

**“EFFECT OF RESTING PERIOD AND PRE SOWING
TREATMENTS ON SEED NUT GERMINATION AND HEIGHT OF
SEEDLING OF COCONUT (*Cocos nucifera* L) Cv. D×T”**

A

**THESIS
SUBMITTED TO THE
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI**

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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ABSTRACT

The present investigation examined effect of rooting and growing treatments on seed set, germination and seedling of *Conium maculatum* L.

ABSTRACT



**“EFFECT OF RESTING PERIOD AND PRE SOWING TREATMENTS ON
SEED NUT GERMINATION AND HEIGHT OF SEEDLING OF COCONUT
(*Cocos nucifera* L.) Cv. D×T”**

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A B S T R A C T

The present investigation entitled “Effect of resting period and pre sowing treatments on seed nut germination and height of seedling of coconut (*Cocos nucifera* L.) cv. D×T” was conducted during year 2010-2011 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari.

The present experiment was laid out in Complete Randomized Design with Factorial concept with fourteen treatments (twelve treatment combinations of R×S and two special treatments) repeated three times. The treatments were comprising of three resting period (fresh; just after harvesting, 15 days rest and 30 days rest), four pre sowing treatments (control: without any treatment, water soaking for 15 days without punching, water soaking for 15 days with punching and soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut). Between special treatment, SP₂ i.e. stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest) proved to be the best for minimum days taken to germination, maximum germination

percentage, height of seedling, number of leaves per plant, girth at collar region, number of roots per plant and survival percentage of seedling.

Considering the effect of resting period 15 days rest after harvest was found better with respect to earliness in germination with higher percentage and growth with maximum height of seedling and number of leaves. Whereas in pre sowing treatments, S₃ treatment (water soaking for 15 days with punching) was superior in early germination, growth and higher survival percentage.

An interaction between resting period and pre sowing treatments (R×S) was found significant for most of the characters under study. Although, fifteen days rest treated with water soaking for 15 days with punching (R₂S₃) was found better for minimum days taken to germination, germination percentage at 75 and 90 days, height of seedling at 120 and 180 days, girth at collar region at 120 days and survival percentage at uprooting, after sowing of seed nut.

Thus, from the above results it can be concluded that stalk end down (invert) placement of coconut seed nut before sowing for 15 days was found better in special treatments. Fifteen days rest with soaking of seed nut for 15 days with punching were found most effective in minimum days taken to germination, increasing germination percentage, height of seedling, girth at collar region quality and quantity of roots and survival percentage of seedling.



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CERTIFICATE

This is to certify that the thesis entitled "**Effect of resting period and pre sowing treatments on seed nut germination and height of seedling of coconut (*Cocos nucifera* L.) cv. D x T**" submitted by Mr. **NARENDRA KUMAR NAGAR** in partial fulfilment of the requirement for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) in FRUIT SCIENCE** of Navsari Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed on the basis for the award of any degree, diploma or other similar title.

Place: Navsari
Date: 21/5/2011


(B. N. Patel)
Major Advisor

DECLARATION

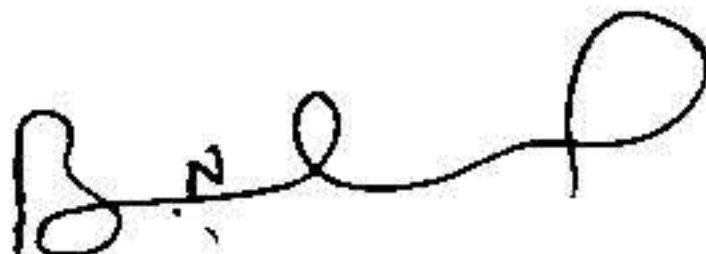
This is to declare that the whole of the research work now submitted in this thesis for the partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** is the result of investigation done by me under direct guidance and supervision of **Dr. B. N. PATEL**, Research Scientist (Hort.), Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, N.A.U., Navsari and that no part of the work has been submitted for any other degree so far.

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ACKNOWLEDGEMENT

At this gratifying moment of completion of my research work, I feel obliged to record my gratitude to those who have helped me.

To become an ideal person for others is difficult but to get an ideal person in our life which guide us toward our goal and whose hand remains always in our hand which helps to bring out of all problems without disturbing the quality of life experiences which makes us more mature in our life. My respected Dr. B. N. Patel, Research Scientist, Regional Horticultural Research Station, N. A. U., Navsari is the person in whom I got my ideal who is not only major advisor to me but the person who mold me in to beautiful pot from mud and polished me into diamond from rough stone.

I feel a great pleasure in getting this proud privilege offering my sincerest and devoted thanks to my co-guide Dr. N. B. Patel, Associate Professor (Horticulture Poly-technic), N. A. U., Navsari; and other members of my advisory committee , Dr. B. V. Padhiar, Professor (Pomology), ASPEE College of Horticulture and Forestry, N. A. U., Navsari, and Mr. H. N. Chhatrola, Asst. Professor (Ag.Stat.), ASPEE College of Horticulture and Forestry, N. A. U., Navsari for their worthy suggestions, ever willing help and unbiased attitude throughout the course of this investigation.

I am highly thankful to Head of Regional Horticultural Research Station, N. A. U., Navsari and its staff members for providing valuable co-operation for post graduate research work, I also thankful to staff of Central Library, Navsari Agricultural University for providing valuable literature materials necessary for P. G. studies and research.

I wish to express my deepest gratitude and sole full respect to shri Ganesh Ji Maharaj, my kulswamini 'Satti Maa' , 'Shree Kheechi Raja Maharaj', and Sai baba who helped me on every path of life and made every step great success and because of their worship I can achieve the goal of my life.

No words in this mortal world can suffice, to express my feelings, high appreciation and deepest sense of reverence towards my worship that taught me value of life, humanity and truth and I realize the painstaking efforts taken up by them, my beloved family members Late Sita bai (Grandmother), Lalta bai and Lakshmi Shankar Nagar (Mother-father), Indra and Babul Lal (Uncle-Aunty) for their everlasting love, filial affection,

constant encouragement, sincere prayers, support and obstinate sacrifices without which this dream could not become a reality.

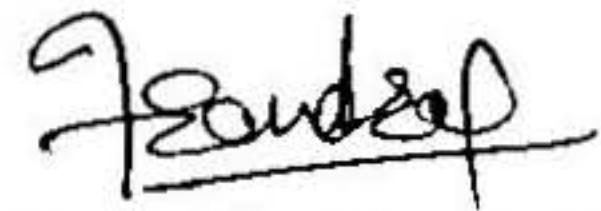
My younger brother Jujhar Singh Nagar , Amit Nagar and cousins and my all the relatives whose encouraging & motivating me for higher studies and dreaming to my bright future.

I shall fail in my duties if I forget the names of my joyous friends Virendra Singh, Sri Ram, Shrawan, Dushyant, Ram Beniwal, Mukesh, Vishnu Kunwar, Manoj Agrawal, Ram Raj, Ganesh, Sagar, Rohidas, Sambaji, Hemant, Saurabh, Rajendra, and Hari who infused in me lot of stamina which fetch fruitful results for this. I do a owe them abundance of gratitude and others who are in my heart for their excellent company, warmer affections and co-operation.

Last, but far from the least Dushyant, Sursa, Shailendra, Rajnish, Surjeet and Surendra Nagar, all my U.G. batchmates and my best friends who are always near to my heart who always help me and motivated me for every good type of step in my life.

Place: Navsari

Date: May. 2011



(Narendra Kumar Nagar)

ABBREVIATIONS

SR. NO.	ABBREVIATION	MEANING
1	%	Per cent
2	(°C)	Degree Celsius
3	@	At the rate of
4	C.D.	Critical difference
5	C.V.	Co-efficient of variance
6	cm	Centimeter
7	cv.	Cultivar
8	<i>et al.</i>	<i>Et alii</i> (and others)
9	Fig.	Figure
10	g	Gram
11	ha	Hectare
12	<i>i.e.</i>	That is
13	KNO ₃	Potassium nitrate
14	mm	Millimeter
15	ppm	Part per million
16	S.Em.	Standard error of mean
17	Var.	Variety
18	<i>viz.</i>	Such as



INTRODUCTION



I. INTRODUCTION

The coconut (*Cocos nucifera* L.) belongs to family Arecaceae/Palmae under the class monocotyledons and is native to south East-Asia. It is an important oilseed as well as a plantation crop in India. The palm has been regarded as "Kalpa Vriksha" (tree of heaven) which gives us livelihood, food, nutritional, health and social security. Coconut oil till date is industry's primary dollar revenue generator particular in oil producing countries by nature of its fatty acid profile, which is rich in lauric acid. It has got antiviral, antimicrobial, antiprotozoal and antibacterial properties particularly beneficial to human health.

India has emerged one of the largest producer of coconut in the world, though only third rank in area (after Indonesia and Phillipines) under the crop (Ramanathan, 2001). In India, coconut grown in 1.90 million ha with an annual production of 14743.56 million nuts and with productivity of 7747 nuts/ha. Among the major coconut growing states, the share of Kerala in area and production is 43.02 and 38.25 per cent followed by Karnataka with 21.29 and 11.09 per cent, Tamil-Nadu with 20.14 and 33.70 percent, respectively (Appendix-II). In Gujarat coconut grown area is 16,400ha with an annual production of 138.30 million nuts and with productivity of 8433 nuts/ha (Anon. 2009). Looking district wise area under coconut cultivation in Gujarat (Appendix-I) it is clear that the coastal belt of Saurashtra occupies nearly 58.70 per cent of total coconut

area and less than 50 per cent area is distributed over remaining parts of the state (Anon., 2009).

Cocos is a monotypic genus and there are no wild forms and hence variability exists only within local types or population. Palm is tall, unbranched with a terminal crown of leaves, growing to a height of 20-30 m and lives for 80-100 years. It is not a tree since no true bark, no branches, no cambium or secondary growth areas seen. Radicle is temporary and penetrates soil vertically. Subsequent ones spread horizontally. Adventitious roots are produced from bole, basal 60 cm swollen portion of stem.

The quality of planting material determines the ultimate returns from arable crops, particularly from tree crops like coconut. The seedling vigour is highly correlated with adult palm characters such as early flowering, nut yield and copra production (Liyanage and Abeywardena. 1957). In the absence of a viable technology for vegetative method of propagation, coconut is propagated through seeds. If the seed nuts happen to be of poor quality, the new plantation will prove to be uneconomic causing considerable loss of time and money to the grower. Coconut, being a perennial crop, needs much attention in the selection of planting materials during establishments of an orchard or even for homestead garden. Further, being cross-fertilized, it does not breed true and makes the selection of seed nuts and seedlings more difficult.

The first and foremost step is the selection of mother palm. The mother palms should be of 25-60 years of age with at least 30-32 fully opened healthy leaves on crown, shape of

crown should be spherical or semi-spherical, petiole length and stalk of the bunches should be short and strong in nature, bearing habit should be regular with at least 80 nuts annual yield during the last 5 years, having medium sized round to oblong nuts (1200 g weight with dried husk). One should avoid drooping crown, de-shaped nut, proximity of cattle shed and compost pit near the palm.

The next step is collection of seed nut. The season of seed nut collection may vary from region to region. Always it is better to collect nuts that had undergone development during rainy season for seed nut purpose. The seed nuts should be collected from February-May with 11-12 months age (full mature), the shape and size should be proper, any type of damage of the nut during harvesting is to be avoided rather the nuts are to be lowered by ropes only to get an undamaged embryo, the presence of water is to be judged by shaking the nuts and getting clear metallic sound on taping.

Storing of nuts is another important step towards quality seedling production. Usually, the seed nuts are stored in open shade for about a month (till the husk becomes dry to facilitate speedy and maximum germination (Thampan, 1982). Then they are arranged on the floor of a shed over 7-8 cm thick layer of dry sand with their stalk end up and covered with the sand to prevent drying of nut water. Five layers of nuts can be arranged one over the other. During summer, sprinkling of water is needed to prevent the drying of nut water. In South Indian condition, Marimuthu and Natarajan (2005) opined that to get

better quality seedlings the seed nuts are to be cured for one month in open shade followed by sand curing for 2 or 3 months.

In Gujarat, the source of planting material for coconut growers are either from various nurseries of state government or Department of horticulture of agricultural universities and to some extent from private nurseries.

An attempt has therefore been made to investigate the "Effect of resting period and pre sowing treatments on seed-nut germination and height of seedling of coconut (*Cocos nucifera* L.) cv. D×T." with following objectives.

1. To know the effect of special treatments on seed nut germination and height of coconut seedling.
2. To know the effect of resting period on seed nut germination and height of coconut seedling.
3. To find-out the effective pre sowing treatment on the seed nut germination and height of coconut seedling.
4. To know the interaction of resting period and pre sowing treatments on the height of coconut seedling.



REVIEW OF LITERATURE



II. REVIEW OF LITERATURE

In general, coconut is propagated through seed nuts. Selection of seed nuts is of utmost importance in coconut as performance of new progeny can be evaluated only after several years of planting. Since coconut is cross-fertilized crop and it does not breed true, selection of seed nuts and raising of seedling is more difficult. Through a series of selection made at different stages, it is possible to eliminate poor quality seedling.

Researchers have revealed the different horticultural techniques for increasing crop production in large number of fruit crops. The use of resting period and pre sowing treatments of coconut seed nut remained little or untouched due to less extension and carelessness of nurserymen.

An attempt is being made here to present a brief account of some previous studies related to the present investigation in coconut and other fruit crops under the following heads.

- 2.1 Effect of special treatments on germination and height of seedling.**
- 2.2 Effect of resting period on germination and height of seedling.**
- 2.3 Effect of pre sowing treatments on germination and height of seedling.**
- 2.1 Effect of special treatments on germination and height of seedling.**

Coconut (*Cocos nucifera* L.)

Mandal (1998), reported that the horizontal planting of coconut seed nut was advantageous as it gave highest percentage of early germination, produces vigorous seedling with good girth at the collar region; because the endosperm (nut water) remains close to the embryo.

Chattopadhyay *et al.* (2004) observed that for better germination percentage and distant transportation, the seed nut should be sowing vertically in full buried condition because the author reported that higher but non-significant germination percentage was recorded in horizontal planting (82.69 %) as compared to vertical sowing (79.94 %).

Thomas (1978), concluded that horizontal planting of seed nut resulted in quicker germination and greater growth of seedling.

Thomas (2008), noted that if the nut water is less in the seed nut horizontal planting is advisable.

2.2 Effect of the resting period on germination and height of seedling

Coconut (*Cocos nucifera* L.)

Marimuthu and Natarajan (2005) observed that to get more quality seedlings, seed nuts are to be cured for one month in open shade followed by sand for 2-3 months.

Peter and Kurian (2007) recommended storage of seed nuts in shade for a minimum period of 60 days prior to sowing in tall cultivars and 15-30 days in dwarf cultivars.

Mango (*Mangifera indica* L.)

Chandra (1980) observed that mango cultivars Desi and Dasherri were germinated 100% at 0 and 30 days after harvest and it declined to 66% at 45 days after harvest.

Teaotia and Singh (1971) revealed that the open jar storage treatment for 10 days after extraction of pulp gave significantly highest germination percentage (85%) over stones stored in leaf media (65%), charcoal powder (65%) and polythene bags (45%) storage.

Papaya (*Carica papaya* L.)

Lima *et al.* (1985) recorded that the seeds stored for 33 days in sand medium at room temperature shows highest germination percentage in papaya cv. Maradol Roja.

Citrus (*Citrus reticulata* L.)

Saipari *et al.* (1998) reported that maximum germination (79% and 77%), maximum length of tap root (22 cm and 19 cm), maximum number of secondary roots (58 and 60) and maximum number of leaves per plant (19 and 16) were noted in fresh seeds over air dried seeds for 24 hrs at $27 \pm 2^{\circ}\text{C}$ and seeds dried for 1 week in silica gel in Karna khatta and Jatti khatti.

Doijode (2003) noted that the fresh seeds exhibited high seedling vigour as compared to 30 days old stored seeds of Mandarin.

Kadam *et al.* (1994) studied the effect of various storage condition and storage periods on viability and germination percentage of Rangpur lime seeds. Viability and

germination percentage was significantly affected by different storage conditions. After fifth week of storage, maximum viability and germination percentage was recorded when seeds stored at room temperature followed by seeds sealed in polythene bags, stored at 90% relative humidity, sealed in polythene bags and stored at 90% relative humidity at room temperature.

Jackfruit (*Artocarpus heterophyllus* L.)

Chiesotsu *et al.* (1995) observed highest germination percentage, percentage of survivability in field, height and diameter of seedling and minimum days taken for germination in fresh seeds over stored seeds for 15 days in jackfruit.

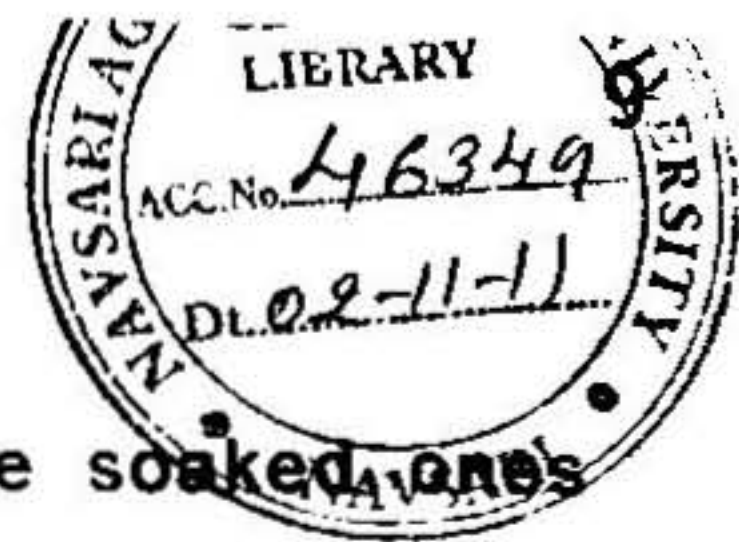
Krishnaswamy (1990) reported that seeds of jackfruit when stored in plastic tray and kept in room temperature for shade drying for 9 days gave 100% germination.

Warrier *et al.* (2009) reported that seeds stored under ambient condition ($25\pm 2^{\circ}\text{C}$) were most effective to increase germination percentage for 1 week of storage over 20°C , 15°C and $0\pm 2^{\circ}\text{C}$ temperature in *Artocarpus heterophyllus* L.

2.3 Effect of pre sowing treatments on germination and height of seedling

Coconut (*Cocos nucifera* L.)

Menon and Pandalia (1958) observed that the soaking treatment was particularly effective when dry condition prevailed after planting the seed nut in the nursery. This however, might be an indication that the non soaked nuts in the nursery had



been insufficiently irrigated as compared to the soaked ones being completely saturated with water.

Fremond and Brinin (1966) noted that the removal of a slice of the husk from the upper part of the nut at the distal end above the germinating eye has the advantage of facilitating the penetration of water in the nut and the early emergence of the sprout. Similar result was also observed by Kenman (1973), Arvindakshan *et al.* (1988) and Mandal (1991). However Child (1974) reported that the removal of husk slice from the nut was useless and unnecessary refinement which increased nursery cost. The statement was also supported by Harries (1981 b) particularly in the adequate irrigation or rainfall.

Hadas and Russor (1974) reported that in general, the water soaking which enhances the germination of nuts, may be due to the higher quantum of water required for the initial imbibitions of water by a bigger nut like that palmyrah and coconut. Similar trends were also seen by Srivastava (1975), Yaklich and Orzolak (1977) and Harries (1981 b) in coconut.

Silva and Alputharajah (1977) reported that there was no significant effect on hastening germination by applied nutrient solution in husk by injection.

John and Fernanded (1979) observed that some kind of soaked seeds removed water soluble substances from pericarp, so improved germination percentage.

Harries (1981 a) observed that Tanzanian Tall variety of coconut shows two quite distinct sets of results. The Tanzanian Tall may therefore be regarded as a Niukafa type

(Tall variety). The more rapid germination was observed in this variety by the water treatment.

Harries (1981 b) studied that less amount of dilute salt solution which showed negligible effect while much quantities of stronger solution (i.e. sea water) might have delay germination. Soaking in plain water seems to be the only beneficial treatment. He further studied that the only beneficial effect of soaking coconut seed nuts which might be accounted for in terms of water potentials. The liquid inside coconut of all age has osmotic potentials of about 2 bars, whereas, the hydrostatic pressure within the nut cavity ranges from 5-bar in the young fruit which decreasing with age, until fully ripe when there is a gas phase somewhat below atmospheric pressure.

Sufeliffe (1981) noted that metric potential may be greatest in the husk. This frames proportionally larger part of the young fruit and with age becomes gradually cut off from the water in the nut cavity by increasing impermeability of developing shell of the nut. In a ripe fruit the water in the nut cavity would tend to migrate to the husk because of the metric potential. The very long storage could result in the moist endosperm converted to copra inside the shell (Ball copra). Soaking of seed nut in water, after harvesting or storage would bring the matric potential to zero. Water could then migrate into the nut primarily through the soft eye in the proximity of the embryo. Germination process might be triggered immediately or when the negative osmotic potential of the nut water is raised to zero. Similar finding were also noted by Harries (1981 b).

Sadashivaih (1983) concluded that 2-4 D, Urea and GA3 promoted seed nut germination which is applied into the seed nut by injecting technique.

Ohler (1984) noted that improving the germination of seed nuts has also been tried by soaking the nuts in water or in chemical solution. Soaking of the nuts in water for a period of about two weeks has been recommended to improve sprouting or germination of the nuts. Soaking of the nuts for the periods longer than two weeks affects the germination of the nuts. Similar trend was also previously seen by Thomas (1973) at Tanzania in Tall variety of coconut.

Thomas (1973) concluded that the soaking of coconut seed nut in water for a period of 15 days before sowing recorded the lowest period of germination (81.1days) as compared to (142.9 days) for untreated nut.

Kutty (1964) applied pre-sowing treatment of coconut seed nuts of tall variety with micronutrients ($MgSO_4$ 11,500 ppm and 2,300 ppm; $Na_2B_4O_7$ 5,700 ppm and 11,500 ppm; $CuSO_4$ 5,500 ppm and 11,000 ppm; $MnSO_4$ 4,250 ppm and 8,500 ppm; $FeSO_4$ 3,750 ppm and 7,500 ppm; $(NH_4)_6Mo_7O_{21}$ 50 ppm and 100 ppm and $ZnSO_4$ 6,500 ppm and 13,000 ppm) in two concentrations each case. The nutrients were injected into the husk of the seed nuts through the tuft portion using a syringe before sowing. It may be interesting to observe that of all the treatments, the seed nut treated with Boron (11,500ppm) have germinated in 57 days compared to control (11-12week).

Edmondson (1941) reported that 10 out of 15 coconuts were capable to developing after having floated up to 110 days in the sea.

Bose (1992) reported that the many pre-sowing treatments recommended for reducing the period of germination with higher germination percentage, but the soaking the seed nuts in water for two weeks period has been found to be very effective.

Rao (1953) recommended that seed nut should be soaked in water before sowing in nursery for higher germination and recovery of quality seedling.

Palmyrah Palm (*Borassus flabellifer* L.)

Daniel (1992) observed that the soaking of palmyrah-palm seed nut in water for three hours increases the germination by 24.5 per cent as compared to un-soaked.

Das (2003) applied pre-treatment of palmyrah nuts with cow-dung slurry for 7-10 days in earthen pit. Then these nuts were removed from the pit and cleaned in water and then dibbled in the field. Within a period of 2 to 3 months, the palmyrah nuts start germination. The rate of success was found not less than 65 percent and this method is full-proof and the success is assured.

Ber (*Zizyphus mauritiana* Lamk)

Ghosh and Sen (1988) studied that maximum germination percentage, basal girth and leaf number were found when seeds treated with KNO_3 1 % over GA_3 (100 ppm) after 30 days of storage. While, maximum germination percentage,

seedling height, basal girth and leaf number when seeds treated with 1% KNO_3 over thiourea and control treatment at seeds stored for 203 days in ber.

Singh *et al.* (2001) conducted field experiment and reported that ber seeds when soaked in water for 48 hrs + 4 days in moist gunny bag got less time taken to start germination, less time taken to complete germination, maximum germination percentage and maximum height of seedling as compare to water soaking for 48 hrs, control and concentrated sulphuric acid soaking for 6 minutes.

Hore and Sen (1994) recorded that the pre-sowing treatment of Ber seeds with thiourea 1 percent causes earlier seed germination with 8.1 days after sowing as against 12.8 days required in untreated seeds to start germination.

Singhrot and Makhija (1979) revealed that water soaking treatment for 48 hrs gave earliness in days taken to 50 percent germination (17.60 days), minimum days for completion of germination (28 days) and increase in overall germination percent (83.60%) over concentrated sulphuric acid treatment for 3 minutes (17.80 days, 29.40 days and 79.20%), respectively in Ber.

Mankar *et al.* (1997) stated that soaking extracted seeds for 24 hrs in water promoted early germination, good vegetative growth and higher percentage of germination compared with control.

Bhambota and Singh (1971) revealed that less time required for germination, maximum germination percentage,

height and girth of seedling were found when seeds sown after soaking in water for 24 hrs over seeds sown as such.

Chattopadhyay and Dey (1992) revealed that seeds soaked in water for 48 hrs gave maximum germination percentage when seeds sown in June over control and sulphuric acid soaking treatment in Ber.

Cardamom (*Elettaria cardamomum* (L))

Gurumurthy and Hedge (1987) revealed that the pre-sowing treatment of cardamom seeds with 25 per cent nitric acid and soaking them in water for 24 hours increases seed germination percentage compared to untreated control.

Sapota (*Manilkara achras*)

Pampanna and Sulikeri (1999) reported that seeds soaked in water for 24 hrs shows significantly maximum shoot length (6.35 cm), root length (3.79 cm) and number of leaves (3.06) over unsoaked seeds (4.90 cm, 3.12 cm and 2.68, respectively) at 90 days after sowing in sapota.

Cherry (*Prunus avium* L.)

Centinbas and Koyuncu (2006) stated that the thiourea treatment improved the germination of *Prunus avium* L. seeds and the effect of thiourea on germination was statistically significant. The highest germination rate was observed with 120 days stratification + 10,000ppm thiourea with seed coat and 100 days stratification + 10,000ppm thiourea for seed without coat.

Khirnee (*Manilkara hexandra* (Roxb.)Dub.

Patel *et al.* (1996) revealed that for better germination of Khirnee seeds, it should be soaked in thiourea 1 per cent for 6 hours or should be treated with dung slurry for 24 hours before sowing.

Custard apple (*Annona squamosa* L.)

Ratan *et al.* (1993) revealed that the soaking of custard apple seeds in water for 24 hours resulted in highest germination (71%) followed by soaking for 36 hours (67%). There was 15 percent germination in control (dry seeds). Number of days taken for initiation of germination was minimum (16 days) with seeds soaked in water for 48 hours, where as the velocity of germination was higher with 24 hours water treatment and lower with dry seeds. Seeds soaked in water for 24 hours recorded maximum seedling vigour and significantly differed with 48 hours treatment and control.

Nutmeg (*Myristica fragrans* Houtt.)

Khandekar *et al.* (2007) revealed that the effect of pre-sowing treatment in nutmeg give the mean maximum germination (88.88%) was observed in thiourea (500 ppm) treatment, which was significantly superior to the rest of the growth regulator treatments. The minimum germination (77.09%) was observed in thiourea (1000 ppm) treatment, which was lower than control.

Phoenix species

Singh and Bhargava (2009) reported that pre-sowing treatment of *Phoenix dactylifera* and *P. sylvestris* seeds with

different treatments in which seed soaking in water for 24 hours increase germination percentage, plant height, number of leaves and length of roots as compared to control.

Lettuce (*Lactuca sativa*):

Mayer and Poljakoff-Mayber (1958) reported that thiourea causes maximal stimulation of germination at 20°C. The lettuce seeds were treated for first 24 hours with thiourea and then were transferred to water, 90 per cent germination being obtained as compared with 40 per cent in water control and 70-80 per cent for shorter and longer period in thiourea.

Forest tree species

Shukla *et al.* (2008) concluded that in tarai zone of West Bengal, proper and quicker germination of *Terminalia arjuna* can be ensured for better seedling development when the seeds are heavily pinched or seed coat nearly removed and then dipped for one minute in concentrated sulphuric acid, washed and subsequently dipped in cold water for 12 hours.

Hossain *et al.* (2005) revealed that the pre-sowing treatment, de-pulped and cold water soaking of the Horitaki (*Terminalia chebula*) seeds increase the germination and height of seedling. Seeds were subjected to six pre sowing treatments in which the highest germination percentage (66%) shoot length, root length, collar diameter and number of leaf were observed in the fruit de-pulped and soaked in cold water for 48 hours followed by 60 percent in the de-pulped seeds soaked in cold water for 24 hours. The lowest germination percentage (48.9 %) was obtained from control.

Butola *et al.* (2007) revealed that pre-sowing treatment of thiourea to *Hypericum perforatum* L. seeds with medium concentration (100 μ M) had better germination as compared to control.

Kalia *et al.* (2005) studied the effect of mechanical scarification and hot water treatment before sowing of seeds of *stylosanthes scabra*. The result obtained showed that mechanical scarification by rubbing with commercial thin sand paper for 5 minutes recorded highest germination percentage followed by hot water treatment for 15 minutes.

Singh *et al.* (2005) reported that the pre-sowing treatment of *Pongamia glabra* L. seeds with hot water (50 $^{\circ}$ C) for 15 minutes enhanced seed germination up to 94 to 98 per cent over the control.

Kundu *et al.* (1997) concluded that the soaking of *Alstonia scholaris* seeds in distilled water for 24 hours and continuous hot water soaking at 50 $^{\circ}$ C for 30 minutes performed equally well registering two fold increase in germination.

VIGOUR OF SEEDLING

Kutty (1955) reported that the mature seed coconuts with and without cracks at stigmatic ends has shown, that the seed nuts without cracks were more vigorous than those obtained by with cracks.

Thomas (1974) studied the effect of certain physical and chemical treatments on the germination and subsequent growth of coconut seedlings. The result indicated that all the treatments except the chopping of the ends significantly reduced the germination period and gave the higher percentage and

greater growth of seedling as compared to control. Among all treatments, soaking in water for two-weeks was the best and it ranked first in all the characters. Similar result was also found by Singh (1983) in ber seedling.

Silva and Atputharajah (1977) reported that injection of micronutrient solution and water (control) into the husk was applied at the distal end of the nuts. The injected solutions contained about ten times more nutrient than total amount present in the kernel and nut water. The treatment of Zn, Cu, and control (water applied) could reduced the sprouting period and increased the sprouting percentage. The Cu treatment produced the highest percentage seedling, whereas the Zn and control had adverse effects on sprouting and height of seedling. Similar finding was also reported by Silva (1981).

Willatt and Stress (1979) reported that the availability of sufficient water was essential for the imbibition of water in seeds, their germination and height of seedling. The rate of seed swelling, germination, root and shoot extension depends on the water potential of the soil and seed.

Sadashivaiah (1983) observed that urea (2%) and potassium nitrate treated seed nut showed higher seedling vigour as expressed morphological features such as early leaf splitting, number of leaves, height and higher girth at collar due to early sprouting of seed nut.

Arvindakshan *et al.* (1988) reported that in coconut the removal of husk from coconut hastened the process of germination and also increased the girth at collar.

Parmar (1982) observed that the water soaking treatment was found significantly superior which increased the plant height of tuberose at flower initiation than rest of the chemical and growth regulator treatments. Though water soaking recorded maximum number of leaves per plant, the difference was non-significant with all other treatments except control. Similar trend was also obtained by Jayaselan (1983). He found that significantly increase in vegetative parts of gladiolus by soaking treatments. This might be due to the early sprouting of bulb under water soaking as compared to rest of the treatments.

QUALITY SEEDLING:

Rao (1953) recommended that seed nut should be soaked in water before sowing in nursery for higher germination and recovery of quality seedlings.

Aiyadural (1956) reported that in coconut nursery practice, the seed nut without water should be rejected at the time of planting. But from the experiment it was seen that possible to utilize the rejected nuts for producing seedling by soaking only those which become heavy after the treatment, this was an important and useful hint to nursery men who produce quality seedling for coconut growers.

Kumar and Pillai (1990) revealed that the husked and de-husked treatments of seed nut had no deleterious effect on seedling vigor and production of quality seedling.

Markose and Kutty (1987) concluded that physiologically matured seed nut when sown in the nursery affects very much on the duration taken for germination, which

ultimately influences the seedling size and vigor. They have also reported that seed nuts should be fully matured (i.e. 11-12 month old).

Arvindakshan *et al.* (1988) concluded that germination of coconut seed nuts depended to a great extent on the quantity and quality of the kernel (Meat) in the nut which in depended on maturity. The maximum development of kernel takes place when the nut attained full maturity. In West Coast Tall variety 12 month old seed nut were found relatively more superior to the other age group (i.e. 11 and 13 month old), but the differences were not significant. Therefore, the seed nuts of both age groups (11 and 12 month old) were considered suitable for nursery purposes. Similar trends were also reported by Thampan (1981).



MATERIALS & METHODS



III. MATERIALS AND METHODS

The present investigation was conducted employing resting period, pre sowing and special treatments (SP₁: stalk end down (invert) placement of coconut seed nut before sowing for 10 days and SP₂: stalk end down (invert) placement of coconut seed nut before sowing for 15 days) on coconut seed nut with the objective to know the effect on germination and height of coconut seedling. The details of material used, experimental methods followed and techniques adopted during the course of the investigation have been described in this chapter.

3.1 Location

3.1.1 Experimental site and location

The present investigation on "Effect of resting period and pre sowing treatments on seed nut germination and height of seedling of coconut (*Cocos nucifera* L.) cv. D×T." was carried out at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during year 2010-2011.

3.2 Soil characteristics

As per the seventh approximation, the soil of Navsari has been placed under the great group of vertic ustochrepts, Sub order chrepts and order inceptisols with Jalalpore series, which include deep, moderately drained clayey soil, which was classified earlier as "deep black soil".



Plate-I : General view of experiment

The soil of experimental site is black, deep and rich in organic matter and potash, having good water holding capacity with good drainage.

The soil sample was taken randomly from nursery, covering the complete experimental area with the help of auger up to 30cm depth. The soil analysis was done as per the standard procedures. The physical and chemical properties of the soil of experimental block have been presented in Table 3.1 and Table 3.2, respectively.

Table-3.1: Physical properties of the soil

Sr. No.	Particulars	Value in per cent (0-30 cm depth)	Texture
1.	Coarse sand	0.69	Clay
2.	Fine sand	09.17	
3.	Silt	24.94	
4.	Clay	65.20	

Table-3.2: Chemical characteristics of the soil

Sr. No.	Particulars	Value(0-30 cm depth)	Methods employed
1	Soil pH (1:2.5 soil: water ratio)	7.7	Backman's pH meter (Jackson, 1967)
2	Total N (%)	0.052	Modified kjeldahl's method (Jackson, 1967)
3	Available N (kg ha ⁻¹)	160.00	Alkaline permanganate method (Jackson, 1967)
4	Available P ₂ O ₅ (kg ha ⁻¹)	40.02	Olsen's method (Olsen's et al., 1954)
5	Available K ₂ O (kg ha ⁻¹)	384.50	Flame photometer (Jackson, 1967)

3.3 Climate and weather

The climate of this region is typical tropical, characterized by fairly hot summer, moderately cold winter and most humid and warm monsoon. In general, monsoon sets by the second fortnight of June and ends by second fortnight of September. Most of the precipitation is received from South-West monsoon, concentrating in months of July and August. Average annual rainfall of this region approximates about 1500 mm. Winter commences from October onwards and ends by the middle of February, while December and January are the coldest of the year. The summer season commences from the middle of February and ends by the first week of June. April and May are the hottest months in summer. The mean monthly meteorological data on maximum and minimum temperatures, relative humidity and rainfall during the course of investigation recorded at the meteorological observatory of university. (Appendix-3)

3.4 Planting material

Selection of seed nuts was done according to certain criteria such as yield consistency, bearing ability of individual palm under average conditions of package of practices and least incidence of disease and pests. Therefore, the Regional Horticultural Research Station ASPEE College of Horticulture & Forestry, N. A. U., Navsari was selected as source of centre of seed nuts.

3.5 Planting time

Planting was done in January 2010.

Sowing of seed nut



Invert placement of seed nut



Punching of seed nut



Plate-II : Sowing of seed nut, stalk end down (invert) placement and punching on seed nut

3.6 Experimental details

- 3.6.1 Experimental design** : FCRD (Complete Randomized Design with Factorial concept)
- 3.6.2 Crop** : Coconut, cv. D×T
- 3.6.3 Number of repeatation** : 3
- 3.6.4 Details of treatments** : 14

Special treatments

SP₁: stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)

SP₂: stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)

Factor I: - Resting period (R)

R₁: Fresh just after harvesting

R₂: 15 days rest

R₃: 30 days rest

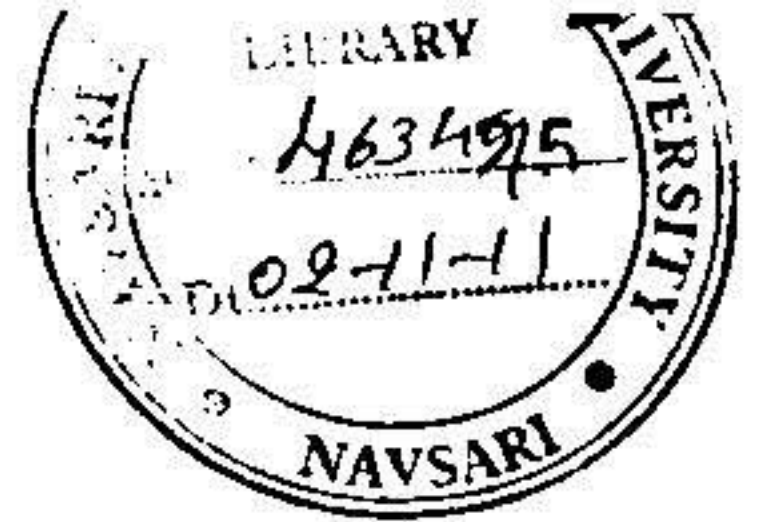
Factor II: - Pre sowing treatments (S)

S₁:- Control without any treatment

S₂:- water soaking for 15 days without punching

S₃:- water soaking for 15 days with punching

S₄ :- soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut



3.6.5 Treatment combinations:

1. R_1S_1 : Fresh + Control (without any treatment)
2. R_1S_2 : Fresh + water soaking for 15 days without punching
3. R_1S_3 : Fresh + water soaking for 15 days with punching
4. R_1S_4 : Fresh + soaking of seed nut in 10000 ppm solution of thiourea for 24 hrs. after punching on seed nut
5. R_2S_1 : 15 days rest + Control (without any treatment)
6. R_2S_2 : 15 days rest + water soaking for 15 days without punching
7. R_2S_3 : 15 days rest + water soaking for 15 days with punching
8. R_2S_4 : 15 days rest + soaking of seed nut in 10000 ppm solution of thiourea for 24 hrs. after punching on seed nut
9. R_3S_1 : 30 days rest + Control (without any treatment)
10. R_3S_2 : 30 days rest after harvesting + water soaking for 15 days without punching
11. R_3S_3 : 30 days rest + water soaking for 15 days with punching
12. R_3S_4 : 30 days rest + soaking of seed nut in 10000 ppm solution of thiourea for 24 hrs. after punching on seed nut

3.6.6 No. of seed nut per treatment : 25

3.7 Preparation of solution

3.7.1 Thiourea solution

For making 10000 ppm solution 10 g thiourea was weighted and dissolved in 1 litre water. Seed nuts were soaked in solution for 24 hrs.

3.7.2 Water

Fresh and clean water was used for treatments. Seed nut soaked in water for 15 days in water in a way that each and every seed nut homogenously sink in water.

3.8 Sowing details

3.8.1 Planting of seed nut:

The seed nuts were planted in vertical position so, as keep the embryonic stalk-end up uniform depth of planting was maintained by keeping the upper portion of husk slightly above the soil surface.

3.8.2 Irrigation:

First irrigation was given just after planting and subsequently irrigation was given daily during dry period and such irrigation cycle was maintained for a period of 4-5 months. After this period, irrigation should be done twice a week. There was no need of watering in rainy season.

3.8.3 After care of plants

No special care was needed in this crop, however weeding was regularly done to keep the experimental area clean and free from weeds.

Girth at collar region



Height of seedling



Plate-III : Measurement of seedling girth at collar region and height of seedling

3.9 Collection of experimental data

Five plants were randomly selected from each plot of each treatment and tagged for recording the observations.

For collection of plant samples, the plants were carefully uprooted from the soil and soil particles on roots are carefully removed with the help of tap water and for observing root length and number of roots per seedling at the end of experiment.

The data obtained from all treatments per repeatation under each treatment were averaged and reported.

3.10 Observations recorded

The details about the observations recorded during the investigation are given below.

3.10.1 No. of days taken to germinate the seed nut

Number of days was counted from nut sowing to first sprout emergence and number of days were taken to germinate the seed nut.

3.10.2 Germination percentage after 60, 75 and 90 days after seed nut sowing

The germination percentage was calculated at 60, 75 and 90 days after sowing of the seed nuts.

3.10.3 Height of seedling at 120 , 180 , 270 and 360 days after sowing of seed nut

The height of seedlings was measured in cm from ground level to the tip of the longest recent unfolded leaf with the help of measuring tape at 120 , 180 ,270 and 360 days.

3.10.4 Number of leaves per plant

The number of leaves was counted at 120, 180, 270 and 360 days after sowing for each randomly selected five plants of each treatment and mean value of leaves per plant was calculated.

3.10.5 Girth at collar region of seedling (cm)

The girth at collar region of five randomly selected seedlings was measured at ground level with the help of digital caliper in centimeter. Girth at collar region of seedling was measured at 120, 180, 270 and 360 days after sowing and average of five seedlings was considered for recording of girth of seedling.

3.10.6 Number of roots per plant at uprooting

To study the number of roots per seedling, five seedlings from each plot at 270 and 360 days after sowing were uprooted carefully after watering. The roots were counted and the average of five seedlings was considered for recording the number of roots per seedling.

3.10.7 Root length (cm)

To study the length of root per seedling, five seedlings uprooted for number of roots per plant were also consider for measuring the root length and the longest root was measured and average value was calculated.

3.10.8 Survival percentage of seedling

The total number of survival seedlings was computed at uprooting. The data were expressed in percentage.

3.11 Statistical analysis

The data of all characters studied were subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1967). The method of analysis of variance for complete Randomized Design with Factorial concept (FCRD) was used. The appropriate standard error of mean (S.Em \pm) was calculated in each case and the critical difference (C.D.) at five per cent level of probability was worked out to compare the treatments means where the treatment effects were significant. The data were analyzed on computer. The data were subjected to statistical analysis in the department of Agricultural Statistics, N.M. college of Agriculture, N.A.U. Navsari. The results have been depicted with the help of graphs or diagrams where necessary.



EXPERIMENTAL RESULTS



IV. EXPERIMENTAL RESULTS

The present investigation was undertaken with a view to determine the effect of resting period after harvesting, pre sowing and special treatments (SP₁: stalk end down (invert) placement of coconut seed nut before sowing for 10 days and SP₂: stalk end down (invert) placement of coconut seed nut before sowing for 15 days) on germination and growth parameters of coconut seedling during 2010-11. The data collected on various characters were analyzed statistically and the results pertaining to each aspect have been presented and described along with statistical inferences under the following broad topics.

4.1 Number of days taken to germinate the seed nut

4.2 Germination

4.3 Height of seedling

4.4 Number of leaves per seedling

4.5 Girth at collar region

4.6 Number of roots at uprooting

4.7 Root length at uprooting

4.8 Survival percentage

4.1 Number of days taken to germinate the seed nut

The data pertaining to days taken to germinate the seed nut of coconut as influenced by special treatments, resting period and pre sowing treatments are presented in Table-4.1 and depicted in Fig.1.

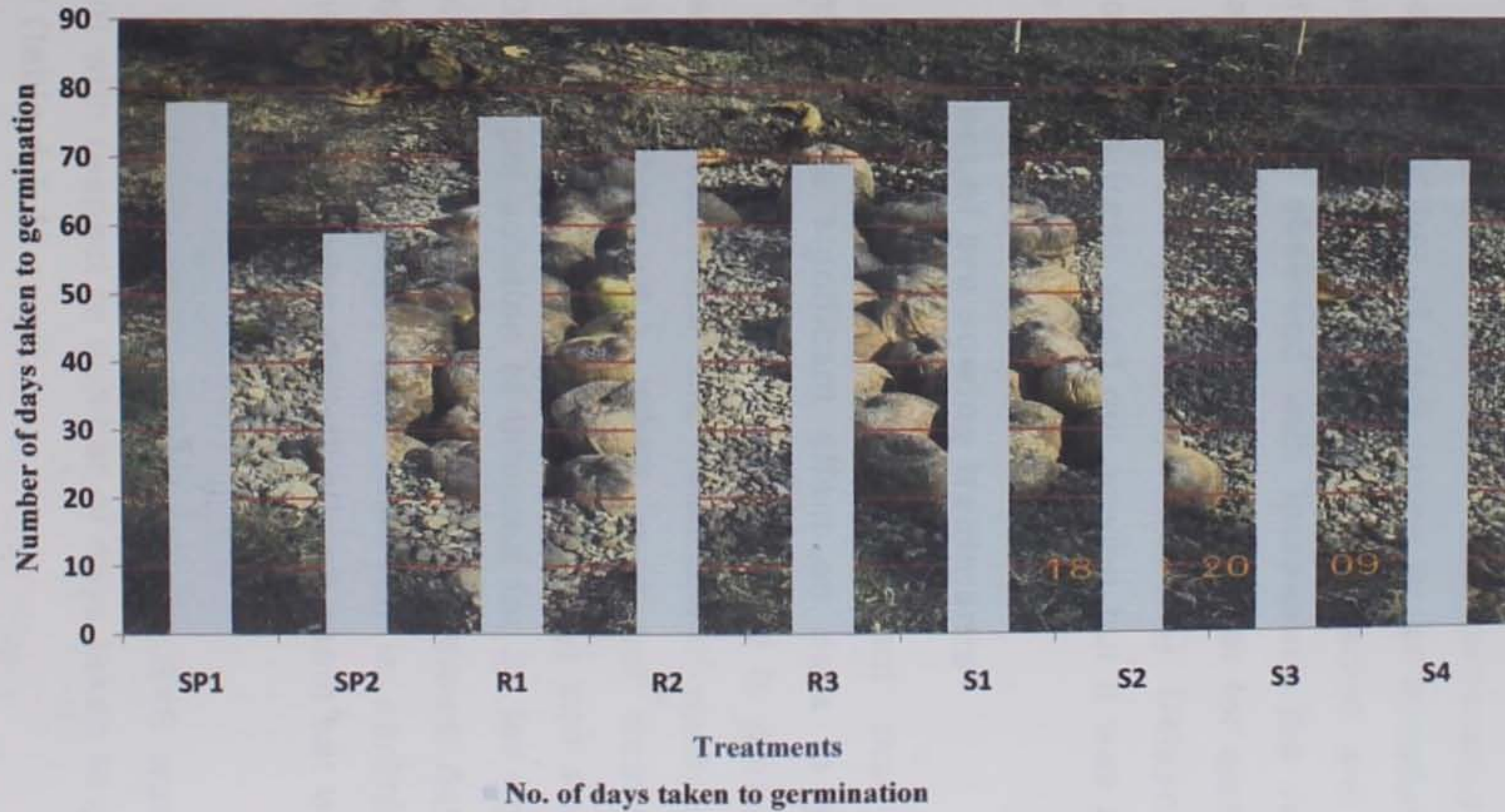
4.1.1 Effect of special treatments

A perusal of data presented in table-4.1 revealed that the number of days taken to germinate the seed nut was significantly influenced by special treatments under study. An earliness in germination (59 days) was recorded with distal end down (invert)

Table: 4.1. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on number of days taken to germination of seed nut.

Treatments	No. of days taken to germination
Special treatments (SP)	
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	78.00
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	59.00
S.Em. ±	3.48
C.D. at 5%	10.09
Resting Period (R)	
R ₁ : Fresh just after harvesting	75.91
R ₂ : 15 days rest	71.00
R ₃ : 30 days rest	68.91
S.Em. ±	1.86
C.D. at 5%	5.43
Pre sowing treatment (S)	
S ₁ : Control (without any treatment)	78.11
S ₂ : Water soaking for 15 days without punching	72.44
S ₃ : Water soaking for 15 days with punching	68.00
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	69.22
S.Em. ±	2.15
C.D. at 5%	6.27
Interaction of R×S	
S.Em.±	3.72
C.D.at 5%	10.87
C.V. %	8.97

Fig. 1 - Effect of time of invert placement of seed nut, resting period and pre-sowing treatments on number of days taken to germination of seed nut



placement of coconut seed nut before sowing for 15 days (SP₂) as compared to distal end down (invert) placement of coconut seed nut before sowing for 10 days (SP₁).

4.1.2 Effect of resting period

It is evident from the data presented in table-4.1 indicated that number of days taken to germination of seed nut was significantly affected by resting period and earliness in germination was observed with increasing the resting period. Thirty days resting period was found better for early germination of seed nut followed by 15 days rest (R₂). Delayed germination was recorded in fresh seed nut sowing but it was at par with R₂ (15 days rest).

4.1.3 Effect of pre sowing treatments

From Table-4.1, it is evident that, pre sowing treatments had a significant effect on days to germination in coconut seed nut. Minimum days required to germination (68.00 days) was observed under the treatment of water soaking for 15 days with punching (S₃). While seed nut treated with water soaking for 15 days without punching (S₂) and soaking of seed nut in 10000 ppm solution of thiourea for 24 for hours (S₄) were at par with S₃. Whereas, significantly maximum days required to germination (78.11 days) was observed in control without any treatment (S₁) and it was statistically on same bar with S₂.

4.1.4 Interaction effect

The interaction effect between R×S was found to be significant with respect to number of days taken to germination of seed nut (table 4.1.1).

Regarding to interaction between R×S, significantly minimum days required for germination of seed nut (60.00 days) was noted under R₂S₃ treatment combination (15 days rest + water soaking for 15 days with punching). It was statistically on same bar with R₁S₄, R₂S₂, R₃S₁ and R₃S₃. Treatment combination R₁S₁ had maximum values (86.66 days) for number of days taken to germinate the seed nut.

Table-4.1.1: Interaction effect of R x S on number of days taken to germination of coconut seed nut

Treatments	Number of days taken to germination of seed nut		
	R ₁	R ₂	R ₃
S ₁	86.66	80.66	67.00
S ₂	78.60	68.33	71.00
S ₃	76.66	60.33	67.00
S ₄	62.33	74.66	70.00
S. Em. ±	3.72		
C.D. at 5%	10.87		

4.2 Germination (%)

The data pertaining to germination at 60, 75 and 90 DAS as influenced by special treatments, resting period and pre sowing treatments of coconut seed nut are presented in Table-4.2 and graphically depicted in Fig. 2.

4.2.1 Germination after 60 DAS

4.2.1.1 Effect of special treatments

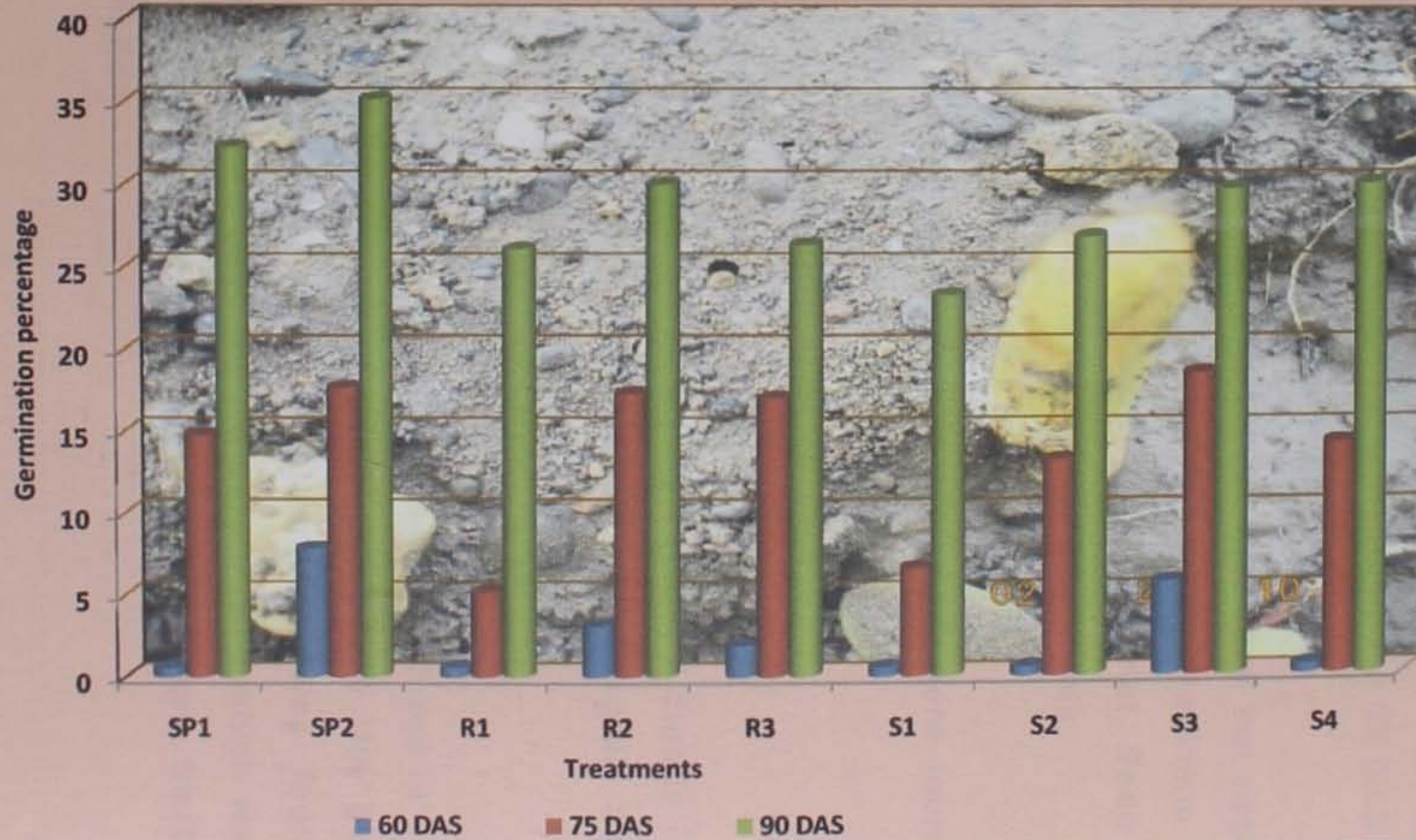
The data presented in Table-4.2 clearly indicated that there was significant effect due to special treatment on

Table: 4. 2. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on seed nut germination after 60, 75 and 90 DAS.

Treatments	Germination (%)		
	60 DAS	75 DAS	90 DAS
Special treatments (SP)			
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	0.00 (0.57)	6.67 (14.79)	28.67 (32.32)
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	2.67 (7.87)	9.33 (17.70)	33.33 (35.19)
S.Em. ±	2.29	2.81	4.14
C.D. at 5%	6.64	NS	NS
Resting Period (R)			
R ₁ : Fresh just after harvesting	0.00 (0.57)	3.00 (5.20)	20.33 (26.10)
R ₂ : 15 days rest	1.33 (3.12)	14.08 (17.30)	27.00 (30.01)
R ₃ : 30 days rest	0.66 (1.89)	9.00 (17.03)	21.00 (26.35)
S.Em. ±	1.12	1.49	2.00
C.D. at 5%	NS	4.35	NS
Pre sowing treatment (S)			
S ₁ : Control (without any treatment)	0.00 (0.57)	3.55 (6.65)	16.00 (23.30)
S ₂ : Water soaking for 15 days without punching	0.00 (0.57)	8.44 (13.27)	22.22 (26.84)
S ₃ : Water soaking for 15 days with punching	2.66 (5.73)	15.11 (18.54)	26.22 (29.75)
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	0.00 (0.57)	7.66 (14.24)	26.66 (30.08)
S.Em. ±	1.29	1.72	2.31
C.D. at 5%	3.77	5.02	NS
Interaction of R×S			
S.Em.±	2.24	2.98	4.01
C.D. at 5%	NS	8.70	12.00
C.V.%	208.35	39.2	11.72

Note: Data in parenthesis indicates arc sin transformed value

Fig.2- Effect of time of invert placement of seed nut, resting period and pre sowing treatments on seed nut germination after 60, 75 and 90 days after sowing



germination at 60 days after sowing. The maximum germination (7.89 %) was observed in treatment SP₂, as compared to SP₁.

4.2.1.2 Effect of resting period

With regards to resting periods, the results were found statistically non significant for germination at 60 DAS.

4.2.1.3 Effect of pre sowing treatments

It was clearly observed that seed nut soaked in water for 15 days with punching (S₃) gave maximum germination (5.73%) at 60 days after sowing of seed nut. Seed nut was not germinated at 60 DAS in rest of the treatments.

4.2.1.4 Interaction effect

The interaction effect of R×S were found to be non significant for germination at 60 DAS.

4.2.2 Germination after 75 DAS

4.2.2.1 Effect of special treatments

The data presented in Table-4.2 clearly indicated that there was no significant effect of special treatments on germination at 75 days after sowing.

4.2.2.2 Effect of resting periods

It is evident from the data presented in Table-4.2 that resting period was significantly influenced the germination of seed nut after 75 DAS. Germination was found maximum (17.30 %) with 15 days resting period (R₂), which was at par with 30 days rest (R₃). While the seed nut sown fresh gave least germination.

4.2.2.3 Effect of pre sowing treatments

From Table-4.2, it is evident that, pre sowing treatments had a significant effect on germination of coconut at 75 DAS. The maximum germination (18.54 %) was observed under water soaking for 15 days with punching (S_3) and it was on same bar with soaking of seed nut in 10000 ppm solution of thiourea (S_4). Whereas, significantly minimum germination (6.65 %) was observed in control without any treatment (S_1).

4.2.2.4 Interactions effect

The interaction effect between resting period and pre sowing treatments with respect to germination at 75 DAS was found to be statistically significant (table-4.2.1). The maximum germination (34.98) was observed in treatment combination R_2S_3 .

Table-4.2.1: Interaction effect of R x S at 75 DAS on germination

Treatments	Germination (%) at 75 DAS		
	R_1	R_2	R_3
S_1	0 (0.57)	0 (0.57)	10.67 (18.80)
S_2	0 (0.57)	20.00 (26.08)	5.33 (13.16)
S_3	0 (0.57)	33.33 (34.98)	12.00 (20.08)
S_4	12.00 (19.09)	3.00 (7.57)	8.00 (16.07)
S. Em. \pm	2.98		
C.D. at 5%	8.70		

Note: Data in parenthesis indicates arc sin transformed value

4.2.3 Germination after 90 DAS

4.2.3.1 Effect of special treatments

The data presented in Table-4.2 clearly indicated that there was no significant effect of special treatments on germination at 90 days after sowing.

4.2.3.2 Effect of resting periods

It is evident from the data presented in Table-4.2 that resting periods had no significant effect on germination at 90 DAS.

4.2.3.3 Effect of pre sowing treatments

From Table-4.2, it is evident that, pre sowing treatments had no significant effect on germination of coconut at 90 DAS.

4.2.3.4 Interaction effect

The interaction effect between resting period and pre sowing treatments with respect to germination at 90 DAS was found to be statistically significant (table-4.2.2). The maximum germination (44.53 %) was observed in treatment combination R_2S_3 which was at par with R_3S_4 and R_2S_2 . The least germination (16.07 %) was noted in R_3S_2 treatment combination.

Table-4.2.2: Interaction effect of R x S at 90 DAS on germination

Treatments	Germination (%) at 90 DAS		
	R ₁	R ₂	R ₃
S ₁	17.33 (24.38)	10.67 (19.03)	20.00 (26.48)
S ₂	22.67 (28.04)	36.00 (36.41)	8.00 (16.07)
S ₃	12.00 (20.25)	49.33 (44.53)	17.33 (24.45)
S ₄	29.33 (31.74)	12.00 (20.08)	38.67 (38.42)
S. Em. ±	4.01		
C.D. at 5%	12.00		

Note: Data in parenthesis indicates arc sin transformed value

4.3 Height of seedling (cm)

4.3.1 Height of seedling at 120 days after sowing

The data on height of seedling at 120 DAS as influenced by various treatments are presented in Table-4.3 and graphically depicted in Fig. 3.

4.3.1.1 Effect of special treatments

A perusal of data revealed that effect of special treatments was found to be non significant on height of seedling at 120 days after sowing.

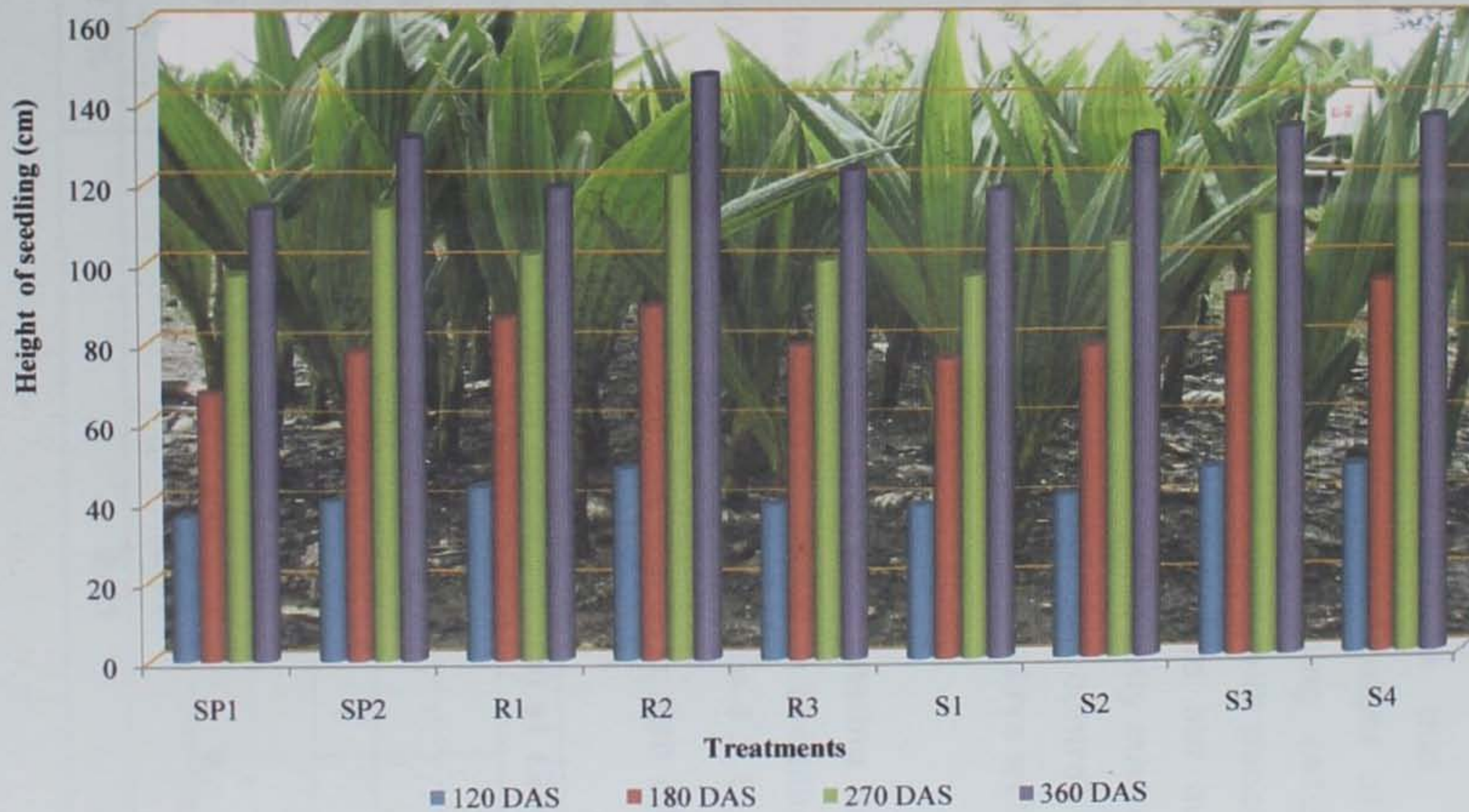
4.3.1.2 Effect of resting period

From the data presented in Table-4.3, resting period was significantly influenced the height of seedling in coconut after 120 DAS. Height of seedling was found maximum (48.15 cm)

Table: 4.3. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on height of seedling at 120, 180, 270 and 360 DAS.

Treatments	Height of seedling (cm)			
	120 DAS	180 DAS	270 DAS	360 DAS
Special treatments (SP)				
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	36.10	67.13	97.00	113.67
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	40.03	77.70	114.00	131.00
S.Em. \pm	2.72	6.02	6.90	6.31
C.D. at 5%	NS	NS	NS	NS
Resting Period (R)				
R ₁ : Fresh just after harvesting	43.45	86.10	102.07	118.72
R ₂ : 15 days rest	48.15	88.80	121.94	146.30
R ₃ : 30 days rest	38.79	79.00	100.21	122.67
S.Em. \pm	1.44	3.23	3.27	3.02
C.D. at 5%	4.20	NS	9.55	8.84
Pre sowing treatment (S)				
S ₁ : Control (without any treatment)	38.44	75.41	96.16	117.52
S ₂ : Water soaking for 15 days without punching	40.75	78.42	104.84	130.95
S ₃ : Water soaking for 15 days with punching	47.35	90.62	111.43	133.02
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	47.31	94.10	119.86	135.44
S.Em. \pm	1.66	3.73	3.77	3.49
C.D. at 5%	4.86	10.88	11.03	10.21
Interaction of R×S				
S.Em. \pm	2.88	6.46	6.54	6.05
C.D. at 5%	8.41	18.86	19.10	17.68
C.V. %	11.49	13.22	10.49	8.12

Fig-3 Effect of time of invert placement of seed nut, resting period and pre sowing treatments on height of seedling at 120, 180, 270 and 360 days



with 15 days resting period (R_1). While the seed nut sown, after thirty days rest (R_3) gave least height of seedling (38.79 cm.) at 120 DAS.

4.3.1.3 Effect of pre sowing treatments

From Table-4.3, it is evident that, pre sowing treatments had a significant effect on height of seedling in coconut at 120 DAS. The tallest seedling (47.35 cm) was observed under water soaking for 15 days with punching (S_3) and it was at same bar with soaking of seed nut in 10000 ppm solution of thiourea (S_4). Whereas, significantly minimum height of seedling (38.44 cm) was observed in control without any treatment (S_1) and it was at par with S_2 (15 days water soaking).

4.3.1.4 Interaction effect

The interaction effect between resting period and pre sowing treatments with respect to height of seedling at 120 DAS was found to be statistically significant (table-4.3.1).

Table-4.3.1: Interaction effect of R x S at 120 DAS on height of seedling

Treatments	Height of seedling(cm) at 120 DAS		
	R_1	R_2	R_3
S_1	34	33.06	48.26
S_2	44.1	52.40	25.96
S_3	45.4	64.66	32.00
S_4	50.33	42.46	49.13
S. Em. \pm	2.88		
C.D. at 5%	8.41		

Significantly maximum height of seedling (64.66 cm) was observed in treatment combination of R_2S_3 . Whereas, minimum height of seedling (25.96 cm) was noted in treatment combination R_3S_2 . And this combination was on same bar with R_3S_3 , R_2S_1 and R_1S_1 .

4.3.2 Height of seedling at 180 days after sowing

The effect of different treatments and their interactions on height of seedling at 180 DAS are presented in Table-4.3 graphically depicted in Fig. 3.

4.3.2.1 Effect of special treatments

A perusal of data revealed that effect of special treatments was found to be non significant on height of seedling at 180 days after sowing.

4.3.2.2 Effect of resting period

From the data, effect of resting period on height of seedling at 180 DAS was found to be non significant.

4.3.2.3 Effect of pre sowing treatments

The data in Table-4.3 show that there was significant effect of pre sowing treatments on height of seedling at 180 DAS. The maximum height of seedling (94.10 cm) was recorded under S_4 (soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching) which was at par with S_3 (water soaking for 15 days with punching). Lower value of height of seedling (75.41 cm) was noted in S_1 (control without any treatment), it was at par with S_2 (water soaking for 15 days without punching).



**Plate-IV : Effect of pre sowing treatments on height of seedling
at 270 DAS**

4.3.2.4 Interaction effect

All the interactions between R × S under study were found to be significant with respect to height of seedling (Table-4.3.2). Treatment combination of R₂S₃ results significantly maximum height of seedling (105.33 cm) which was at par with R₁S₃, R₁S₄, R₂S₂ and R₃S₄. However treatment combination R₃S₂ gave minimum height of seedling (53.06 cm) of seedling at 180 DAS. This treatment combination was on same bar with R₂S₁ and R₁S₁.

Table-4.3.2: Interaction effect of R x S at 180 DAS on height of seedling

Treatments	Height of seedling(cm) at 180 DAS		
	R ₁	R ₂	R ₃
S ₁	70.73	67.26	88.23
S ₂	81.66	100.53	53.06
S ₃	92.66	105.13	74.06
S ₄	99.36	82.26	100.66
S. Em. ±	6.46		
C.D. at 5%	18.86		

4.3.3 Height of seedling at 270 days after sowing

The data on height of seedling at 270 DAS as influenced by various treatments are presented in Table-4.3 graphically depicted in Fig. 3.

4.3.3.1 Effect of special treatments

A perusal of data revealed that effect of special treatments was found to be non significant on height of seedling at 270 days after sowing.

4.3.3.2 Effect of resting period

There was increasing trend in height of seedling with increasing the period of observation (Table-4.3) at 270 DAS. Higher value of height of seedling i.e. 121.94 cm, was recorded with R_2 (15 days rest). While lower value was observed in R_3 (30 days rest), and it was on same bar with R_1 (fresh just after harvesting).

4.3.3.3 Effect of pre sowing treatments

From table-4.3, it is evident that pre sowing treatments had a significant effect on height of seedling of coconut at 270 DAS. The highest height of seedling (119.86 cm) was noted in treatment S_4 (soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut), which was at par with S_3 (water soaking for 15 days with punching). Minimum height of seedling (96.16 cm) was noted in treatment S_1 (control without any treatment) and it was statistically at par with S_2 (water soaking for 15 days without punching).

4.3.3.4 Interaction effect

The interaction effect of $R \times S$ found to be significant for height of seedling at 270 days and are presented in Table- 4.3.3.

Significantly maximum height of seedling (140.66 cm) was noted in R_2S_2 (15 days rest + water soaking for 15 days without punching) treatment combination. Which was at par with treatment combination R_2S_3 (15 days rest + water soaking for 15 days with punching) and R_3S_4 (30 days rest + soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after

punching). Treatment combination R₃S₂ had minimum value (73.80 cm) for growth of seedling. This treatment combination was at par with R₃S₃ and R₁S₁

Table-4.3.3: Interaction effect of R x S at 270 DAS on height of seedling

Treatments	Height of seedling (cm)at 270 DAS		
	R ₁	R ₂	R ₃
S ₁	87.5	94.06	106.93
S ₂	100.06	140.66	73.80
S ₃	114.00	133.83	86.46
S ₄	106.73	119.2	133.66
S. Em. ±	6.54		
C.D. at 5%	19.10		

4.3.4 Height of seedling at 360 days after sowing

The data on height of seedling at 360 DAS as influenced by various treatments are presented in Table-4.3 and graphically depicted in Fig. 3.

4.3.4.1 Effect of special treatments

A perusal of data revealed that effect of special treatments was found to be non significant on height of seedling at 360 days after sowing.

4.3.4.2 Effect of resting period

The data presented in Table-4.3 indicated that different resting period significantly influence the height of seedling in coconut at 360 DAS. Maximum height of seedling (146.30 cm) was produced with the seed nut sown with 15 days

Fresh just after harvesting



15 days rest



Plate-V : Effect of resting period on height of seedling at 360 DAS

resting period (R_2). The seed nut sown fresh (R_1) gave least height of seedling (118.72 cm) and it was on same bar with R_3 (30 days rest).

4.3.4.3 Effect of pre sowing treatments

From Table-4.3, it is evident that, pre sowing treatments had significant effect on height of seedling in coconut at 360 DAS. Significantly tallest seedling (135.44 cm) was observed in treatment soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut (S_4), which was at par with water soaking for 15 days without punching (S_2) and water soaking for 15 days with punching (S_3). Whereas minimum height of seedling (117.52 cm) was observed in control without any treatment (S_1).

4.3.4.4 Interaction effect

All the interactions under study were found to be significant with respect to height of seedling (Table-4.3.3). Treatment combination of R_2S_2 (15 days rest + water soaking for 15 days without punching) resulted significantly maximum height of seedling (166.60 cm), which was statistically at par with R_2S_3 (15 days rest + water soaking for 15 days with punching) and R_3S_4 (30 days rest + soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut). Treatment combination R_3S_2 (30 days rest + water soaking for 15 days without punching) gave minimum (100.60 cm) height of seedling, and it was on same bar with R_3S_3 , R_3S_1 , R_1S_1 and R_1S_4 .

Table-4.3.4: Interaction effect of R x S at 360 DAS on height of seedling

Treatments	Height of seedling (cm) at 360 DAS		
	R ₁	R ₂	R ₃
S ₁	110.16	115.36	127.03
S ₂	125.66	166.60	100.60
S ₃	132.33	160.26	106.46
S ₄	106.73	143.14	156.6
S. Em. \pm	6.05		
C.D. at 5%	17.68		

4.4 Number of leaves per seedling

4.4.1 Number of leaves per seedling at 120 DAS

The data regarding to the number of leaves per seedling at 120 DAS affected by special treatments, resting period and pre sowing treatments are presented in Table-4.4 and graphically depicted in Fig. 4.

4.4.1.1 Effect of special treatments

There was significant difference in number of leaves per seedling at 120 DAS. The treatment SP₂ (stalk end down (invert) placement of coconut seed nut before sowing for 15 days) was found better for producing maximum number of leaves per seedling (2.66) as compared to 1.8 in SP₁.

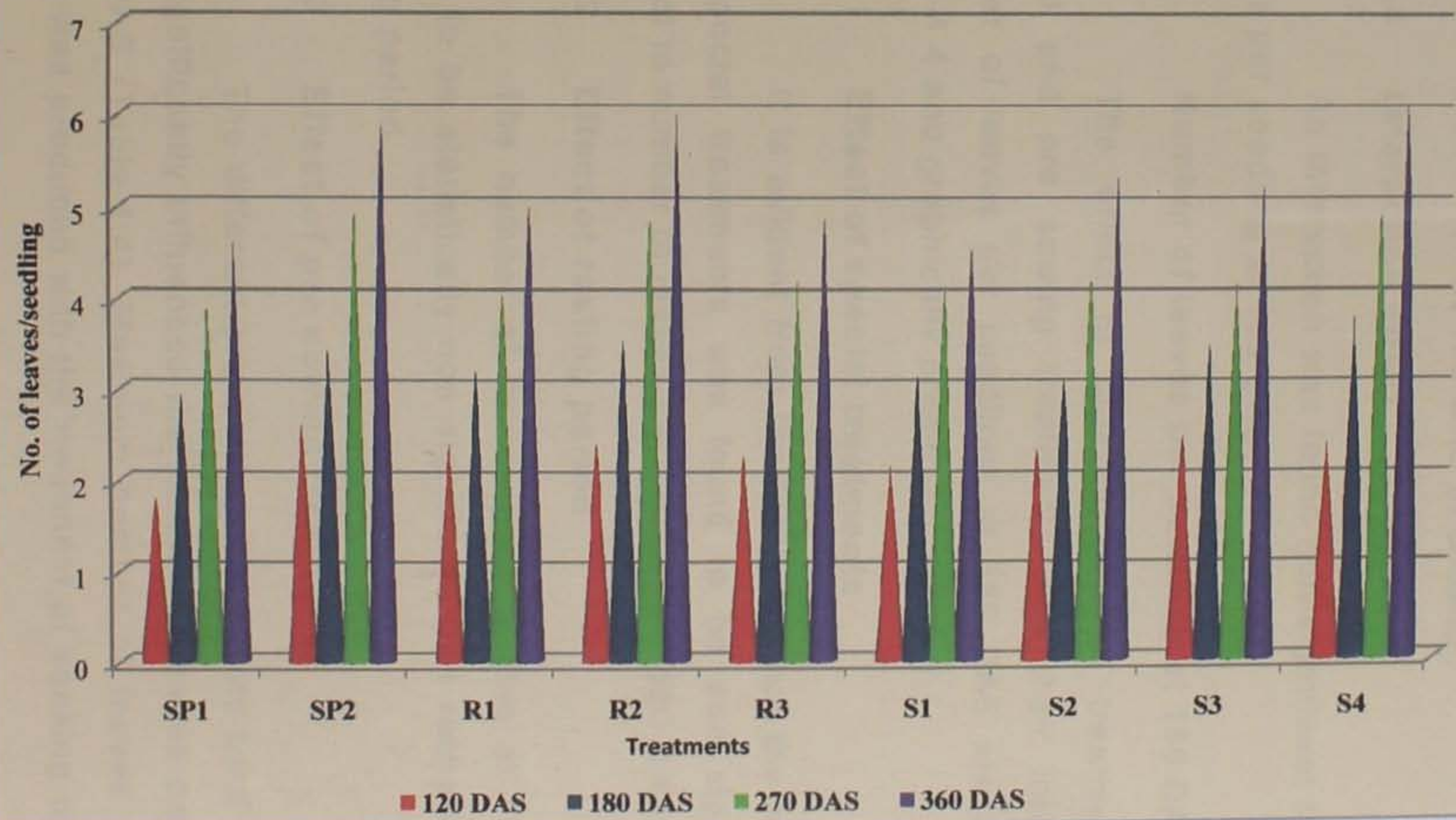
4.4.1.2 Effect of resting period

The data presented in Table-4.4 indicated that there was no significant effect of different resting period on the number of leaves per seedling at 120 DAS.

Table: 4.4. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on number of leaves at 120, 180, 270 and 360 DAS.

Treatment	No. of leaves/seedling			
	120 DAS	180 DAS	270 DAS	360 DAS
Special treatments (SP)				
SP ₁ : stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	1.80	2.93	4.00	4.66
SP ₂ : stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	2.66	3.53	4.93	5.90
S.Em. \pm	0.18	0.23	0.11	0.19
C.D. at 5%	0.54	NS	0.52	0.57
Resting Period (R)				
R ₁ : Fresh just after harvesting	2.39	3.20	4.03	5.00
R ₂ : 15 days rest	2.40	3.54	4.87	6.00
R ₃ : 30 days rest	2.27	3.42	4.18	4.88
S.Em. \pm	0.08	0.12	0.06	0.09
C.D. at 5%	NS	NS	0.18	0.27
Pre sowing treatment (S)				
S ₁ : control (without any treatment)	2.17	3.16	4.06	4.54
S ₂ : water soaking for 15 days without punching	2.33	3.11	4.20	5.32
S ₃ : water soaking for 15 days with punching	2.47	3.47	4.27	5.21
S ₄ : soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	2.44	3.80	4.91	6.11
S.Em. \pm	0.10	0.14	0.07	0.10
C.D. at 5%	NS	0.41	0.21	0.32
Interaction of R×S				
S.Em. \pm	0.17	0.24	0.12	0.19
C.D. at 5%	NS	NS	0.36	0.55
C.V.%	13.01	12.63	4.96	6.22

Fig -4 Effect of time of invert placement of seed nut, resting period and pre sowing treatments on number of leaves at 120, 180, 270 and 360 DAS



4.4.1.3 Effect of pre sowing treatments

It is evident from the data presented in Table-4.4 that application of pre sowing treatments had no significant influence on leaves production at 120 DAS in coconut.

4.4.1.4 Interaction effect

An interaction was found non-significant for number of leaves per seedling at 120 DAS.

4.4.2 Number of leaves per seedling at 180 DAS

The effect of different special treatments, resting period and pre sowing treatments and their interactions on number of leaves per seedlings at 180 DAS are presented in Table-4.4 and graphically presented in Fig. 4.

4.4.2.1 Effect of special treatments

It is evident from the table 4.4 that the effect of both the special treatments was found to be non significant with respect to number of leaves per seedling at 180 DAS.

4.4.2.2 Effect of resting period

The number of leaves per seedling at 180 DAS was found to be statistically non significant with respect to different resting period.

4.4.2.3 Effect of pre sowing treatments

The different pre sowing treatments tried during study had significantly influenced the number of leaves per seedling at 180 DAS (Table-4.4). Maximum number of leaves per seedling (3.80) was produced with the treatment of soaking of seed nut in

10000 ppm solution of thiourea for 24 hours after punching on seed nut (S_4) which was at par with water soaking for 15 days with punching (S_3). Water soaking for 15 days without punching (S_2) gave least number of leaves per seedling (3.11), but it was similar to S_1 (control without any treatment)

4.4.2.4 Interaction effect

The interaction effect between resting period and pre sowing treatments with respect to number of leaves per seedling at 180 DAS was found to be non-significant.

4.4.3 Number of leaves per seedling at 270 DAS

The data on number of leaves per seedling at 270 DAS as influenced by special treatments, resting period and pre sowing treatments are presented in Table-4.4 and graphically presented in Fig. 4.

4.4.3.1 Effect of special treatments

At 270 DAS, SP_2 (stalk end down(invert) placement of Coconut seed nut before sowing for 15 days) was found better with respect to produce higher number of leaves per seedling (4.93) as compared to SP_1 (4.00).

4.4.3.2 Effect of resting period

The data presented in Table-4.4 indicated that different resting period was significantly influenced the number of leaves in coconut seedling at 270 DAS. Maximum number of leaves per seedling (4.87) was produced with 15 days rest (R_2). When seed nut sown fresh (R_1) gave least number of leaves per seedling (4.03), which was at par with R_3 (30 days rest).

4.4.3.3 Effect of pre sowing treatments

It is seen from Table-4.4, the soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut (S_4) was also found superior to produce maximum number of leaves per plant (4.91). Whereas, significantly minimum number of leaves per seedling (4.06) was observed in control (S_1) and it was statistically on same bar with S_2 and S_3 .

4.4.3.4 Interaction effect of R X S

It can be predicted from the table 4.4.1 that the interaction between resting periods and pre sowing treatments with respect to number of leaves per seedling at 270 DAS was found to be significant.

Table 4.4.1: Interaction effect of R x S on number of leaves per seedling at 270 DAS

Treatment	Number of leaves per seedling at 270 DAS		
	R ₁	R ₂	R ₃
S ₁	3.73	4.66	3.80
S ₂	3.80	5.00	3.80
S ₃	3.93	4.83	4.06
S ₄	4.66	5.00	5.06
S.E.m. ±	0.12		
C.D. at 5%	0.36		

The maximum number of leaves per seedling (5.06) was observed in treatment combination R₃S₄ (30 days rest + soaking of seed nut in 10000 ppm solution of thiourea for 24

hours after punching on seed nut), which was at par with R_2S_2 , R_2S_3 and R_2S_4 . The treatment combination R_1S_1 (fresh + control without any treatment) had least number of leaves per seedling (2.73), which was at par with R_1S_2 , R_1S_3 , R_3S_1 and R_1S_2 .

4.4.4 Number of leaves per seedling at 360 DAS

The data pertaining to number of leaves per seedling at 360 DAS as influenced by different special treatment, resting period and pre sowing treatments and their interaction are presented in Table-4.4 and graphically presented in Fig. 4.

4.4.4.1 Effect of special treatments

After 360 DAS, there was also similar trend in increasing the number of leaves per seedling. Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (SP_2) was found superior with higher number of leaves per seedling (5.9) as compared to SP_1 (4.6).

4.4.4.2 Effect of resting period

The data as shown in Table-4.4 indicated that, there was increased in number of leaves per plant, but trend remain same as noted at 270 DAS. Fifteen days resting period had maximum number of leaves per plant (6.0). While 30 days resting period had least number of leaves per seedling (4.88), but it was at par with R_1 .

4.4.4.3 Effect of pre sowing treatments

The different pre sowing treatments also significantly affected number of leaves per seedling at 360 DAS (Table-4.4). Soaking of seed nut in 10000 ppm solution of thiourea for 24

hours after punching on seed nut (S_4) produced maximum number of leaves per seedling (6.11). While seed nut without any treatment (S_1) gave minimum values for leaves production (4.54).

4.4.4.4 Interaction effect

The interaction effect of resting periods and pre sowing treatment combinations was found statistically significant for number of leaves per seedling at 360 DAS (Table-4.4.2). Treatment combination R_2S_2 (15 days rest + 15 days water soaking without punching) gave maximum number of leaves per seedling (6.90). While minimum number of leaves was observed in R_3S_1 (30 days rest + control without any treatment), which was at par with R_3S_2 .

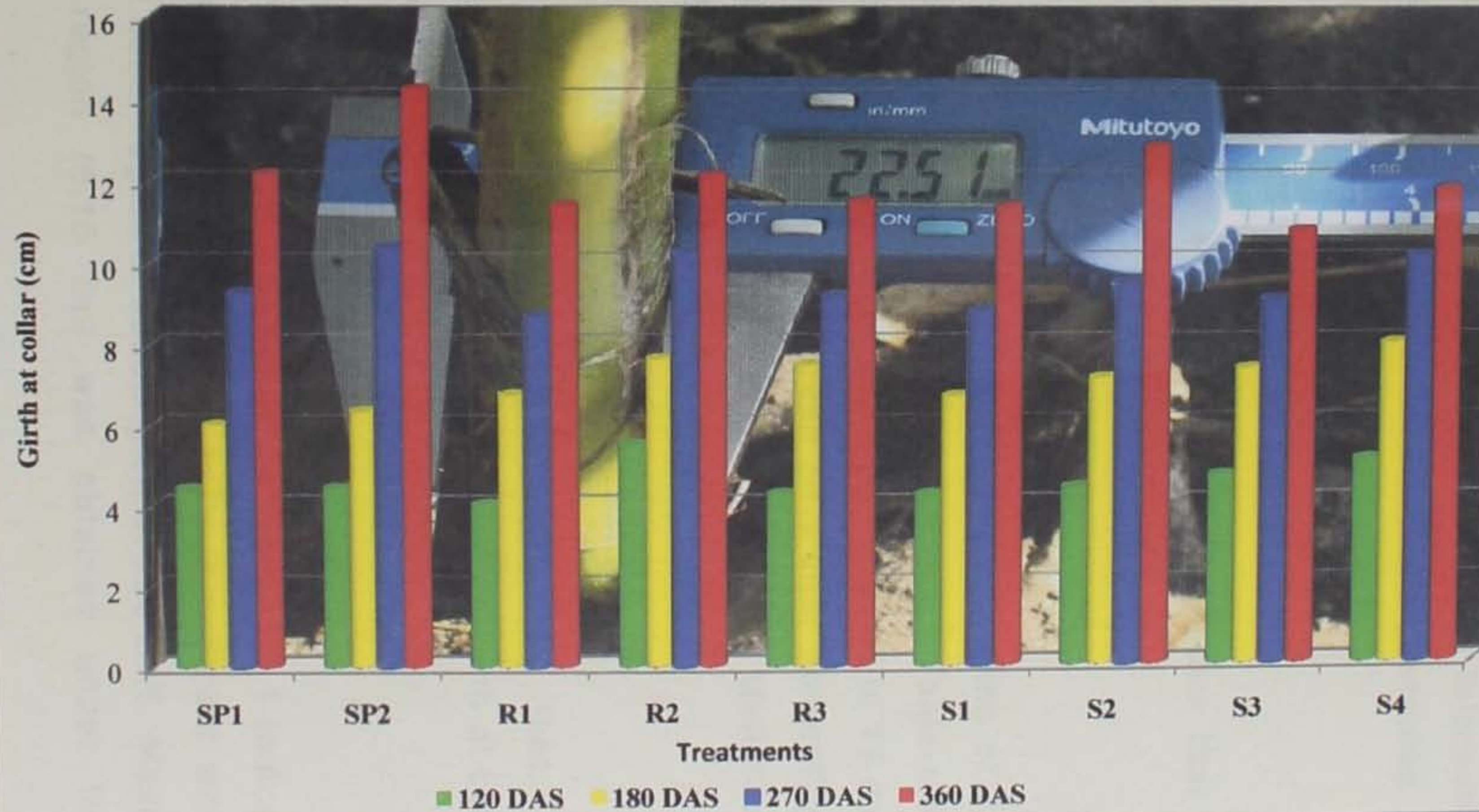
Table 4.4.2 Interaction effect of R x S on number of leaves per seedling at 360 DAS

Treatment	Number of leaves per seedling at 360 DAS		
	R_1	R_2	R_3
S_1	4.73	4.90	4.00
S_2	4.56	6.90	4.46
S_3	4.83	5.86	4.93
S_4	5.86	6.33	6.13
S.Em. \pm	0.19		
C.D. at 5%	0.55		

Table: 4.5. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on girth at collar region of seedling at 120, 180, 270 and 360 DAS.

Treatment	Girth at collar region (in cm)			
	120 DAS	180 DAS	270 DAS	360 DAS
Special treatments (SP)				
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	4.43	6.02	9.26	12.20
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	4.46	6.36	10.37	14.26
S.Em. ±	0.33	0.41	0.35	0.36
C.D. at 5%	NS	NS	1.00	1.04
C.V. %				
Resting Period (R)				
R ₁ : Fresh just after harvesting	4.07	6.78	8.69	10.15
R ₂ : 15 days rest	5.54	7.68	10.25	13.02
R ₃ : 30 days rest	4.32	7.51	9.19	10.87
S.Em. ±	0.16	0.22	0.18	0.18
C.D. at 5%	0.47	0.64	0.53	0.52
Pre sowing treatment (S)				
S ₁ : Control(without any treatment)	4.30	6.73	8.80	10.78
S ₂ : Water soaking for 15 days without punching	4.44	7.17	9.48	11.78
S ₃ : Water soaking for 15 days with punching	4.73	7.39	9.08	10.68
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	5.10	8.00	10.14	12.14
S.Em. ±	0.19	0.25	0.21	0.21
C.D. at 5%	0.54	0.74	0.62	0.60
Interaction of R×S				
S.Em.±	0.33	0.44	0.36	0.36
C.D. at 5%	0.95	1.29	1.07	1.04
C.V.%	12.48	10.48	6.80	5.47

Fig-5 Effect of time of invert placement of seed nut, resting period and pre sowing treatments on girth at collar region of seedling in 120, 180, 270 and 360 DAS



4.5 Girth at collar region (cm)

4.5.1 Girth at collar region at 120 DAS

The data related to effect of special treatments, resting periods and pre sowing treatments and their interactions on girth at collar region of plant at 120 DAS are presented in Table-4.5 and depicted in Fig. 5.

4.5.1.1 Effect of special treatments

Data presented in Table-4.5 shows that the girth at collar region was found to be non significant.

4.5.1.2 Effect of resting period

The girth at collar region of seedling at 120 DAS was significantly affected by resting periods (Table-4.5). Maximum girth at collar region (5.54 cm) was recorded in 15 days rest (R_2). While the seed nut sown fresh (R_1) after harvesting gave least girth at collar region (4.07 cm), and it was statistically on same bar with R_3 .

4.5.1.3 Effect of pre sowing treatments

From Table-4.5, it is evident that, pre sowing treatments had a non significant effect on girth at collar region at 120 DAS.

4.5.1.4 Interaction effect

The data presented in Table- 4.5.1 indicated that the interaction of $R \times S$ was found to be significant with respect to girth at collar region of seedling on at 120 DAS. Maximum girth at collar region (6.10 cm) was obtained under the treatment

combination of R_2S_3 . It was statistically on same bar with R_2S_4 and R_2S_2 . Treatment combination R_1S_1 (3.47 cm) had minimum girth at collar region and it was on same bar with R_1S_3 , R_1S_2 , R_3S_2 and R_3S_3 .

Table-4.5.1: Interaction effect of R x S on girth at collar region at 120 days after sowing

Treatments	Girth at collar region(cm) at 120 DAS		
	R_1	R_2	R_3
S_1	3.47	4.83	4.60
S_2	4.10	5.60	3.63
S_3	4.20	6.10	3.90
S_4	4.53	5.64	5.10
S. Em. \pm	0.33		
C.D. at 5%	0.95		

4.5.2 Girth at collar region at 180 DAS

The data on girth at collar region at 180 DAS as influenced by special treatments, resting periods and pre sowing treatments are presented in Table-4.5 and depicted in Fig. 5.

4.5.2.1 Effect of special treatments

The data presented in table 4.5 clearly indicated that special treatments were not affected on girth at collar region at 180 DAS.

4.5.2.2 Effect of resting period

It is evident from the data presented in Table-4.5 that the girth at collar region per seedling in coconut at 180 DAS was increased in all treatments. Girth at collar region was found superior (7.68 cm) with 15 days rest (R_2) which was at par with 30 days rest (R_3). While lower value for girth at collar region (6.78cm) was noted in the fresh just after harvesting (R_1).

4.5.2.3 Effect of pre sowing treatments

The data in Table-4.5 shows that there was also significant influence of pre sowing treatments on girth at collar region at 180 DAS. An increasing trend remains similar to previous observation recorded at 120 DAS. Maximum girth at collar region (8.0 cm) was obtained under S_4 , which was at par with S_3 being 7.39 cm. While significantly least value for girth at collar region (6.73 cm) was observed in S_1 and it was on same bar with S_2 .

4.5.2.4 Interaction effect

The data presented in Table- 4.5.2 indicated that the interaction of $R \times S$ was found to be significant with respect to girth at collar region of seedling. Maximum girth at collar region (8.63 cm) was obtained under the treatment combination of R_2S_2 . It was statistically on same bar with R_1S_4 , R_2S_3 , R_2S_4 , R_3S_1 , R_3S_3 and R_3S_4 . Treatment combination R_1S_1 (5.90 cm) had minimum girth at collar region.

Table-4.5.2: Interaction effect of R x S on girth at collar region at 180 days after sowing

Treatments	Girth at collar region(cm) at 180 DAS		
	R ₁	R ₂	R ₃
S ₁	5.90	6.68	7.63
S ₂	6.53	8.63	6.36
S ₃	6.66	7.50	8.02
S ₄	8.03	7.94	8.05
S. Em. \pm	0.44		
C.D. at 5%	1.29		

4.5.3 Girth at collar region at 270 DAS

The data regarding the girth at collar region at 270 DAS as affected by special treatments, resting periods and pre sowing treatments are presented in Table-4.5 and depicted in Fig. 5.

4.5.3.1 Effect of special treatments

The data presented in table 4.5 clearly indicated that effect of special treatments was to be found statistically significant with respect to girth at collar region at 270 DAS. The maximum girth (10.37 cm) was noted in SP₂ as compared to SP₁.

4.5.3.2 Effect of resting period

It is evident from the data presented in Table-4.5 that the girth at collar region per seedling in coconut at 270 DAS was increased in all treatments. Girth at collar region was found superior (10.25 cm) with 15 days rest (R₂). While lower value for

girth at collar region (8.69 cm) was noted in the fresh just after harvesting (R_1), which was on same bar with R_3 .

4.5.3.3 Effect of pre sowing treatments

The data in Table-4.5 shows that there was also significant influence of pre sowing treatments on girth at collar region at 270 DAS. Maximum girth at collar region (10.14 cm) was obtained under S_4 . While significantly least value for girth at collar region (8.80 cm) was observed in S_1 and it was at par with S_2 and S_3 .

4.5.3.4 Interaction effect

The data presented in Table- 4.5.3 indicated that the interaction of $R \times S$ was found to be significant with respect to girth at collar region of seedling.

Table-4.5.3: Interaction effect of R x S on girth at collar region at 270 days after sowing

Treatments	Girth at collar region(cm) at 270 DAS		
	R_1	R_2	R_3
S_1	8.06	8.83	9.50
S_2	8.20	11.80	8.46
S_3	8.36	9.90	9.00
S_4	10.13	10.50	9.80
S. Em. \pm	0.36		
C.D. at 5%	1.07		

The maximum girth at collar region (11.80 cm) was obtained under the treatment combination of R_2S_2 . Treatment combination R_1S_1 (8.06 cm) had minimum girth at collar region.

Treatment combination of R_1S_2 , R_1S_3 , R_2S_1 , R_3S_2 and R_3S_4 were statistically similar with R_1S_1 .

4.5.4 Girth at collar region at 360 DAS

The effect of different special treatments, resting periods and pre sowing treatments and their interactions on girth at collar region at 360 DAS are presented in Table-4.5 and depicted in Fig. 5.

4.5.4.1 Effect of special treatments

The data presented in table 4.5 clearly indicated that effect of special treatments was to be found statistically significant with respect to girth at collar region at 360 DAS. The maximum girth (14.26 cm) was noted in SP_2 as compared to SP_1 .

4.5.4.2 Effect of resting period

It is evident from the data presented in Table-4.5 that the girth at collar region per seedling in coconut at 360 DAS was increased in all treatments. Girth at collar region was found superior (12.16 cm) with 15 days rest (R_2). While lower value for girth at collar region (11.42 cm) was noted in the fresh just after harvesting (R_1) and it was at par with R_3 .

4.5.4.3 Effect of pre sowing treatments

The data in Table-4.5 shows that there was also significant influence of pre sowing treatments on girth at collar region at 360 DAS. Maximum girth at collar region (12.85 cm) was obtained under S_2 (water soaking for 15 days without punching) While significantly least value for girth at collar region (10.78 cm) was observed in S_3 .

4.5.4.4 Interaction effect

An interaction between R×S was found significant for girth at collar region at 360 DAS and are presented in Table-4.5.4. Maximum girth at collar region (15.93 cm) was obtained under the treatment combination R₂S₂ (15 days rest + water soaking for 15 days without punching). Treatment combination R₁S₂ had minimum girth at collar region (9.46 cm) after 360 DAS and it was on same with R₁S₁, R₁S₃ and R₃S₂ and R₃S₃.

Table-4.5.4: Interaction effect of R x S on girth at collar region at 360 days after sowing

Treatments	Girth at collar region (cm) at 360 DAS		
	R ₁	R ₂	R ₃
S ₁	9.76	11.33	11.26
S ₂	9.46	15.93	9.96
S ₃	9.93	12.00	10.13
S ₄	11.46	12.83	12.13
S. Em. ±	0.30		
C.D. at 5%	0.89		

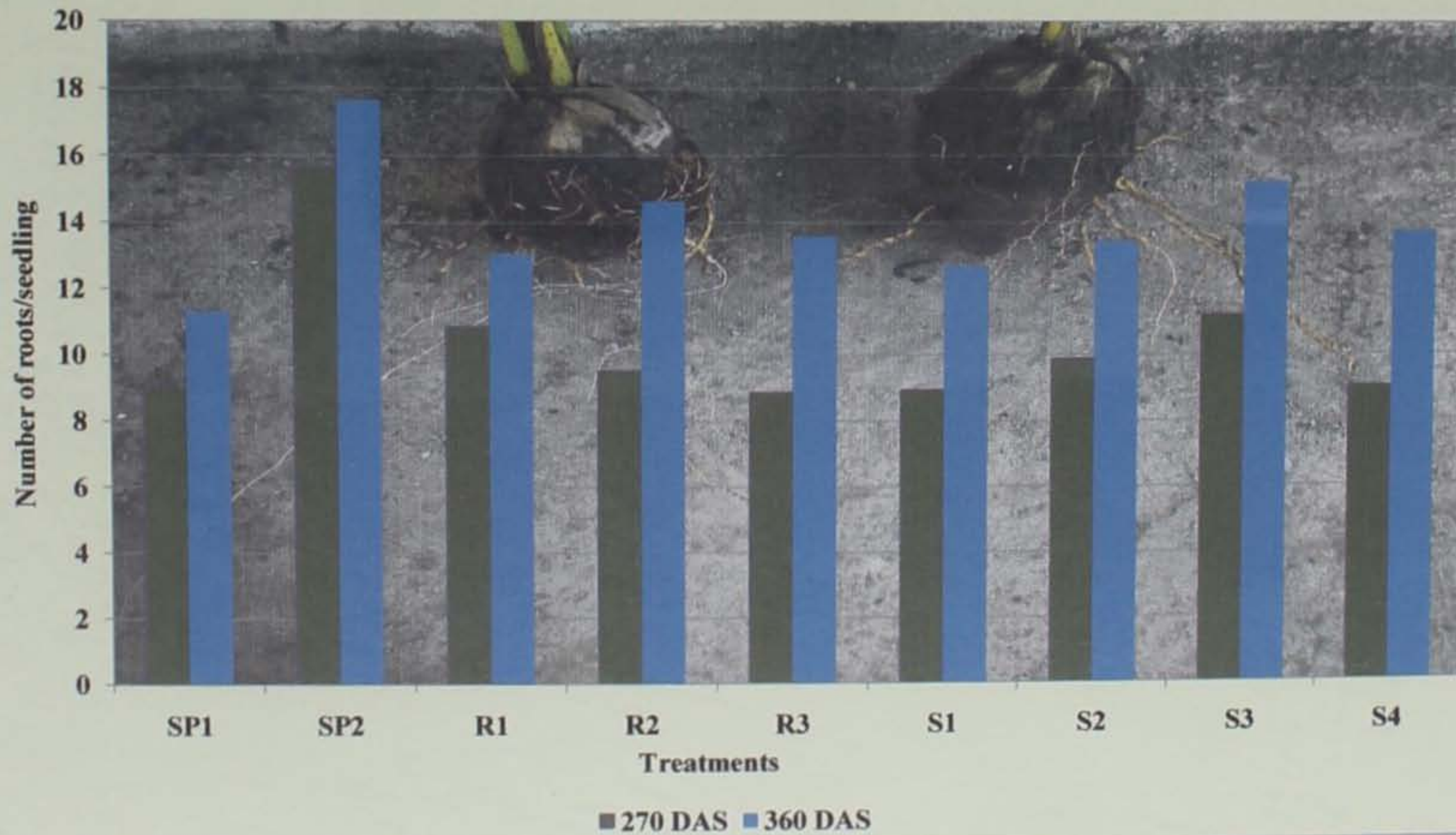
4.6.1 Number of roots per seedling at uprooting at 270 DAS

The data pertaining to number of roots per plant at uprooting as affected due to special treatments, resting periods and pre sowing treatments were found significant and are presented in Table-4.6 and depicted graphically in Fig. 6.

Table: 4.6. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on number of roots at 270 and 360 DAS.

Treatment	No. of roots/seedling	
	270 DAS	360 DAS
Special treatments (SP)		
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	9.00	11.33
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	15.66	17.66
S.Em. ±	0.90	1.12
C.D. at 5%	2.58	3.22
Resting Period (R)		
R ₁ : Fresh just after harvesting	10.87	13.08
R ₂ : 15 days rest	9.54	14.63
R ₃ : 30 days rest	8.87	13.58
S.Em. ±	0.44	0.56
C.D. at 5%	1.30	NS
Pre sowing treatment (S)		
S ₁ : Control (without any treatment)	8.94	12.70
S ₂ : Water soaking for 15 days without punching	9.88	13.44
S ₃ : Water soaking for 15 days with punching	11.20	15.22
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	9.02	13.70
S.Em. ±	0.51	0.65
C.D. at 5%	1.51	NS
Interaction of R×S		
S.Em.±	0.89	1.12
C.D. at 5%	NS	NS
C.V.%	15.90	14.20

Fig-6 Effect of time of invert placement of seed nut, resting period and pre sowing treatments on number of roots at 270 and 360 DAS



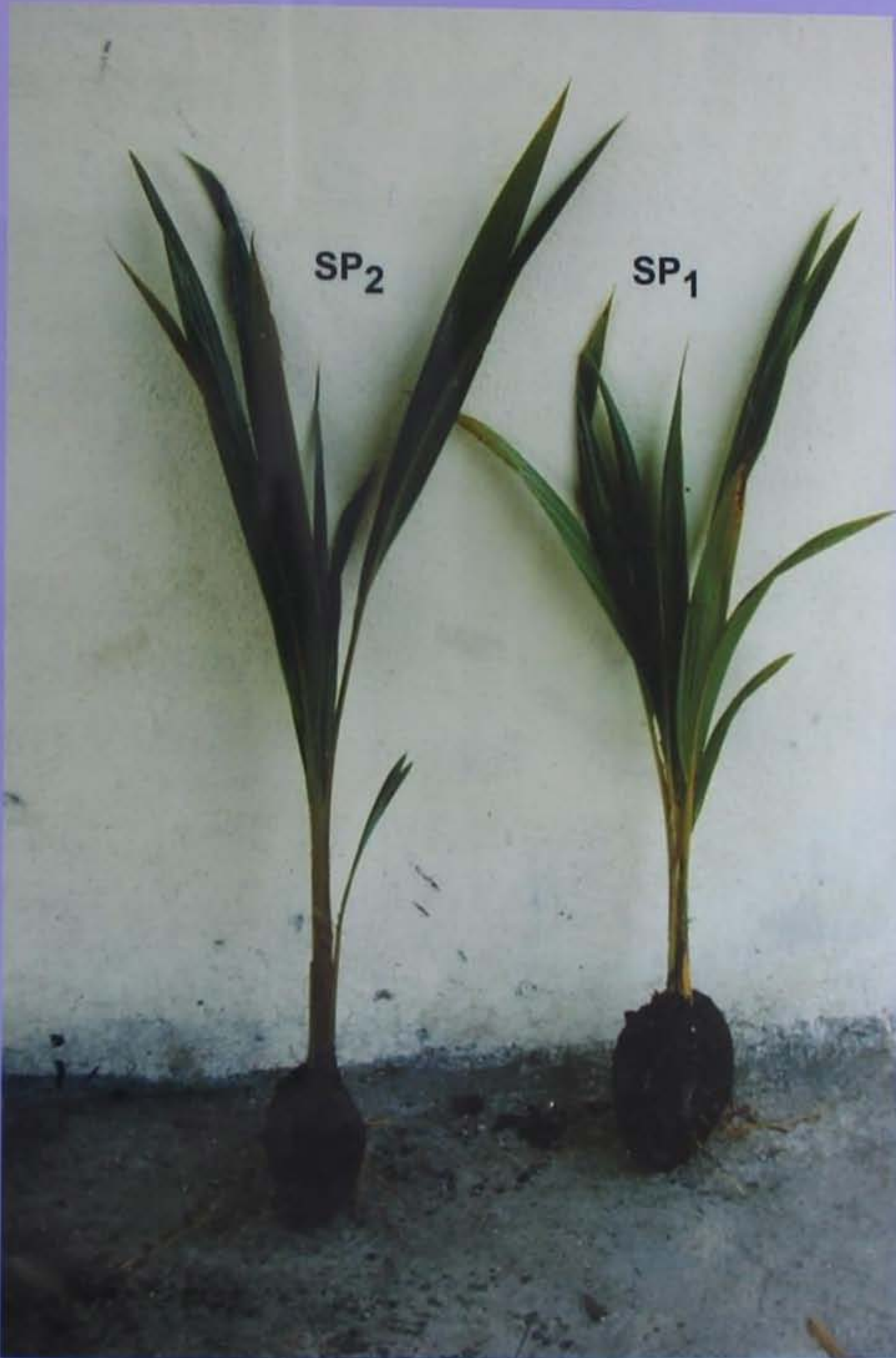


Plate-VI : Effect of special treatments on number of roots at 270 DAS

4.6.1.1 Effect of special treatments

From the Table-4.6 it can be said that number of roots per plant differ significantly due to special treatments. Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (SP_2) gave maximum number of roots per seedling (15.66) as compared to 9.00 in Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (SP_1).

4.6.1.2 Effect of resting period

Number of roots per seedling was influenced significantly due to different resting period. Maximum number of roots per seedling (10.87) was obtained with fresh just after harvesting (R_1). However 30 days rest (R_3) produce lowest number of roots per seedling (8.87) at the uprooting of 270 DAS and it was at par with R_2 .

4.6.1.3 Effect of pre sowing treatments

Table-4.6 indicated that maximum number of roots per seedling was noted with water soaking for 15 days with punching (S_3) treatment, which produced 11.20 roots per seedling which was at par with water soaking for 15 days without punching (S_2). Whereas control without any treatment (S_1) was noted minimum values for root production per seedling (8.94), but this treatment was at par with S_2 and S_4 .

4.6.1.4 Interaction effect

An interaction effect between $R \times S$ was found to be non significant with respect to number of roots per seedling at 270 DAS.



Plate-VII : Effect of pre-sowing treatments on number of roots per seedling at 270 DAS

4.6.2.2 Number of roots per seedling at uprooting at 360 DAS

4.6.2.1 Effect of special treatments

From the Table-4.6 it can be said that number of roots per seedling was influenced significantly due to special treatments, stalk end down (invert) placement of coconut seed nut before sowing for 15 days (SP₂) gave maximum number of roots per seedling (17.66) as compared to 11.33 in stalk end down (invert) placement of coconut seed nut before sowing for 10 days (SP₁).

4.6.2.2 Effect of resting period

It was evident from table 4.6 that the effect of resting period with respect to number of roots per seedling of coconut was found to be non significant at 360 DAS at uprooting.

4.6.2.3 Effect of pre sowing treatments

Table-4.6 indicated that, effect of resting periods were found to be non significant with respect to number of roots per seedling at 360 days after sowing at uprooting.

4.6.1.4 Interaction effect

All interaction effects were found to be non significant with respect to number of roots per seedling at 360 DAS at uprooting.

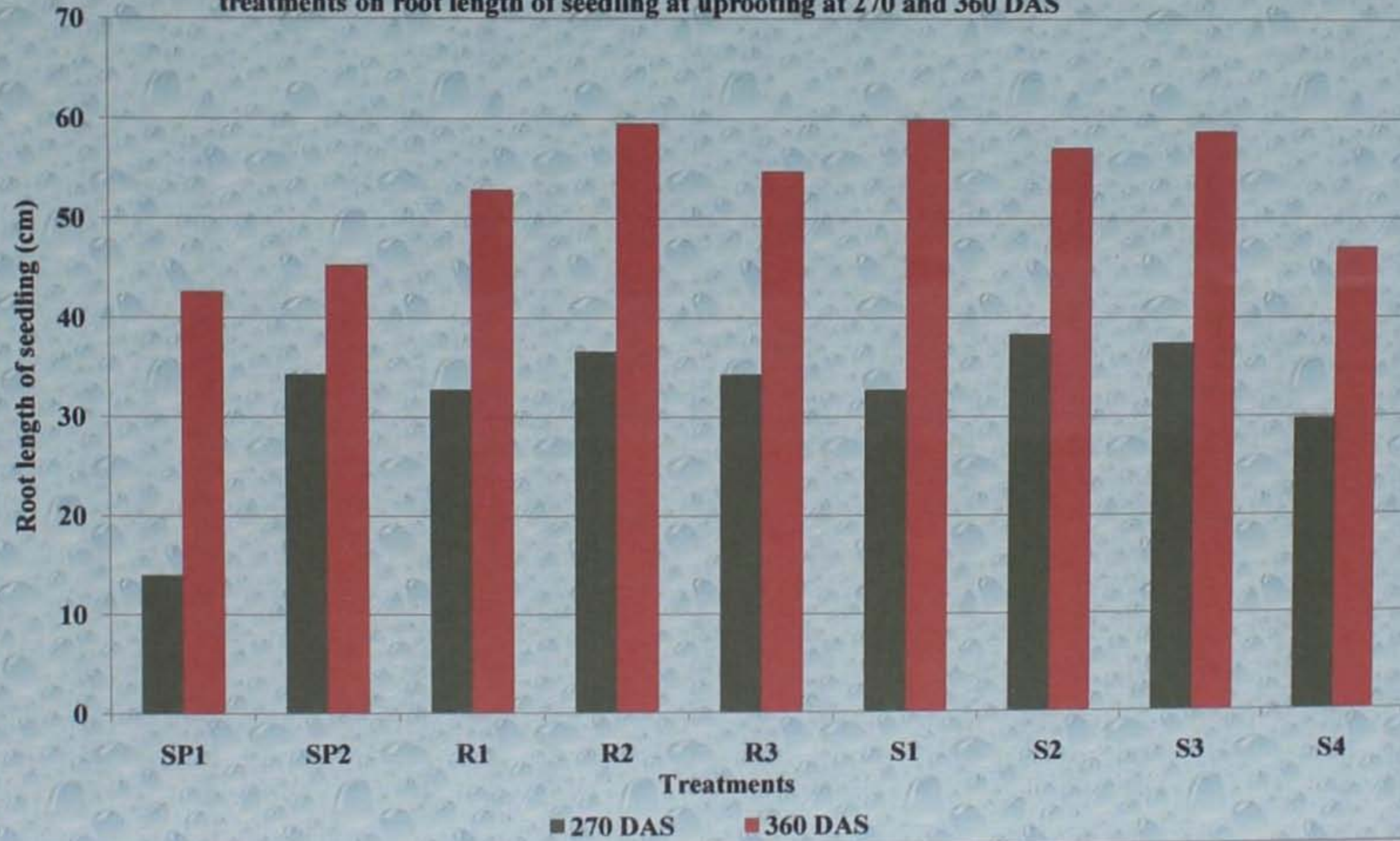
4.7 Root length of seedling at uprooting (cm)

The data on effect of special treatments, resting period and pre sowing treatments on length of roots per plant are presented in Table-4.7 and depicted in Fig.7.

Table: 4.7. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on root length of seedling at uprooting in 270 and 360 days

Treatment	Root length of seedling (cm)	
	270 DAS	360 DAS
Special treatments (SP)		
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	27.00	42.66
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	34.33	45.33
S.Em. ±	3.21	6.01
C.D. at 5%	NS	NS
Resting Period (R)		
R ₁ : Fresh just after harvesting	32.77	52.91
R ₂ : 15 days rest	36.63	59.55
R ₃ : 30 days rest	41.08	54.75
S.Em. ±	1.60	3.18
C.D. at 5%	4.58	NS
Pre sowing treatment (S)		
S ₁ : Control(without any treatment)	32.76	59.95
S ₂ : Water soaking for 15 days without punching	38.33	57.11
S ₃ : Water soaking for 15 days with punching	37.43	58.77
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	38.78	47.11
S.Em. ±	1.85	3.67
C.D. at 5%	NS	NS
Interaction of R×S		
S.Em.±	3.21	6.30
C.D. at 5%	NS	NS
C.V.%	15.45	19.80

Fig-7 Effect of time of invert placement of seed nut, resting period and pre sowing treatments on root length of seedling at uprooting at 270 and 360 DAS



4.7.1 Root length of seedling at uprooting (cm) at 270 DAS

4.7.1.1 Effect of special treatments

Table-4.6 indicated that, effect of special treatments were found to be non significant with respect to root length per seedling at 270 days after sowing at uprooting.

4.7.1.2 Effect of resting period

It is seen from the Table-4.7 that root length varied significantly due to resting period. R₃ (30 days rest) had recorded maximum length of roots per seedling (41.08 cm) as compared to 32.77 cm in R₁ at the time of uprooting at 270 DAS.

4.7.1.3 Effect of pre sowing treatments

Table-4.6 indicated that, effect of pre sowing treatments were found to be non significant with respect to root length per seedling at 270 days after sowing at uprooting.

4.7.1.4. Interaction effect

All interaction effects were found to be non significant with respect to root length of seedling at 270 DAS at uprooting.

4.7.2 Root length of seedling at uprooting (cm) at 360 DAS

4.7.2.1 Effect of special treatments

The data presented in table 4.7 clearly indicated that the effect of special treatments was found to be non significant with respect to root length at 360 DAS at uprooting.

4.7.2.2 Effect of resting period

It was evident from table 4.7 that the effect of resting period with respect to root length of coconut seedling was found to be non significant at 360 DAS at uprooting.

4.6.2.3 Effect of pre sowing treatments

Table-4.7 indicated that, effect of resting periods were found to be non significant with respect to root length per seedling at 360 days after sowing at uprooting.

4.7.2.4 Interaction effect

All interaction effects were found to be non significant with respect to root length per seedling at 360 DAS at uprooting.

4.8 Survival percentage of seedling at 360 DAS

The data pertaining to survival percentage of seedling as influenced by special treatments, resting period and pre sowing treatments are presented in Table-4.8 and graphically illustrated in Fig.8.

4.8.1 Effect of special treatments

The data presented in Table-4.8 clearly indicated that there was no significant effect on survival percentage of special treatments at 360 DAS at uprooting.

4.8.2 Effect of resting period

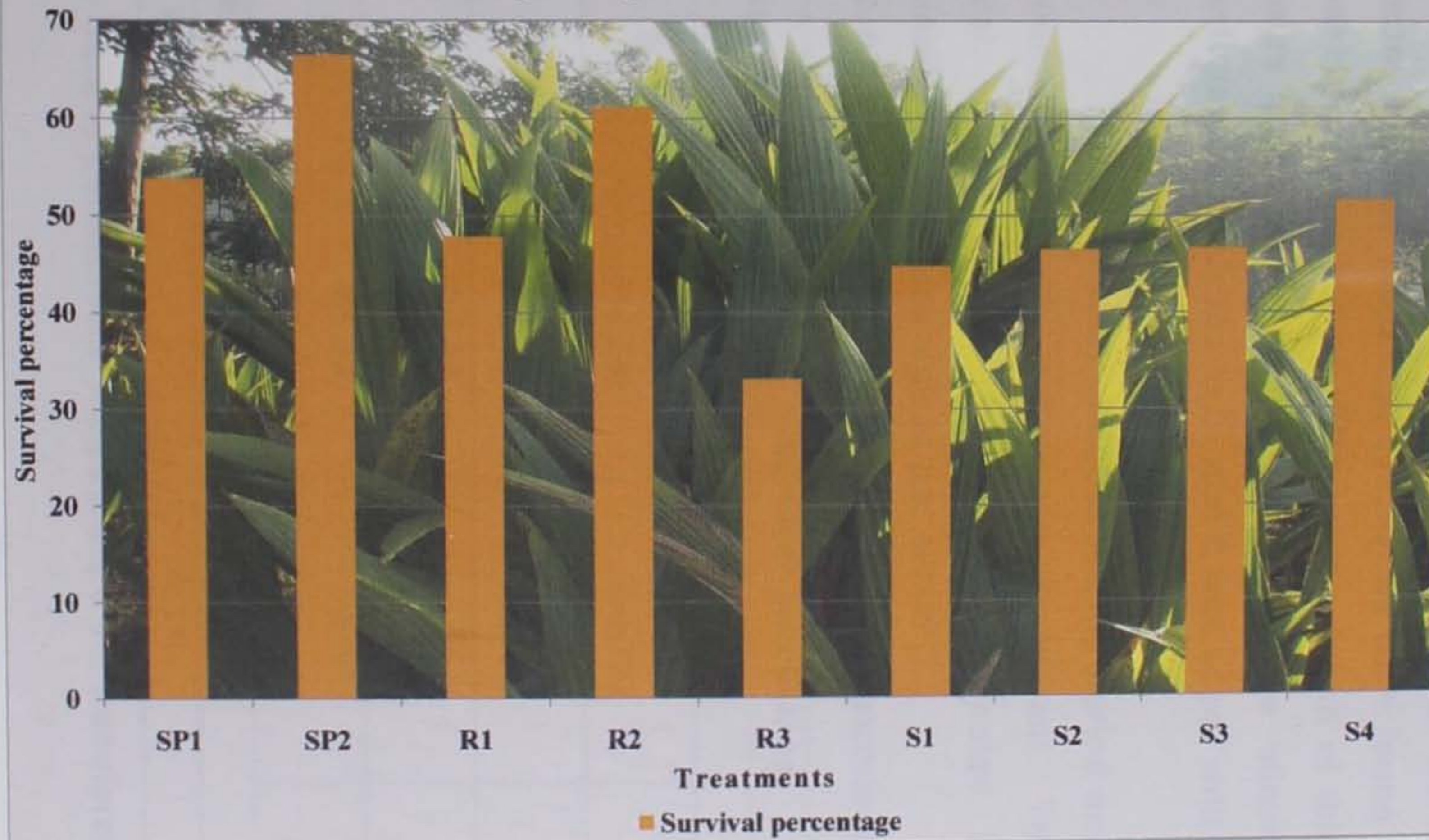
With regards to resting period, the results were found significant for survival of seedling (Table-4.8). Highest value for survival of seedling was recorded under 15 days resting period (R_2) which gave 61.23 per cent survived seedlings. Whereas 30

Table: 4. 8. Effect of time of invert placement of seed nut, resting period and pre sowing treatments on survival percentage

Treatment	Survival percentage
Special treatments (SP)	
SP ₁ : Stalk end down (invert) placement of coconut seed nut before sowing for 10 days (without any rest)	64.67 (53.80)
SP ₂ : Stalk end down (invert) placement of coconut seed nut before sowing for 15 days (without any rest)	84.00 (66.48)
S.Em. \pm	4.64
C.D. at 5%	NS
Resting Period (R)	
R ₁ : Fresh just after harvesting	55.00 (47.89)
R ₂ : 15 days rest	76.50 (61.23)
R ₃ : 30 days rest	30.33 (33.24)
S.Em. \pm	1.05
C.D. at 5%	3.07
Pre sowing treatment (S)	
S ₁ : Control(without any treatment)	49.77 (44.86)
S ₂ : Water soaking for 15 days without punching	52.44 (46.57)
S ₃ : Water soaking for 15 days with punching	52.66 (46.73)
S ₄ : Soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut	60.88 (51.65)
S.Em. \pm	1.21
C.D. at 5%	3.54
Interaction of R×S	
S.Em. \pm	2.10
C.D.at	6.14
c.v. %	7.68

Note: Data in parenthesis indicates arc sin transformed value

Fig-8 Effect of time of invert placement of seed nut, resting period and pre sowing treatments on survival percentage



days resting period (R_3) gave lowest values for survival of seedling (33.24%).

4.8.3 Effect of pre sowing treatments

From Table-4.7, it is evident that, pre sowing treatments had significant effect on survival percentage. The maximum survived seedlings (51.65 %) were found in treatment S_4 (soaking of seed nut in 10000 ppm solution of thiourea for for 24 hours after punching on seed nut). The minimum survival percentage was recorded in S_1 and it was at par with S_2 and S_3 .

4.8.4. Interaction effect

The interaction effect of resting period and pre sowing treatment was found statistically significant. The maximum survival percentage (64.93 %) was noted in treatment combination R_2S_3 which was at par with R_2S_2 .

Table-4.8.1: Interaction effect of R x S on survival percentage at 360 DAS

Treatments	Survival percentage		
	R_1	R_2	R_3
S_1	49.33 (44.59)	66.67 (54.76)	33.33 (35.24)
S_2	52.00 (46.13)	78.67 (62.59)	26.67 (30.97)
S_3	53.33 (46.89)	82 (64.93)	22.67 (28.34)
S_4	65.33 (53.96)	78.67 (62.59)	38.67 (38.39)
S. Em. \pm	2.10		
C.D. at 5%	6.14		

Note: Data in parenthesis indicates arc sin transformed value

The Minimum survival percentage (28.34 %) was recorded in R_3S_3 treatment combination, which was statistically similar to R_3S_2 .



DISCUSSION



V. DISCUSSION

With objective to improve germination and height of coconut seedlings, special treatments comprising (Time of invert placement of coconut seed nut), resting periods and pre sowing treatments, were taken in the present experiment under South Gujarat condition. The experiment was conducted in Complete Randomized Design with Factorial concept consisting of fourteen treatments (Two special + twelve combination of R×S) during the year 2010-2011 at Regional Horticultural Research Station, Navsari Agricultural University, Navsari.

During the course of presenting the results of this experiment in preceding chapter many significant variations among the different treatments were reported. So, an attempt has been made to discuss the findings of the present study in terms of effect and cause of relationship in the light of available evidences and relevant literature. The results, obtained in response of these treatments, have been discussed in this chapter under following headings.

5.1 Effect of special treatments

5.2 Effect of resting periods

5.3 Effect of pre sowing treatments

5.1 Effect of special treatments

The results of present investigation revealed that stalk end down placement (invert) of coconut seed nut before sowing for 15 days (without any rest) gave most promising results by minimum days taken to germinate the first nut and

increase germination percentage at 60 DAS as compared to SP₁. The superiority of stalk end down placement (invert) of coconut seed nut before sowing for 15 days with respect to earliness in germination and increase germination percentage at 60 days might be due to endosperm (nut water) would be in contact with embryo and provide better stimulation for germination which facilitate less time for germination than other treatments. The results in response to different treatments given are in conformity with horizontal planting obtained by Thomas (1978), who reported horizontal sowing position of seed nut offers earlier germination. He (2008) noted that if the nut water is less in the seed nut horizontal planting is advisable. Similar trend were also seen by Chattopadhyay *et al.* (2004), Thampan, (1981), Fremond *et al.* (1966), Gopalakrishnan (1969), Ambrose (1951) and Menon and Pandalai(1958).

It is clearly indicated from the data that number of leaves, girth at collar, and number of roots at 270 and 360 DAS of seedling were maximum in stalk end down placement (invert) of coconut seed nut before sowing for 15 days as compared to stalk end down placement (invert) of coconut seed nut before sowing for 10 days. The probable reason might be due to the endosperm (nut water) remains close to embryo for longer time in stalk end down placement of seed nut produced early and well develop tap root which increased the number of roots, number of leaves and girth at collar region of seedling, and thus all the character develop quality seedling production. Mandal (1998) reported that early germinated seedling are significantly superior to late germinated ones in respect of plant height and girth at

collar. Early germinated nuts have faster rate of leaf production, production of number of leaves and splitting of leaflets in the nursery. These results are in conformity with horizontal planting obtained by Thomas (1978) and Thampan, (1981).

5.2 Effect of resting periods

It is clear from the data that the seed nut sown 30 days rest after harvesting gave the most promising results by minimum days required for germination, which was followed by 15 days rest and increase in germination percentage at 75 DAS as compared to fresh sown nut. The superiority of 30 days rest of seed nut after harvest with respect to minimum days required for germination and increase in germination percentage as a result of, the drying up of the husk which increases the rapid entry of water or freshly harvested nuts may not have the stage of ripeness and hence under normal condition, a storage period of one month, prior to sowing in the nursery, is considered useful to facilitate early and higher percentage of germination. These results are also in conformity with those of Mandal, (1998) in coconut.

It is clear from the data that height of seedling at 120 270 and 360 DAS was maximum in 15 days rest followed by 30 days rest after harvest. Number of leaves was maximum at 270 and 360 DAS in 15 days rest (R_2) after harvesting. Girth of the seedling at collar region was maximum in 15 days rest (R_2) followed by 30 days rest (R_3) as compared to fresh sown (R_1). Number of roots at 270 DAS was also maximum in 15 days rest (R_2). Highest root length was recorded in 30 days rest (R_3). The

results are also in conformity with Thomas *et al.* (2008) in coconut.

Fifteen days resting period significantly increased survival percentage of coconut seedling due to resting period.

5.3 Effect of pre sowing treatments

The results of the present investigation revealed that water soaking for 15 days with punching significantly gave the most promising results by minimum days required for germination and increased germination percentage as compared to control (without any treatment). The superiority of this treatment with respect to minimum days required for germination and increase germination percentage might be due to cause for softening of husk and leached out germination inhibitors present in hard seed coat or might be due to softening of seed coat and making it permeable to water. Similar results was noted by Singh, *et al.*(2005) in *Pongamia glabra*. This might have lessened the days taken to germination and increase germination percentage. Hadas and Russor (1974) reported that in general, the water soaking which enhances the germination of nuts, may be due to the higher quantum of water intake required for the initial imbibitions of water by a bigger nut like that palmyrah and coconut. These results are in agreement with the findings of Fremond and Brinin (1966), Srivastava (1975), Yaklich and Orzolak (1977) and Harries (1981 b) in coconut, Ghosh and Sen (1988) in ber, Ratan *et al.* (1993) in *Annona squamosa*, Shukla *et al.* (2008) in *Terminalia arjuna*. Crooker(1953) in *Cassia angustifolia*.

The next best pre sowing treatment was soaking of seed nut in 10000ppm solution of thiourea for 24 hours after punching on seed nut with respect to earliness in germination and increased germination percentage. An enhanced in germination might be attributed to the stimulatory effect of thiourea. Khandekar *et al.* (2007) revealed that the effect of pre sowing treatment of thiourea (500 ppm) in nutmeg give the mean maximum germination (88.88%), which was significantly superior to the rest of the growth regulator treatments. Thiourea causes maximum stimulation of germination if the seeds are treated for the first 24 hours and then transferred to water (Mayer and Poljakoff-mayer, 1958a) in lettuce seeds. These results are in agreement with the finding of Hore and Sen (1989) in ber, Patel *et al.* (1996) in Khirnee, Rashmi *et al.* (2007) in aonla, Butola *et al.* (2007) and Centinbas and Koyuncu (2006) in cherry.

It is evident from the results that height of seedling, girth at collar region, number of leaves and survival percentage were significantly maximum in thiourea treated compared to control without any pre sowing treatment and followed by treatment of water soaking for 15 days with and without punching. The increased height of seedling might be due stimulatory effect of thiourea. In aonla, height of seedling, girth may be possible due to stimulus of immediate cell progeny or stem girth may be due to greater cell division and elongation of stem portion (Rashmi *et al.*, 2007). These results are in consonance with the finding of Hore and Sen (1989) in ber and Mayber and Mayer (1958) in lettuce.

It is clear from the data that the water soaking for 15 days with punching gave maximum number of roots at 270 DAS per seedling. Punching provided rapid and highest imbibitions, resulting in increase more number of roots. Similar findings were reported for *Lupinus hawardii* Mackay *et al.*, 1995 and Shukla *et al.* (2008) in arjuna who reported that heavily pinched seeds resulted into significantly better germination which led to quicker seedling development and establishment at initial stage which facilitate proper and quicker height of seedling, significantly better root length, root diameter and shoot dry weight.



SUMMARY & CONCLUSION



VI. SUMMARY AND CONCLUSION

The present investigation entitled "Effect of resting period and pre-sowing treatments on seed nut germination and height of seedling of coconut (*Cocos nucifera* L.) cv. D×T" was conducted at Regional Horticultural Research Station, Navsari Agricultural University, Navsari during 2010-2011.

The experiment was laid out in Complete Randomized Design with Factorial concept (FCRD) with three replications. In all, there were fourteen treatment (twelve treatment combination of R×S and two special treatment (SP₁: stalk end down (invert) placement of coconut seed nut before sowing for 10 days and SP₂: stalk end down (invert) placement of coconut seed nut before sowing for 15 days)) repeated three times comprising of three resting period (fresh: just after harvesting (R₁), 15 days rest (R₂) and 30 days rest (R₃)), four pre sowing treatments (control: without any treatment (S₁), water soaking for 15 days without punching (S₂), water soaking for 15 days with punching (S₃) and soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut (S₄)). The observations on number of days taken to germination of seed nut, germination percentage, height of seedling, number of leaves per seedling, girth at collar region of seedling, number of roots, root length and survival percentage were recorded.

The results presented and discussed in previous chapters are summarized as under.

1. Regarding special treatments, SP₂(stalk end down (invert) placement of coconut seed nut before sowing for 15 days)

was found better for earliness in germination of seed nut. Whereas in resting period, R_3 (30 days rest) rank first for earliness in germination of seed nut over R_2 (15 days rest) and R_1 (fresh just after harvesting). Among different pre-sowing treatments tried, water soaking for 15 days with punching (S_3) was found superior with respect to earliness in germination followed by soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut (S_4).

2. Germination percentage of coconut seed nut was maximum under SP_2 (stalk end down (invert) placement of coconut seed nut before sowing for 15 days) in special treatments, R_2 (15 days rest) in resting period and S_3 (water soaking for 15 days with punching) in pre sowing treatments in present study.
3. Maximum height of seedling was noted under SP_2 (stalk end down (invert) placement of coconut seed nut before sowing for 15 days), R_2 (15 days rest) and S_4 (soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut). In pre sowing treatments second best treatment was water soaking for 15 days with punching (S_3)
4. Among different special treatments tried, SP_2 (stalk end down (invert) placement of coconut seed nut before sowing for 15 days) was found superior with respect to producing higher number of leaves per seedling. While, in resting period, maximum number of leaves per seedling was noted in R_2 (15 days rest). Seed nut treated with soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after

punching on seed nut (S_4) produce maximum number of leaves.

5. Regarding special treatments, SP_2 (stalk end down (invert) placement of coconut seed nut before sowing for 15 days) had higher value for girth at collar region. Whereas in resting period, maximum girth at collar region was registered in R_2 (15 day rest). Maximum girth at collar region was observed under soaking of seed nut in 10000 ppm solution of thiourea for 24 hours after punching on seed nut (S_4).
6. Maximum number of roots per seedling in coconut was noted under SP_2 (stalk end down (invert) placement of coconut seed nut before sowing for 15 days). Whereas in resting period, R_2 (15 day rest) produce maximum roots per plant. Seed nut treated with water soaking for 15 days with punching (S_3) had maximum roots per seedling.
7. Root length of coconut seedling was highest under R_3 (30 days rest).
8. Survival percentage at the time of uprooting of coconut seedling was highest in similar treatments *i.e.* SP_2 (stalk end down (invert) placement of coconut seed nut before sowing for 15 days), R_2 (15 days rest) and water soaking for 15 days with punching (S_3).
9. Regarding the interaction effect between resting period and pre sowing treatment ($R \times S$), fifteen days rest with water soaking for 15 days with punching (R_2S_3) proved to be best with respect to minimum days taken to germination.

germination percentage at 75 and 90 days, height of seedling, girth at collar region and survival percentage at uprooting.

Conclusion

On the basis of experimental result it can be concluded that fifteen days resting period with water soaking for 15 days with punching, was found most effective for earliness in germination, increase germination percentage, height of seedling, girth at collar region, and survival percentage of seedling.



REFERENCES



REFERENCES

- Aiyadurai, S.G. (1956). Observation on dry seed coconuts. *Madras Agric. J.*, 43 (9): 464 -466.
- Ambrose, C. (1951). Vertical or Horizontal? Which is the correct method of planting out seed nuts. *Ceylon Cocon. Q.*, 2: 169.
- Anonymous, (2009). Monthly operations in the coconut gardens. *Indian Coconut J.*, LII (8): 31-32.
- Anonymous, (2009). Directorate of Horticulture (Coconut), Gujarat State.
- Arvindakshan, M.; Nair, R. and Whid, P.A. (1988). Six dicades of coconut research. *Kerala Agric. Uni.*, Trichur, pp. 12-21.
- Anonymous (1997). Raising coconut seedlings of guaranteed quality. *Indian Coconut J.*, XXVIII (2) 11-13.
- Bhambota, J. R. and Singh A. (1971). A quick method of raising ber rootstock. *The Punjab Hort. J.* 11(3/4): 251-253.
- Bose, T. K. (1992). Fruits of India. Tropical and subtropical. Naya prokash, Culcutta, pp. 345-387.
- Butola, Jitendra S.; Pant, Shreekar and Samant S.S. (2007). Effect of pre-sowing seed treatment in *Hypericum perforatum* L. A high value medicinal plant. *Seed Res.*, 35(2): 205-209.
- Centinbas, M. and Koyuncu, F. (2006). Improving germination of *Prunus avium* L. seeds by gibberellic acid, potassium

nitrate and thiourea. *Hort. Sci. (Prague)*, **33**(3):119-123.

- Chandra, N. (1980). Some physiological changes accompanying loss of viability of the seeds of *Mangifera indica* L. *Plant Biochem. J.* **7**(2): 105-109.
- Chattopadhyay, N.; Sharangi, A.B. and Hore, J.K. (2004). Effect of position and depth of planting on germination of coconut. *Haryana J. Hort. Sci.*, **33** (1&2):85-86.
- Chattopadhyay, P. K. and Dey, S.S. (1992). Note on standardization of some aspects of ber propagation. *Indian J. Hort.* **49** (1):47-49.
- Child, R. (1974). *Coconuts*. Longman group Ltd., London. Pp. 57-100.
- Chiesotsu, S.; Kar, P.L. and Sanyal, D. (1995). A note on germination and seedling vigour of jackfruit seeds as influenced by growth regulators and storage. *The Hort. J.* **8** (2): 151-155.
- Crooker, W. (1953). *Physiology of seed*. *Cronica Botanica*, Co Walton.
- Daniel, P. (1992). Effect of pre-treatment of seeds and shade in the germination of palmyrah (*Borassus flabellifer* L.). *J. Plant. Crops*, **20**(2): 163-164.
- Das, S.K. (2003). Pre-Treatment of palmyrah Nuts. A circular No.3/2003/U.1, published by S.K. Das (IFS), Principal Chief Conservator of Forest, Govt. of Andhra-Pradesh (Forest department).

- Doijode, S. D. (2003). Changes in viability, vigour and solute leakage during storage of mandarin (*Citrus reticulata*) seeds. *Seed Res.* 31 (1): 77-79.
- Edmondson, C.H. (1941). Viability of coconut seeds after floating in sea. *Occasional Papers B.P. Bishop Museum, Honolulu, Hawaii*, 16(12): 293- 304.
- Fremond, V. and Brinin, C.H. (1966). Production de feuilles et precocite ched le jeune cocotier. *Oleagineux*, 24(4): 213-216.
- Fremond, Yan; Zillar, R.; Limothe, De; and Nuce De M.(1966).The coconut palm. *International Potash Institute, Berne, Switzerland*, pp 82.
- Ghosh S. N. and Sen. S. K. (1988). Effect of seed treatment on germination, seedling growth and longevity of ber (*Ziziphus mauritiana* Lam.) seeds. *South Indian Hort.* 36 (5): 260-261.
- Gopalkrishnan, S.(1969).Effect of different method of seed nut planting in (*Cocos nucifera* L.).*Madras Agric.J.*, 56: 120.
- Gurumurthy, B.R. and Hegde Mahabaleshwara V. (1987). Effect of temperature on germination of cardamom (*Elattaria cardamom* (L) Maton) seeds. *J. Plantation Crops* 15 (1): 5-8.
- Hadas, A. and Russor, D. (1974). Water uptake by seeds affected by water stress, capillary conductivity and

seed soil water contact. II. Ann. Expe. Data. Agro. J.,
66 : 647-652.

Harries, H.C. (1981 a). Practical identification of coconut variety.
Oeagineux, 36(2): 63-72.

Harries, H.C. (1981 b). Germination and taxonomy of the
coconut. *Ann. Bot.*, 48: 873-883.

Hore, J.K. and Sen, S.K.(1994). Role of pre sowing seed
treatment on germination, seedling growth and
longevity of Ber (*Zizyphus mauritiana*. Lam.) *Indian J.*
Agric. Res., 28(4): 285-289.

Hossain M.A.; Arefin, M.K.; Khan, B.M. and Rahman, M.A.
(2005). Effect of seed treatments on germination and
seedling growth attributes of Horataki (*Terminalia*
chebula Retz.) in the nursery. *Res J. Agri. and*
Biological Sci., 1 (2): 135-141.

John, B.M. and Fernanded, G. (1979). Rol del. Pericarpio de arti
Plex. Repandu. En la. Germination. *Phyton*, 37(2):
145-151.

Kadam, A. S.; Khedkae, D. M.; Patil, V. K. and Anserwadekar, K.
W. (1994). Studied on viability and germinability of
rangpur lime seeds during storage. *J. Maharashtra*
Agric. Univ. 19 (1): 130-131.

Kalia, V.; chandel, K. and kumar, P. (2005). Effect of
scarification treatments on germination of shrubby
stylo (*Stylosanthes scabra*) seeds. *Seed Res.*, 33(1):
119-119.

- Kenman, E.T. (1973). Effect of seed nut trimming on the germination and growth of coconut of coconut Rapalla, *New Guinea Agric. J.*, **24**(1): 26-29.
- Krishnaswamy, V. (1990). Assessment of critical moisture for seed viability in jack. *South Indian Hort.* **38** (4): 218-219
- Kumar, A.S. and Pillai, S.J. (1989). Nursery observation on the production of West Coast Tall and komadan Quality of seedling. *Indian Coconut. J.*, **20**(2): 8-12
- Kundu, Maitreyee; Sharma, Papor; Kachari, Jatin and Sett, Rupnarayan (1997). Effect of pre-treatment on germination and seedling vigour in *Alstonia scholaris*. *Seed Res.*, **25**(1): 16-18.
- Kutty, B.S.A. (1964). Preliminary studies on the effect of micro-nutrients on the germination of coconut seed nuts. *Current Sci.*, **33**(2):59-60.
- Kutty, O.V.U. (1955). External characters of seed coconuts and the quality of seedlings. *Indian Coconut J.*, **8**: 74-78.
- Lima Diaz, S.; Lima Diaz, I.; Valenzuela Galindo, R. and Macias, P. (1985). Study of seed viability of *Carica papaya* L. (cv. Maradol Roja). *Centro Agricola* **12** (3): 119-130.
- Liyanage, D.V. and Abeywardena, (1957). Correlations between seed nut, seedlings and adult Palm characters in coconut. *Tropical Agriculturist*, **133**: 325-340.
- Mackay, W.A., T.D. Davis and D. Sankhla. 1995. Influence of scarification and temperature treatments on seed

germination of *Lupinus havardii*. *Seed Sci. & Tech.*,
23: 815-821.

Mandal, R.C. (1991). Coconut Production and Protection Technology. *Agro. Bot. Pub., Bikaner*, pp. 15-54.

Mandal, R.C. (1998). Coconut Production and Protection Technology. *Agro. Bot. Pub., Bikaner*, pp. 47-54.

Mankar, S. W.; Dod, V. N. and Bharad S. G. (1997). Effect of different methods of seed germination in ber. *Crop Res. Hisar*. 14 (3): 437-439.

Marimuthu, R. and Natarajan, C., (2005). Sand curing is essential for obtaining more recovery of quality seedlings in coconut. *Indian Coconut J.* 35 (2): 10-11.

Markose, V.T. and Kutty, T.I.M. (1987). How to grow coconut. *Govt. India, New Delhi*, pp. 14-23.

Mayber, A.M. and Poljakoff-Mayer (1958). Effect of thiourea on germination and growth. *Indian J. Plant Physiol.*, 3:125-138.

Menon, K.P.V. and Pandalia, K.M. (1958). Coconut Palm. A monograph Indian Central Coconut Comm. *Ernakulam S. India*.

Ohler, J. G. (1984). Coconut tree of life. *Plant Prod. Prot. Paper* 57, F.A.O., Rome, pp 129-139.

Pampanna, Y. and Sulikeri G.S. (1999). Growth of sapota (*Manilkara achras*) seedlings as influenced by pre

sowing seed treatment with growth regulators. *Seed Res.*, 27 (1): 49-53.

Parmar, P.B. (1992). Standardization of cultivation practices in tuberose cv. Double. Thesis submitted to G.A.U., S.K., Nagar, Gujarat

Patel, B.N.; Patel, C.B. and Patel, A.N. (1996). A Note on seed germination technique for Khirnee. *J. Applied Horti.*, 2 (1&2): 149-150.

Peter ,K. V. and Kurian, Alice (2007). *Commercial Crops Technology. Horticulture Science Series Vol.8.* New Delhi; New India Publishing Agency, 2007.

Khandekar R.G.; Joshi, G.D., and Haldankar, P.M. (2007). Effect of growth regulators on germination and seedling growth in nutmeg (*Myristica fragrans* Hoult.). *South Indian Hort.*, 55(1-6): 315-322.

Ramanathan, T. (2001). Coconut and oil palm. Daya publishing house Delhi.

Rao, K. T. (1953). Coconut nursery practice in Andhra Pradesh. *Coconut Bull.* 7: 43-47.

Rashmi, Kumari; Sindhu, S.S.; Sehrawat and Dudi, O.P. (2007). Germination studies in Aonla. *Haryana J. hortic. Sci.*, 36(1&2): 9-11.

Ratan, Babu P.; Reddy, Eswara S. and Reddy, Narayana Y. (1993). Influence of water soaking on *Annona squamosa* L. seed and subsequent seedling growth. *South Indian Hort.*, 41 (3): 171-173.

- Sadashivaiah, K.N. (1983). Studies on hastening of seed nut (*Cocos nucifera* L.) by injection technique. Thesis submitted to *Dharwad Agric. Uni.*, Karnataka.
- Saipari, E.; Goswami, A. M. and Dadlani, M. (1998). Effect of seed drying on germination behavior in citrus. *Scientia. Hort.* 71: 185-190.
- Shukla, Gopal; Malla, Suman and Chakravarty, Sumit (2008). Pre sowing treatments of germination and seedling growth of *Terminalia arjuna* in Tarai zone of west Bengal. *Seed research*, 36 (2): 183-186.
- Silva , M.A.T and Alputharajah, P.P. (1977). Micro-nutrients in the nutrition of coconut-II. Effect of micronutrient on germination and growth of coconut seedling. *Ceylon Cocon. Q.*, 28 : 89-93.
- Singh, K.P.; Dhakre, Gunjan and Chauhan, S.V.S. (2005). Effect of mechanical and chemical treatments on seed germination in *Pongamia glabra* L. *Seed Res.*, 33 (2) : 169-171.
- Singh, R.S. and Bhargava. R. (2009). Effect of seed treatments on germination and growth behavior in date palm (*Phoenix species*) under hot arid condition. *J. Tropical Forestry*, 25: 42-48.
- Singh, S.; Singh rot, R. S. and Bhatia S. K. (2001). Effect of seed treatment on germination growth and budding success in ber rootstock (*Ziziphus rotundfolia*) sown

in nurseery beds and polythene tubes. *Haryana J. Hort. Sci.* **30** (3-4): 156-159.

- Singhrot, R. S. and Makhija M. (1979). Vegetative propagation of ber (*Zizyphus mauritiana* L.) III. Effect of time of sowing and acid treatment on ber seed germination and seedling performance. *Haryana J. Hort. Sci.* **8** (3-4): 168-172.
- Srivastava, A.K. and Singh, G. (1975). Ecology of germination of wheat. Triticula seeds in relation to temperature on moisture stress. *Indian J. Eco.*, **2**: 120-123.
- Sufeliffe, H.C. (1981). Practical identification of coconut varieties. *Oleagineux*, **36**: 63-73.
- Thampan, P.K. (1981). Handbook on coconut palm. *Oxford and IBH. Pub.Co.*, New Delhi, pp 59-79.
- Thampan, P.K. (1981). Handbook on coconut palm. *Oxford & IBH Publishing Co.*, New Delhi. p.71.
- Teaotia, S. S.; and Singh, R. D. (1971). Studies on media for storage and germination of mango seed stones. *The Punjab Hort. J.* **11** (1/2): 52-56.
- Thomas, R.M. (1974). Influence of certain physical and chemical treatments on the germination and subsequent growth of coconut seedling. *East Africa Agric. J.* **40**: 152-156.
- Thomas, K.M. (1978). Influence of seed size and planting orientation on the germination and growth of coconut seedling in the nursery. *Indian J. Agric. Sci.*, **48**(2): 63-66.

Thomas, R.J.; George, D.J.; Nair, S.A.; Sairam, C.V. and Jacob, P.M. (2008). Raising coconut nursery for the root (wilt) disease prevalent tracts. *Indian Coconut J.*, **LI** (3): 2-5.

Thomas, K.M. (1973). Influence of seed size and planting orientation on the germination and growth of coconut. *Ceylon Cocon. Quart.* **24**: 85-90.

Warrrier ,R.R; Singh, B.G.; Anandlakshmi, R; Shivkumar, V; Geetha, S. and Kumar, A.M.(2009). Standardization of storage conditions of prolong viability of seeds of *Artocarpus heterophyllus* Lam. A tropical fruit tree. *ARPN J. Agric. Bio. Sci.*, **4**(2):6-9.

Willlattt, S.T. and Stress, R.C. (1979). Germination and early growth of studied using neutron ratio graphy. *Ann. Bot.*, **43** (4): 415-422.

Yaklich, R.W. and Orzolak, M.D. (1977). Effect of polyethylene glycol coco on pepper seeds. *Hort. Sci.*, **12**: 263-264.



APPENDIX



Appendix -I: District- wise area and production of coconut in Gujarat (Year 2008-2009).

District	Area (hetares)	Production ('000' nuts)
Ahmedabad	3	15
Amreli	137	1096
Anand	65	487
Banaskantha	10	55
Bharuch	38	266
Bhavnagar	3800	37240
Jamnagar	405	3058
Junagadh	6540	71940
Kheda	8	48
Kutch	862	6034
Narmada	2	14
Navsari	345	2415
Patan	5	43
Porbadar	595	4343
Rajkot	12	120
Surat	133	998
Surendranagar	5	52
Tapi	33	247
Vadodara	170	850
Valsad	2810	28100
Total	15978	157421

Source: Directorate of Horticulture (Coconut), Gujarat State.

Appendix-II: State-wise area and production of India (2008-09)

States/Union territories	Area ('000' hectares)	Production (Million nuts)	Productivity (Nuts/ha)
Andhra Pradesh	104.00	970.00	9327
Assam	18.80	147.10	7824
Goa	25.61	128.18	5005
Gujarat	15.98	157.42	9851
Karnataka	419.00	2176.00	5193
Kerala	787.77	5802.00	7365
Maharashtra	21.00	175.10	8338
Nagaland	0.92	0.55	598
Orissa	51.00	275.80	5408
Tamil Nadu	389.60	5365.00	13771
Tripura	5.80	11.40	1966
West Bengal	28.60	355.50	12430
A & N Island	21.69	82.00	3781
Lakshadweep	2.70	53.00	19630
Pondicherry	2.10	30.70	14619

Source: Directorate of economics & statistics, Ministry of Agriculture, Govt. of India.

Appendix-III : Meteorological data during the experimental period (Jan. 2010- Feb. 2011)

Month	Average temperature (°c)		Relative humidity %		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
January-2010	30.7	15.7	70.4	37.3	0.0
February-2010	28.0	13.9	69.8	31.5	0.0
March-2010	35.1	19.7	82.7	34.3	0.0
April-2010	33.2	22.2	85.1	53.1	0.0
May-2010	36.2	27.0	89.0	61.6	0.0
June- 2010	32.7	26.8	90.7	73.9	9.0
July-2010	29.7	25.5	94.5	85.2	17.6
August -2010	29.7	25.5	94.0	82.2	140.5
September-2010	30.8	24.6	94.7	77.7	134.0
October-2010	33.5	23.2	88.2	55.2	7.4
November-2010	31.5	21.8	89.2	59.0	9.2
December-2010	29.0	13.6	80.7	37.5	0.0
January-2011	30.4	12.3	72.4	32.0	0.0
February-2011	32.3	14.6	78.2	34.5	0.0

Source: Agricultural Meteorological Observatory, Agricultural Experimental Station

Navsari Agricultural University.

CERTIFICATE

This is to certify that I have no objection to supply one copy of any part of this thesis at a time to any scientist through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : Navsari

Date : 21/5/2011



(Narendra Kumar Nagar)