

**“Standardization of Kiwifruit (*Actinidia deliciosa*) Propagation Techniques
through Cuttings”**

A thesis submitted to

Uttar Banga Krishi Viswavidyalaya

In partial

Fulfilment of the requirements for the award of the Degree of

MASTER OF SCIENCE (HORTICULTURE)

IN

FRUIT SCIENCE

By

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(H-2019-15-M)



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The assistance and help received from various sources during the course of investigation have been duly acknowledged.


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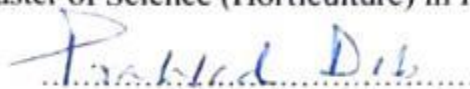
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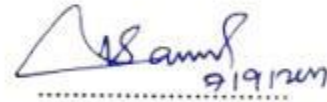
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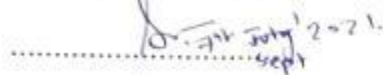
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ABSTRACT

The kiwifruit (*Actinidia deliciosa*) is the edible berry of a woody vine in the genus *Actinidia*. In ancient times, kiwifruit was a remedy for digestive disturbances, rheumatism, dyspepsia, diminution of skin disorders in China and later it has gained worldwide popularity since consumers associated the consumption of kiwi fruits with potential health effects. Kiwifruit is a dioecious plant, belonging to family Actinidiaceae and native to China. Propagating through sexual means is not much successful in kiwi as it is with the vegetative propagation specially stem cuttings. Kiwifruit is considered as temperate fruit crops having some chilling requirement. It has a potentiality to grow in the Darjeeling & Kalimpong districts of West Bengal. However, the availability of planting materials with reasonable cost is one of the limiting factors for expansion of the areas in the areas of eastern Indian states. Thus an experiment was conducted at the Experimental Farm of Darjeeling Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Dalapchand, Kalimpong during December 2020 to July 2021 with Factorial Randomized Block Design having sixteen treatment combinations replicated thrice. There were three factors such as girdling, etiolation and growth promoter (IBA). Girdling consisted of two levels, girdled and non-girdled, etiolation with etiolated and non-etiolated and growth promoter (IBA) consisted of four levels (0, 3000 ppm, 4000 ppm and 5000 ppm). It may be concluded from the study that, T₁₆ (girdling + etiolation + IBA @5000 ppm) showed better response for number of days taken for sprouting (77 days), length of the sprout (2.07 cm), sprouting percentage (68.33%), number of roots of cuttings (5), rooting percentage (68.33 %), number of days taken for rooting (87.33 days), longest root length (5.90 cm), survival percentage (64.53 %), mortality rate (46.02 %) and T₈ (etiolation + IBA@ 4000 ppm) was effective in number of leaves per shoot (5.67). From this experiment, it can be concluded that girdling and etiolation had a positive effect on the kiwifruit cuttings and growth promoter (IBA @5000 ppm) gave the best results.

Keywords: Girdling, Etiolation, Growth Promoter, Kiwifruit, Cuttings

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INTRODUCTION

The kiwifruit (*Actinidia deliciosa*) is an edible berry of a woody vine in the genus *Actinidia* (Stirk, 2005). In ancient times, in China, kiwifruit was a remedy for digestive disturbances, rheumatism, dyspepsia, diminution of skin disorders and lately has gained worldwide popularity since consumers associated the consumption of kiwi fruits with possible health effects (Singletary, 2012). Kiwifruit is a dioecious plant, with separate male and female plants belonging to family Actinidiaceae and native to China (Ali *et al* 2017b). *Actinidia* species are perennial, present vigorous growth and has climbing and strangling characteristics (Cangiet *al* 2006). It is a large, vigorous, woody deciduous vine and can reach over 10 meters in length. It starts bearing in 3rd year while commercial bearing starts up from 5th year. The genus contains more than 50 species scattered in the temperate and subtropical regions of the Asian continent. All member of the genus *Actinidia* are functionally dioecious, with pistillate and staminate flowers occurring on the separate plants (Ferguson, 1990).

To determine gender of kiwi, we have to wait for the plant till flowering. The difference between the sex of male and female kiwi vines can be only differentiated by the flowers. Looking at the difference between male and female kiwi vines we will know whether the plant will yield fruits or not. The identification of the female kiwi vines can be done by the flowers with long sticky stigmas going out from the center of the flower. The female flowers also do not produce any pollen. When determining the sex of kiwi blooms, the female will also have bright white, well defined ovaries at the base of the flower, which is not present in males.

Kiwi has been introduced in the last 15 years and actually covers about 30 hectare in all the country, with an intensive growing trend. Fruit trees are highly heterozygous in nature, hence propagation by seed never yields a true to type offspring and therefore, the asexual methods of propagation are employed to overcome this problem. Their seeds are not guaranteed to produce plants with desirable characteristics (bloom time, cane growth, fruit shape, or edibility) present in either parent plant. They also have a very long juvenile phase which may go upto seven years before even sex determination can be carried out which is one of the most important factor in establishing a kiwi orchard and also for propagation. Because of these complications kiwifruit propagation is only done by seed for breeding purpose and developing

new cultivars or to produce rootstocks. The use of semi-hardwood cuttings is one of the easiest methods of vegetative propagation.

Richardson *et al* (2018) stated that the nutritional composition, the high amount of vitamin C, supports its position as a well nutritious, low energy fruit. With the excess of man-made, processed health foods available to the consumer, one aspect that sets kiwifruit apart is that it is a natural, whole food this tart fruit can improve heart health, digestive health, and immunity. Antioxidants present in the fruit help to get rid of free radicals within the body and decrease oxidative stress. Eventually this may protect the body from inflammation and disease. Its tart flavor, pleasing texture, and lowcalorie count make it a delicious and healthy option for snacking, sides, or a unique dessert.

Kiwi can be grown in areas which can provide 700-800 chilling hours (no. of hours during which temperature remains at or below 7⁰ C during the winter season). The plant can be grown at 800-1500 m. or above main sea level. 150 cm. per year of rainfall is adequate. The rainfall should be well distributed during the growing period. The plant does not hold out strong winds and frost during the growing period because of its vigorous vegetative growth, large leaves and viny habit.

Kiwi vine commercial production starts at the age of 7-8 years but they start bearing from the age of 4-5 years. The fruits mature later at high altitudes because of variation in temperature and earlier at lower altitude. Large sized berries are harvested first while smaller ones are allowed to increase in size. After harvesting, the fruits are rubbed with a rough cloth to remove the stiff hairs found on their surface. Hard fruits are transported to the market. Subsequently, they lose their firmness in two weeks and become

Cutting propagation is the most important means of clonal regeneration of many horticultural crops such as fruit, nuts, ornamentals (Hartmann *et al* 2002). Another study showed that kiwi plants obtained by micro-propagation had higher growth rates over plants from cuttings, but the fruit yields were the same over a six year period (Xiloyannis *et al* 1997). The production of kiwifruit more quickly and cheaply would be of considerable commercial value, and growing cuttings on their own roots could achieve this purpose by eliminating the need for rootstocks as well as for budding and grafting. Previous researches have shown that kiwifruit cuttings are characterized by a variable rooting ability (Manfroiet *al*1997). Hartmann *et al* (1997) reported that the auxins stimulated and speeder up the cutting's rooting Kiwi multiplication is

generally carried out through sexual reproduction and by vegetative propagation using stems and roots for new plants.

Auxin is one of the most important PGRs regulating the speed of rooting. Plants produce natural auxin in their branches and young leaves, but synthetic auxin (Miri-narges and Sedaghathoo2015).The propagation for stem cuttings is the usual method for the multiplication of the plant (Bosman &Uys, 1978).Propagating through sexual means is not much successful in kiwi as it is with the vegetative propagation specially stem cuttings. In the multiplication through hardwood cuttings low rooting percentage were observed. On the other hand, in the propagation for semi hardwood cuttings up to 90% of rooting were observed. Thus, this method could be used for fast multiplication (Bosman &Uys, 1978).

The need of nursery plants is high and nurseries are facing technical problems. Thus, research has been carried out to optimize the propagation methods and improve the efficiency of production Çakalliet al (2017).*Actinidia* are of commercial importance in the world out of which seven species are used as ornamental vine and three other species including *Actinidia chinensis*, *A. arguta*, and *A. kolomickta* are used to produce fruit. Among these three species, *A. chinensis* has special economic importance owing to its high quality for exporting (Ebrahimi, 1981).

Kiwifruit is considered as temperate fruit crops having some chilling requirement. Apart from north western Himalayan states it is grown successfully in few areas of north eastern states of India. It has also potentiality to grow in the Darjeeling & Kalimpong districts of West Bengal. However, the availability of planting materials with reasonable cost is one of the limiting factors for expansion of the areas in the areas of eastern Indian states. Considering the foregoing points and economic importance of kiwifruit the present experiment was carried out with the following objectives:

- a.To find out the effect of girdling, etiolation and growth promoter (IBA) for sprouting and rooting characteristics of kiwifruit.
- b. To find out the most suitable combination of treatments for the Hill Agro-climatic Zone of West Bengal

REVIEW OF LITERATURE

The present investigation entitled “**Standardization of Kiwifruit (*Actinidia deliciosa*) Propagation Techniques through Cuttings**” was conducted during the year 2020-2021. Important review of literature relevant to this investigation is discussed in this chapter.

2.1 Effect of rooting hormone in stem cuttings

Goswami (1995) treated the hardwood cuttings of kiwifruit cv. Allison with IBA (1000 – 6000 ppm) as quick dip (5 seconds) and planted in open field conditions and recorded maximum rooting (50.73 %) and survival (60.18 %) percentage with 6000 ppm IBA. Maximum number of adventitious roots (11.70), number of tertiary roots (77.37), maximum root length (8.40 cm) total root length (111.70 cm), fresh weight of shoot (37.0 g), dry weight of shoot (12.52 g) was recorded when treated with IBA (6000 ppm) however, maximum length of shoot (35.40 cm), number of leaves (15.95), total leaf area (942.8 cm) was recorded under 4000 ppm IBA.

The propagation through cuttings is most rapid and suitable method of multiplication. Stem cuttings viz. hard wood, semi-hardwood and soft wood are quite successful, with different degree of rooting success. The application of root promoting growth regulatory substances, especially auxins is the most common treatment to enhance rooting in stem cuttings (Hartmann *et al* 1997).

Manfroiet *al* (1997) found that semi-hardwood cuttings of kiwifruit cv. Monty when treated with 2000, 6000 or 8000 ppm IBA and placed in clay, sand and manure (1:1:1) medium showed no effect on rooting percentage, however they recorded significant increase in average shoot length, shoot dry weight and root dry weight.

Kishore *et al* (2001) assessed the effect of different concentrations of IBA (0, 2500, 3000, 3500 and 4000 ppm) and rooting medium on root initiation and root development of hardwood cuttings of kiwifruit (Hayward, Monty, Tomuri, Abbott, Bruno and Allison) planted in beds containing either sand or sawdust rooting medium. Highest rooting percentage was obtained with IBA (3000 ppm) with both sand and sawdust rooting media.

A considerably higher percentage of rooting was obtained with the apical cuttings of different kiwifruit cultivars treated with IBA (5000 ppm). The length of primary roots and survival of rooted cuttings was observed highest in IBA @ 5000 ppm (Rana and Jindal, 2001).

Ercisliet *al* (2002) observed that hardwood stem cuttings of kiwifruit cv. Hayward treated with the bacteria, and IBA plus bacteria were found to promote rooting. Highest rooting percentage was obtained from cuttings treated with 4000 ppm IBA plus.

Ercisliet *al* (2002) observed that treatment of cuttings with IBA enhanced rooting. Rooting was significantly higher in cuttings in peat+perlite and peat+ sawdust media than the others. However, the lowest rooting percentage was obtained from sawdust medium. For the most of media, the rooting increased with IBA concentration up to 6000 ppm.

Ozenc and Ozenc (2007) studied the effect of different concentrations of IBA @2000, 4000 and 6000 ppm and growing media on root growth of kiwifruit cuttings under mist propagation in greenhouse conditions and observed IBA @6000 ppm concentration gave highest rooting of cuttings and root length, followed by with IBA.@2000 ppm

Alamet *al* (2007) reported that maximum plant survival (33.33%), number of roots (5.0), root length (16.0 cm), root weight (2.3 g), root diameter (3.0 cm), number of leaves (11.0), shoot diameter (4.0 cm) was obtained in cuttings of kiwifruit cv. Hayward and in cultivar Abbott plant survival (10.0 %), number of roots (5.0), root length (15.0 cm), root weight (2.3 g), root diameter (3.0 cm), number of leaves (13.0), shoot diameter (4.3 cm) when treated with IBA @4000 ppm.

Singh *et al* (2008) treated the semi-hardwood cuttings of kiwifruit with IBA @4000 ppm along with pinching resulted in higher rooting percentage, number of roots/cutting, length of primary and secondary roots, however IBA (5000 ppm) along with shoot pinching gave the maximum root weight in semi-hardwood cutting.

Razaghiet *al* (2010) obtained the highest root fresh weight under the treatment of 6000 mg/l IBA and 6000 mg/l IBA + 2000 mg/l NAA.

Higher rooting percentage in the “AU Golden Sunshine” cuttings were observed with 5000 ppm and 10,000 ppm IBA over the control(Sims, 2011)

Kiwifruit cuttings are tough to root in nature. Application of some plant growth retardants together with IBA has been reported to improve rooting ability and survival in several plant species (Hartmann *et al* ,2011)

Miri-narges and Sedagathoo (2015) reported that semi-hardwood cuttings of kiwifruit treated with IBA @4000 mg/l gave maximum callus percentage (100 %) and fresh (0.70 g) and

dry (0.07 g) weight of callus. Maximum length of the longest root (2.01 cm) was obtained with Sand × Matua × IBA (4000 mg/l) whereas maximum diameter of roots (0.80 mm) was obtained under Sand×Matua× NAA (2000 mg/l).

Sharma *et al* (2015) brought into being by treating and recording IBA 5000ppm the best root characteristics (per cent rooted cuttings, number of primary roots secondary roots, length of roots total root length, root biomass); shoot characteristics (shoot length, shoot diameter, shoot biomass) and leaf characteristics (number of leaves and leaf area) in both hardwood and semi-hardwood cuttings. They concluded hardwood cuttings showed better results on root characteristics compared to semi-hardwood cuttings. However, semi-hardwood cuttings gave better results on shoots and leaf characteristics

Peticilăet *al* (2016a) recommended treatment with NAA+IBA 1000 ppm for rooting stimulation in which the best results were recorded for kiwifruit cv.Jumbo.

The best rooting parameters were found when NAA+IBA 1000 ppm solution was used for *kiwifruit* cv. Hayward with rooting (73.1%), number of formed roots(17.2) and root length (19.3 cm/cutting) (Peticilăet *al.*,2016b).

Çakalliet *al* (2017) demonstrated that the use of both hormones IBA and IAA has improved rooting compared to control. The IBA solution 1000 ppm was responsible for an additional rooting of 24.1% and 20% compared to control. In general, the bioregulators have promoted the differentiation of callus and root meristem. The amount of rooting was correlated to the dose and type of bioregulators, showing a pronounced variance in favor of 1000 ppm concentration.

Ali *et al* (2017a) investigated the effect of IBA (1500, 2500 and 3500 ppm) + Paclobutrazol (500 ppm) on the rooting response of semi-hardwood cuttings of kiwifruit under zero energy polyhouse and the results reveals that the treatment of IBA at 3500 ppm + Paclobutrazol 500 ppm provided best results of rooting percentage (63.33 %), number of primary roots (7.59), number of secondary roots (49.59), average root length (10.50 cm), length of longest root (13.53 cm), diameter of longest root (1.25 mm) and survivality of rooted cutting percentage (93.33 %).

Ali *et al* (2017b) recorded maximum rooting percentage of 56.94 when IBA was applied at 3500 ppm followed by 53.61 at IBA application of 2500 ppm. IBA @3500 ppm increased the

number of roots per cutting, number of secondary roots per cutting, average root length (cm) and other parameters with respect to control.

Bishwas *et al* (2018) observed that GA₃ primed seed have faster germination rate and lower mean germination time than hydro-primed seed. Seed germination can be enhanced by treating 4000-6000ppm GA₃ for Abbot, Allison while Bruno requires no pre-treatments of seeds.

Ali *et al* (2018) concluded that kiwifruit initiate best cutting growth, sprouting percentage and took less time with IBA@3000ppm.

Khan *et al* (2020) concluded that IBA @ 3000 ppm was optimum for better seedlings growth and evaluation of seedlings root systems architecture and seedling growth attributes could be used to predict the field performance of seedlings.

2.2 Effect of planting time in stem cuttings

Casini *et al* (1978) reported that mist propagation of kiwifruit cv. Hayward cuttings treated with IBA (4000 ppm) was more successful.

Lawes and Sim (1980) opined that root cuttings taken in winter and spring and placed horizontally in trays of sand on a heated mist bench provided an effective method of propagation of kiwifruit, cv. Abbott. Shoot regeneration from root cuttings was increased by treatment with sucrose and benzylaminopurine.

Beylet *et al* (1995) found out that the best cuttings for root formation had eight to nine buds (with three to four in active growth), diameters <2 mm, and lengths >10 cm. Cuttings with five to seven buds (with one to three in active growth), diameters between 2 to 8 mm, and lengths >8 cm exhibited the best root development in terms of number of roots formed, root length, and root grade.

Stem cuttings of kiwifruit (Hayward, Allison, Bruno, Monty, Abbott and Tomuri) taken in February gave better results in all the cultivars ranging from 15.0 to 43.0 per cent rooting when treated with IBA @ 1000 ppm (Verma *et al.*, 1996).

Rooting process of the kiwi cv Bruno stem cuttings was best during summer even without necessity of auxin treatments (Ono *et al.*, 1999).

Higher rooting percentages were observed when shoots were collected in February rather than in January (Ercisli *et al.*, 2002).

Cuttings taken in July had better rooting ability in terms of main root numbers, the mean length of the longest 5 roots and rooting area (Ucleret *et al.*, 2003)

Miri-narges and Sedaghatoo (2015) observed that Hayward produced the highest root fresh weight and the lowest root fresh weight was observed in cv. Bruno.

Rahman *et al.* (2015) opined that kiwi fruit cutting planted in the month of February showed good results for most of the parameters

Sharma *et al.* (2015) concluded that the best rooting performance in terms of per cent rooted cuttings, number of primary and secondary roots, length of the longest root, total root length, fresh and dry weight of roots and shoots per cutting were recorded in semi-hardwood cuttings prepared in mid-July, whereas, the best results for various shoot and leaf characteristics, viz., shoot length, shoot diameter, shoot biomass, leaf number and leaf area, were noticed with hardwood cuttings prepared in mid-January.

Thangamani *et al.* (2020) said that among the different type of cuttings and the season of collection, semi hardwood cuttings collected during June and July has higher survival percentage and performing propagation during this season was found to be suitable for successful planting material production.

2.3 Effect of rooting percentage on different rooting media

Carman (1980) studied the influence of rooting media and growth regulators on rooting of cuttings in kiwifruit and obtained highest rooting (72.70 %) in hardwood cuttings treated with IBA (1 %) + NAA (0.50 %) solution and planted in peat + washed sand media.

Tuet *et al.* (1991) revealed that vermiculite as the rooting medium, the cuttings held in full sunshine gave a much higher percentage of rooted cuttings, and a more rapid root production than those held in the shade

Shylla *et al.* (2000) studied the effect of ten different rooting media on various rooting parameters of hardwood cuttings of kiwifruit under polyhouse conditions and obtained highest rooting and root growth under sawdust + soil (2:1) medium.

Ercisliet *al* (2002) found out that the highest rooting percentage obtained in peat+perlite and peat+sawdust media in both months. Higher rooting percentages were obtained when shoots were collected February rather than January

Rana *et al*(2004) treated kiwifruit cuttings (summer and winter) of Allison and Abbott with IBA (0, 2000, 4000 and 6000 ppm) and observed that IBA @ 4000 ppm increased the rooting percentage and number of roots. Cuttings prepared at the active growth stage (July-August) gave better results than those prepared in the dormant season.

Chhukit (2009) evaluated different rooting media combinations consisting of cocopeat, vermicompost, forest leaf compost, sand and soil for rooting in hardwood cuttings of kiwifruit treated with 5000 ppm IBA. The results revealed that highest rooting (67.64%), number of adventitious roots (16.67) length of longest root (30.63 m), total root length (22.90 m), number of leaves per plant (15.60), leaf area (56.95 cm²) and shoot length (43.16 cm) was recorded in sand + forest leaf compost + cocopeat (1:1:1).

Chandel and Chhukti (2013) recorded highest rooting, total root length and growth of rooted plants in hard-wood cuttings of cultivar Hayward in sand + forest leaf compost + cocopeat rooting media. The rooting percentage varies with the type and node per cuttings.

Gjeloshiet *al* (2014) experimented and found out thatthat greenwood and semi-hardwood cuttings of planted in substrate prelate-peat(60:40) rooted better than cuttings of planted in substrate only prelate, in both planting periods. The highest rooting percentages were achieved using semi-hardwood cuttingsplanted in 5thSeptember.

The maximum diameter of roots was obtained under Sand × Matua× NAA2000 mg/l and sand + perlite was found to be the most suitable substrate for rooting of kiwifruit cuttings (Miri-narges and Sedaghathoo, 2015).

Kiwi cuttings planted in February in soil media with combination of (Silt: Clay: FYM at the ratio of 2:1:1) was better for growth and development (Rahman *et al.*, 2015).

MATERIALS AND METHODS

The study “**Standardization of Kiwifruit (*Actinidia deliciosa*) Propagation Techniques through Cuttings**” was conducted from December 2020 to July 2021. The details of the experimental materials used, methods followed and the statistical Techniques adopted during the course of study is described below.

3.1 Experimental Site

The experimental was carried out at the Darjeeling Krishi Vigyan Kendra, Dalapchand Farm, Kalimpong, Uttar Banga Krishi Viswavidyalaya at 27°05'45.3"N latitude and 88°32'46.0"E longitude about 1200 m above main sea level.

Table 3.1. 1. Chemical properties of the experimental soil

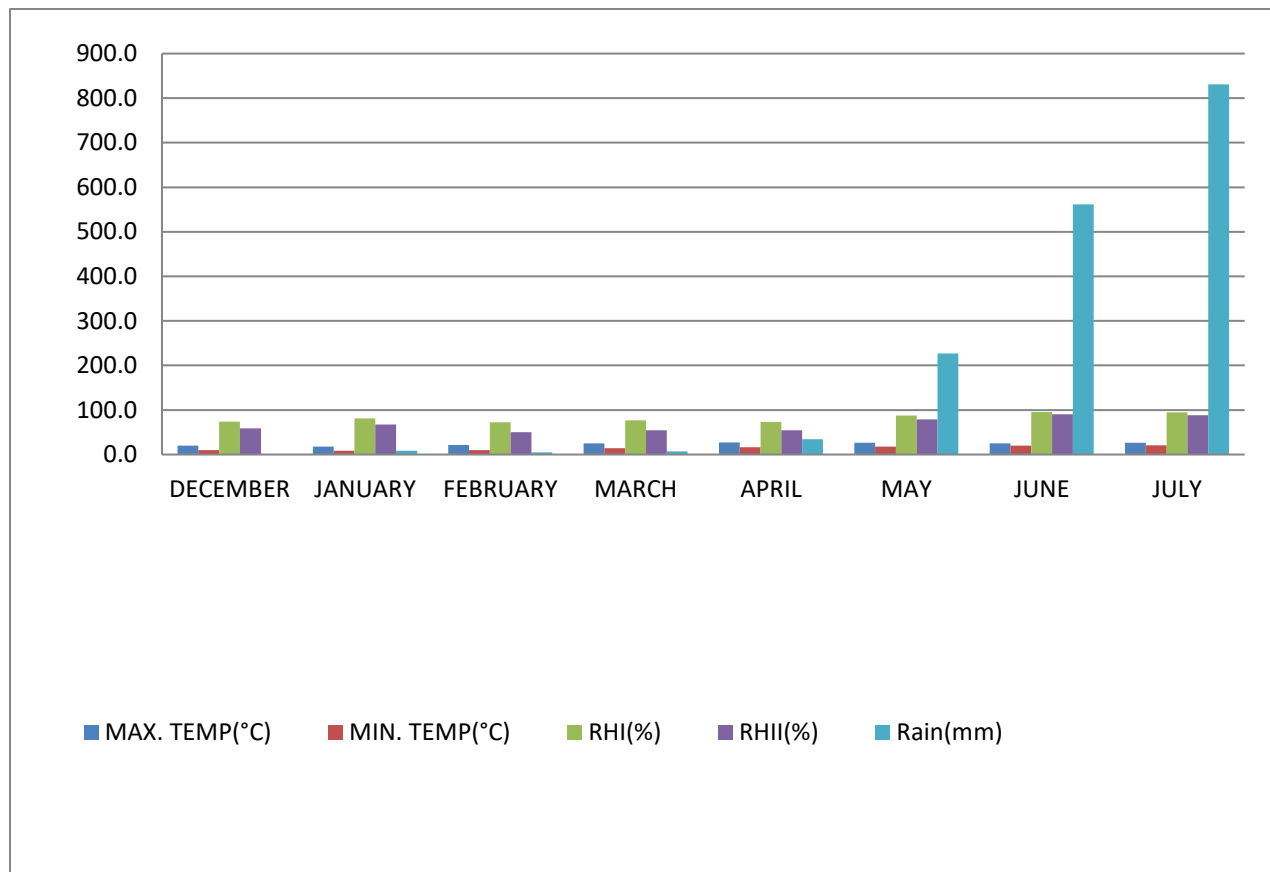
Particulars	Value	Method employed
Ph	5.36	pH meter (Jackson, 1973)
Organic carbon (%)	0.64	Walkley and Black's rapid titration method (Jackson,1973)
Available N (kgha ⁻¹)	405	Modified Kjeldahl method (Jackson, 1973)
Available P (kgha ⁻¹)	26.2	Brays's method-Bray and Kurtz, (Jackson, 1973)
Available K (kgha ⁻¹)	329	Flame Photometer method (Jackson, 1973)

Table 3.1.2. Mean meteorological data during the period of field experimentation, (2020-2021) at Kalimpong , West Bengal.

2020..	MAX. TEMP(°C)	MIN. TEMP(°C)	RHI(%)	RHII(%)	Rain(mm)
DECEMBER	19.9	9.9	74	59	0.6
2021..					
2021..	MAX. TEMP(°C)	MIN. TEMP(°C)	RHI(%)	RHII(%)	Rain(mm)
JANUARY	18.1	8.3	81	67	8.4
FEBRUARY	21.7	10.1	72	50	4.7
MARCH	24.9	13.9	77	55	7.3
APRIL	27.0	16.8	73	55	34.2
MAY	26.2	17.7	88	79	227.0
JUNE	25.2	20.2	95	91	561.3
JULY	26.7	21.0	95	88	831.2

Source: Integrated Agromet Advisory Services, Uttar Banga Krishi Viswavidyalaya

Figure 3.1.2 Mean meteorological data during the period of field experimentation, (2020-2021) at Kalimpong, West Bengal.



3.2 Experimental details

3.2.1 Experiment

“Standardization of Kiwifruit (*Actinidia deliciosa*) Propagation Techniques through Cuttings”

In this investigation kiwi fruit crop cuttings were treated as individual treatment as per following details

Factors of the Experiment

Factor A: Girdling

Factor B: Etiolation

Factor C: Root Growth promoter

Levels of Factors

Factor A: Girdling

Sl	Treatments	Level
1	G ₀	Non-girdled
2	G ₁	Girdled

Factor B: Etiolation

Sl	Treatments	Level
1	E ₀	Non-etiolated
2	E ₁	Etiolated

Factor C: Root Growth promoter

Sl	Treatments	Level
1	P ₀	No promoter
2	P ₁	IBA @ 3000 ppm
3	P ₂	IBA @ 4000 ppm
4	P ₃	IBA @ 5000 ppm

Treatment Combinations

Sl	Treatments	Combination	Treatment Details
1	T ₁	G ₀ E ₀ P ₀	No Girdling + No Etiolation + No IBA
2	T ₂	G ₀ E ₀ P ₁	No Girdling + No Etiolation + IBA@3000ppm
3	T ₃	G ₀ E ₀ P ₂	No Girdling + No Etiolation+ IBA@4000ppm
4	T ₄	G ₀ E ₀ P ₃	No Girdling +No Etiolation+ IBA@5000ppm
5	T ₅	G ₀ E ₁ P ₀	No Girdling + Etiolation + No IBA
6	T ₆	G ₀ E ₁ P ₁	No Girdling+ Etiolation+ IBA@3000ppm
7	T ₇	G ₀ E ₁ P ₂	No Girdling+ Etiolation+ IBA@4000ppm
8	T ₈	G ₀ E ₁ P ₃	No Girdling+ Etiolation+ IBA@5000ppm
9	T ₉	G ₁ E ₀ P ₀	Girdling+ No Etiolation+ No IBA
10	T ₁₀	G ₁ E ₀ P ₁	Girdling+ No Etiolation+ IBA@3000ppm
11	T ₁₁	G ₁ E ₀ P ₂	Girdling+ No Etiolation+ IBA@4000ppm
12	T ₁₂	G ₁ E ₀ P ₃	Girdling+ No Etiolation+ IBA@5000ppm
13	T ₁₃	G ₁ E ₁ P ₀	Girdling+ Etiolation+ No IBA
14	T ₁₄	G ₁ E ₁ P ₁	Girdling+ Etiolation+ IBA@3000ppm
15	T ₁₅	G ₁ E ₁ P ₂	Girdling+ Etiolation+ IBA@4000ppm
16	T ₁₆	G ₁ E ₁ P ₃	Girdling+ Etiolation+ IBA@5000ppm

Design of experiment was factorial randomized block design (FRBD) with sixteen numbers of treatment combinations replicated thrice (fifty cuttings per replication). The experiment was conducted during December 2020 to July 2021

Girdling

Girdling was done by removing a ring bark of 4mm wide and 25 -30 cm below the shoot tip

Etiolation

Etiolation was done as a pre treatment before taking the cuttings by wrapping the shoots with a black plastic around the shoot that is going to be the base of the cuttings.

Preparation of rooting hormone

The required concentrations of IBA (Indole 3-Butyric Acid) of 3000, 4000, 5000 ppm were prepared by dissolving 0.3, 0.4, 0.5 g of respective growth regulator in small quantity of ethanol. Then the mixture was stirred with help of a glass rod to make homogenous solution and to reduce precipitation. Finally, the volume was made up to 100 ml by adding distilled water. Fresh solution of respective growth hormone was prepared each time for treatment of cuttings.

Preparation of cuttings

Semi hardwood cuttings (30 cm length and having atleast three nodes) from kiwifruit cv. Hayward aged 6 years old was taken from the Kiwi Orchard, Darjeeling Krishi Vigyan Kendra, Dalapchand, Kalimpong during December, 2020. Fifty numbers of cuttings were prepared per replication under each treatment combinations. Each cutting was given a slanting cut at the basal end with a sharp razor blade to expose maximum observing surface for effective rooting. The cuttings were then bundled and than taken for hormone treatment by dipping it for thirty seconds. After that cuttings were planted on the 15 cm raised nursery beds. Beds were prepared by mixing of repeatedly washed sand, soil and FYM (2:1:1)

3.4 Observation recorded

The following observations were recorded during the course of investigation-

3.4.1 Time taken for sprouting (days to sprout)

The numbers of days taken by cuttings to achieve sprouting in each treatment was recorded and mean was calculated for each treatment.

3.4.2 Length of the Sprout(cm)

The length of each individual sprout under each treatment was measured with the help of measuring scale at 100 days after cutting (expressed in centimetre) and the data was presented on mean value basis.

3.4.3 Number of leaves per shoot

Total number of leaves was counted at 120 days after cutting under each cutting and the average data of the replication are presented.

3.4.4 Shoot Sprouting percentage (%)

The total number of cuttings that sprouted under each treatment was counted and expressed as sprouting percentage (at 120 days after cutting)..

3.4.5 Time taken for rooting (days to root)

The numbers of days taken by cuttings for root formation in each treatment was recorded and mean was calculated for each treatment.

3.4.6 Rooting percentage (%)

The cuttings were carefully removed from the field without damaging the root system for recording the data. The total number of cuttings within each treatment that showed the formation of roots ($\geq 1\text{mm}$) were counted and expressed in percentage.

3.4.7 Number of roots per cuttings

Total number of primary roots per cuttings were counted and recorded under each cutting at 150 days after cutting and the average data of the replication are presented

3.4.8 Longest root length (cm)

The length of the longest root in each treatment was measured with the help of a measuring scale at 150 days after cutting and their average length was calculated (expressed in centimeter).

3.4.9 Survival Percentage (%)

The survival percent was calculated by following formula.

$$\text{Survival \%} = \frac{\text{Number of cuttings survived}}{\text{Number of cuttings sprouted}} \times 100$$

3.4.10 Mortality Rate (%)

The mortality rate was calculated by total number of deaths divided by the total number of plants multiplied by 100 and expressed in percentage.

3.5 Statistical analysis

For statistical interpretation, analysis of variance for each parameter was performed using Proc Glm of Statistical analysis System (SAS) Software (Version 9.3). Means separations for different accessions under different parameter were performed using Least Significant Difference (LSD) test ($P \leq 0.05$). Normality of residuals under the assumptions of ANOVA was tested using Kolmogorov-Smirnov test using Proc- Univariate procedure of SAS (Version 9.3).

Data Transformation: Data transformation is the most appropriate remedial measure for variance heterogeneity where the variance and the mean are functionally related with this Techniques, the original data are converted into a new scale resulting in a new data set that is expected to satisfy the condition of homogeneity of variance.

The following rules may be useful in choosing the proper transformation scale for percentage data derived from current data.

Rule 1: For percentage data lying within the range of 30 to 70 percent, no transformation is needed.

Rule 2: For percentage data lying within the range of 0- 30 percent or 70-100 percent, but not both the square root transformation should be used.

Rule 2: For percentage data that do not follow the ranges specific either Rule 1 or Rule 2, the arcsine transformation or transformation should be used (Gomez and Gomez, 1984).

Plate 1: Mother Block of Kiwifruit



Plate 2: Girdling and Etiolation in mother plant



Girdling



Etiolation

Plate 3: Preparation and planting of cuttings



RESULT AND DISCUSSION

The present titled study “**Standardization of Kiwifruit (*Actinidia deliciosa*) Propagation Techniques through Cuttings**” was carried out at the Darjeeling Krishi Vigyan Kendra, Dalapchand Farm, Kalimpong, Uttar Banga Krishi Viswavidyalaya during the year 2020 – 2021. The following are the significant findings under different treatments in Kiwi cuttings.

The following heads and sub-heads are used to present and discuss the experimental results collected during the course of the study:

4.1 Sprouting related characteristics:

4.1.1 Number of days taken for shoot sprouting

From the data presented in the Table 4.1a it showed that girdling showed significant variation in terms of days taken for sprouting. Whereas, for etiolation it did not show any amount of variable effect. But the growth promoter with different levels of concentration had a major significant result with IBA@5000ppm (77.25 days) which required lesser days for shoot sprouting as compared with, IBA@4000ppm (79.00days), IBA@3000ppm (80.75 days) and lastly control (87.25 days) required the highest number of days. From the data presented in Table 4.1b it is clear that, minimum number of days required for sprouting was recorded in T₁₆ (77 days) which is statically at par with T₈ (77 days) and the maximum number of days was required in T₁ (88 days).

Similar result was recorded by López *et al* (2015). He reported that sprouting was profuse after girdling during the first month of the experiment.

4.1.2 Length of the sprout

From the data presented in Table 4.1a it is evident that significant variation in terms of growth promoter was observed in IBA@5000ppm(1.86 cm) having the longest sprouting which was followed by, IBA @4000ppm (1.76 cm), IBA@ 3000ppm (1.61 cm) and least in control (1.21 cm) which had the smallest length within all levels. However, girdling had no significant effect in length of the sprout. Etiolation has a significant effect on the length of sprout (Table 4.1a). Significant differences in length of the sprout were observed among interaction of different treatment combinations (Table 4.1b). It was recorded maximum in T₁₆ (2.7 cm) and the lowest in T₁(0.87). It is clear from the Table no. 4.1b that treatments have no significant effect for the length of sprout except for control (T₁)

4.1.3 Number of leaves per shoot

The data pertaining to the number of leaves per shoot in Table 4.1a shows that growth promoter have a significant effect on number of leaves per shoot with IBA@5000ppm(5.50) having the highest number of leaves followed by, IBA@4000ppm (4.58) , IBA@3000ppm (4.25) and lastly with no growth promoter(4.25) which had the smallest of all four levels. On the other hand etiolation also had a noteworthy effect with E₀ (3.83) and E₁ (5.04) Perusal of the data Table 4.1b .indicated that T₈ (6.67) had the maximum number of leaves and minimum was observed in T₁(2.00)

Comparable results were found by Sharma *et al* (2015) that the highest (15.6 and 12.4) leaf number in both hardwood and semi-hardwood cuttings was recorded with IBA @ 5000ppm.

4.1.4 Sprouting percentage (%)

The sprouting percentage was considerably influenced by girdling as shown in Table 4.1a with G₀ (53.12) and G₁ (57.91). Etiolation also showed a significant effect E₀ (51.88) and E₁ (57.91). Whereas, growth promoter showed an evident significance with the highest sprouting percentagewith IBA@5000 ppm (61.67 %) having the highest percentage followed by, IBA@4000ppm (58.75%) , IBA@3000 ppm (54.17%) and lastly with control (47.5 %) which had the least among all four levels. It was observed from the data presented in Table 4.2b that T₁₆ (68.33 %) had the topmost sprouting percentage and the lowest was recorded in T₁ (35 %).

Table 4.1aEffect of main factors (Girdling, Etiolation and IBA) on sprouting characteristics

Treatments	Number of days taken for sprouting	Length of sprouts 110 DAC (cm)	Number of leaves per shoots 120 DAC	Sprouting percentage (%)
G ₀	79.88b	1.56a	4.37a	53.12b
G ₁	82.25a	1.65a	4.50a	57.91a
S.Em.(±)	0.66	0.13	0.31	1.15
L.S.D (P≤0.05)	1.92	NS	NS	3.34
E ₀	81.62a	1.54a	3.83b	51.88b
E ₁	80.50a	1.68a	5.04a	59.17a
S.Em.(±)	0.66	0.13	0.31	1.15
L.S.D (P≤0.05)	NS	NS	0.90	3.34
P ₀	87.25a	1.21b	3.41b	47.5c
P ₁	80.75b	1.61ab	4.25ab	54.17b
P ₂	79.00bc	1.76a	4.58ab	58.75ab
P ₃	77.25c	1.86a	5.50a	61.67a
S.Em.(±)	0.94	0.18	0.44	1.63
L.S.D (P≤0.05)	2.72	0.55	1.28	4.73

DAC = Days after cutting

Table 4.1bEffect of treatment interactions on sprouting characteristics

Treatment Combination	Number of days taken for sprouting	Length of sprouts 100 DAC (cm)	Number of leaves per shoots 120 DAC	Sprouting percentage (%)
T ₁ (G ₀ E ₀ P ₀)	88.00a	0.87b	2.00c	35.00f
T ₂ (G ₀ E ₀ P ₀)	79.00cd	1.33ab	3.33bc	50.00e
T ₃ (G ₀ E ₀ P ₂)	80.67bcd	1.87ab	4.33abc	53.33de
T ₄ (G ₀ E ₀ P ₃)	78.00cd	1.83ab	5.00ab	56.67bcde
T ₅ (G ₀ E ₁ P ₀)	86.00ab	1.17ab	3.67bc	51.67de
T ₆ (G ₀ E ₁ P ₁)	79.00cd	1.93ab	4.67ab	55.00cde
T ₇ (G ₀ E ₁ P ₂)	71.33e	1.67ab	5.00ab	60.00abcd
T ₈ (G ₀ E ₁ P ₂)	77.00d	1.83ab	6.67a	63.33abc
T ₉ (G ₁ E ₀ P ₀)	88.00a	1.23ab	3.67bc	50.00e
T ₁₀ (G ₁ E ₀ P ₁)	79.00cd	1.67ab	4.00bc	55.00cde
T ₁₁ (G ₁ E ₀ P ₂)	83.33ac	1.83ab	3.67bc	56.67bcde
T ₁₂ (G ₁ E ₀ P ₃)	77.00d	1.70ab	4.67ab	58.33bcde
T ₁₃ (G ₁ E ₁ P ₀)	87.00a	1.57ab	4.33abc	53.33de
T ₁₄ (G ₁ E ₁ P ₁)	86.00a	1.50ab	5.00ab	56.67bcde
T ₁₅ (G ₁ E ₁ P ₂)	80.97cd	1.67ab	5.00ab	65.00ab
T ₁₆ (G ₁ E ₁ P ₃)	77.00d	2.07a	5.67ab	68.33a
S.Em.(±)	1.34	1.13	0.13	3.27
L.S.D (P≤0.05)	4.07	3.43	0.42	9.47

Means with same letter are not significantly differs with each other

G₀:Non-girdled, G₁=Girdled, E₀=Non-etiolated, E₁=Etiolated,

P₀=No promoter, P₁=IBA @3000 ppm, P₂=IBA @4000 ppm, P₃=IBA @5000 ppm

DAC = Days after cutting

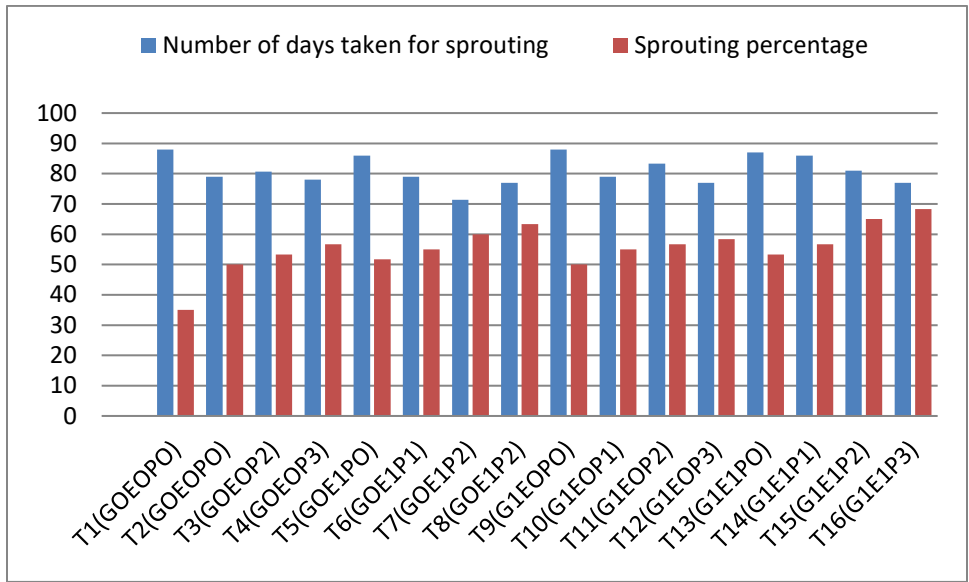


Figure 4.1.1 Effect of Treatment combinations on Number of days taken for sprouting and sprouting percentage

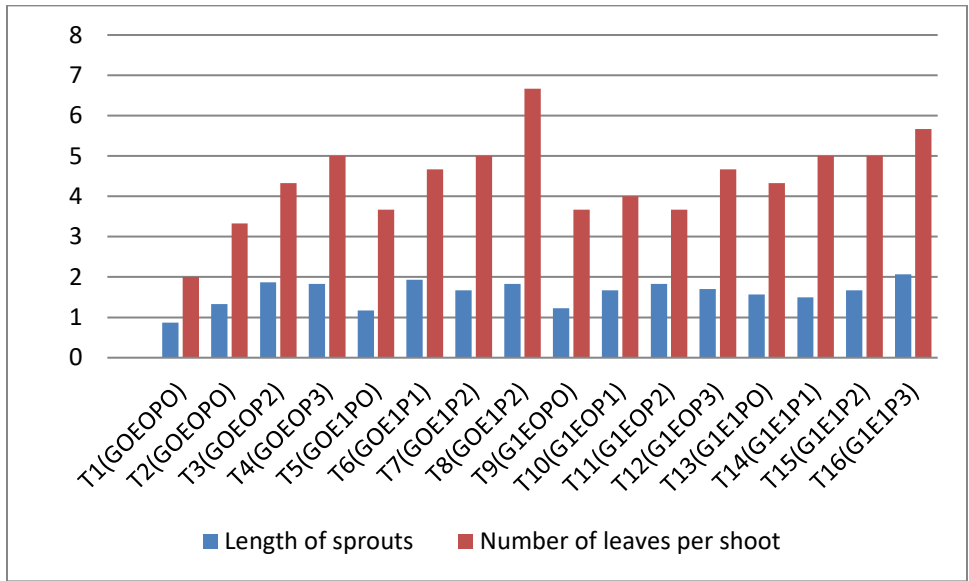


Figure 4.1.2 Effect of Treatment combinations on Length of the Sprout and Number of leaves per shoot

Plate 4: First sprouting observed 77DAC



4.2 Rooting related characteristics

4.2.1 Rooting Percentage (%)

Observation recorded on rooting percentage from Table 4.2a showed that girdling had no significant amount of effect. But there was significant amount of variation in terms of etiolation with E₀(51.67 %) and E₁(56.04 %). Whereas, growth promoter also showed a major significance with IBA@5000ppm (62.50 %) having the highest percentage followed by, IBA@4000ppm (55.41 %), IBA@3000ppm (52.91%) and lastly with control (46.67%) which had the least among all four levels. However according to the data presented in Table 4.2b T₁₆ (68.33 %) showed the highest rooting percentage and T₁ (36.67 %) had the minimum rooting percentage.

Equivalent type of results was obtained by (Rana and Jindal, 2001) that higher percentage of rooting was obtained with the apical cuttings of different kiwifruit cultivars treated with IBA @5000 ppm.). (Ali *et al* 2017) observed the highest rooting percentage of cuttings was observed at the IBA concentration of 3500 ppm (56.94%) followed by 2500 ppm (53.61%). However, in untreated cuttings mini-mum (32.50%) rooting was recorded.(Sim and Lawes 1981) reported that cuttings of kiwifruit cuttings treated with IBA (5000 ppm) improved rooting upto 95.0 per cent.

4.2.2 Number of roots per cuttings

Number of roots per cuttings were significantly affected by growth promoter as depicted in Table 4.2a where IBA5000ppm (4.33) which was the highest as compared with, IBA@4000ppm (3.75), IBA@3000ppm (3.33) and lastly control (2.23). And no major significance was observed in terms of girdling and etiolation. From the data presented in Table 4.2b it is pragmatic that T₁₆(5.00) had the highest number of roots and T₁(2.00) had the least number of roots.

Sharma *et al* (2015) showed a similar result that the highest number of primary roots (8.5 and 12.6) in hardwood and semi-hardwood cuttings corresponding with IBA@ 5000ppm .

4.2.3 Days taken for rooting

From the data pertaining to girdling and etiolation presented in Table 4.2a indicates non significant variation, but as in for growth promoter it exhibited a significant amount of variation from IBA@5000 ppm (89.75 days) which was the least number of days as compared with, IBA@4000ppm (90.25 days), IBA@3000ppm (94.17 days) and least control (102.83 days) with the maximum number of days. From the data presented in Table 4.2b it indicates that minimum number of days was recorded with T₁₆(87 days) and the maximum with T₁(105.67) which is also statistically at par with T₉(105.33).

4.2.4 Longest root length

Observations recorded on longest root length varied significantly are summarized in Table 4.2a with respect to girdling G₀ (3.12) and G₁ (4.01) and etiolation E₀(3.09) E₁(4.04). also for growth significant amount of variation was observed with regard to IBA@5000ppm (5.09 cm) which was peak as compared with, IBA@4000ppm (3.41 cm), IBA @3000ppm (3.28 cm) and last of all control (2.49 cm). From the data presented in Table 4.2b it can observed that T₁₆ (5.90 cm) had the longest root length and T₁ (0.50 cm) had the shortest.

. Alamet *al* (2007) concluded that cuttings of male and female plants treated with 4000/ppm IBA solution gave the highest root length of 16 and 15 cm respectively. As reported by Ali *et al* (2018) it was observed that maximum root length recorded for IBA @ 3000 (19.11) and the minimum root length was observed in control treatment

Table 4.2aEffect of main factors (Girdling, Etiolation and IBA) on rooting characteristics

Treatments	Rooting percentage (%)	Number of roots per cutting 150 DAC	Days taken for rooting	Longest root length 150 DAC
G ₀	52.70a	3.25a	93.38a	3.12b
G ₁	56.04a	3.60a	95.12a	4.01a
S.Em.(±)	1.58	0.23	0.62	0.24
L.S.D (P≤0.05)	NS	NS	NS	0.70
E ₀	51.67b	3.25a	93.38a	3.09b
E ₁	57.09a	3.60a	95.12a	4.04a
S.Em.(±)	1.58	0.23	0.62	0.24
L.S.D (P≤0.05)	4.56	NS	NS	0.70
P ₀	46.67c	2.23c	102.83a	2.49b
P ₁	52.91bc	3.33b	94.17b	3.28b
P ₂	55.41b	3.75ab	90.25c	3.41b
P ₃	62.50a	4.33a	89.75c	5.09a
S.Em.(±)	2.23	0.33	0.87	0.34
L.S.D (P≤0.05)	6.45	0.95	2.53	0.99

DAC = Days after cutting

Table 4.2bEffect of treatment interactions on rooting characteristics

Treatment Combination	Rooting percentage	Number of roots per cutting 150 DAC	Days taken for rooting	Longest root length 150 DAC
T ₁ (G ₀ E ₀ P ₀)	36.67d	2.00e	105.67a	0.50f
T ₂ (G ₀ E ₀ P ₀)	48.33cd	3.33abcde	96.33cd	2.50de
T ₃ (G ₀ E ₀ P ₂)	51.67c	3.67abcde	94.00cdef	2.00ef
T ₄ (G ₀ E ₀ P ₃)	60.00abc	4.00abcd	92.33defg	4.43abcd
T ₅ (G ₀ E ₁ P ₀)	50.00c	2.33de	98.00bc	3.17cde
T ₆ (G ₀ E ₁ P ₁)	53.33bc	3.00bde	94.33cdef	3.37cde
T ₇ (G ₀ E ₁ P ₂)	56.67abc	3.67abcde	91.33defg	3.47cde
T ₈ (G ₀ E ₁ P ₂)	65.00ab	4.00abcd	89.00fgh	5.53ab
T ₉ (G ₀ E ₀ P ₀)	51.67c	2.33de	105.33a	3.43cde
T ₁₀ (G ₁ E ₀ P ₁)	53.33bc	3.33abcde	92.67def	3.67bcde
T ₁₁ (G ₁ E ₀ P ₂)	55.00bc	3.00bcd	84.33h	3.70bcde
T ₁₂ (G ₁ E ₀ P ₃)	56.67abc	4.33abc	90.33efg	4.50abc
T ₁₃ (G ₁ E ₁ P ₀)	48.33cd	2.50cde	102.33ab	2.83cde
T ₁₄ (G ₁ E ₁ P ₁)	56.67abc	3.67abcde	93.33cdef	3.57bcde
T ₁₅ (G ₁ E ₁ P ₂)	58.33abc	4.67ab	91.33defg	4.50abc
T ₁₆ (G ₁ E ₁ P ₃)	68.33a	5.00a	87.33gh	5.90a
S.Em.(±)	4.47	0.66	1.75	0.69
L.S.D (P≤0.05)	12.91	1.90	5.06	1.99

Means with same letter are not significantly differs with each other

DAC = Days after cutting

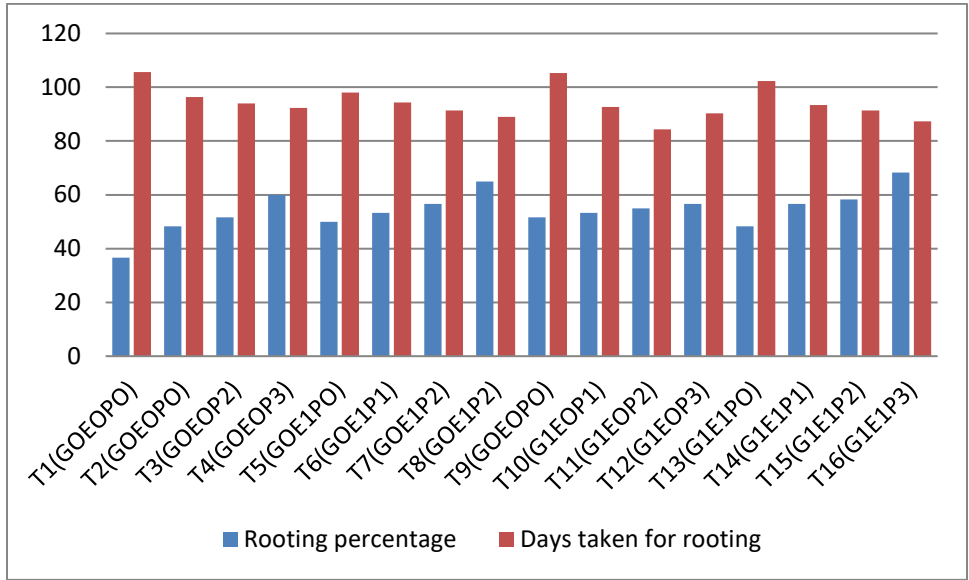


Figure 4.2.1 Effect of Treatment combinations on Rooting percentage and Days taken for rooting

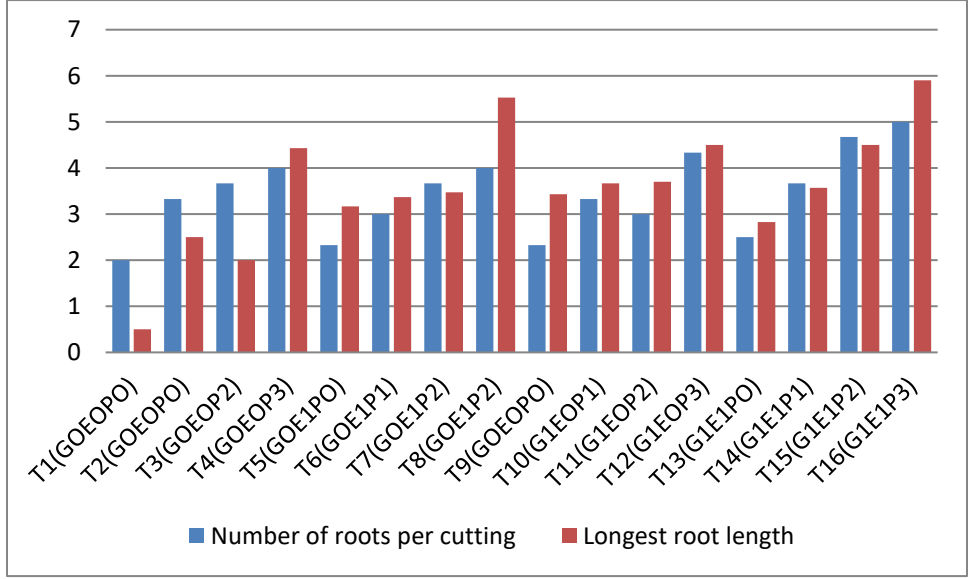


Figure 4.2.2 Effect of Treatment combinations on Number of roots per cutting and Longest root length.

4.3 Survival Percentage (%)

Results presented in the Table 4.3a indicated significant difference with respect to girdling G_0 (53.23 %) and G_1 (57.05 %) and in case of etiolation E_0 (52.77 %) and E_1 (58.43 %). Subsequently growth promoter also had an important significance difference with IBA@5000ppm (62.21 %) having the highest percentage followed by, IBA @4000ppm (57.07 %), IBA @3000ppm (54.89 %) and lastly with control (48.21 %) which had the least among all four levels. Whereas, data presented in Table 4.3b it was observed that T_{16} (64.53 %) had the highest which was statistically at par with T_8 (63.33 %) and lowest was recorded in T_1 (36.77 %).

Relatable type of results was obtained by Goswami (1995) hardwood cuttings of kiwifruit cv. Allison with IBA (1000 – 6000 ppm) as quick dip (5 seconds) and planted in open field conditions and the results reveals that maximum rooting (50.73 %) and survival (60.18 %) percentage was recorded with IBA @6000 ppm. Ali *et al* (2018) observed that maximum survival percentage was recorded for IBA@ 3000ppm (81.34) and the minimum survival percentage was observed in control treatment 19.00.

4.3.1 Mortality Rate (%)

It is evident from the recorded observation on mortality rate presented in Table 4.3a that girdling had a positive significant effect with G_0 (50.77 %) and G_1 (55.72 %). Similarly etiolation also exhibited variation with E_0 (55.22 %) and E_1 (51.27 %). However growth promoter showed a major significance with IBA@5000 ppm (51.38%) having lowest mortality rate followed by, IBA @4000ppm (52.60 %), IBA @3000ppm (52.87 %) and lastly with control (56.13 %) which had the highest among all four levels. It was observed from the data presented in Table 4.3b that T_{16} (46.02 %) had the lowest mortality rate and maximum was recorded in T_1 (65.99 %).

Table 4.3a

Treatments	Survival percentage(%)	Mortality rate(%)
G ₀	53.23b	55.72a
G ₁	57.05a	50.77b
S.Em.(±)	0.86	0.85
L.S.D (P≤0.05)	2.50	2.48
E ₀	52.77b	55.22a
E ₁	58.43a	51.27b
S.Em.(±)	0.86	0.85
L.S.D (P≤0.05)	2.50	2.48
P ₀	48.21c	56.13
P ₁	54.89b	52.87ab
P ₂	57.07b	52.60b
P ₃	62.21a	51.38a
S.Em.(±)	1.22	1.21
L.S.D (P≤0.05)	3.54	3.50

Table 4.3b

Treatment Combination	Survival percentage(%)	Mortality rate(%)
T ₁ (G ₀ E ₀ P ₀)	36.77e	83.33(65.99) a
T ₂ (G ₀ E ₀ P ₀)	48.33d	68.33(55.80) bc
T ₃ (G ₀ E ₀ P ₂)	51.67cd	65.00(53.89) bcd
T ₄ (G ₀ E ₀ P ₃)	60.67ab	65.00(53.79) bcd
T ₅ (G ₀ E ₁ P ₀)	51.67cd	70.00(56.87) b
T ₆ (G ₀ E ₁ P ₁)	55.53bc	68.33(55.80) bc
T ₇ (G ₀ E ₁ P ₂)	57.93abc	66.67(54.78) bc
T ₈ (G ₀ E ₁ P ₂)	63.33a	56.67(48.86) cde
T ₉ (G ₀ E ₀ P ₀)	51.67cd	60.00(50.85) bcde
T ₁₀ (G ₁ E ₀ P ₁)	55.00bcd	58.33(49.82) cde
T ₁₁ (G ₁ E ₀ P ₂)	57.67abc	66.67(54.81) bc
T ₁₂ (G ₁ E ₀ P ₃)	60.33ab	70.00(56.87) b
T ₁₃ (G ₁ E ₁ P ₀)	52.77cd	60.00(50.81) bcde
T ₁₄ (G ₁ E ₁ P ₁)	60.70ab	58.33(50.02) bcde
T ₁₅ (G ₁ E ₁ P ₂)	61.00ab	53.33(46.94) de
T ₁₆ (G ₁ E ₁ P ₃)	64.53a	51.67(46.02)e
S.Em.(±)	2.45	2.42
L.S.D (P≤0.05)	7.09	7.01

*Means with same letter are not significantly differs with each other
Values in parenthesis are arc sine transformed value*

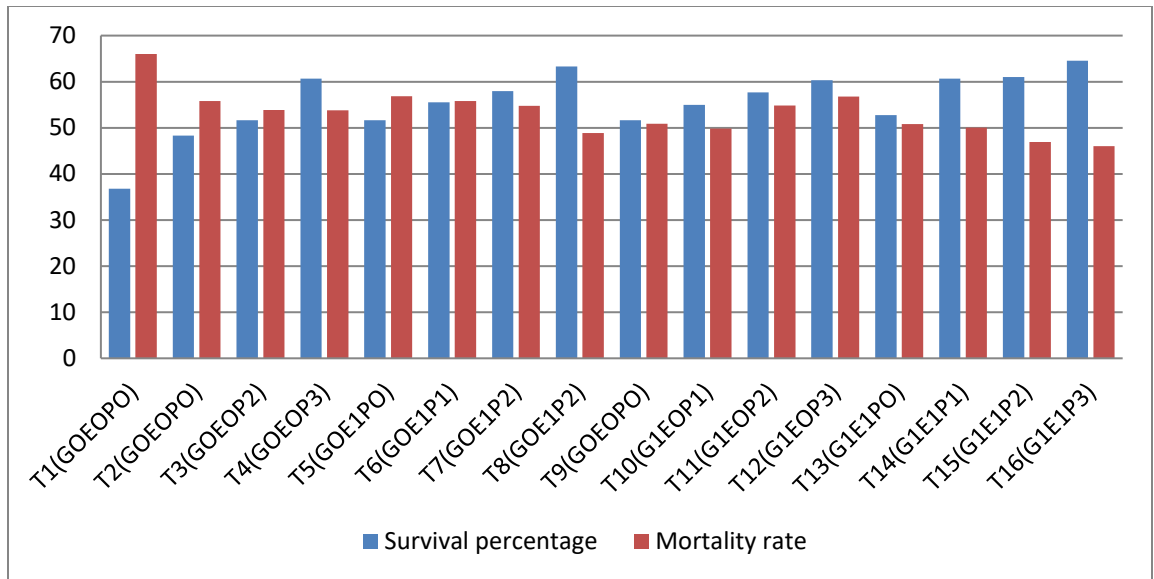
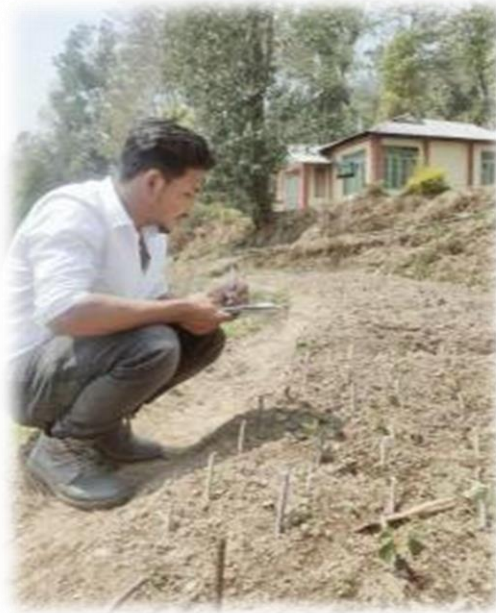


Figure 4.3.1 Effect of treatment interaction for survival percentage and mortality rate

Plate 5: Data observation for various parameters



**Plate 6a: Observation of rooting in
different treatments**



Plate 6b:



SUMMARY AND CONCLUSION

An experiment was conducted in Darjeeling Krishi Vigyan Kendra, Dalapchand, Kalimpong Uttar Banga Krishi Viswavidyalaya, during December 2020 to July 2021. Results revealed that girdling, etiolation and growth promoter have a positive effect in kiwifruit (*Actinidia deliciosa*) cuttings.

From this present study, with respect to etiolation, girdling and growth promoter. it was found that T₁₆(girdling + etiolation + IBA @5000 ppm) showed better result in terms of number of days taken for sprouting (77 days), length of the sprout (2.07 cm), sprouting percentage (68.33%), number of roots of cuttings (5), rooting percentage (68.33 %), number of days taken for rooting (87.33 days), longest root length (5.90 cm), survival percentage (64.53 %), mortality rate (46.02 %) and minimum performance was observed in T₁(G₀E₀P₀). Whereas, in case of number of leaves per shoot maximum was observed in T₈(G₀E₁P₂). In case of factors, girdling was found most effective in increasing the parameters particularly number of days taken for sprouting (79.88 days), sprouting percentage (%), longest root length (4.01 cm), survival percentage (57.05 %) and mortality rate (50.77%) and etiolation was found effective in number of leaves per shoots (5.04), sprouting percentage (59.17%), rooting percentage (57.09 %), longest root length (4.04 cm), survival percentage (58.43%), mortality rate (51.27 %) and lastly growth promoter (IBA @5000 ppm) was found to be the most effective in all the parameters compared to other levels

Among all the treatments, T₁₆ (girdling + etiolation + IBA @5000 ppm) showed better results in terms of sprouting related parameters, rooting related parameters, survival and mortality rate with respect to all three main factors. However, in some parameters like number of days taken for sprouting and survival percentage T₁₆ was at par with T₈(No girdling+etiolation + IBA@ 4000 ppm). Whereas, least performance for sprouting and rooting characteristics were observed in T₁(G₀E₀P₀) for all the parameters. Girdling and etiolation had a significant positive effect in most of the parameters. Girdling increased the rooting, and sprouting performance of the cuttings, with P₃ (IBA @5000 ppm) as compared to other treatment combinations. In case of growth promoter, it was observed that in P₃ (IBA @5000 ppm) was showing the best result in all the parameters, and minimum was observed in P₀. It may be concluded that T₁₆(Girdling + Etiolation + IBA @5000 ppm) and T₈(No Girdling+ Etiolation + IBA@ 4000 ppm) exhibited most of the desirable sprouting and rooting characteristics of kiwifruit cv. Hayward cutting in hillagro-climatic condition (Kalimpong) of West Bengal.

FUTURE SCOPE OF THE RESEARCH

The endeavour has been made in the present study, “**Standardization of Kiwifruit (*Actinidia deliciosa*) Propagation Techniques through Cuttings**”. There is, however, an immense scope of future research in the same line and further research may be undertaken on the following aspects.

- Incorporation of other root growth promoter, rooting co factor on different concentration may be examined.
- Role of different rooting media may also be investigated.
- Experiment under controlled condition with misting facility may also be carried out.
- The effect of different seasons on sprouting and rooting parameters may be conducted.
- Performance of the cuttings of different varieties can also be studied.

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ABSTRACT

The kiwifruit (*Actinidia deliciosa*) is the edible berry of a woody vine in the genus *Actinidia*. In ancient times, kiwifruit was a remedy for digestive disturbances, rheumatism, dyspepsia, diminution of skin disorders in China and later it has gained worldwide popularity since consumers associated the consumption of kiwi fruits with potential health effects. Kiwifruit is a dioecious plant, belonging to family Actinidiaceae and native to China. Propagating through sexual means is not much successful in kiwi as it is with the vegetative propagation specially stem cuttings. Kiwifruit is considered as temperate fruit crops having some chilling requirement. It has a potentiality to grow in the Darjeeling & Kalimpong districts of West Bengal. However, the availability of planting materials with reasonable cost is one of the limiting factors for expansion of the areas in the areas of eastern Indian states. Thus an experiment was conducted at the Experimental Farm of Darjeeling Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Dalapchand, Kalimpong during December 2020 to July 2021 with Factorial Randomized Block Design having sixteen treatment combinations replicated thrice. There were three factors such as girdling, etiolation and growth promoter (IBA). Girdling consisted of two levels, girdled and non-girdled, etiolation with etiolated and non-etiolated and growth promoter (IBA) consisted of four levels (0, 3000 ppm, 4000 ppm and 5000 ppm. It may be concluded from the study that, T16 (girdling + etiolation + IBA @5000 ppm) showed better response for number of days taken for sprouting (77 days), length of the sprout (2.07 cm), sprouting percentage (68.33%), number of roots of cuttings (5), rooting percentage (68.33%), number of days taken for rooting (87.33 days), longest root length (5.90 cm), survival percentage (64.53%), mortality rate (46.02%) and T8 (etiolation + IBA@ 4000 ppm) was effective in number of leaves per shoot (5.67). From this experiment, it can be concluded that girdling and etiolation had a positive effect on the kiwifruit cuttings and growth promoter (IBA @5000 ppm) gave the best results. Keywords: Girdling, Etiolation, Growth Promoter, Kiwifruit, Cuttings.

The kiwifruit (*Actinidia deliciosa*) is an edible berry of a woody vine in the genus *Actinidia* (Stirk, 2005). In ancient times, in China, kiwifruit was a remedy for digestive disturbances, rheumatism, dyspepsia, diminution of skin disorders and lately has gained worldwide popularity since consumers associated the consumption of kiwi fruits with possible health effects (Singletary, 2012). Kiwifruit is a dioecious plant, with separate male and female plants belonging to family Actinidiaceae and native to China (Ali et al 2017b). *Actinidia* species are perennial, present vigorous growth and has climbing and strangling characteristics (Cangiet al 2006). It is a large, vigorous, woody deciduous vine and can reach over 10 meters in length. It starts bearing in 3rd year while commercial bearing starts up from 5th year. The genus contains more than 50 species scattered in the temperate and subtropical regions of the Asian continent. All member of the genus *Actinidia* are functionally diocious, with pistillate and staminate flowers occurring on the separate plants (Ferguson, 1990). To determine gender of kiwi, we have to wait for the plant till flowering. The difference between the sex of male and female kiwi vines can be only differentiated by the flowers. Looking at the difference between male and female kiwi vines we will know whether the plant will yield fruits or not. The identification of the female kiwi vines can be done by the flowers with long sticky stigmas going out from the center of the flower. The female flowers also do not produce any pollen. When determining the sex of kiwi blooms, the female will also have bright white, well defined ovaries at the base of the flower, which is not present in males. Kiwi has been introduced in the last 15 years and actually covers about 30 hectare in all the country, with an intensive growing trend. Fruit trees are highly heterozygous in nature, hence propagation by seed never yields a true to type offspring and therefore, the asexual methods of propagation are employed to overcome this problem. Their seeds are not guaranteed to produce plants with desirable characteristics (bloom time, cane growth, fruit shape, or edibility) present in either parent plant. They also have a very long juvenile phase which may go upto seven years before even sex determination can be carried out which is one of the most important factor in establishing a kiwi orchard and also for propagation. Because of these complications kiwifruit propagation is only done by seed for breeding purpose and developing new cultivars and to produce rootstocks. The use of semi-hardwood cuttings is one of the easiest methods of vegetative propagation. Richardson et al (2018) stated that the nutritional composition, the high amount of vitamin C, supports its position as a well nutritious, low energy fruit. With the excess of man-made, processed health foods available

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