under different IBA treatments over T_1 (IBA @ 2500 ppm)

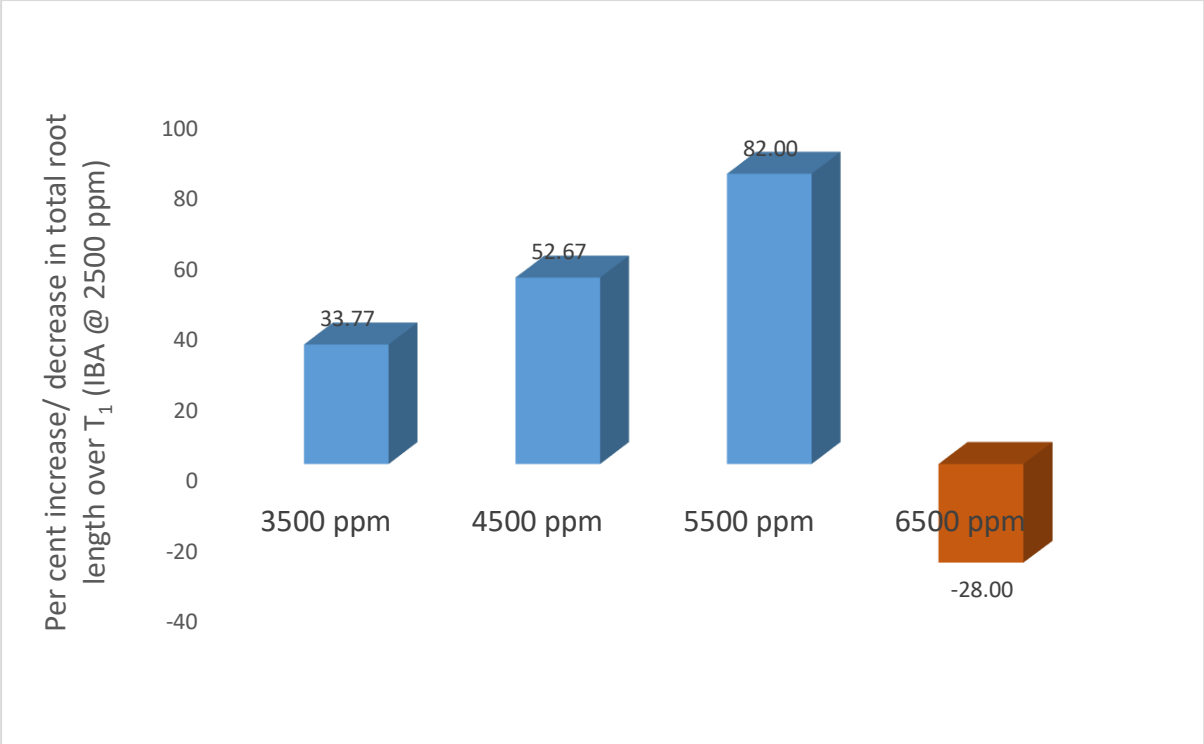

Fig. 2: Per cent increase/ decrease in total root length under different IBA treatments over T_1 (IBA @ 2500 ppm)

other and significantly superior to rest of the treatments under study. Whereas, minimum length of longest root (24.00 cm) was recorded under 6500 ppm of IBA treatment (T_5) which was statistically at par with T_1 (IBA @ 2500 ppm) and T_2 (IBA @ 3500 ppm).

4.1.1.5 Diameter of the main root

The data with respect to effect of different IBA treatments on diameter of the main root are presented in Table 4.2.

It is clear from the data that diameter of the main root was significantly influenced by different IBA treatments. The stool shoots treated with IBA 4500 ppm (T_3) exhibited maximum diameter of the main root (8.46 mm) which was significantly higher than those of all other treatments under study. However, minimum diameter (3.04 mm) was recorded under 6500 ppm IBA treatment (T_5) which was statistically par with T_1 (IBA @ 2500 ppm) and significantly lower than rest of the treatments under study.

Table 4.2: Effect of different IBA concentrations on length of the longest root, diameter of the main root and total root length in stool shoots of cherry rootstock 'Gisela-5'

Treatment	Length of longest root (cm)	Diameter of the main root (mm)	Total root length (m)
IBA @ 2500 ppm (T_1)	32.40	4.01	5.98
IBA @ 3500 ppm (T_2)	34.00	5.26	8.00
IBA @ 4500 ppm (T_3)	53.40	8.46	9.13
IBA @ 5500 ppm (T_4)	47.20	5.19	6.80
IBA @ 6500 ppm (T_5)	24.00	3.04	4.30
$CD_{0.05}$	11.10	2.02	1.24

4.1.1.6 Total root length

The data presented in Table 4.2 and Fig.2 reveal that treatment of stool shoots with IBA had significantly influenced the total root length. The highest total root length (9.13 m) was recorded in stool shoots treated with 4500 ppm IBA (T_3) which was statistically at par with T_2 (IBA @ 3500 ppm) and significantly higher than all other treatments under consideration. However, minimum total root length (4.30 m) was observed in stool shoots treated with 6500 ppm concentration of IBA (T_5) which was significantly lower than all other treatments under study. The data depicted in Fig. 2 shows that IBA treatments of 3500 ppm, 4500 ppm, 5500 ppm and 6500 ppm registered 33.77, 52.67, 82.00 and -28.00 per cent increase, respectively over T_1 (IBA @ 2500 ppm) with respect to total root length.

Present finding indicates that different IBA concentrations had a significant influence on rooting percentage, number of rooted shoots, number of main roots per stool shoot, length of longest root, diameter of main root and total root length of 'Gisela-5' rootstock of cherry. The rooting percentage, number of main roots per stool shoot and root length increased initially with increasing concentration of IBA up to 4500 ppm and start declining gradually thereafter. The findings of the present study are in partial conformity with those of Mishra et al. (1984), who recorded highest rooting in stool shoots of behmi with 5000 ppm IBA treatment. Similarly, Shaltout et al. (1998) reported an increase in rooting up to 95.00 per cent and number of roots up to 75.40 per plant with 4000 ppm IBA treatment in peach rootstock 'Nemaguard' layers. Srivastava et al. (2006) in trench layers, Khatik and Sharma (2013) in mound layers and Verma and Chauhan (2015) in hard wood stem cuttings of apple clonal rootstocks, had also recorded higher rooting percentage, number of rooted shoots and root length with IBA treatment at higher concentration of 2500 ppm. Similarly, Alam et al. (2007) in kiwifruit and Galavi et al. (2013) in grape, reported a significant increase in rooting and number of roots in hardwood cuttings with 4000 ppm IBA treatment.

The increase in rooting initiation and number as well as length of roots in mounded shoots treated IBA may be attributed to increased cell division and translocation of movable rhizocaline to the rooting zone along with its activation in the presence of auxin (Galavi et al. 2013). Higher concentrations of IBA activates hydrolyzing enzymes like amylase and invertase, which catalyze the breakdown of starch into sugars that are needed for the production of new cells and increasing the respiratory activity in the regenerating tissues at the time of initiation of new root primordia (Prasad and Peterkofsky 1976). The downward movement of hydrolyzing enzymes results in increasing the number of roots and percentage of rooting (Tyagi and Patel 2004). However, auxin may be effective up to certain concentration level beyond which there could be an inhibitory effect at higher concentrations (Yu et al. 2022). The optimal concentration of IBA promotes carbohydrate and nitrogen fraction mobilization and utilization in the presence of a co-factor at the wound site (Srivastava et al. 2005) which could have aided in improved root initiation and increased number of roots under 4500 ppm treatment. The increase in length and diameter of roots with increasing IBA concentration could be due to the increased cell division and cell wall elasticity in the presence of auxin, which in turn, could have resulted in increased length of main root and total root length (Taiz and Zeiger 2006). Additionally, IBA promote the rate of cell enlargement by affecting the synthesis of enzymes which could have increased the length

of roots. IBA boost the uptake of nutrients that leads to increased root diameter (Siddiqui and Hussain 2007). Auxin enhance the histological features like formation of callus and tissue and differentiation of vascular tissue that helps in increasing the length, diameter and total root length (Mitra and Bose 1954).

4.1.1.7 Height of stool shoots

The data pertaining to the effect of different IBA concentrations on height of stool shoots in cherry rootstock 'Gisela-5'are presented in Table 4.3 and Fig.3.

It is evident from the data (Table 4.3) that stool shoots subjected to IBA @ 4500 ppm treatment (T_3) attained maximum height (160.60 cm). This treatment was statistically at par with all other treatments except T_5 (IBA @ 6500 ppm). However, minimum height of stool shoot (93.40 cm) was observed in T_5 (IBA @ 6500 ppm) which was significantly lower than all other treatments under consideration. As depicted in Fig.3, IBA @ 3500 ppm, 4500 ppm, 5500 ppm and 6500 ppm treatments exhibited 2.65, 6.40, 0.53 and -38.06 per cent increase, respectively in height of the stool shoots over T_1 (IBA @ 2500 ppm).

Table 4.3: Effect of different IBA concentrations on height, diameter and proportion of graftable stool shoots in cherry rootstock 'Gisela-5'

Treatment	Height of the stool shoots (cm)	Diameter of the stool shoots (mm)	Proportion of graftable rootstock (%)*
IBA @ 2500 ppm (T_1)	150.80	10.64	87.61 (74.04)
IBA @ 3500 ppm (T_2)	154.80	14.17	100.00 (90.00)
IBA @ 4500 ppm (T_3)	160.60	11.85	100.00 (90.00)
IBA @ 5500 ppm (T_4)	151.60	9.88	94.91 (81.65)
IBA @ 6500 ppm (T_5)	93.40	6.26	75.47 (63.48)
$CD_{0.05}$	27.20	2.09	14.39

*Values in the parenthesis are angular transformed

4.1.1.8 Diameter of stool shoots

It is clear from the data presented in Table 4.3 that diameter of the stool shoots was significantly influenced by different IBA treatments. The maximum diameter of the stool shoots (14.17 mm) was recorded under 3500 ppm IBA treatment (T_2) which was significantly higher than all other treatments under consideration. Whereas, minimum diameter of the stool shoots (6.26 mm) was observed under 6500 ppm IBA treatment (T_5) which was significantly lower than all other treatments under study.

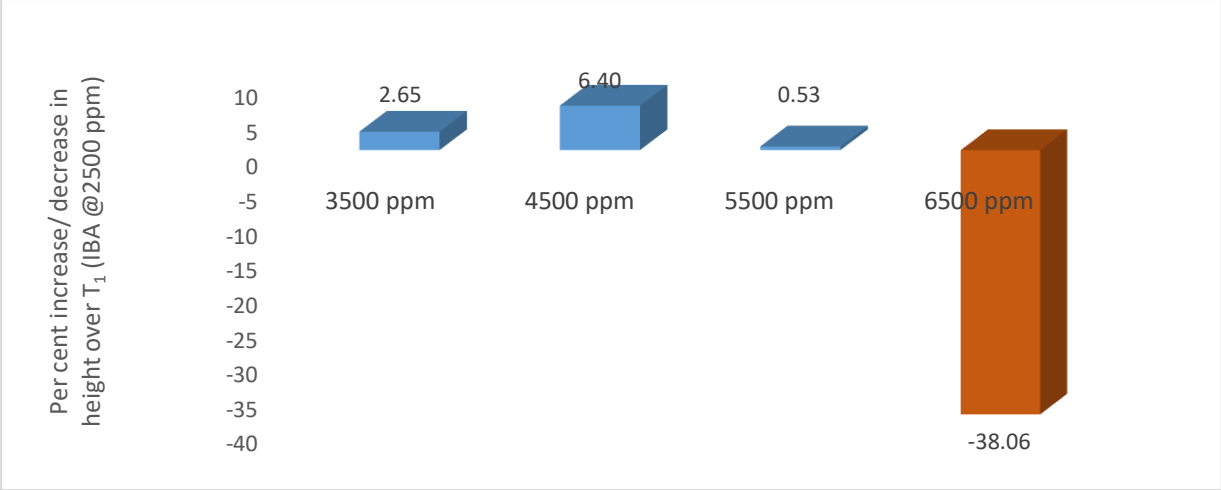

Fig. 3: Per cent increase/decrease in height of stool shoots under different IBA treatments over T_1 (IBA @ 2500 ppm)

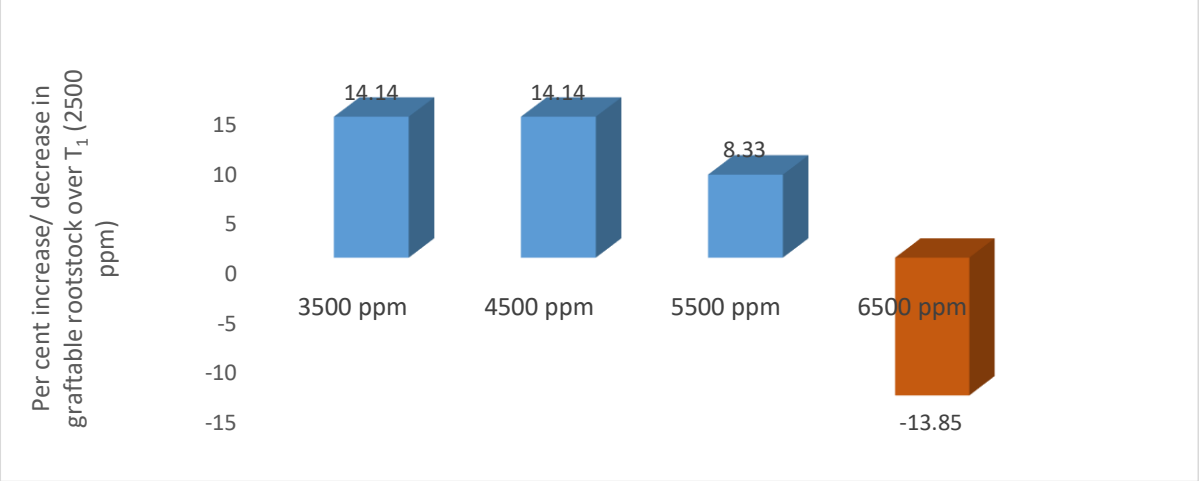

Fig. 4: Per cent increase/decrease in proportion of graftable stool shoots under different IBA treatments over T_1 (IBA @ 2500 ppm)

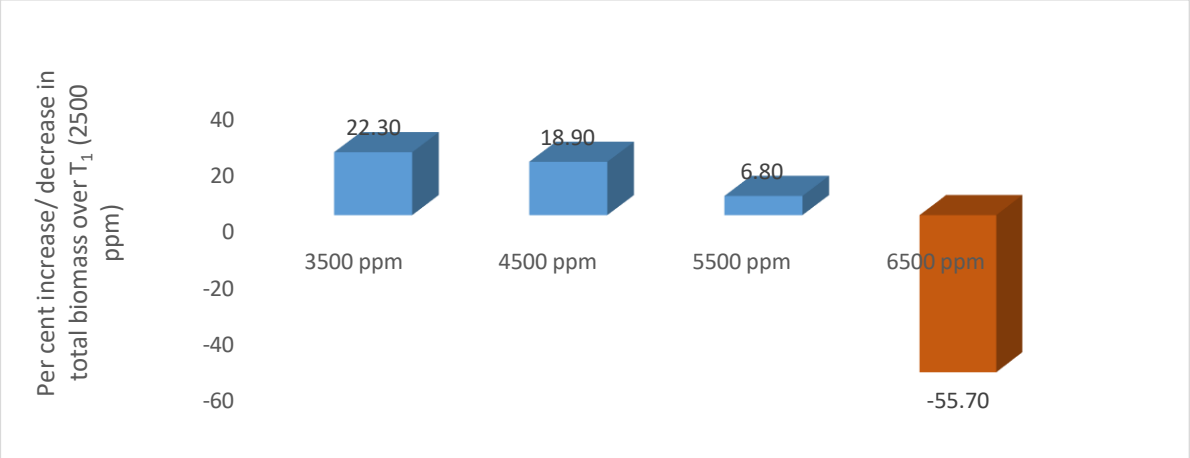

Fig. 5: Per cent increase/decrease in total plant biomass under different IBA treatments over T_1 (IBA @ 2500 ppm)

4.1.1.9 Proportion of graftable stool shoots

It is evident from the data presented in Table 4.3 and Fig.4 that percentage of graftable stool shoots was significantly influenced by different IBA treatments. The treatment of stool shoots with IBA @ 3500 ppm (T_2) and 4500 ppm (T_3) exhibited maximum proportion of graftable rootstocks (100.00 %). Both these treatments were statistically at par with T_4 (IBA @ 5500 ppm) but significantly superior to T_1 (IBA @ 2500 ppm) and T_5 (IBA @ 6500 ppm). The minimum proportion of graftable stool shoots (75.47 %) was noticed under 6500 ppm IBA treatment (T_5) which was statistically at par with T_1 (IBA @ 2500 ppm) and significantly lower than rest of the treatments under study. Data depicted in Fig.4 convey that an increase of 14.14, 14.14, 8.33 and -13.85 per cent in proportion of graftable rootstocks was observed under IBA treatments of 3500 ppm, 4500 ppm, 5500 ppm and 6500 ppm, respectively over T_1 (IBA @ 2500 ppm).

4.1.1.10 Leaf area

It is evident from the data presented in Table 4.4 that different IBA treatments had a significant effect on leaf area of cherry rootstock 'Gisela-5'. Highest leaf area (29.91 cm^2) was recorded in plants subjected to 4500 ppm IBA treatment (T_3) which was statistically at par with T_2 (IBA @ 3500 ppm) and significantly higher than rest of the treatments under study. The lowest leaf area (12.24 cm^2) was observed under treatment T_5 (IBA @ 6500 ppm) which was significantly lower than all other treatments under study.

Table 4.4: Effect of different IBA concentrations on leaf area, total number of leaves and internodal length in cherry rootstock 'Gisela-5'

Treatment details	Leaf area (cm^2)	Total number of leaves/stool shoot	Internodal length (mm)
IBA @ 2500 ppm (T_1)	24.44	374.20	3.11
IBA @ 3500 ppm (T_2)	28.34	430.00	3.55
IBA @ 4500 ppm (T_3)	29.91	576.80	3.32
IBA @ 5500 ppm (T_4)	24.39	378.00	3.32
IBA @ 6500 ppm (T_5)	12.24	159.60	3.00
$CD_{0.05}$	3.18	49.31	NS

4.1.1.11Total number of leaves

It is pertinent from the data presented in Table 4.4 that IBA treatments had significant influence on total number of leaves per stool shoots. The highest number of leaves (576.80)

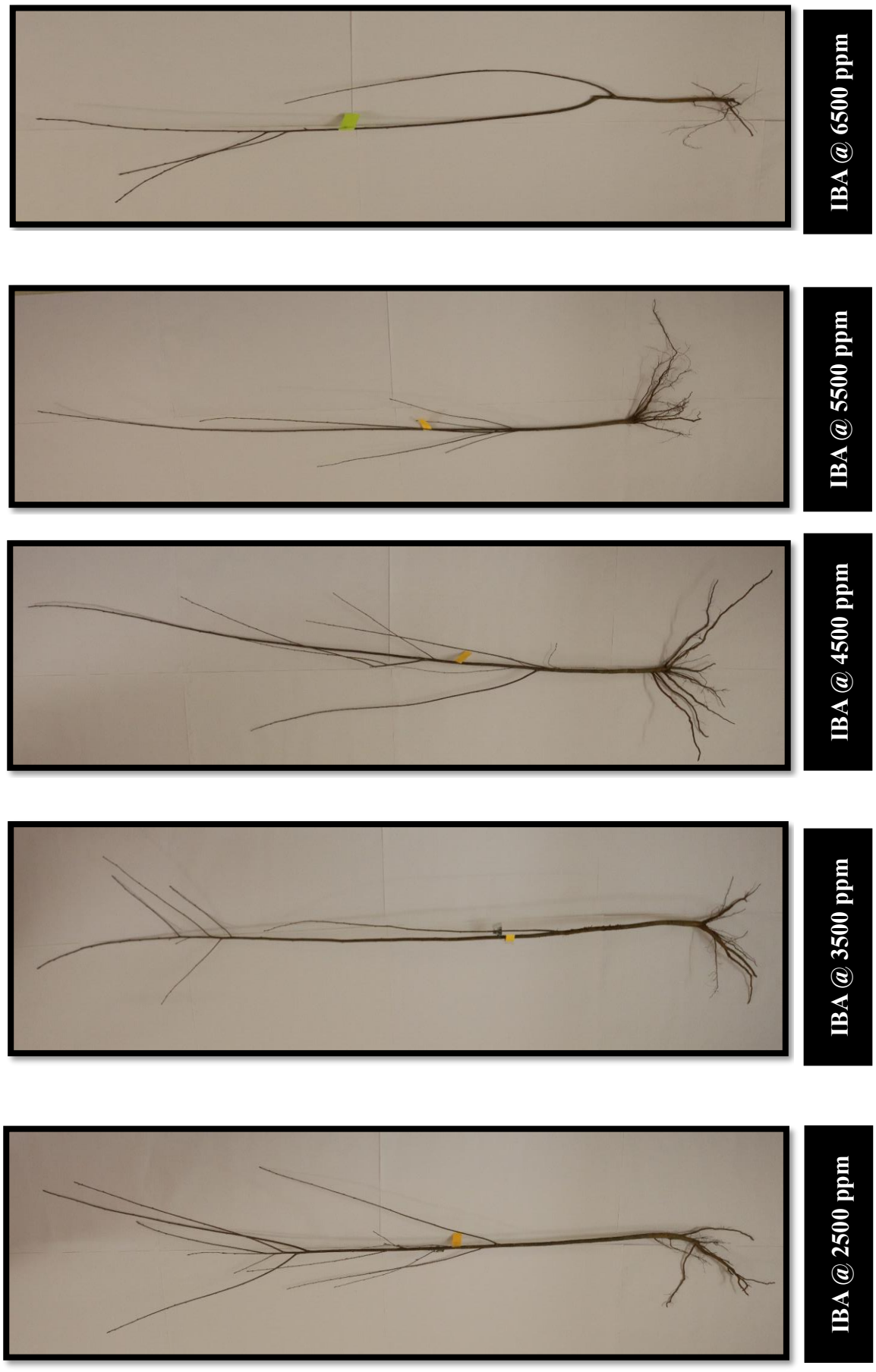

Plate 3. Comparison of root and shoot system of 'Gisela-5'stools of cherry rootstock under different IBA treatments

Plate 4. Comparison of root and shoot system of ‘Gisela-6’stools of cherry rootstock under different propagation media

was recorded in stool shoots treated with IBA @ 4500 ppm (T_3) which was significantly higher than T_1 (IBA @ 2500 ppm), T_2 (IBA @ 3500 ppm), T_4 (IBA @ 5500 ppm) and T_5 (IBA @ 6500 ppm). Whereas, minimum number of leaves per stool shoot (159.60) was recorded under IBA @ 6500 ppm treatment (T_5) which was significantly lower than all other treatments under consideration.

4.1.1.12 Internodal length

It is clear from the data presented in Table 4.4 that different IBA concentrations did not exert any significant effect on internodal length of stool shoots. However, maximum internodal length (3.55 mm) was recorded in stool shoots treated with IBA @ 3500 ppm (T_2) and minimum internodal length (3.00 mm) was observed under 6500 ppm IBA treatment (T_5).

The results obtained in the present study shows that IBA had significantly influenced the height of stool shoots, diameter of stool shoots, proportion of graftable stool shoots, leaf area and total number of leaves. The growth of stool shoots initially increased with increasing IBA concentration and decreased thereafter with the further increase in IBA concentration. The results of study are in agreement with those of Noor et al. (1995), who reported maximum shoot length in cuttings of apple rootstock M-26 and M-27 treated with 3000 ppm IBA. Similarly, Ahmed et al. (2001) in olive and Alam et al. (2007) in kiwifruit, had also recorded significantly higher shoot growth and leaf numbers in stem cuttings treated with IBA 4000 ppm. Mehta et al (2016) had reported significantly higher proportion of graftable 'Quince-C' and 'BA-29' rootstocks of pear raised through stem cuttings treated with 1000 ppm IBA. Naithani et al. (2018) had observed more height of stool shoots in guava layers treated with IBA 4500 ppm.

The higher growth of stool shoots with 3500 and 4500 ppm IBA treatment might have increased the cell division and enlargement in treated area which in turn resulted in better rooting leading to efficient absorption of water and nutrients and contributed for better length and diameter of the stool shoots (Chauhan and Maheshwari 1970). Higher number of leaves on these shoots may be attributed to more length of shoots. The development of good root system under the influence of optimum IBA concentration resulted in absorption of minerals and water from the soil might have increased the number of nodes leading to development of more number of leaves and leaf area in the stool shoots (Rao et al. 2020). Increased shoot

diameter might be attributed to increased leaf count and leaf area due to increased glucose generation and assimilation. The increased stool shoot diameter could have resulted in higher proportion of graftable shoots as increase in shoot diameter is crucial for the production of graftable rootstock (Kaur 2017).

4.1.1.13 Fresh weight of roots

The data with respect to effect of different IBA treatments on fresh weight of the roots are presented in Table 4.5.

It is clear from the data that IBA had a significant influence on fresh weight of roots produced in stool shoots treated with different IBA concentrations. The maximum fresh weight of the roots (48.44 g) was recorded in stool shoots receiving treatment of IBA @ 4500 ppm (T_3). This treatment was significantly superior than all other treatments under study. The minimum fresh weight of roots (23.40 g) was noticed under treatment T_5 (IBA @ 6500 ppm) which was considerably lower than all other treatments under study.

Table 4.5: Effect of different IBA concentrations on fresh weight and dry weight of roots in cherry rootstock 'Gisela-5'

Treatment	Fresh weight of roots (g)	Dry weight of roots (g)
IBA @ 2500 ppm (T_1)	35.80	15.60
IBA @ 3500 ppm (T_2)	35.90	14.20
IBA @ 4500 ppm (T_3)	48.44	19.10
IBA @ 5500 ppm (T_4)	30.10	10.80
IBA @ 6500 ppm (T_5)	23.40	6.50
$CD_{0.05}$	5.06	6.13

4.1.1.14 Dry weight of roots

The data (Table 4.5) explains that dry weight of roots in cherry rootstock 'Gisela-5' was significantly influenced by different IBA treatments. The stool shoots treated with 4500 ppm IBA (T_3) exhibited maximum dry weight of roots (19.10 g). This treatment was statistically at par with T_1 (IBA @ 2500 ppm) and T_2 (IBA @ 3500 ppm) but significantly superior to rest of the treatments under study. However, minimum dry weight of roots (6.50 g) was recorded under 6500 ppm IBA treatment (T_5) which was statistically at par with T_4 (IBA @ 5500 ppm) and significantly lower than all other treatments.

4.1.1.15 Fresh weight of shoots

It is evident from the data presented in Table 4.6 that IBA at different concentrations had a significant effect on fresh weight of 'Gisela-5' stool shoots. Highest fresh weight of shoots (132.60 g) was registered by stool shoots subjected to IBA @ 3500 ppm treatment (T_2). This treatment was statistically at par with T_3 (IBA @ 4500 ppm) and significantly superior to all other treatments under study. The minimum fresh weight of shoots (32.20 g) was observed in stool shoots treated with 6500 ppm IBA (T_5) which was significantly lower than other IBA concentrations under consideration.

Table 4.6: Effect of different IBA concentrations on fresh weight, dry weight and total plant biomass of stool shoots in cherry rootstock 'Gisela-5'

Treatment	Fresh weight of the shoots (g)	Dry weight of the shoots (g)	Total biomass(dry weight basis) (g)
IBA @2500 ppm (T_1)	109.00	69.10	83.30
IBA @3500 ppm (T_2)	132.60	90.00	105.60
IBA @4500 ppm (T_3)	126.02	83.10	102.20
IBA @5500 ppm (T_4)	117.80	79.30	90.10
IBA @6500 ppm (T_5)	32.20	21.10	27.60
$CD_{0.05}$	8.74	7.13	7.64

4.1.1.16 Dry weight of shoots

The data presented in Table 4.6 reveal that application of IBA at different concentrations significantly influenced the dry weight of shoots. The maximum dry weight of shoots (90.00 g) was recorded in stool shoots treated with 3500 ppm IBA (T_2) which was statistically at par with T_3 (IBA @ 4500 ppm) and significantly higher than all other treatments under study. However, minimum dry weight of shoots (21.10 g) was found under 6500 ppm IBA treatment (T_5) which was significantly lower than all other treatments under study.

4.1.1.17 Total plant biomass (Dry weight basis)

It is clear from the data presented in Table 4.6 and Fig.5 that total plant (root-shoot) biomass of stools was significantly influenced by different IBA treatments. The maximum total plant biomass (105.60 g) was recorded under 3500 ppm IBA treatment (T_2), closely followed by T_3 i.e. IBA @ 4500 ppm (102.20 g). Both these treatments were statistically at par with each other and significantly superior to all other treatments under consideration. Whereas, minimum total biomass (27.60 g) was observed under IBA @ 6500 ppm treatment

(T_5) which was significantly lower than all other treatments under study. It is clear from the data depicted in Fig.5 that IBA treatments @ 3500 ppm, 4500 ppm, 5500 ppm and 6500 ppm had registered an increase of 22.30, 18.90, 6.80 and -55.70 per cent, respectively over T_1 (IBA @ 2500 ppm).

It is clearly visible from the results obtained in the present study, that different IBA concentration had significantly influenced the fresh and dry weight of roots, fresh and dry weight of shoots as well as total biomass of stool shoots. The fresh and dry biomass of stool shoots increased with the increasing dose of IBA up to certain level. The plants treated with IBA @ 4500 ppm exhibited higher value for fresh and dry weight of roots and shoots. The results of present study are corroborated by the findings of Khatik and Sharma (2013), who reported significantly higher total plant biomass in terms of dry weight in stool shoots of apple rootstock Merton 793 treated with IBA @ 2500 ppm. Singh et al. (2015) in lemon and Rolaniya and Sarvanan (2018) in grape, had also recorded significantly higher fresh and dry weight of roots and shoots in stem cuttings treated with 2000 ppm IBA.

The higher biomass of roots under optimum IBA concentration may be attributed to the fact that exogenous application of auxin stimulates the movement of natural auxin in a downward direction from the leaves and shoot tips, which accumulate at the treated point of incision made on the shoot. Higher accumulation of auxin results in better initiation and growth of roots contributing to the formation of roots with higher fresh weight and ultimately the higher dry weight (Kaur et al. 2002). The higher number, diameter and length of roots (Table 4.1 and 4.2) and carbohydrate partitioning to the roots (Table 4.9) under 3500 and 4500 ppm IBA in the present study might also have resulted in enhanced fresh and dry weight of roots under these treatments. Auxin has a crucial role in vascular differentiation, stimulating cambial activity and xylem growth (Davis and Hassig 1990) which is necessary for the production of primordium cell. This enhanced production of primordium might have contributed for improved fresh and dry biomass of shoots due to enhanced length, diameter, and leaf area resulting in enhanced dry matter accumulation as a result of high photosynthetic activity (Mehta et al. 2016).

4.1.2 PHYSIOLOGICAL CHARACTERS

Physiological characters include leaf chlorophyll content, photosynthetic rate, transpiration rate, stomatal conductance and carbon partitioning in roots, shoots and leaves The data pertaining to physiological parameters are presented in Table 4.7 to 4.9.

4.1.2.1 Leaf chlorophyll content

It is evident from the data depicted in Table 4.7 that leaf chlorophyll content was significantly influenced by different IBA treatments. The maximum leaf chlorophyll content (2.31mg/g) was recorded in stool shoots subjected to 4500 ppm IBA treatment (T_3), closely followed by T_2 (2.23 mg/g) and T_4 (1.99 mg/g). These three treatments were statistically at par with each other and had significantly higher leaf chlorophyll content than T_1 (IBA @ 2500 ppm) and T_5 (IBA @ 6500 ppm). However, minimum leaf chlorophyll content (1.20 mg/g) was observed under T_5 (IBA @ 6500 ppm) which was statistically at par with T_1 (IBA @ 2500 ppm).

Table 4.7: Effect of different IBA concentrations on leaf chlorophyll content and photosynthetic rate in stool shoots of cherry rootstock 'Gisela-5'

Treatment	Leaf chlorophyll content (mg/g fresh weight)	Photosynthetic rate (µmol CO_2 m^{-2} s^{-1})
IBA @ 2500 ppm (T_1)	1.32	9.50
IBA @ 3500 ppm (T_2)	2.23	10.47
IBA @ 4500 ppm (T_3)	2.31	13.49
IBA @ 5500 ppm (T_4)	1.99	10.01
IBA @ 6500 ppm (T_5)	1.20	5.51
$CD_{0.05}$	0.43	1.96

4.1.2.2 Photosynthetic rate

A cursory glance of the data presented in Table 4.7 reveals that IBA treatments had a significant effect on photosynthetic rate of 'Gisela-5' cherry stool shoots. The highest photosynthetic rate (13.49µmol CO_2 m^{-2} s^{-1}) was observed in stool shoots treated with IBA @ 4500 ppm (T_3) which was significantly higher than all other treatments under study. While, minimum photosynthetic rate (5.51µmol CO_2 m^{-2} s^{-1}) was recorded under T_5 (IBA @ 6500 ppm) which was considerably lower than all other treatments under study.

4.1.2.3 Transpiration rate

A cursory glance of the data presented in Table 4.8 explains that transpiration rate of stool shoots was significantly influenced by different concentrations of IBA. The stool shoots treated with 4500 ppm IBA (T_3) exhibited maximum transpiration rate (5.98mmol H_2O m^{-2} s^{-1}). This treatment was statistically at par with T_2 (IBA @ 3500 ppm) and T_4 (IBA @ 5500 ppm) but significantly superior to all other treatments under study. The minimum

transpiration rate (2.48 mmol H_2O m^{-2} s^{-1}) was observed under 6500 ppm IBA treatment (T_5) which was significantly lower than all other treatments under study.

Table 4.8: Effect of different IBA concentrations on transpiration rate and stomatal conductance in stool shoots of cherry rootstock 'Gisela-5'

Treatment	Transpiration rate (mmol H_2O m^{-2} s^{-1})	Stomatal conductance (mol H_2O m^{-2} s^{-1})
IBA @ 2500 ppm (T_1)	4.08	0.20
IBA @ 3500 ppm (T_2)	4.89	0.23
IBA @ 4500 ppm (T_3)	5.98	0.34
IBA @ 5500 ppm (T_4)	5.27	0.23
IBA @ 6500 ppm (T_5)	2.48	0.13
$CD_{0.05}$	1.23	0.07

4.1.2.4 Stomatal conductance

The data with respect to effect of different IBA treatments on stomatal conductance of 'Gisela-5' cherry stool shoots are presented in Table 4.8.

It is clear from the data that IBA treatments had a significant effect on stomatal conductance. The maximum stomatal conductance (0.34 mol H_2O m^{-2} s^{-1}) was recorded in plants receiving 4500 ppm IBA (T_3). This treatment was significantly superior to all other treatments under study. However, minimum stomatal conductance (0.13 mol H_2O m^{-2} s^{-1}) was recorded under IBA treatment @ 6500 ppm (T_5) which was statistically at par with T_1 (IBA @ 2500 ppm) and significantly lower than all other treatments under study.

Present findings reveal that application of different IBA treatments had a significant effect on leaf chlorophyll content, photosynthetic rate, transpiration rate and stomatal conductance in stool shoots of cherry rootstock 'Gislea-5'. A significant increase in physiological traits of stool shoots was observed with IBA treatments @ 4500 ppm. The results obtained in the present study are partially supported by Rao et al. (2020), who had reported significant increase in leaf chlorophyll content in pomegranate cuttings treated with IBA @ 5000 ppm. Similar observations were also made by Samim et al. (2021) in stem cuttings of barbados cherry treated with IBA @ 4500 and 5000 ppm. However, Khandaker et al. (2022) found higher chlorophyll content and stomatal aperture in air layered wax apple with 2000 mg L^{-1} of IBA treatment. The significantly higher values of physiological traits with the treatment of 4500 ppm IBA might be due to larger leaf area observed under this

treatment in the present study (Table 4.4) which might have activated more photosynthates resulting in more chlorophyll content in leaves (Kumar et al. 2023).The increase in leaf area and chlorophyll content as a result of improved nutrient absorption, leads to greater photosynthate generation and enough food supply for plant metabolic activities like photosynthetic efficiency, transpiration rate and stomatal conductance (Galston and Davies 1969).

4.1.2.5 Carbon partitioning to roots

The data depicted in Table 4.9 represents effect of IBA treatments on accumulation of carbohydrates in roots of 'Gisela -5' cherry stool shoots. The maximum carbohydrates (99.66 mg/g) in roots of stool shoots was recorded under IBA treatment @ 4500 ppm (T_3) which was significantly higher than all other treatments under study. However, minimum carbohydrates (41.85 mg/g) in roots of stool shoots was recorded under 6500 ppm IBA treatment (T_5) which was significantly lower than all other treatments under study.

4.1.2.6 Carbon partitioning to shoots

It is evident from the data presented in Table 4.9 that different IBA doses had a significant effect on carbon partitioning to the shoots. The highest carbohydrate accumulation (73.92 mg/g) in shoots was recorded under 4500 ppm IBA treatment (T_3) which was significantly higher than all other treatments under study. However, minimum carbohydrate accumulation in shoots (36.95 mg/g) was observed under T_1 (IBA @ 2500 ppm) which was significantly lower than rest of the treatments under consideration.

Table 4.9: Effect of different IBA concentrations on carbon partitioning to roots, shoots and leaves in stool layers of cherry rootstock 'Gisela-5'

Treatment	Carbohydrate content (mg/g)		
	Roots	Shoots	Leaves
IBA @ 2500 ppm (T_1)	52.88	36.95	30.08
IBA @ 3500 ppm (T_2)	92.48	43.39	42.66
IBA @ 4500 ppm (T_3)	99.66	73.92	42.92
IBA @ 5500 ppm (T_4)	66.30	62.52	41.55
IBA @ 6500 ppm (T_5)	41.85	40.26	28.13
CD $_{0.05}$	4.76	2.55	3.35

4.1.2.7 Carbon partitioning to leaves

It is pertinent from the data presented in Table 4.9 that different IBA treatments had a significant influence on carbon partitioning in leaves. The highest leaf carbohydrate contents

(42.92 mg/g) was recorded in stool shoots treated with 4500 ppm IBA (T_3), closely followed by T_2 (42.66 mg/g) and T_4 (41.55 mg/g). These three treatments were statistically at par with each other and significantly superior to T_1 (IBA @ 2500 ppm) and T_5 (IBA @ 6500 ppm). Whereas, minimum carbohydrate content (28.13 mg/g) in the leaves was observed under stool shoots treated with 6500 ppm IBA (T_5) which was statistically at par with T_1 (IBA @ 2500 ppm) and significantly lower than all other treatments under study.

Present findings reveal that application of IBA had a significant influence on carbon partitioning in stool shoots of cherry rootstock 'Gisela-5'. The maximum accumulation of carbohydrate contents in roots, shoots and leaves was observed with IBA treatment @ 4500 ppm, which may be attributed to higher number of leaves, chlorophyll content and photosynthetic rate under this treatment in the present study (Table 4.4 &4.7). Leaves being photosynthetically active organ, increases the carbohydrate content at the site. The exogenous auxin application stimulates the mobilization of carbohydrates in stem and roots. Stem and roots act as sink for photo assimilates from the leaves, mainly due to respiratory activity maintenance, storage capacity and little photosynthetic activity (Otiende and Maimba 2020) and thereby increased the translocation of carbohydrates towards the stem and roots. The results of present study are in conformity with those of Al-Imam and Hamid (2019), who had recorded higher carbon partitioning in olive cuttings treated with 4000 ppm IBA.

4.2 EXPERIMENT-2: Effect of propagation media on rooting and growth of mother stool shoots of cherry rootstock

4.2.1 MORPHOLOGICAL CHARACTERS

Morphological characters include rooting percentage, number of rooted shoots per stool, number of main roots per stool shoot, length of longest root, diameter of the main root, total root length, height of the stool shoots, diameter of the stool shoots, proportion of graftable rootstock, leaf area, number of leaves, internodal length, fresh and dry weight of roots and shoots and total plant biomass. The data pertaining to the input of different propagating media on morphological parameters of cherry rootstock 'Gisela-6' are presented in Table 4.10 to 4.15.

4.2.1.1 Rooting percentage

Data with respect to effect of different propagation media treatments on percentage of rooting in shool shoots of 'Gisela -6' are presented in Table 4.10 and Fig.6.

It is pertinent from the data that different propagation media significantly affected the rooting in stool shoots. The maximum rooting (100.00 %) was recorded in stool shoots subjected to cocopeat (T_2) which was statistically at par with T_4 (Vermicompost + Cocopeat) and significantly higher than all other treatments under study. However, minimum rooting (67.65 %) was registered by stool shoots mounded with soil + FYM (T_3) which was statistically at par with T_1 (Sawdust) and significantly lower than all other treatments under study. Data depicted in Fig.6 convey that an increase of 18.40, 47.81, 39.18 and 29.75 per cent in rooting was observed under propagation media treatments of sawdust, cocopeat, vermicompost + cocopeat and sawdust + sand + vermicompost, respectively over control (Soil + FYM).

Table 4.10: Effect of different propagation media on rooting, number of rooted shoots and main roots in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Rooting percentage*	Number of rooted shoots/ mother stool	Number of main roots/ stool shoot
Sawdust (T_1)	80.16 (63.70)	4.40	5.20
Cocopeat (T_2)	100.00 (90.00)	7.80	7.80
Soil + FYM (T_3)	67.65 (55.55)	2.80	4.00
Vermicompost + Cocopeat (T_4)	94.16 (81.02)	6.40	6.40
Sawdust + Sand + Vermicompost (T_5)	87.78 (71.64)	7.20	6.80
$CD_{0.05}$	10.75	1.91	1.36

*Values in the parenthesis are angular transformed

4.2.1.2 Number of rooted shoots per mother stool

It is pertinent from the data presented in Table 4.10 that different rooting media had a significant influence on number of rooted shoots per mother stool. The maximum number of rooted shoots per mother stool (7.80) was recorded under mounding with cocopeat (T_2), closely followed by T_4 (Vermicompost + Cocopeat) and T_5 (Sawdust + Sand + Vermicompost). These three treatments were statistically at par with each other and significantly superior to rest of the treatments under consideration. The minimum number of rooted shoots per mother stool (2.80) was noticed under soil + FYM (T_3) which was statistically at par with T_1 (Sawdust) and significantly lower than all other treatments under study.

4.2.1.3 Number of main roots per stool shoot

It is clear from the data presented in Table 4.10 that number of main roots per stool shoot was significantly influenced by propagation media. The maximum number of main roots per stool shoot (7.80) was recorded in stools subjected to cocopeat (T_2) which was statistically at par with T_5 (Sawdust + Sand + Vermicompost) and significantly higher than all other treatments under consideration. However, minimum number of main roots per stool shoot (4.00) was observed in stools treated with soil + FYM (T_3) which was statistically at par with T_1 (Sawdust) and significantly lower than all other treatments.

4.2.1.4 Length of longest root

It is clear from the data presented in Table 4.11 that rooting media had a significant effect on length of longest root. The maximum length of main root (42.60 cm) was recorded in sawdust (T_1). This treatment was statistically at par with T_2 (Cocopeat) and T_5 (Sawdust + Sand + Vermicompost) but significantly superior to rest of the treatments. However, minimum length of longest root (29.00 cm) was noticed under T_3 (Soil + FYM) which was significantly lower than all other treatments under study.

Table 4.11: Effect of different propagation media on length of longest root, diameter of main roots and total root length in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Length of longest root (cm)	Diameter of main roots (mm)	Total root length (m)
Sawdust (T_1)	42.60	5.34	7.45
Cocopeat (T_2)	38.20	6.30	9.86
Soil + FYM (T_3)	29.00	3.48	5.94
Vermicompost + Cocopeat (T_4)	37.80	5.52	9.34
Sawdust + Sand + Vermicompost (T_5)	40.40	6.29	7.50
$CD_{0.05}$	4.56	1.03	0.91

4.2.1.5 Diameter of main roots

The data presented in Table 4.11 explains that diameter of main roots was significantly influenced by different rooting media. The stool shoots subjected to cocopeat propagation media (T_2) exhibited maximum diameter of main roots (6.30 mm). This treatment was statistically at par with all other treatments except T_3 (Soil + FYM). Whereas, minimum diameter of main roots (3.48 mm) was observed under soil + FYM (T_3) which was significantly lower than all other treatments under study.

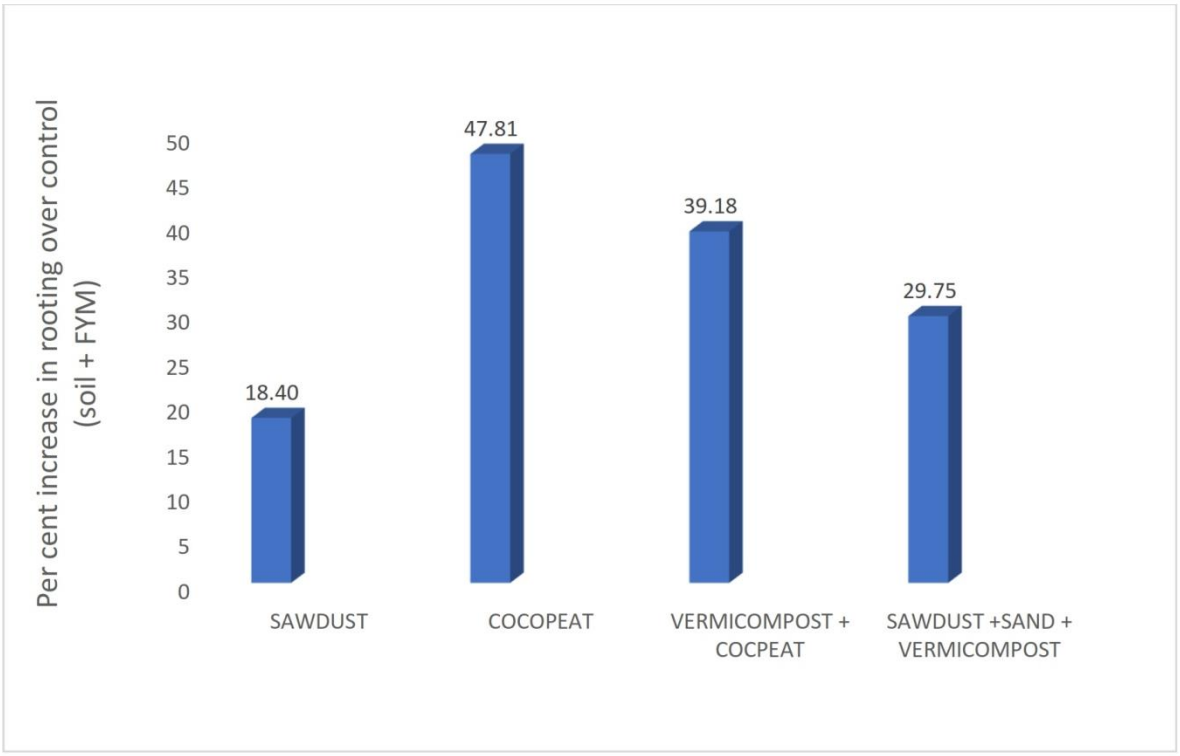

Fig. 6: Per cent increase in rooting under different propagation media treatments over control (Soil + FYM)

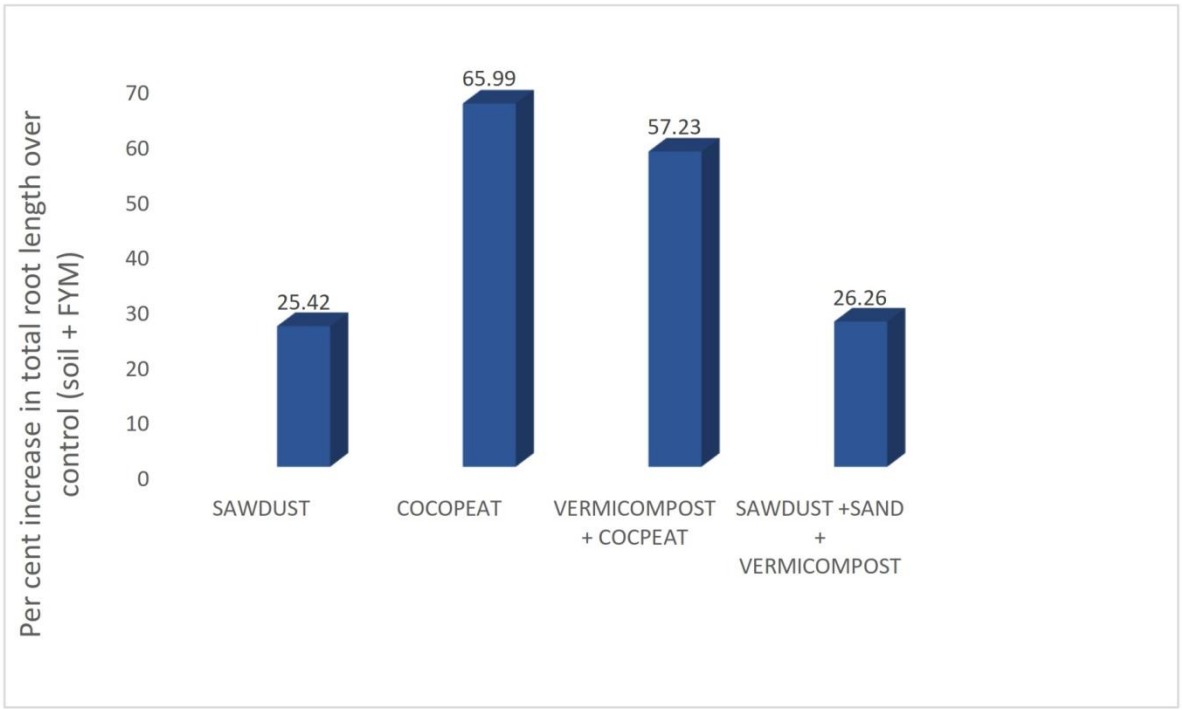

Fig.7: Per cent increase in total root length under different propagation media treatments over control (Soil + FYM)

4.2.1.6 Total root length

The data presented in Table 4.11 explains that total root length in stool shoot was significantly influenced by different propagation media. The stool shoots mounded with cocopeat (T_2) registered maximum total root length (9.86 m), closely followed by T_4 i.e. vermicompost + cocopeat (9.34 m). Both these treatments were statistically at par with each other and significantly superior to all other treatments under study. The minimum total root length (5.94 m) was observed under soil + FYM propagation media (T_3) which was significantly lower than all other treatments under study. The data depicted in Fig.7 shows that there was an increase of 25.42, 65.99, 57.23 and 26.26 per cent in total root length under sawdust, cocopeat, vermicompost + cocopeat and sawdust + sand + cocopeat, respectively over control (Soil + FYM).

It is clearly visible from the results obtained in present study that propagation media had exhibited significant influence on rooting percentage, number of rooted stool shoots, number of main roots, length of longest root, diameter of main roots and total root length in cherry rootstock 'Gisela-6'. Amongst different propagation media, cocopeat (T_2) was found to be most effective for initiate and enhance rooting in stool shoots. This might be due to positive effect of cocopeat in increasing the water absorption and maintaining the cell turgidity and cell elongation as confirmed from the present study (Table 3.1) showing maximum values for water holding capacity, water retention and porosity. High soil moisture and aeration helps in supplying substantial amount of nutrients and maintain respiration at optimum level (Chopde et al. 1999). The increased respiration favours the metabolic activity of processes associated with root initiation (Hartmann et al. 2007) leading to favourable rooting and growth of stool shoots. The increase in diameter and root length may be due to the fact that cocopeat increases the nutrient content and decrease fluctuation of soil temperature (Hartmann et al. 2007). Cocopeat could have improved number of cells and their elongation because of its richness in cytokinin (Ellyard and Ollerenshaw 1984) which encouraged the induction of adventitious roots, length, diameter and total root length of stools.

The present findings are in agreement with those of Atak and Yalcin (2015) and Parmar et al. (2018), who reported cocopeat as best rooting medium for cuttings of kiwifruit and guava, respectively. Divin et al. (2011) and Rahimi et al. (2011) had also recorded

highest rooting percentage and root number with cocopeat + perlite medium in stem cuttings of apple.

4.2.1.7 Height of stool shoot

It is evident from the data depicted in Table 4.12 and Fig.8 that height of stool shoot was significantly influenced by rooting media. The maximum height (189.00 cm) was attained by stool shoot subjected to cocopeat propagation medium (T_2), closely followed by T_5 i.e. sawdust + sand + vermicompost (177.00 cm). Both these treatments were statistically at par with each other and had significantly higher height of stool shoots than those of T_1 (Sawdust) and T_3 (Soil + FYM). However, minimum height of stool shoot (106.20 cm) was recorded under T_3 (Soil + FYM) which was significantly lower than all other treatments under study. Data presented in Fig.3 reveals that propagation media viz. sawdust, cocopeat, vermicompost + cocopeat and sawdust + sand + vermicompost exhibited an increase of 48.77, 66.66, 54.42 and 77.96 per cent, respectively in height of stool shoots over control (Soil + FYM).

Table 4.12: Effect of different propagation media on height, diameter and proportion of graftable stool shoots in cherry rootstock 'Gisela-6'

Treatment	Height of stool shoot (cm)	Diameter of stool shoot (mm)	Proportion of graftable rootstocks*
Sawdust (T_1)	158.40	12.77	87.66 (71.56)
Cocopeat (T_2)	189.00	12.95	100.00 (90.00)
Soil + FYM (T_3)	106.20	8.95	72.18 (58.70)
Vermicompost + Cocopeat (T_4)	164.00	12.66	100.00 (90.00)
Sawdust + Sand + Vermicompost (T_5)	177.00	11.70	95.00 (81.70)
$CD_{0.05}$	13.26	1.51	11.76

*Values in the parenthesis are angular transformed

4.2.1.8 Diameter of stool shoot

The data with respect to effect of different rooting media on diameter of stool shoots are presented in Table 4.12.

It is clear from the data that stool shoots mounded with cocopeat propagation media (T_2) attained maximum diameter (12.95 mm) which was statistically at par with all other treatments except T_3 (Soil + FYM). Whereas, minimum diameter of the stool shoots (8.95

mm) was observed in (T_3) which was significantly lower than all other treatments under consideration.

4.2.1.9 Proportion of graftable stool shoots

It is evident from the data depicted in Table 4.12 and Fig. 9 that proportion of graftable stool shoots was significantly influenced by different propagation media treatments. The maximum proportion of graftable rootstocks (100 %) was recorded in stools subjected to cocopeat (T_2) and vermicompost + cocopeat (T_4) propagation media. These treatments were statistically at par with T_5 (Sawdust + Sand + Vermicompost) and significantly superior to other treatments under consideration. However, minimum proportion of graftable rootstocks (72.18 %) was recorded under treatment T_3 (Soil + FYM) which was significantly lower than all other treatments under study. It is worthy to be noted from Fig. 9 that there was an increase of 21.44, 38.54, 38.54 and 31.61 per cent in proportion of graftable rootstocks under sawdust, cocopeat, vermicompost + cocopeat and sawdust + sand+ vermicompost, respectively over control (Soil + FYM).

4.2.1.10 Leaf area

The data presented in Table 4.13 reveals that propagation media had significantly influenced the leaf area in stool shoots of cherry rootstock 'Gisela-6'. The maximum leaf area (32.96 cm^2) was recorded in stool shoots mounded with cocopeat propagation medium (T_2). This treatment was significantly superior to all other treatments under study. However, minimum leaf area (23.42 cm^2) was registered by stool shoots subjected to soil + FYM propagation media (T_3) which was significantly lower than all other treatments under study.

Table 4.13: Effect of different propagation media on leaf area, number of leaves and internodal length in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Leaf area (cm^2)	Number of leaves/ stool shoot	Internodal length (mm)
Sawdust (T_1)	27.04	268.80	3.86
Cocopeat (T_2)	32.96	317.60	4.00
Soil + FYM (T_3)	23.42	216.80	3.45
Vermicompost + Cocopeat (T_4)	30.82	294.60	3.84
Sawdust + Sand + Vermicompost (T_5)	29.68	312.60	4.00
$CD_{0.05}$	1.74	41.97	NS

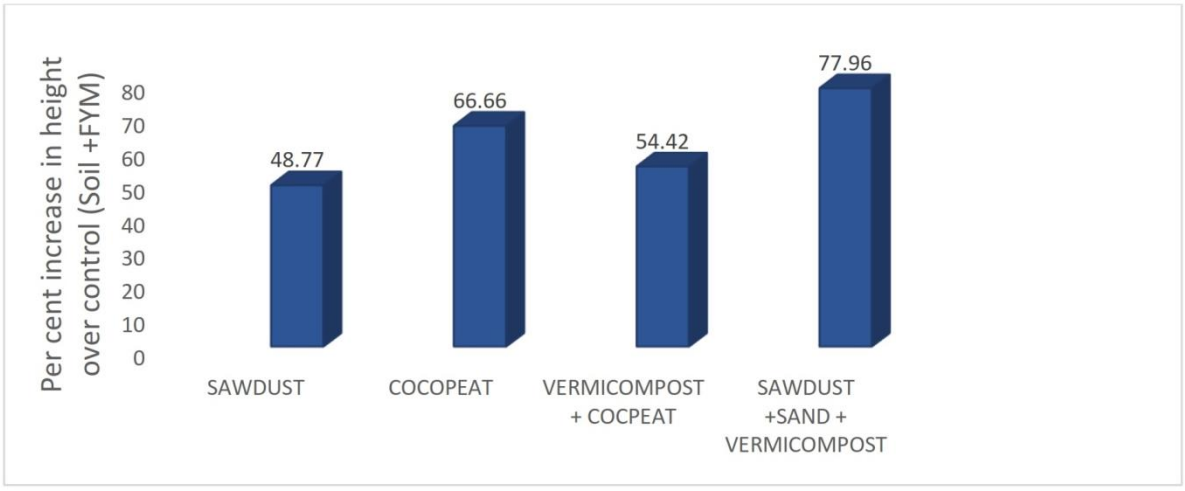

Fig. 8: Per cent increase in height of stool shoots under different propagation media treatments over control (Soil + FYM)

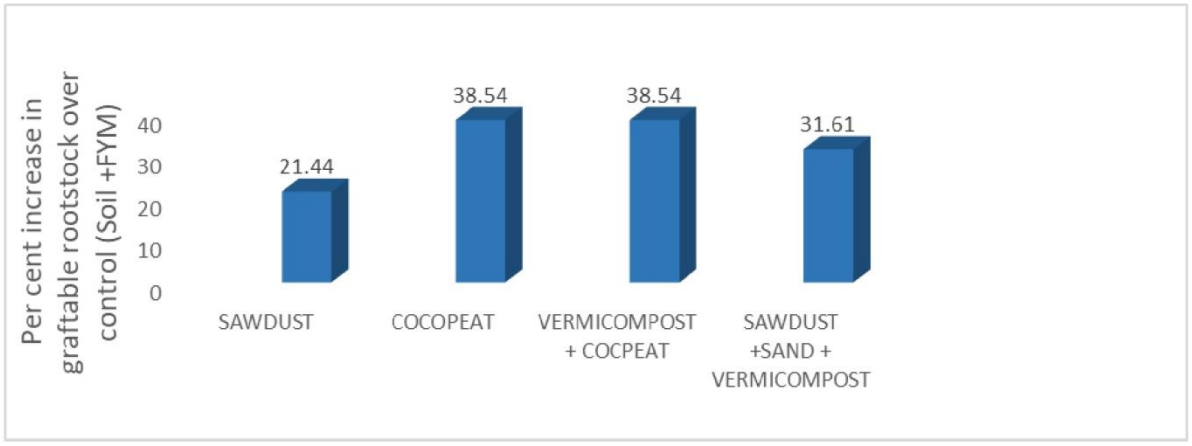

Fig. 9: Per cent increase in proportion of graftable rootstocks under different propagation media treatments over control (Soil + FYM)

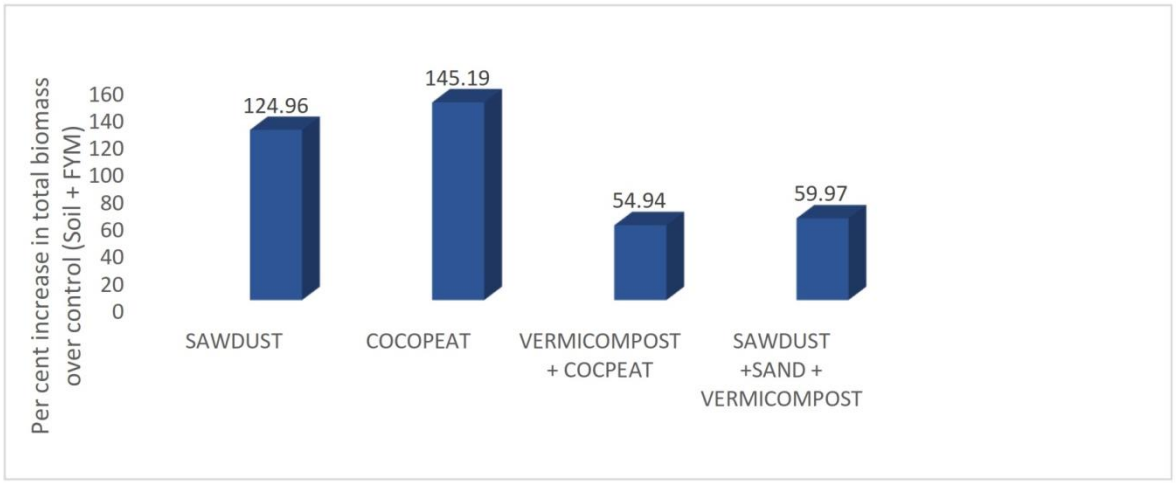

Fig. 10: Per cent increase in total plant biomass (roots + shoots) under different propagation media treatments over control (Soil + FYM)

4.2.1.11 Number of leaves per stool shoot

It is evident from the data presented in Table 4.13 that different propagation media had a significant influence on number of leaves per stool shoot in cherry rootstock 'Gisela-6'. The stool shoots mounded with cocopeat propagation media (T_2) exhibited maximum number of leaves (317.60) which was statistically at par with those of treatments T_4 (Vermicompost + Cocopeat) and T_5 (Sawdust + Sand + Vermicompost). Whereas, minimum number of leaves per stool shoot (216.80) was recorded under treatment T_3 (Soil + FYM) which was significantly lower than all other treatments under consideration.

4.2.1.12 Internodal length

The data presented in Table 4.13 shows that propagation media did not exert any significant effect on intermodal length of stool shoots. However, maximum intermodal length (4.00 mm) was recorded in T_2 (Cocopeat) and T_5 (Sawdust + Sand + Vermicompost), while minimum intermodal length (3.45 mm) was observed in T_3 (Soil + FYM).

It is clearly visible from the results of present study that height and diameter of stool shoots, proportion of graftable rootstocks, leaf area and number of leaves were significantly affected by different propagation media, while cocopeat had shown the significant improvement in these parameters. This could be due to the fact that cocopeat include biodegradable materials which improves nutrient availability for growth and development of stool shoot (Raja et al.2018; Sharma 2022). It could also be attributed to the higher rooting initiation and better root growth in stool shoots under cocopeat propagation medium as observed in the present study (Tables 4.10 and 4.11). Better rooting initiation and growth of roots under cocopeat perhaps resulted in absorption of minerals and nutrients which further improved the height, diameter of the stool shoots and ultimately the proportion of graftable rootstocks. Higher C:N ratio of cocopeat might have led to the more growth and more number of leaves (Awang et al. 2009). Stool shoots with better roots system under cocopeat perhaps enhanced nutrient intake, boosted photosynthesis to support new leaves finally resulting in a larger leaf area. Plant cells grow in size by cell enlargement which in turn requires water that could have made available by the better water holding capacity of cocopeat as evident from Table 3.1 of the present study. Turgidity of cells helps in extension of the cell which further leads to the increased growth (Taiz and Zeiger2006). Thus, plant growth and further development is intimately linked to the moisture content of the plant. Cell

swells with the increase in water content of the plant leads to increased turgor pressure against cell walls and finally results in increasing growth and leaf area.

The present findings are in conformity with those of Singh and Kaur (2021), who had recorded maximum shoot diameter, leaf number and leaf area in stem cuttings of peach cv. Shan-i-Punjab under cocopeat + soil propagation media. Sahu et al. (2022) had also reported significant increase in height, diameter, number of leaves and leaf area of papaya seedlings with cocopeat + peat moss as a propagation media.

4.2.1.13 Fresh weight of roots

It is pertinent from the data presented in Table 4.14 that propagation media had significant influence on fresh weight of roots in stool of cherry rootstock 'Gisela-6'. The maximum fresh weight of roots (61.90 g) was recorded in stool shoots treated with cocopeat (T_2) which was significantly higher than all other treatments under study. The minimum fresh weight of roots (32.90 g) was observed in stool shoots maintained under T_3 (Soil + FYM) which was significantly lower than all other treatments under study.

Table 4.14: Effect of different propagation media on fresh and dry weight of roots in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Fresh weight of roots (g)	Dry weight of roots (g)
Sawdust (T_1)	49.60	25.10
Cocopeat (T_2)	61.90	32.60
Soil + FYM (T_3)	32.90	15.20
Vermicompost + Cocopeat (T_4)	55.42	25.50
Sawdust + Sand + Vermicompost (T_5)	53.20	24.20
CD $_{0.05}$	5.22	3.93

4.2.1.14 Dry weight of roots

A cursory glance of data presented in Table 4.14 reveals that propagation media had a significant effect on dry weight of roots in stool shoots of cherry rootstock 'Gisela-6'. The maximum dry weight of roots (32.60 g) was observed in stool shoots mounded with cocopeat propagation media (T_2). This treatment was significantly superior to all other treatments under study. However, minimum dry weight of roots (15.20 g) was recorded under T_3 (Soil + FYM) which was considerably lower than all other propagation media under study.

4.2.1.15 Fresh weight of shoots

The data with respect to effect of different propagation media on fresh weight of shoots in stools are presented in Table 4.15.

It is clear from the data that propagation media had a significant effect on fresh weight of shoots. The maximum fresh weight of shoots (235.30 g) was recorded in stools mounded with cocopeat (T_2), closely followed by T_1 i.e. sawdust (224.20 g). Both these treatments were statistically at par with each other and significantly superior to all other treatments under study. Whereas, minimum fresh weight of shoots (131.50 g) was observed under T_3 (Soil + FYM) which was significantly lower than all other treatments under study.

Table 4.15: Effect of different rooting media on fresh weight, dry weight and total plant biomass of shoots in stools of cherry rootstock 'Gisela-6'

Treatment	Fresh weight of shoots (g)	Dry weight of shoots (g)	Total biomass (g)
Sawdust (T_1)	224.20	127.20	152.30
Cocopeat (T_2)	235.30	135.38	166.00
Soil + FYM (T_3)	131.50	52.50	67.70
Vermicompost + Cocopeat (T_4)	189.40	79.40	104.90
Sawdust + Sand + Vermicompost (T_5)	198.30	84.10	108.30
$CD_{0.05}$	14.99	15.70	17.22

4.2.1.16 Dry weight of shoots

It is clear from the data presented in Table 4.15 that dry weight of shoots was significantly influenced by propagation media. The maximum dry weight of shoots (135.38 g) was recorded in stool mounded with cocopeat propagation media (T_2), closely followed by T_1 i.e. sawdust (127.20 g). Both these treatments were statistically at par with each other and significantly superior to rest of the treatments under study. However, minimum dry weight of shoots (52.50 g) was registered under soil + FYM propagation media (T_3) which was significantly lower than all the other treatments under consideration.

4.2.1.17 Total plant biomass (dry weight basis)

It is evident from the data presented in Table 4.15 that different propagation media significantly influenced the total plant biomass (roots + shoots). The maximum total plant biomass (166.00 g) was recorded in stool shoots subjected to T_2 (Cocopeat), closely followed by T_1 i.e. sawdust (152.30 g). Both these treatments were statistically at par with each other

and significantly superior to all other treatments under study. However, minimum total plant biomass (67.70 g) was observed in stool shoots mounded with soil + FYM propagation media (T_3) which was significantly lower than all the other treatments under consideration. It is worthy to be noted from Fig. 10 that there was an increase of and 124.96, 145.19, 54.94 and 59.97 per cent in total plant biomass under sawdust, cocopeat, vermicompost + cocopeat and sawdust+ sand+ vermicompost, respectively over control (Soil + FYM).

Present finding indicate that different propagation media had a significant influence on fresh and dry weight of roots, shoots and total plant biomass of cherry rootstock 'Gisela-6'. The highest root, shoot and total plant biomass was recorded in stool shoots mounded with cocopeat. This could be due to the higher number of roots, root diameter, total root length, shoot diameter and height of shoots under cocopeat propagation media in the present study (Table 4.10, 4.11 & 4.12). The formation of healthier roots, greater accumulation of food material, longer root lengths, and modifications in amino acid metabolism during root regeneration under cocopeat propagation media due to better availability of water and minerals could be the cause of higher fresh and dry weight of roots (Singh and Pandey 2009). The most likely cause for a gain in fresh and dry weight of shoot might be the greater utilization of carbohydrates, nitrogen, and other nutrients (Hakim et al. 2018). The higher total dry biomass of the plant could be the result of more accumulation of photosynthates. It is evident from the Table 4.16 of the present study that cocopeat as a propagation media had increased the photosynthetic rate of stool shoots which could have enhanced the total plant biomass.

The results of present study are partial supported by the findings of Rymbai et al. (2012), who had recorded considerably higher fresh and dry weight of roots in the air layers of guava under cocopeat + sphagnum moss propagation media. Similarly, Farooq et al. (2018) had also reported significant increase in fresh and dry weight of roots in grape cuttings grown in a mixture of canal silt + bagasse + cocopeat (1:2:1) propagation media. The findings are also in conformity with those of Vibhas (2019) and Malakar et al. (2019), who had recorded highest fresh and dry weight of roots in stem cuttings of kiwifruit and acid lime, respectively using cocopeat as a propagation media. Similarly, Thakur (2021) also recorded maximum fresh and dry weight of roots in hardwood cutting of kiwifruit with cocopeat + sand as a propagation media.

4.2.2 PHYSIOLOGICAL CHARACTERS

Physiological characters include leaf chlorophyll content, photosynthetic rate, transpiration rate, stomatal conductance and carbon partitioning in roots, shoots and leaves. The data pertaining to the effect of propagation media on physiological parameters of stool shoots of cherry rootstock 'Gisela-6' are presented in Table 4.16 to 4.18.

4.2.2.1 Leaf chlorophyll content

It is clear from the data presented in Table 4.16 that leaf chlorophyll content was significantly influenced by different rooting media. The maximum leaf chlorophyll content (2.43 mg/g) was recorded in stool shoots subjected to cocopeat propagation media (T_2) which was significantly higher than all other treatments under study. However, minimum leaf chlorophyll content (1.30 mg/g) was observed in stool shoots mounded with soil + FYM (T_3) which was statistically at par with T_1 (Sawdust) and significantly lower than rest of the treatments under consideration.

Table 4.16: Effect of different propagation media on leaf chlorophyll content and photosynthetic rate in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Leaf chlorophyll content (mg/g of fresh weight)	Photosynthetic rate (µmol CO_2 m^{-2} s^{-1})
Sawdust (T_1)	1.54	6.97
Cocopeat (T_2)	2.43	10.27
Soil + FYM (T_3)	1.30	6.73
Vermicompost + Cocopeat (T_4)	2.02	7.25
Sawdust + Sand + Vermicompost (T_5)	1.94	8.58
$CD_{0.05}$	0.25	2.16

4.2.2.2 Photosynthetic rate

The perusal of data given in Table 4.16 clearly indicates that different propagation media had a significant effect on photosynthetic rate of stool shoots. The highest photosynthetic rate (10.27µmol CO_2 m^{-2} s^{-1}) was observed in stool shoots treated with cocopeat propagation media (T_2) which was statistically at par with T_5 (Sawdust + Sand + Vermicompost) and significantly higher than all other growing media under study. The lowest photosynthetic rate (6.73µmol CO_2 m^{-2} s^{-1}) was noticed under T_3 (Soil + FYM) which was statistically at par with all other treatments except T_2 (Cocopeat).

4.2.2.3 Stomatal conductance

The data presented in Table 4.17 explains that stomatal conductance in stool shoots of cherry rootstock 'Gisela-6' was significantly influenced by different propagation media treatments. The stool shoots subjected to cocopeat propagation media(T_2) and Sawdust + Sand + Vermicompost (T_5) exhibited maximum stomatal conductance (0.29mol H_2O m^{-2} s^{-1}). These two treatments were significantly superior than all other treatments under study. However, minimum stomatal conductance (0.14 mol H_2O m^{-2} s^{-1}) was recorded under T_3 (Soil + FYM) which was significantly lower than all other treatments under consideration.

Table 4.17: Effect of different propagation media on stomatal conductance and transpiration rate in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Stomatal conductance (mol H_2O m^{-2} s^{-1})	Transpiration rate (mmol H_2O m^{-2} s^{-1})
Sawdust (T_1)	0.19	5.27
Cocopeat (T_2)	0.29	5.98
Soil + FYM (T_3)	0.14	4.89
Vermicompost + Cocopeat (T_4)	0.17	4.08
Sawdust + Sand + Vermicompost (T_5)	0.29	2.48
CD $_{0.05}$	0.02	1.23

4.2.2.4 Transpiration rate

It is evident from the data depicted in Table 4.17 that transpiration rate was significantly influenced by different propagation media treatments. The highest transpiration rate (5.98mmol H_2O m^{-2} s^{-1}) was recorded in stool shoots mounded with cocopeat propagation media (T_2). This treatment was statistically at par with T_1 (Sawdust) and T_3 (Soil + FYM) but significantly superior to T_4 (Vermicompost + Cocopeat) and T_5 (Sawdust + Sand + Vermicompost). Whereas, lowest transpiration rate (2.48 mmol H_2O m^{-2} s^{-1}) was observed under T_5 (Sawdust + Sand +Vermicompost) which was significantly lower than all other treatments under study.

Present study reveals that different propagation media had significantly influenced the physiological characteristics in stool shoots of cherry rootstock 'Gisela-6'. Cocopeat as propagation media was found to significantly increase the leaf chlorophyll content, photosynthetic rate, stomatal conductance and transpiration rate. This could be due to larger leaf area and more number of leaves under this treatment in the present study (Table 4.13)

which might have led to enhance leaf chlorophyll content. Higher water holding capacity of cocopeat perhaps maintained better moisture status in the stool shoots which could have increased the biosynthesis of the precursor of chlorophyll in leaves. Water stress conditions reduce the synthesis of chlorophyll precursor (Makhmudov 1983). Low moisture holding capacity of growing substrates affect the plant photosynthesis ability (Wei et al. 2008; Song and Lee 2010). Optimum water availability under cocopeat media to the plants increased the guard cell turgidity, cell size and leaf area which might have enhanced the photosynthetic rate, transpiration rate and stomatal conductance in stool shoots mounded with cocopeat.

Present results with respect to higher leaf chlorophyll content under cocopeat media aligned with the findings of Dhatrikarani (2019), who had reported a significant increase in chlorophyll content in stem cuttings of guava grown in cocopeat media. Similarly, Islam et al. (2023) had also recorded maximum leaf chlorophyll content in strawberry planted in cocopeat growing media. Alsmairat et al. (2018), also reported significant increase in transpiration of strawberry grown in cocopeat + perlite (4:1).

4.2.2.5 Carbon partitioning to roots

The perusal of data presented in Table 4.18 indicates that propagation media had a significant effect on carbon partitioning to the roots of stool shoots. The maximum carbohydrate contents (312.99 mg/g) in roots of stool shoots was observed under T_2 (Cocopeat), which was significantly higher than all other treatments under study. The minimum carbohydrate contents (97.42 mg/g) was recorded in stool shoots subjected to soil +FYM propagation medium (T_3) which was found significantly lower than all other propagation media under consideration.

Table 4.18: Effect of different propagation media on carbon partitioning to root, shoot and leaves in stool shoots of cherry rootstock 'Gisela-6'

Treatment	Carbohydrate contents (mg/g)		
	Roots	Shoots	Leaves
Sawdust (T_1)	224.15	59.62	16.24
Cocopeat (T_2)	312.99	94.67	54.83
Soil + FYM (T_3)	97.42	71.08	36.13
Vermicompost + Cocopeat (T_4)	173.68	82.78	25.38
Sawdust + Sand + Vermicompost (T_5)	154.76	88.79	21.57
CD $_{0.05}$	34.31	7.77	3.44

4.2.2.6 Carbon partitioning to shoots

A perusal of data given in Table 4.18 shows that carbon partitioning to shoot of cherry stools 'Gisela-6' was significantly affected by different propagation media. The maximum carbohydrate contents (94.67 mg/g) in stool shoots was registered under cocopeat propagation media (T_2) which was found statistically at par with T_5 (Sawdust + Sand + Vermicompost) and significantly higher than all other treatments. However, minimum carbohydrate contents (59.62 mg/g) was noticed in stool shoots mounded with sawdust (T_1) which was significantly lower than all other treatments.

4.2.2.7 Carbon partitioning to leaves

The data with respect to effect of different propagation media on carbon partitioning to leaves are presented in Table 4.18.

It is clear from the data that propagation media had a significant effect on carbon partitioning to the leaves of stool shoots. The maximum carbohydrate contents (54.83 mg/g) in leaves of stool shoots was recorded under T_2 (Cocopeat). This propagation media was found considerably superior to all other media under study. However, minimum carbohydrate contents (16.24 mg/g) was observed in stool shoots mounded with sawdust propagation media (T_1) which was significantly lower than all other treatments under consideration.

The results of present findings reveal that different propagation media had a significant influence on carbon partitioning to the roots, shoots and leaves in stool shoots of cherry rootstock 'Gisela-6'. The maximum carbohydrate accumulation was observed in stool shoots mounded with cocopeat propagation media. This increase in carbohydrate content could be attributed to higher photosynthetic rate of stool shoots under cocopeat media as evident from (Table 4.16) of present study, as a result of higher number of leaves and leaf area. Carbohydrate content in plant is positively correlated with the rate of photosynthesis (Arrijani and Setyawati 2023) and photosynthetic rate per unit leaf area is proportional to the number of photosynthetic cells per unit area (Warner and Edward 1993). More photosynthetic activity of leaves under cocopeat media perhaps increased the translocation of carbohydrates towards the sink (Abadi et al. 2020) and its accumulation in roots, stem and leaves. The results in the present study are in conformity with those of Barman et al. (2016), who reported higher leaf carbohydrate contents in jamun seedlings under fermented cocopeat growing media.

Chapter-5

SUMMARY AND CONCLUSION

The present investigation entitled **"Studies on propagation of cherry rootstocks through mound layering"** was carried out in Nursery Block of the Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the years 2023-2024. The results obtained during the course of study are summarized under following heads:

5.1 EXPERIMENT 1: EFFECT OF IBA TREATMENTS ON ROOTING AND GROWTH OF MOTHER STOOL SHOOTS OF CHERRY ROOTSTOCK

5.1.1 MORPHOLOGICAL CHARACTERS

5.1.1.1 Different IBA treatments significantly influenced the rooting percentage in stool shoots of cherry rootstock 'Gisela-5'. The stool shoots treated with IBA @ 4500 ppm (T_3) exhibited maximum rooting (97.50 %), whereas, minimum rooting (69.99 %) was recorded in stool shoots treated with 6500 ppm IBA (T_5).

5.1.1.2 The highest number of rooted shoot per mother stool (6.60) was recorded under T_3 (IBA @ 4500 ppm). However, lowest number of rooted shoots per mother stool (3.40) was observed under IBA @ 6500 ppm (T_5).

5.1.1.3 The maximum number of main roots per stool shoot (8.00) was observed in stool shoots subjected to IBA treatment of 4500 ppm (T_3). The minimum number of main roots per stool (2.80) was noticed in stool shoots kept under IBA treatment of 6500 ppm (T_5).

5.1.1.4 The maximum length of longest root (53.40 cm) was registered by stool shoots treated with IBA 4500 ppm (T_3) and the minimum length of longest root (24.00 cm) was noticed under stool shoots treated with IBA 6500 ppm (T_5).

5.1.1.5 The maximum diameter of the main root (8.46 mm) was recorded in stool shoots treated with IBA @ 4500 ppm (T_3) and the lowest diameter (3.04 mm) was found in stool shoots treated with IBA @ 6500 ppm (T_5).

5.1.1.6 The stool shoots treated with IBA @ 4500 ppm (T_3) exhibited highest total root length (9.13 m), whereas, minimum total root length (4.30 m) was recorded under IBA @ 6500 ppm (T_5).

5.1.1.7 The maximum height of the stool shoots of 'Gisela-5' (160.60 cm) was recorded with IBA @ 4500 ppm (T_3) and the minimum height of stool shoot (93.40 cm) was observed in stool shoots treated with IBA @ 6500 ppm (T_5).

5.1.1.8 Maximum diameter of shoots (14.17 mm) was recorded in stools subjected to IBA @ 3500 ppm (T_2) and lowest diameter of stool shoot (6.26 mm) was observed under IBA treatment of 6500 ppm (T_5).

5.1.1.9 The maximum proportion of graftable stool shoots (100.00 %) was obtained with treatment of IBA @ 3500 ppm (T_2) and 4500 ppm (T_3). However, minimum proportion of graftable stool shoots (75.47 %) was observed under IBA treatment of 6500 ppm (T_5).

5.1.1.10 Stool shoots subjected to 4500 ppm IBA treatment (T_3) attained maximum leaf area (29.91 cm^2), while, minimum leaf area (12.24 cm^2) was observed under IBA @ 6500 ppm (T_5).

5.1.1.11 The highest total number of leaves (576.80) per stool shoot was recorded with IBA @ 4500 ppm (T_3). However, minimum total number of leaves per stool shoot (159.60) was observed in stool shoots treated with 6500 ppm IBA (T_5).

5.1.1.12 The highest fresh weight of the roots (48.44 g) was recorded in stool shoots subjected to IBA treatment of 4500 ppm (T_3), whereas, minimum fresh weight of stool shoots (23.40 g) was observed under T_5 (IBA @ 6500 ppm).

5.1.1.13 The maximum dry weight of the roots (19.10 g) was recorded in stool shoots treated with IBA @ 4500 ppm (T_3), however, minimum dry weight of roots (6.50 g) was recorded under IBA treatment of 6500 ppm (T_5).

5.1.1.14 The highest fresh weight of shoots (132.60 g) was recorded in stool layers subjected to 3500 ppm of IBA (T_2) and minimum fresh weight of shoots (32.20 g) was observed in stool layers treated with IBA @ 6500 ppm (T_5).

5.1.1.15 The maximum dry weight of shoots (90.00 g) was recorded in stool layers treated with IBA @ 3500 ppm (T_2) and minimum dry weight of shoots (21.10 g) was noted in 6500 ppm IBA(T_5) treated stool layers.

5.1.1.16 The highest total plant biomass (105.60g) was recorded in stool shoots receiving IBA treatment of 3500 ppm (T_2), whereas, minimum total plant biomass (27.60 g) was found under IBA treatment of 6500 ppm (T_5).

5.1.2 PHYSIOLOGICAL CHARACTERS

5.1.2.1 Leaf chlorophyll content in stool shoots of cherry rootstock 'Gisela-5' was significantly influenced by different IBA treatments. The maximum leaf chlorophyll content (2.31mg/g) was recorded in stool shoots subjected to IBA @ 4500 ppm (T_3) and minimum leaf chlorophyll content (1.20 mg/g) was observed under IBA @ 6500 ppm (T_5).

5.1.2.2 The highest photosynthetic rate (13.49 μmol CO_2 m^{-2} s^{-1}) was observed in stool shoots treated with 4500 ppm of IBA (T_3), while minimum photosynthetic rate (5.51 μmol CO_2 m^{-2} s^{-1}) was recorded under T_5 (IBA @ 6500 ppm).

5.1.2.3 The highest transpiration rate (5.98 mmol H_2O m^{-2} s^{-1}) was observed in stool shoots receiving IBA @ 4500 ppm (T_3). However, minimum transpiration rate (2.48 mmol H_2O m^{-2} s^{-1}) was recorded under treatment T_5 (IBA @ 6500 ppm).

5.1.2.4 The maximum stomatal conductance (0.34 mol H_2O m^{-2} s^{-1}) was noted in stool shoots treated with 4500 ppm IBA (T_3) and minimum stomatal conductance (0.13 mol H_2O m^{-2} s^{-1}) was recorded under IBA @ 6500 ppm (T_5).

5.1.2.5 The highest carbohydrate content in roots (99.66 mg/g) was observed in stool shoots treated with IBA @ 4500 ppm (T_3), whereas, minimum carbohydrate content in roots (41.85 mg/g) was recorded under treatment T_5 (IBA @ 6500 ppm).

5.1.2.6 The maximum carbohydrate content in shoots (73.92mg/g) was recorded in layers subjected to IBA @ 4500 ppm (T_3) and minimum carbohydrate content (36.95 mg/g) was observed under IBA @ 2500 ppm (T_1).

5.1.2.7 The maximum carbohydrate content in leaves (42.92 mg/g) was recorded in stool shoots treated with 4500 ppm IBA (T_3), whereas, minimum carbohydrate content in leaves (28.13 mg/g) was observed in stool shoots treated with IBA @ 6500 ppm (T_5).

5.2 EXPERIMENT-2: EFFECT OF PROPAGATION MEDIA ON ROOTING AND GROWTH OF MOTHER STOOL SHOOTS OF CHERRY ROOTSTOCK

5.2.1 MORPHOLOGICAL CHARACTERS

5.2.1.1 Percentage of rooting in stool shoots of cherry rootstock 'Gisela-6' was significantly affected by different propagation media treatments. The stool shoots subjected to cocopeat media (T_2) exhibited maximum percentage of rooting

(100.00 %), however, minimum rooting (67.65 %) was recorded in stool shoots mounded with soil + FYM (T_3).

5.2.1.2 The highest number of rooted shoots per mother stools (7.80) was recorded under T_2 (Cocopeat), whereas, minimum number of rooted stools per mother stool (2.80) was observed under soil + FYM propagation media (T_3).

5.2.1.3 The maximum number of main roots per stool shoot (7.80) was registered by stools mounded with cocopeat (T_2) and minimum number of main roots per stool shoot (4.00) was observed under soil + FYM (T_3).

5.2.1.4 The maximum length of longest root (42.60 cm) was recorded in stool shoots mounded with sawdust (T_1). However, minimum length of longest root (29.00 cm) was observed under soil + FYM (T_3) as a propagation media.

5.2.1.5 The maximum diameter of main roots (6.30 mm) was exhibited by stool shoots subjected to cocopeat (T_2), while, minimum diameter of main roots (3.48 mm) was observed in stool shoots mounded with soil + FYM (T_3).

5.2.1.6 The highest total root length (9.86 m) was noticed in stool shoots treated with cocopeat (T_2) and minimum total root length (5.94 m) was observed under T_3 (Soil + FYM) rooting media treatment.

5.2.1.7 The maximum height of stool shoot (189.00 cm) was recorded under treatment T_2 (Cocopeat). However, minimum height of stool shoot (106.20 cm) was recorded under T_3 (Soil + FYM).

5.2.1.8 The maximum diameter of shoot (12.95 mm) was recorded in stools treated with cocopeat (T_2) as a propagation media and minimum diameter of the shoot (8.95 mm) was observed in soil + FYM propagation media (T_3).

5.2.1.9 The maximum proportion of graftable stool shoots (100 %) was recorded under treatment T_2 (Cocopeat) and T_4 (Vermicompost + Cocopeat). However, minimum proportion of graftable stool shoots (72.18 %) was recorded under soil + FYM (T_3).

5.2.1.10 The maximum leaf area (32.96 cm^2) was attained by stool shoots subjected to cocopeat (T_2) as propagation media and minimum leaf area (23.42 cm^2) was recorded under soil + FYM (T_3).

5.2.1.11 The highest number of leaves per stool shoot (317.60) was observed in stool shoots mounded with cocopeat (T_2), while, minimum number of leaves (216.80) was recorded under soil + FYM (T_3).

5.2.1.12 The highest fresh weight of the roots (61.90 g) was recorded in stool shoots mounded with cocopeat (T_2), whereas minimum fresh weight of roots (32.90) was observed under treatment T_3 (Soil + FYM).

5.2.1.13 The maximum dry weight of the roots (32.60 g) was observed in stool shoots mounded with cocopeat (T_2). However, minimum dry weight of roots (15.20 g) was recorded under T_3 (Soil + FYM).

5.2.1.14 The maximum fresh weight of shoots (235.30 g) was recorded under cocopeat (T_2) propagation media and minimum fresh weight of shoots (131.50 g) was recorded under soil + FYM (T_3).

5.2.1.15 The maximum dry weight of shoots (135.38 g) was noticed under stool shoots mounded with cocopeat (T_2). However, minimum dry weight of shoots (52.50 g) was observed under treatment T_3 (Soil + FYM).

5.2.1.16 The maximum total plant biomass (166.00 g) was observed in stool shoots subjected to cocopeat (T_2) propagation media, however, minimum total plant biomass (67.70 g) was recorded under treatment T_3 (Soil + FYM).

5.2.2. PHYSIOLOGICAL CHARACTERS

5.2.2.1 Different propagation media had a significant effect on leaf chlorophyll content in stool shoots of cherry rootstock 'Gisela-6'. The maximum leaf chlorophyll content (2.43 mg/g) was noted in stool shoots subjected to cocopeat (T_2) and minimum leaf chlorophyll content (1.30 mg/g) was observed under T_3 (Soil + FYM).

5.2.2.2 The highest photosynthetic rate (10.27 μmol CO_2 m^{-2} s^{-1}) was observed in stool shoots mounded with cocopeat (T_2). However, lowest photosynthetic rate (6.73 μmol CO_2 m^{-2} s^{-1}) was recorded under soil + FYM (T_3).

5.2.2.3 The highest stomatal conductance (0.29mol H_2O m^{-2} s^{-1}) was registered by stool shoots subjected to cocopeat (T_2) and sawdust + sand + vermicompost (T_5). However, minimum stomatal conductance (0.14 mol H_2O m^{-2} s^{-1}) was recorded in stool shoots subjected to soil + FYM (T_3).

5.2.2.4 The stool shoots treated with cocopeat (T_2) exhibited maximum transpiration rate (5.98 mmol H_2O m^{-2} s^{-1}), however, minimum transpiration rate (2.48 mmol H_2O m^{-2} s^{-1}) was recorded under T_5 (Sawdust + Sand + Vermicompost).

5.2.2.5 The maximum carbohydrate content in roots (312.99 mg/g) was observed in stool shoots mounded with cocopeat (T_2) and minimum carbohydrate content (97.42 mg/g) was recorded under soil +FYM (T_3).

5.2.2.6 The maximum carbohydrate content in shoots (94.67 mg/g) was found in layers mounded with cocopeat (T_2), whereas, minimum carbohydrate content in shoots (59.62 mg/g) was observed under treatment T_1 (Sawdust).

5.2.2.7 The maximum carbohydrate content in leaves (54.83 mg/g) was noticed in stool shoots mounded with cocopeat (T_2). However, minimum carbohydrate content in leaves (16.24 mg/g) was recorded under treatment T_1 (Sawdust).

5.3 CONCLUSIONS

On the basis of results obtained from the present study it can be concluded that application of IBA @ 4500 ppm to the stool shoots of cherry rootstock 'Gisela-5' was proved to be the most effective treatment for higher rooting and production of rootstocks with good root and shoot system. Among the different propagation media, cocopeat was found to be most effective treatment for multiplication of cherry rootstock 'Gisela-6' as this media resulted in significantly higher rooting and development of good root as well as shoot system.

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APPENDIX-I

Effect of IBA treatments on rooting and growth of mother stool shoots of cherry rootstock

ANOVA for rooting percentage

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	828.735			
Treatment	4	2,553.78	638.444	5.635	0.00501
Error	16	1,812.79	113.299		
Total	24	5,195.30			

ANOVA for number of rooted shoots per stool

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	3.04			
Treatment	4	29.44	7.36	6.083	0.00357
Error	16	19.36	1.21		
Total	24	51.84			

ANOVA for number of main roots perstool shoot

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	7.2			
Treatment	4	83.2	20.8	3.036	0.04855
Error	16	109.6	6.85		
Total	24	200			

ANOVA for length of longest root

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	1.379			
Treatment	7	1,678.93	239.847	221.736	0.00000
Error	14	15.144	1.082		
Total	23	1,695.45			

ANOVA for diameter of the main root (mm)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.356			
Treatment	7	13.125	1.875	6.686	0.00133
Error	14	3.926	0.28		
Total	23	17.408			

ANOVA for total root length

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.024			
Treatment	7	5.007	0.715	70.564	0.00000
Error	14	0.142	0.01		
Total	23	5.173			

ANOVA for height of the stool shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	2.335			
Treatment	7	660.076	94.297	22.383	0.00000
Error	14	58.98	4.213		
Total	23	721.39			

ANOVA for diameter of the stool shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	3.338			
Treatment	4	168.258	42.064	17.604	0.00001
Error	16	38.232	2.389		
Total	24	209.827			

ANOVA for Proportion of graftable rootstock (%) of the stool shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	3.338			
Treatment	4	168.258	42.064	17.604	0.00001
Error	16	38.232	2.389		
Total	24	209.827			

ANOVA for leaf area

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	1.073			
Treatment	7	119.542	17.077	27.66	0.00000
Error	14	8.644	0.617		
Total	23	129.259			

ANOVA for total number of leaves

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	3,852.24			
Treatment	4	448,874.24	112,218.56	84.373	0.00000
Error	16	21,280.56	1,330.04		
Total	24	474,007.04			

ANOVA for internodal length

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.698			
Treatment	4	0.893	0.223	0.802	0.54142
Error	16	4.453	0.278		
Total	24	6.044			

ANOVA for fresh weight of the roots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	53.137			
Treatment	4	1,701.42	425.354	30.27	0.00000
Error	16	224.835	14.052		
Total	24	1,979.39			

ANOVA for dry weight of the roots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	23.26			
Treatment	4	461.06	115.265	5.61	0.00511
Error	16	328.74	20.546		
Total	24	813.06			

ANOVA for fresh weight of the shoot

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	275.212			
Treatment	4	33,361.91	8,340.48	199.532	0.00000
Error	16	668.804	41.8		
Total	24	34,305.93			

ANOVA for dry weight of shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	189.44			
Treatment	4	15,195.84	3,798.96	136.298	0.00000
Error	16	445.96	27.872		
Total	24	15,831.24			

ANOVA for total plant biomass

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	336.76			
Treatment	4	19,956.86	4,989.22	155.931	0.00000
Error	16	511.94	31.996		
Total	24	20,805.56			

ANOVA for leaf chlorophyll content

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.074			
Treatment	4	5.332	1.333	13.101	0.00006
Error	16	1.628	0.102		
Total	24	7.034			

ANOVA for photosynthetic rate

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	20.534			
Treatment	4	163.095	40.774	19.346	0.00001
Error	16	33.722	2.108		
Total	24	217.351			

ANOVA for stomatal conductance

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	20.534			
Treatment	4	163.095	40.774	19.346	0.00001
Error	16	33.722	2.108		
Total	24	217.351			

ANOVA for transpiration rate

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	1.319			
Treatment	4	35.859	8.965	10.786	0.0002
Error	16	13.298	0.831		
Total	24	50.476			

ANOVA for carbohydrate content in roots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	18.815			
Treatment	4	12,409.87	3,102.47	249.6	0.00000
Error	16	198.876	12.43		
Total	24	12,627.56			

ANOVA for carbohydrate content in shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	22.496			
Treatment	4	5,139.15	1,284.79	359.422	0.00000
Error	16	57.194	3.575		
Total	24	5,218.84			

ANOVA for carbohydrate content in leaves

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	8.667			
Treatment	4	1,060.27	265.067	43.068	0.00000
Error	16	98.475	6.155		
Total	24	1,167.41			

APPENDIX-II

Effect of propagation media on rooting and growth of motherstool shoots of cherry rootstock

ANOVA for rooting percentage

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	108.615			
Treatment	4	3,182.69	795.672	12.59	0.00008
Error	16	1,011.20	63.2		
Total	24	4,302.50			

ANOVA for number of rooted shoots / mother stool

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	7.84			
Treatment	4	86.24	21.56	10.466	0.00023
Error	16	32.96	2.06		
Total	24	127.04			

ANOVA for Number of main roots per stool shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	11.36			
Treatment	4	43.36	10.84	10.68	0.00021
Error	16	16.24	1.015		
Total	24	70.96			

ANOVA for length of longest root

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	174			
Treatment	4	536	134	11.78	0.00012
Error	16	182	11.375		
Total	24	892			

ANOVA for diameter of main root

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	4.684			
Treatment	4	26.581	6.645	11.334	0.00015
Error	16	9.381	0.586		
Total	24	40.647			

ANOVA for total root length

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	5.27			
Treatment	4	50.15	12.54	27.126	0.00000
Error	16	7.40	0.46		
Total	24	62.82			

ANOVA for height of stool shoot

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	669.04			
Treatment	4	20,185.84	5,046.46	52.466	0.00000
Error	16	1,538.96	96.185		
Total	24	22,393.84			

ANOVA for diameter of stool shoot

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.56			
Treatment	4	55.625	13.906	11.112	0.00017
Error	16	20.024	1.252		
Total	24	76.209			

ANOVA for proportion of graftable rootstock

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	24.701			
Treatment	4	2,715.47	678.867	8.768	0.0006
Error	16	1,238.75	77.422		
Total	24	3,978.92			

ANOVA for leaf area

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.754			
Treatment	4	270.967	67.742	40.777	0.00000
Error	16	26.581	1.661		
Total	24	298.302			

ANOVA for total number of leaves

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	10,233.84			
Treatment	4	33,938.64	8,484.66	8.805	0.00059
Error	16	15,417.36	963.585		
Total	24	59,589.84			

ANOVA for internodal length

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.614			
Treatment	4	2.638	0.659	2.294	0.10417
Error	16	4.598	0.287		
Total	24	7.85			

ANOVA for fresh weight of the root

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	50.345			
Treatment	4	2,359.87	589.966	39.532	0.00000
Error	16	238.782	14.924		
Total	24	2,648.99			

ANOVA for dry weight of the root

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	23.64			
Treatment	4	767.74	191.935	22.687	0.00000
Error	16	135.36	8.46		
Total	24	926.74			

ANOVA for fresh weight of the shoot

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	485.06			
Treatment	4	32,742.46	8,185.62	66.616	0.00000
Error	16	1,966.04	122.877		
Total	24	35,193.56			

ANOVA for dry weight of the shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	633.683			
Treatment	4	24,166.23	6,041.56	44.806	0.00000
Error	16	2,157.40	134.837		
Total	24	26,957.31			

ANOVA for total plant biomass (dry weight basis)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	567.26			
Treatment	4	31,296.76	7,824.19	48.207	0.00000
Error	16	2,596.84	162.302		
Total	24	34,460.86			

ANOVA for total leaf chlorophyll content

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.045			
Treatment	4	3.894	0.974	26.593	0.00000
Error	16	0.586	0.037		
Total	24	4.525			

ANOVA for photosynthetic rate

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	17.458			
Treatment	4	43.629	10.907	4.254	0.01559
Error	16	41.025	2.564		
Total	24	102.112			

ANOVA for stomatal conductance

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	0.005			
Treatment	4	0.093	0.023	56.41	0.00000
Error	16	0.007	0		
Total	24	0.104			

ANOVA for transpiration rate

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	1.243			
Treatment	4	9.121	2.28	6.564	0.00252
Error	16	5.558	0.347		
Total	24	15.921			

ANOVA for carbohydrate content in roots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	7,897.15			
Treatment	4	131,701.31	32,925.33	51.124	0.00000
Error	16	10,304.45	644.028		
Total	24	149,902.91			

ANOVA for carbohydrate content in shoots

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	135.005			
Treatment	4	3,967.40	991.851	29.995	0.00000
Error	16	529.068	33.067		
Total	24	4,631.48			

ANOVA for carbohydrate content in leaves

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	4	19.747			
Treatment	4	4,663.95	1,165.99	180.156	0.00000
Error	16	103.553	6.472		
Total	24	4,787.25			

Department of Fruit Science
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Title of the Thesis	:	**Studies on propagation of cherry rootstocks through mound layering**
Name of the Student	:	Riya Chauhan
Admission Number	:	H-2022-25-M
Major Field	:	M.Sc. Horticulture (Fruit Science)
Minor Field(s)	:	Plant Physiology
Date of Thesis Submission	:	
Total Pages of the Thesis	:	73 + viii
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Abstract

The present study entitled, "Studies on propagation of cherry rootstocks through mound layering" was carried under open field condition in the Nursery Block of the Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India, during the years 2022-2023. The study was composed of two experiments, the first experiment was conducted to study the effect of IBA treatments on rooting and growth of stool shoots of cherry rootstock 'Gisela-5'. There were 5 treatments *viz*., IBA @ 2500 ppm (T_1), IBA @ 3500 ppm (T_2), IBA @ 4500 ppm (T_3), IBA @ 5500 ppm (T_4) and IBA @ 6500 ppm (T_5). The second experiment was conducted to assess the effect of propagation media on rooting and growth of stool shoots of cherry rootstock 'Gisela-6'. This experiment includes 5 treatments *viz*., Sawdust (T_1), Cocopeat (T_2), Soil+FYM (T_3), Vermicompost + Compost (T_4) and Sawdust + Sand + Vermicompost (T_5). Both experiments were laid out in randomized block design (RBD) and treatments were replicated five times. Results of the study revealed that different IBA and propagation media treatments had significant effect on rooting and growth of stool layers. Amongst IBA treatments, maximum rooting percentage (97.50 %), number of rooted shoots per stool (6.60), number of main roots per stool shoot (8.00), length of longest root (53.40 cm), diameter of main root (8.46 mm), total root length (9.13 m), height of the stool shoots (160.60 cm), leaf area (29.91cm^2), total number of leaves (576.80) and root fresh weight (48.44 g) and dry weight (19.10 g) was recorded under T_3 (IBA @ 4500 ppm) however, proportion of graftable rootstocks (100 %) was recorded under both T2 (IBA @ 3500 ppm) and T3 (IBA @ 4500 ppm). Similarly, highest leaf chlorophyll content (2.31 mg/g), photosynthesis rate (13.49 µmol CO_2 m^{-2} s^{-1}), transpiration rate (5.98 mmol H_2O m^{-2} s^{-1}), stomatal conductance (0.34 mol H_2O m^{-2} s^{-1}) and carbohydrate content in roots (99.66 mg/g), shoots (73.92 mg/g) and leaves (42.92 mg/g) was noted in the same treatment. However, maximum diameter of the stool shoots (14.17 mm), shoot fresh weight (132.60 g), dry weight (90.00 g) and total plant biomass (105.60 g) was observed under IBA @ 3500 ppm (T_2). An increase of 9.08, 13.38, 5.20 and -18.60 per cent in rooting, 33.77, 52.67, 82.00 and -28.00 per cent in total root length, 2.65, 6.40, 0.53 and -38.06 per cent in height of the stool shoots, 14.14, 14.14, 8.33 and -13.85 per cent in proportion of graftable stools and 22.30, 18.90, 6.80 and -55.70 per cent in total plant biomass was noticed under treatments T_2, T_3, T_4 and T_5, respectively over T_1 (IBA @ 2500 ppm). Amongst different propagation media, maximum rooting (100 %), number of rooted shoots per stool (7.80), number of main roots per stool shoot (7.80), diameter of main root (6.30 mm), total root length (9.86 m), height of the stool shoots (189.00 cm), diameter of the stool shoots (12.95 mm), leaf area (32.96 cm^2), total number of leaves (317.60), root fresh weight (61.90 g) and dry weight (32.60 g), shoot fresh weight (235.30 g) and dry weight (135.38 g) and total plant biomass (166.00 g) was recorded in stool shoots mounded with cocopeat (T_2). This treatment also exhibited highest leaf chlorophyll content (2.43 mg/g), photosynthesis rate (10.27 µmol CO_2 m^{-2} s^{-1}), transpiration rate (5.98 mmol H_2O m^{-2} s^{-1}), carbohydrate content in roots (312.99 mg/g), shoots (94.67 mg/g) and leaves (54.83 mg/g) while, stomatal conductance (0.29 mol H_2O m^{-2} s^{-1}) was recorded under T_2 (Cocopeat) and T_5 (Sawdust + Sand + Vermicompost). However, maximum length of longest root was observed under T_1 (sawdust) and maximum proportion of graftable rootstocks was noted under T_2 (Cocopeat) as well as T_4 (Vermicompost + Cocopeat). There was seen an increase of 18.40, 47.81, 39.18 and 29.75 per cent in rooting, 25.42, 65.99, 57.23 and 26.26 per cent in total root length, 48.77, 66.66, 54.42 and 77.96 per cent in height of stool shoots, 21.44, 38.54, 38.54 and 31.61 per cent in proportion of graftable rootstocks and 124.96, 145.19, 54.94 and 59.97 per cent in total plant biomass under sawdust (T_1), cocopeat (T_2), soil + FYM (T_3), vermicompost + cocopeat (T_4) and Sawdust + Sand + Vermicompost (T_5), respectively over soil + FYM (T_3). Thus, application of IBA @ 4500 ppm to the stool shoots and mounding of stool shoots with cocopeat propagation media can be recommended for successful multiplication of cherry rootstocks 'Gisela-5 and 'Gisela-6'.

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