



# Effect of Saline Irrigation Water and Growing Media on Germination of Seednut of Hybrid Coconut (*Cocos nucifera* L.)

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

A field experiment was conducted at Agriculture Research Station (Fruit Crops), Junagadh Agricultural University, Mahuva to assess the "Effect of saline irrigation water levels and different growing media on germination of hybrid coconut cv. DxT (Mahuva) *Cocos nucifera* L." during 2022-23 and 2023-24. The experiment was conducted to evaluate two factors with four and five levels.

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Amongst the two factors, one was different levels of saline irrigation water viz., S<sub>1</sub>: Saline irrigation water with EC<2.0 dS m<sup>-1</sup>, S<sub>2</sub>: Saline irrigation water with EC=4.0 dS m<sup>-1</sup>, S<sub>3</sub>: Saline irrigation water with EC=6.0 dS m<sup>-1</sup> and S<sub>4</sub>: Saline irrigation water with EC=8.0 dS m<sup>-1</sup> and another was different soil growing media viz., M<sub>1</sub>: control (soil only), M<sub>2</sub>: Soil: Sand @ 1:1 (v/v), M<sub>3</sub>: Soil: Sand: FYM @ 1:1:1 (v/v), M<sub>4</sub>: Soil: Sand: Vermicompost @ 1:1:1 (v/v) and M<sub>5</sub>: Soil: Sand: Cocopeat @ 1:1:1 (v/v). The experiment was laid out in randomized block design with factorial concept (FRBD) with three replications. Total sixteen seednuts of hybrid coconut cv. DxT (Mahuva) sown in each plot with the spacing of 30 cm x 30 cm. The application of irrigation with desired EC levels was done during dry period. The results obtained from the present investigation revealed that the application of saline irrigation water levels greater than EC 4.0 dS m<sup>-1</sup> (S<sub>3</sub> and S<sub>4</sub>) affected coconut seednut germination and days for germination (first and complete). The application of irrigation water with EC<2.0 dS m<sup>-1</sup> obtained significantly higher numbers of seednut germinations during 2022-23 (13.33), 2023-24 (14.27) and pooled (13.80). The soil media containing organic materials especially Cocopeat and FYM as component exerts positive impact on early and total germination of seednuts, and days to first germination. The use of Soil: Sand: Cocopeat @ 1:1:1 (v/v) obtained significantly higher total germination (13.50) in pooled and found at par (13.00) with Soil: Sand: FYM @ 1:1:1 (v/v).

**Keywords:** Saline; irrigation water; growing media; coconut; germination; FYM; cocopeat.

## 1. INTRODUCTION

The coconut palm (*Cocos nucifera* L.) belongs to the palm family (Arecaceae) is the most useful palm in the world. Every part of the tree is useful to human life for some purpose or other. Hence, the coconut palm is endearingly called '*Kalpa vriksha*' meaning the tree of heaven. The copra obtained by drying the kernel of coconut is the richest source of vegetable oil containing 65 to 70 per cent oil (Anon., 2017).

The coconut palm is suitable to grow under varying climatic and soil conditions. It is essentially a tropical plant growing mostly between 20° N and 20° S latitudes. However, a well distributed rainfall of about 2000 mm/year is ideal for proper growth and maximum production. Coconut is grown under different soil types, such as loamy, laterite, coastal sandy, alluvial, clayey and reclaimed soils of the marshy low lands. The ideal soil conditions for better growth and performance of the palm are proper drainage, good water-holding capacity and presence of a water table within 3 m and absence of rock or any hard substratum within 2 m of the surface (Avinash, et al., 2019).

The coconut palm continues to yield for more than 80 years and the full bearing capacity becomes known only 10 to 15 years after planting. If the seedling material happens to be unselected and inferior in quality, the garden will prove to be highly uneconomical and a continuous source of loss to the grower, which leads to poor establishment of plantation.

To avoid such situations, planting vigorous seedlings is a prerequisite.

In coconut, which is a perennial plantation crop, production and use of good quality seedlings have great importance. Conventionally, coconut seedlings are raised in a nursery prior to field planting as proper care and maintenance of a seedbed facilitates the selection of early germinating vigorous seedlings. Seedling vigour is correlated with adult palm characteristics such as early flowering, high nut and copra yield.

Coconut is currently grown in more than 90 countries spread along the tropical belt of 12.26 million hectares (Anon., 2021) in the world, eight million hectares, or about 70 % is in South East & East Asia (Carpio, et al., 2005).

India occupies an area of 2.28 million hectares with an annual production of 20535.88 million nuts as per an estimate (All India final estimates) of 2022-23 (Anon., 2023). Cultivation of coconuts in India is restricted to fifteen states / Union Territories and most of these are located on coastal belts or sea shore. Amongst the various states / Union Territories, Kerala and Karnataka rank first and second in area respectively and Karnataka and Kerala rank first and second in production respectively, whereas Gujarat stands at 8<sup>th</sup> position in area (24,780 ha) and 7<sup>th</sup> position in production (211.33 million nuts).

The area and production data of the world and India are presented in Table 1, Table 2 (Data collected from Coconut Development Board website

<https://coconutboard.gov.in/Statistics.aspx> on 26<sup>th</sup> May, 2024).

In order to attain self-sufficiency for coconut and its byproducts, it is necessary to improve and increase production. This can be achieved either by increasing the production per unit area or by

increasing the existing area under the coconut crop through new planting. The solution to the problem on a long-term basis lies in extending the area under the coconut and also replacing the old and inefficient trees in the existing gardens by planting vigorous seedlings of new and improved cultivars of coconut (Kutty, 1955).

**Table 1. Area, Production and Productivity of Coconut in Major Coconut Growing Countries (2021)**

Sr. No.	Countries	Area ('000 ha)	Production (Million Nuts)	Productivity (Nuts/ha)
1	Philippines	3,647.00	14,717.00	4,035
2	Indonesia	3,374.00	14,200.00	4,209
3	India	2,199.00	20,736.00	9,430
4	Sri Lanka	444.00	3,120.00	7,027
5	Papua New Guinea	222.00	1,483.00	6,680
6	Vietnam	168.00	1,410.00	8,393
7	Thailand	126.00	644.00	5,111
8	Vanautau	88.00	303.00	3,443
9	Kenya	85.00	289.00	3,400
10	Malaysia	83.00	556.00	6,699
11	Fiji	61.00	244.00	4,000
12	Solomon Islands	38.00	100.00	2,632
13	Tonga	26.00	53.00	2,038
14	Kiribati	25.00	145.00	5,800
15	Samoa	20.00	53.00	2,650
16	F.S.Micronesia	18.00	78.00	4,333
17	Jamaica	16.00	167.00	10,438
18	Timor Leste	12.00	26.00	2,167
19	Guyana	12.00	92.00	7,667
20	Marshall Island	7.00	18.00	2,571
21	Other Countries	1,586.00	8,240.00	5,195
	<b>Total</b>	<b>12,257.00</b>	<b>66,674.00</b>	<b>5,440</b>

**Table 2. State wise Area, Production and Productivity of Coconut in India (2022-23)**

Sr. No.	States/Union Territories	Area ('000 ha)	Production (Million Nuts)	Productivity (Nuts/ha)
1	Andhra Pradesh	106.86	1,705.98	15,964
2	Arunachal Pradesh	0.07	0.30	4,605
3	Assam	21.58	156.92	7,272
4	Bihar	12.27	78.69	6,415
5	Chhatisgarh	1.67	14.82	8,890
6	Gujarat	24.78	211.33	8,527
7	Karnataka	705.11	5,949.46	8,438
8	Kerala	760.35	5,628.42	7,402
9	Maharashtra	30.54	201.03	6,583
10	Mizoram	0.03	0.15	4,350
11	Nagaland	1.07	9.63	8,983
12	Odisha	52.84	397.77	7,528
13	Others	49.23	317.54	6,450
14	Tamil Nadu	472.71	5,421.76	11,469
15	Telangana	0.90	9.38	10,375
16	Tripura	4.70	13.37	2,844
17	West Bengal	32.46	419.33	12,917
	<b>Total</b>	<b>2,277.18</b>	<b>20,535.88</b>	<b>9,018</b>

To achieve the suggested goal of extending the area of coconut plantation there is the need for supplying healthy and quality coconut seedlings (Samsuceen and Thamban, 2019; Liyanage, 1953; Thampan, 1971; Satyabalan and Mathew, 1984). The selection of planting material (seedling) is mainly done at the nursery stage on the basis of early germination within 5 months after sowing of nut in the nursery and the vigour of the seedling, i.e. girth, number of functioning and splitting leaves. On the basis of these criteria only 60-65 per cent quality seedlings can be produced, following traditional nursery technique (Jnanadevan, 2019; Markose and Kutty, 1987). To standardize the nursery techniques, little effort has been made in India. These techniques are not found convenient for the common nurseryman due to their impracticality and higher cost factor.

Coconut is a cross pollinated perennial crop, which can be propagated only through seeds and the selection of the planting material is of a vital importance.

Environmental stress, both biotic and abiotic, is a serious threat to the sustainability of global agriculture. In arid and semi-arid regions, drought and salinity can be considered as stress agents capable of causing the most severe damage to plants, as they result in large reductions in the cultivated area, in addition to compromising both crop productivity and quality (Nakabayashi and Saito, 2015).

Irrigation crops with saline water can result in yield loss and decreased quality. Crop yields can be markedly reduced before visual symptoms of salinity damage become apparent. Plants vary greatly in their tolerance to saline water. The extent of yield loss when plants are irrigated with saline water depends on a number of factors including soil type, drainage and the frequency, method and time of irrigation.

Salts in irrigation water are mainly common salts (sodium chloride), calcium and magnesium bicarbonates, chlorides and sulphates. Salty irrigation water can affect plant growth in two ways: salinity effect and toxicity effect. Plants are generally more susceptible to salinity damage during germination and at the seedling stage than when established.

Growing media are materials that can include organic materials such as peat, compost, tree bark, coir, poultry feathers, or inorganic materials

such as clay, perlite, vermiculite, and mineral wool (Grunert et al., 2008; Vaughn et al., 2011) or mixes such as peat and perlite; coir and clay, peat and compost. Growing medium also acts as a source of nutrients for plant growth and growing place for seed germination. Coco peat is one that has good growing media component with acceptable pH. Besides, coco peat also has good physical properties, high total pore space and water content, low shrinkage and bulk density, and slow biodegradation. Organic substances or material which is added with inorganic substances can give more advantages to the culture as it can increase water holding capacity and aeration.

In Gujarat, the source of planting materials for coconut growers are either from various nurseries of the state government or the Department of Horticulture of Agricultural Universities and to some extent, from private nurseries. The most common method of production of coconut seedlings is the nuts sown in nursery beds and to allow them to grow there itself till they are ready for transplanting in the main field.

The farmers who produce coconut seedlings for themselves generally raise coconut seedlings under coconut palms in ordinary field soil. On the other hand, nurserymen usually prepare a nursery by adding coarse sand and most commonly FYM as an organic amendment to the nursery soil as per their beliefs and experiences.

Above that, in coastal regions, due to ingress of the sea, most of the well water was converted to saline and brackish. In the situation of scarcity of rain water or sweet water, farmers and nurserymen are forced to use different levels of saline irrigation water to produce coconut seedlings. Which may greatly affect the germination and subsequent growth of coconuts.

Due to a lack of developed technologies like tissue culture in coconut, it is nearly impossible to cope with the full demand of quality seedlings by the government and private nurseries. But it is also important to find some way to fulfil as much as a possible supply of such seedlings.

There are very few findings available about the use of different growing media and the use of saline irrigation water to check its combined effects on coconut germination, particularly of the hybrid coconut variety DxT (Mahuva). Mostly

nurserymen and coconut growers' communities are producing seedlings in a conventional way.

Therefore, this research was carried out to investigate the effect of saline irrigation water and different growing media on seednut germination and seedling quality of hybrid coconut cv. 'DxT (Mahuva)' *in situ* with the following objectives:

- i. To find out the effect of saline water irrigation levels on germination of hybrid coconut cv. DxT (Mahuva).
- ii. To find out the effect of different growing media on germination of hybrid coconut cv. DxT (Mahuva).

## 2. MATERIALS AND METHODS

The present study was taken up at the Agriculture Research Station (Fruit Crops), Junagadh Agricultural University, Mahuva, Dist. Bhavnagar, Gujarat, India during the years 2022-2024 (From February 2022 to February 2023 and from February 2023 to March 2024).

A mixture of pond water and well water was utilized for the experiment. The procurement and selection of coconut seednuts was made as per the method suggested by Menon and Pandalai (1960). The selected source for seednuts was the Agriculture Research Station (Fruit Crops) at Junagadh Agricultural University, Mahuva, Dist. Bhavnagar, Gujarat, India, a distinguished centre for the production of high-quality coconut nuts.

Selection of mother palms was done based on the annual nut yield per individual palm. Moreover, certain morphological features of palms were also considered while selecting the mother palm, such as regular bearing, thick trunk with more number of leaves, uniform leaf orientation showing umbrella like appearance and uniform age group. The required number of mother palms were selected from different plots of dwarf green variety where the hybridization for DxT took place.

To impose the age of seednuts, the selection of inflorescence after the appearance of female flowers and fertilization was made based on length, strength and number of female flowers per spadix and date of fertilization. On the basis of the date of fertilization the inflorescence were selected and tags were tied on the selected individual inflorescence. Considering the date of

tied labels on individual bunches, eleven to twelve month old matured bunches of nuts were harvested from individual mother palm during January month of 2022 for the first year and January month of 2023 for the second year of the experiment. Based on nut size, shape and weight the uniform seednuts were selected. The seednuts without liquid endosperm were rejected. The storage of selected seednuts was done at the station itself at ARS, Mahuva. The storage was done under shade of cement roof ventilated properly.

According to treatments for the preparation of different growing media, soil, sand, farmyard manure, vermicompost and cocopeat were required in different quantities. Soil was taken from the farm itself and large clods were removed from the soil. Sand is also taken from the farm itself, where in specific plots the sand part is available. The sand was collected and passed through the construction sieve to avoid very coarse sand from the media. Farmyard manure was prepared in a pit at experiment station. Vermicompost and cocopeat samples were checked and then purchased from a private party. With these soil, sand and organic substrates as per treatments, different growing media were prepared accordingly.

The partially shaded site was selected for sowing the coconut seednuts. An experimental area was earmarked. The top soil of the earmarked area was cultivated with a rotavator to loosen the top soil for ease of preparation of plots. Also, as per treatments, the plots were earmarked with an individual plot size of 1.20 m X 1.20 m. Then as per treatment combinations total 60 plots were labelled as per the randomization of the treatment combinations and dig out the soil up to 0.30 m depth and removed that entire soil from the plot. Thereafter, these plots were filled with soil growing media prepared as per the soil growing media treatments. Here no additional treatments were given, e.g. insecticide application to control termites etc. which are generally given for coconut nursery raising.

On completion of one month rest period, the selection of seednuts was done based on the water content inside the nut. All selected seednuts were destalked. From this lot, 960 nuts were separated and sown as per treatments on 22<sup>nd</sup> February 2022. The same procedure was repeated in the second year of the experiment and 960 nuts were planted as per treatment on 28<sup>th</sup> February 2023.

A uniform distance of 30 x 30 cm (inter and intra row) was maintained at the time of sowing to accommodate 16 seednuts per plot / treatment. The seednuts were sown in a vertical position so as to keep the embryonic stalk-end up.

As per the treatment of saline irrigation water, the irrigation water with different salinity was prepared by mixing rain water harvested pond water and well water. The electrical conductivity of pond water and well water were measured with the help of a digital conductivity meter. Then the well water was added gradually to a known quantity of pond water to get the desired electrical conductivity of irrigation water and then the irrigation water was applied as per the treatments. First irrigation was given just after sowing and subsequent irrigation was given twice a week during summer and once a week during winter and dry periods with the saline irrigation water as per the treatments, and such irrigation cycle was maintained for a period of one year. Other nursery operations such as weeding, digging and plant protection measures were carried out as and when required.

The experiment was set up using Randomized Block Design with a Factorial concept (FRBD), involving two factors and twenty treatment combinations. The first factor as salinity levels of irrigation water *viz.*, S<sub>1</sub>: Irrigation water with EC<2.0 (dS m<sup>-1</sup>), S<sub>2</sub>: Irrigation water with EC 4.0 (dS m<sup>-1</sup>), S<sub>3</sub>: Irrigation water with EC 6.0 (dS m<sup>-1</sup>), S<sub>4</sub>: Irrigation water with EC 8.0 (dS m<sup>-1</sup>) and second factor as growing media *viz.*, M<sub>1</sub>: Soil only, M<sub>2</sub>: Soil + Sand @ 1:1 (V/V), M<sub>3</sub>: Soil + Sand + F.Y.M. @ 1:1:1 (V/V), M<sub>4</sub>: Soil + Sand + Vermicompost @ 1:1:1 (V/V) and M<sub>5</sub>: Soil + Sand + Cocopeat @ 1:1:1 (V/V). The different treatment combinations are as follows (1) S<sub>1</sub>M<sub>1</sub> (2) S<sub>1</sub>M<sub>2</sub> (3) S<sub>1</sub>M<sub>3</sub> (4) S<sub>1</sub>M<sub>4</sub> (5) S<sub>1</sub>M<sub>5</sub> (6) S<sub>2</sub>M<sub>1</sub> (7) S<sub>2</sub>M<sub>2</sub> (8) S<sub>2</sub>M<sub>3</sub> (9) S<sub>2</sub>M<sub>4</sub> (10) S<sub>2</sub>M<sub>5</sub> (11) S<sub>3</sub>M<sub>1</sub> (12) S<sub>3</sub>M<sub>2</sub> (13) S<sub>3</sub>M<sub>3</sub> (14) S<sub>3</sub>M<sub>4</sub> (15) S<sub>3</sub>M<sub>5</sub> (16) S<sub>4</sub>M<sub>1</sub> (17) S<sub>4</sub>M<sub>2</sub> (18) S<sub>4</sub>M<sub>3</sub> (19) S<sub>4</sub>M<sub>4</sub> (20) S<sub>4</sub>M<sub>5</sub>.

The germination was recorded at weekly intervals after the appearance of the first sprout after seednut sowing to continue up to the end of the 12<sup>th</sup> month. Based on the duration, the germinations were classified as suggested by Arvindakshan et al. (1988). The seednuts germinated within 127 days of sowing were considered as early germination. The seednuts, after sowing, took more than 152 days for germination, were considered as late germinated ones. The data collected was expressed in number of seednuts. The seednuts that

germinated between the periods of nut sowing to the end of the 12<sup>th</sup> month were considered as total germination. The number of days required for first germination of seednuts were recorded when the first sprout of the germinated nut reached about 2.5 cm in height above the stalk-end after sowing. The number of days required for complete germination was calculated by subtracting the number of days required for first germination from the number of days required for last germination.

### 3. RESULTS AND DISCUSSION

The outcomes of different treatments were documented, and the results obtained during the investigation were thoroughly discussed, supported by reasoning and relevant references. After sowing coconut seed nuts, the observations taken for germination (early, late, total, and number of days for first germination and number of days taken for complete germination). The data recorded regarding germination are presented in Table 3 to Table 7.

#### 3.1 Early Germination (< 127 days)

The statistical analysis clearly indicated that the saline irrigation water level S<sub>1</sub> obtained the maximum number of early seed nut germination in the year 2022-23 (9.14) and pooled (8.46) out of sixteen seed nuts sown. In pooled data, saline irrigation water level S<sub>2</sub> (7.30) was found statistically at par with level S<sub>1</sub>. The minimum germination of seed nuts was observed in the highest saline irrigation water level S<sub>4</sub> in both years.

This is due to salinity affects the seed germination process through osmotic stress, ion-specific effects and oxidative stress, shown by decreasing germination rate and extended germination time (Munns, 2002). Lee and Luan (2012) reported that salinity may adversely influence seed germination by decreasing the amounts of seed germination stimulants such as GAs, enhancing ABA amounts, and altering membrane permeability and water behaviour in the seed. Similar results obtained by Cuneyt Ucarli (2020) stated that salinity is the major environmental stress source that restricts agricultural productivity and sustainability in arid and semiarid regions by reduction in the germination rate and delay in the initiation of germination and subsequent seedling establishment. Salt stress affects the seed germination and seedling establishment through

**Table 3. Effect of saline irrigation water and growing media on early germination (<127 days) of coconut seed nuts**

Treatments	Early germination (Nos.)		
	2022-23	2023-24	Pooled
<b>Salinity levels of irrigation water (S)</b>			
S <sub>1</sub> : Irrigation water with EC <2.0 dS m <sup>-1</sup>	3.02 (9.14)	2.80 (7.81)	2.91 (8.46)
S <sub>2</sub> : Irrigation Water with EC 4.0 dS m <sup>-1</sup>	2.74 (7.50)	2.67 (7.11)	2.70 (7.30)
S <sub>3</sub> : Irrigation Water with EC 6.0 dS m <sup>-1</sup>	2.44 (5.94)	2.53 (6.39)	2.48 (6.17)
S <sub>4</sub> : Irrigation Water with EC 8.0 dS m <sup>-1</sup>	2.39 (5.72)	2.43 (5.89)	2.41 (5.80)
<b>S.Em. ±</b>	0.080	0.123	0.073
<b>C.D. at 5%</b>	0.23	NS	0.21
<b>Media (M)</b>			
M <sub>1</sub> : Soil only	2.22 (4.92)	2.29 (5.24)	2.25 (5.08)
M <sub>2</sub> : Soil + Sand @ 1:1 (v/v)	2.18 (4.75)	2.60 (6.73)	2.39 (5.70)
M <sub>3</sub> : Soil + Sand + FYM @ 1:1:1 (v/v)	3.04 (9.21)	2.74 (7.51)	2.89 (8.34)
M <sub>4</sub> : Soil + Sand + Vermicompost @ 1:1:1 (v/v)	2.57 (6.60)	2.60 (6.76)	2.58 (6.68)
M <sub>5</sub> : Soil + Sand + Coco peat @ 1:1:1 (v/v)	3.24 (10.47)	2.80 (7.82)	3.02 (9.10)
<b>S.Em. ±</b>	0.09	0.137	0.168
<b>C.D. at 5%</b>	0.26	NS	0.66
<b>S X M</b>			
S.Em. ±	0.18	0.275	0.129
C.D. at 5 %	NS	NS	NS
C.V. %	11.76	18.26	15.30
<b>Year</b>			
S.Em. ±	0.052		
C.D. at 5 %	NS		
<b>Y X S</b>			
S.Em. ±	0.104		
C.D. at 5 %	NS		
<b>Y X M</b>			
S.Em. ±	0.116		
C.D. at 5 %	0.33		
<b>Y X S X M</b>			
S.Em. ±	0.232		
C.D. at 5 %	NS		

\* Followed square root transformation of the data. Data in the parentheses are retransformed values.

There was no interaction observed between saline irrigation water levels and soil growing media on early germination of coconut seed nuts in the experiment

osmotic stress, ion toxicity, and oxidative stress. Epstein et al. (1980) reported that salinity decreased seed germination, retarded plant development, and reduced crop yield. But Marinho et al. (2005), in dwarf-green coconut, found that the salinity did not influence the germination significantly. However, it affected the germination speed and the growth of the seedlings.

The data presented on the effect of soil growing media on the early germination of coconuts are to be found significant and the media M<sub>5</sub> (soil + sand + cocopeat) produced the maximum number of early germination of coconut seednuts in the year 2022-23 (10.47) and pooled (9.10) out of the total seednut of sixteen. In pooled the

media M<sub>3</sub> (8.34) results were statistically at par with the media M<sub>5</sub>, followed by M<sub>4</sub> (6.68) and M<sub>2</sub> (5.70). The data represent the possible effects of organic matter content as well as porosity of the soil.

Cocopeat, when mixed with soil and sand, increases the porosity (enough oxygen), water holding capacity, and improves the physical structure of soil. These properties provide an ideal environment for seednuts for germination and further growth and development, which may be the reason for the higher early germination recorded in the experiment. Abad et al. (2002) also noted that cocopeat is considered as a growing medium component with acceptable pH, EC and other chemical attributes. Bhardwaj

(2013) reported that cocopeat has beneficial effects on the germination and growth of papaya. Abirami et al. (2010) achieved similar results in nutmeg and found maximum early germination, germination percentage, germination index and earliness index in the treatment containing soil: coir dust: sand: vermicompost in 1:1:1:1: as the media followed by soil: coir dust: sand: FYM in 1:1:1:1. The statistically at par results found in media mix of soil with sand + FYM, sand + vermicompost and soil + sand in pooled proved the positive effect of organic materials and porosity of the soil media.

### 3.2 Late Germination (>152 days)

The data on the number of late germinated coconut seed nuts are presented in Table 4 indicated that the saline irrigation water levels affect late germination of coconut seed nuts. The statistical data indicated that in the year 2022-23 the saline irrigation water level S<sub>1</sub> shows a minimum number (1.59) of late germination, which was statistically at par with S<sub>2</sub> (1.92). Whereas, the highest number found in saline irrigation water level S<sub>4</sub> (3.16), which was statistically at par with S<sub>3</sub> (2.94). As discussed in early germination para, the reason behind the lower numbers of late germination in S<sub>1</sub> and S<sub>2</sub> was that the majority of seed nuts germinated in the early phase out of the total seednuts sown. The reverse is also true for S<sub>4</sub> and S<sub>3</sub>, in which the early germination is less and so the remaining seednuts germinate later on. The more late germination numbers of seed nuts with the application of higher levels of water salinity negatively affect germination and the probable reasons already discussed in the discussion part of early germination.

The soil growing media effects were also found significant, with the highest number of late seednut germinations reported in media M<sub>1</sub> (soil only) in the year 2022-23 (4.25) and pooled (4.09), and the media M<sub>2</sub> (soil + sand) was statistically at par with M<sub>1</sub> with the mean value of number of late seed nut germination 3.25. This is because of the less appropriate soil environment in these two media compared to the other three media, viz., soil + sand + FYM, soil + sand + vermicompost and soil + sand + cocopeat (Karthikeyan et al., 2004; Bhardwaj, 2013; Hota et al., 2018; Patel et al., 2019; Varadkar et al., 2020).

There was no interaction observed between saline irrigation water levels and soil growing media on late germination of coconut seed nuts in the experiment.

### 3.3 Total Germination (sowing to 12 months)

The data of total germination, which includes seed nuts germinated from the sowing of seed nuts to completion of a 12month period. The data on the total germination of seed nuts i.e. out of sixteen seed nuts sown, are presented in Table 5.

The perusal of the data depicted that there was a significant difference in total germination with the application of saline irrigation water levels. The statistical analysis indicated that the saline irrigation water level S<sub>1</sub> and S<sub>2</sub> obtained the maximum number of total seed nut germinations in the year 2022-23 (13.33), which was statistically at par with the saline irrigation water level S<sub>3</sub> (12.60). In the year 2023-24 and pooled the saline irrigation water level S<sub>1</sub> shows maximum total seednut germination, with mean numbers 14.27 and 13.80 respectively.

The observed results are in line with the findings of many researchers (Shokohifard et al., 1989; Azhdari et al., 2010; Ali et al., 2018; Cuneyt Ucarli, 2020 and Kheloufi and Mansouri, 2020). The majority of the research reported that salinity decreased seed germination. Salinity effects are the result of complex interactions amongst morphological, physiological, and biochemical processes including seed germination, plant growth, and water and nutrient uptake (Akbarimoghaddam et al., 2011; Singh and Chatrath, 2001). According to Lee and Luan (2012), salinity may adversely influence seed germination by decreasing the amounts of seed germination stimulants such as GAs, enhancing ABA amounts, and altering membrane permeability and water behaviour in the seed.

The effect of different soil growing media did not make the significant difference on the total number of seed nut germinations during individual years, but the data shows significant results on pooled data basis and higher total germination recorded with the media M<sub>5</sub> (13.50), which was statistically at par with the media M<sub>3</sub> (13.00). The growing medium also plays an important role in seed germination. Not only does it act as a support, but also as a source of key nutrients for plant growth (Wilson et al., 2001). This is because the media composition has a conducive impact on the soil porosity, the soil's ability to retain water, and the availability of large amounts of nutrients (Jiya and Wilson, 2020). Similar results were found by Samir et al. (2016), Sajana et al. (2018). And the media M<sub>5</sub> in a

combination ratio of soil:sand:cocopeat in 1:1:1 proportion and M<sub>3</sub> with soil:sand:FYM in 1:1:1 have better organic carbon status, water holding capacity and porosity than the other soil growing media combinations.

There was no interaction observed between saline irrigation water levels and soil growing media on early germination of coconut seed nuts in the experiment.

### 3.4 Number of Days for First Germination

The number of days for first germination of coconut seed nuts are recorded at the time of first sprouting after seed nut sowing and are presented in Table 6.

The perusal of the data on the number of days for first germination depicted that the saline irrigation water levels affect the number of days for first germination of coconut seed nuts. The statistical analysis indicated that the saline irrigation water level S<sub>1</sub> took the minimum number of days for first germination of coconut seed nut in the year 2023-24 (89.13) and pooled (82.73), and was found statistically at par with the saline irrigation water level S<sub>2</sub> in the year 2023-24 (93.67) and pooled (85.33). The maximum days taken for first germination of seed nuts were observed in the highest saline irrigation water level S<sub>4</sub> in both the year 2023-24 (99.07) and in S<sub>3</sub> in pooled (91.00).

**Table 4. Effect of saline irrigation water and growing media on late germination (>152 days) of coconut seed nuts**

Treatments	Late germination (Nos.)		
	2022-23	2023-24	Pooled
<b>Salinity levels of irrigation water (S)</b>			
S <sub>1</sub> : Irrigation water with EC <2.0 dS m <sup>-1</sup>	1.37 (1.59)	1.73 (4.20)	1.55 (2.75)
S <sub>2</sub> : Irrigation Water with EC 4.0 dS m <sup>-1</sup>	1.43 (1.92)	1.52 (2.53)	1.48 (2.22)
S <sub>3</sub> : Irrigation Water with EC 6.0 dS m <sup>-1</sup>	1.58 (2.94)	1.60 (3.08)	1.59 (3.01)
S <sub>4</sub> : Irrigation Water with EC 8.0 dS m <sup>-1</sup>	1.61 (3.16)	1.63 (3.29)	1.62 (3.23)
<b>S.Em. ±</b>	0.056	0.070	0.081
<b>C.D. at 5%</b>	0.16	NS	NS
<b>Media (M)</b>			
M <sub>1</sub> : Soil only	1.74 (4.25)	1.70 (3.93)	1.72 (4.09)
M <sub>2</sub> : Soil + Sand @ 1:1 (v/v)	1.62 (3.25)	1.62 (3.25)	1.62 (3.25)
M <sub>3</sub> : Soil + Sand + FYM @ 1:1:1 (v/v)	1.37 (1.59)	1.57 (2.86)	1.47 (2.18)
M <sub>4</sub> : Soil + Sand + Vermicompost @ 1:1:1 (v/v)	1.49 (2.31)	1.59 (3.03)	1.54 (2.65)
M <sub>5</sub> : Soil + Sand + Coco peat @ 1:1:1 (v/v)	1.27 (1.04)	1.62 (3.25)	1.44 (2.01)
<b>S.Em. ±</b>	0.063	0.078	0.05
<b>C.D. at 5%</b>	0.18	NS	0.14
<b>S X M</b>			
S.Em. ±	0.125	0.156	0.08
C.D. at 5 %	NS	NS	NS
C.V. %	14.46	16.68	15.71
<b>Year</b>			
S.Em. ±	0.057		
C.D. at 5 %	NS		
<b>Y X S</b>			
S.Em. ±	0.063		
C.D. at 5 %	0.18		
<b>Y X M</b>			
S.Em. ±	0.071		
C.D. at 5 %	NS		
<b>Y X S X M</b>			
S.Em. ±	0.141		
C.D. at 5 %	NS		

\* Followed square root transformation of the data. Data in the parentheses are retransformed values.

**Table 5. Effect of saline irrigation water and growing media on total germination (sowing to 12 months) of coconut seed nuts**

Treatments	Total germination (Nos.)		
	2022-23	2023-24	Pooled
<b>Salinity levels of irrigation water (S)</b>			
S <sub>1</sub> : Irrigation water with EC <2.0 dS m <sup>-1</sup>	13.33	14.27	13.80
S <sub>2</sub> : Irrigation Water with EC 4.0 dS m <sup>-1</sup>	13.33	12.27	12.80
S <sub>3</sub> : Irrigation Water with EC 6.0 dS m <sup>-1</sup>	12.60	12.33	12.47
S <sub>4</sub> : Irrigation Water with EC 8.0 dS m <sup>-1</sup>	11.80	11.33	11.57
<b>S.Em. ±</b>	0.391	0.386	0.275
<b>C.D. at 5%</b>	1.12	1.11	0.78
<b>Media (M)</b>			
M <sub>1</sub> : Soil only	12.50	11.83	12.17
M <sub>2</sub> : Soil + Sand @ 1:1 (v/v)	12.00	12.00	12.00
M <sub>3</sub> : Soil + Sand + FYM @ 1:1:1 (v/v)	12.75	13.25	13.00
M <sub>4</sub> : Soil + Sand + Vermicompost @ 1:1:1 (v/v)	12.67	12.58	12.63
M <sub>5</sub> : Soil + Sand + Coco peat @ 1:1:1 (v/v)	13.92	13.08	13.50
<b>S.Em. ±</b>	0.437	0.432	0.307
<b>C.D. at 5%</b>	NS	NS	0.87
<b>S X M</b>			
S.Em. ±	0.874	0.864	0.60
C.D. at 5 %	NS	NS	NS
C.V. %	11.86	11.92	11.89
<b>Year</b>			
S.Em. ±	0.194		
C.D. at 5 %	NS		
<b>Y X S</b>			
S.Em. ±	0.389		
C.D. at 5 %	NS		
<b>Y X M</b>			
S.Em. ±	0.435		
C.D. at 5 %	NS		
<b>Y X S X M</b>			
S.Em. ±	0.869		
C.D. at 5 %	NS		

**Table 6. Effect of saline irrigation water and growing media on number of days for first germination of coconut seed nuts**

Treatments	No. of days for first germination		
	2022-23	2023-24	Pooled
<b>Salinity levels of irrigation water (S)</b>			
S <sub>1</sub> : Irrigation water with EC <2.0 dS m <sup>-1</sup>	76.33	89.13	82.73
S <sub>2</sub> : Irrigation Water with EC 4.0 dS m <sup>-1</sup>	77.00	93.67	85.33
S <sub>3</sub> : Irrigation Water with EC 6.0 dS m <sup>-1</sup>	83.60	98.40	91.00
S <sub>4</sub> : Irrigation Water with EC 8.0 dS m <sup>-1</sup>	80.13	99.07	89.60
<b>S.Em. ±</b>	2.912	2.145	1.808
<b>C.D. at 5%</b>	NS	6.14	5.10
<b>Media (M)</b>			
M <sub>1</sub> : Soil only	84.75	97.33	91.04
M <sub>2</sub> : Soil + Sand @ 1:1 (v/v)	87.17	99.92	93.54
M <sub>3</sub> : Soil + Sand + FYM @ 1:1:1 (v/v)	<b>72.25</b>	92.67	82.46
M <sub>4</sub> : Soil + Sand + Vermicompost @ 1:1:1 (v/v)	79.75	91.17	85.46
M <sub>5</sub> : Soil + Sand + Coco peat @ 1:1:1 (v/v)	72.42	94.25	83.33
<b>S.Em. ±</b>	3.256	2.398	2.022

Treatments	No. of days for first germination		
	2022-23	2023-24	Pooled
<b>C.D. at 5%</b>	9.33	NS	5.70
<b>S X M</b>			
S.Em. ±	6.511	4.796	3.279
C.D. at 5 %	NS	NS	NS
C.V. %	14.23	8.74	11.36
<b>Year</b>			
S.Em. ±	1.279		
C.D. at 5 %	3.61		
<b>Y X S</b>			
S.Em. ±	2.56		
C.D. at 5 %	NS		
<b>Y X M</b>			
S.Em. ±	2.86		
C.D. at 5 %	NS		
<b>Y X S X M</b>			
S.Em. ±	5.72		
C.D. at 5 %	NS		

**Table 7. Effect of saline irrigation water and growing media on number of days for complete germination of coconut seed nuts**

Treatments	No. of days for complete germination		
	2022-23	2023-24	Pooled
<b>Salinity levels of irrigation water (S)</b>			
S <sub>1</sub> : Irrigation water with EC <2.0 dS m <sup>-1</sup>	85.27	102.27	93.77
S <sub>2</sub> : Irrigation Water with EC 4.0 dS m <sup>-1</sup>	88.80	96.73	92.77
S <sub>3</sub> : Irrigation Water with EC 6.0 dS m <sup>-1</sup>	85.67	90.33	88.00
S <sub>4</sub> : Irrigation Water with EC 8.0 dS m <sup>-1</sup>	107.53	91.60	99.57
<b>S.Em. ±</b>	4.692	4.466	6.958
<b>C.D. at 5%</b>	13.44	NS	NS
<b>Media (M)</b>			
M <sub>1</sub> : Soil only	100.50	102.17	101.33
M <sub>2</sub> : Soil + Sand @ 1:1 (v/v)	83.08	90.42	86.75
M <sub>3</sub> : Soil + Sand + FYM @ 1:1:1 (v/v)	100.17	92.83	96.50
M <sub>4</sub> : Soil + Sand + Vermicompost @ 1:1:1 (v/v)	87.42	98.17	92.79
M <sub>5</sub> : Soil + Sand + Coco peat @ 1:1:1 (v/v)	87.92	92.58	90.25
<b>S.Em. ±</b>	5.246	4.993	3.621
<b>C.D. at 5%</b>	NS	NS	NS
<b>S X M</b>			
S.Em. ±	10.493	9.986	7.951
C.D. at 5 %	NS	NS	NS
C.V. %	19.79	18.16	18.97
<b>Year</b>			
S.Em. ±	4.92		
C.D. at 5 %	NS		
<b>Y X S</b>			
S.Em. ±	4.581		
C.D. at 5 %	12.92		
<b>Y X M</b>			
S.Em. ±	5.121		
C.D. at 5 %	NS		
<b>Y X S X M</b>			
S.Em. ±	10.242		
C.D. at 5 %	NS		

The results obtained are resultant effects of salinity, which affects germination of seed nuts. The discussion made on early germination and late germination explains the reason behind the minimum and maximum days taken for seed nut germination in low salinity and high salinity environments. That is due to osmotic stress, ion-specific effects and oxidative stress, decreasing the amounts of seed germination stimulants such as GAs, enhancing ABA amounts, and altering membrane permeability, etc. (Epstein et al., 1980; Munns, 2002; Lee and Luan, 2012; Cuneit Ucarli, 2020).

The perusal of the data presented with respect to the effect of different soil growing media on the number of days for first germination of seed nut indicates a significant difference. In the year 2022-23, the media combination soil + sand + FYM in equal proportion on a volume basis (M<sub>3</sub>) gives the minimum days for the first germination, *i.e.* 72.25 days, and media soil + sand + cocopeat in equal proportion on volume basis (M<sub>5</sub>) *i.e.* 72.42 days, followed by soil + sand + vermicompost in equal proportion on volume basis (M<sub>4</sub>) *i.e.* 79.75 days. A similar trend was found in pooled also (82.56 days, 83.33 days and 85.46 days, respectively).

The physical and chemical characteristics of soil media, like bulk density, porosity, water retention capacity, organic carbon content, nutrient status and supplying capacity *etc.* support early germination of coconut seed nuts (Abad et al., 2002; Bhardwaj, 2013; Abirami et al., 2010). The results obtained are in line with the findings of Prasana et al. (2013), who found that the minimum days taken to germinate (27.11) and maximum percentage of germination of mango stone (77.33%) were reported in growing media, which are the combination of soil, sand and FYM in a ratio of 2:1:1. This is because the presence of FYM allows the organic acids in the medium to contain organic manures, which helps in enhancing nutrient availability. Therefore, more easily available moisture and some acids have made it possible for germination to occur in a minimum of days and with a higher percentage in germination. The similar results were obtained by Bhardwaj (2014) in papaya, Nadeem et al. (2016) and Kaur (2017) in mango, Varadkar et al. (2020) in jack fruit. The same is true for the combination of soil, sand, cocopeat and soil, sand, vermicompost (Karthikeyan et al., 2006; Karthikeyan and Jansirani, 2009; Kaur, 2017; Sajana et al., 2018; Jiya and Wilson, 2020).

There was no interaction observed between saline irrigation water levels and soil growing media on the number of days for first germination of coconut seed nuts in the experiment.

### 3.5 Number of Days for Complete Germination

The number of days for complete germination of coconut seed nuts is recorded from first germination to last germination in days after seed nut sowing and are presented in Table 7.

The perusal of the data on the number of days for complete germination depicted that the saline irrigation water levels affect the number of days for complete germination of coconut seed nuts. The statistical analysis indicated that the saline irrigation water level S<sub>1</sub> took the minimum number of days (85.27 days) for complete germination of coconut seed nuts in the year 2022-23 only. And saline irrigation water levels S<sub>2</sub> and S<sub>3</sub> were found statistically at par with S<sub>1</sub>, with mean values of 88.80 and 85.67 days. The maximum days for complete germination (107.53 days) was observed at saline irrigation water level S<sub>4</sub>, *i.e.* the highest level in the experiment. The non-significant differences were observed in the year 2023-24 and pooled. The result is in accordance with Singh et al. (2011) concluded that increasing salt stress negatively affected the growth and development of tomatoes. When the salt concentration increased, germination of tomato seed was reduced and the time needed to complete germination lengthened. Similar results obtained by Amir et al. (2011) also reported that the salinity notably affects germination in many species but also lengthens the time needed to complete germination.

While in terms of the effect of different soil growing media, there are no significant differences revealed on the number of days required for complete germination.

There was no interaction effects observed between saline irrigation water levels and soil growing media on the number of days for complete germination of coconut seed nuts in the experiment.

## 4. CONCLUSION

On the basis of the results obtained from the two-year field experimentation, it seems quite logical to conclude that higher germination of hybrid coconut cv. DxT (Mahuva) under coconut

nursery can be secured by application of irrigation water with  $EC < 2.0 \text{ dS m}^{-1}$ . Salinity of irrigation water affects the earliness of germination of coconut seednuts, also higher levels of saline irrigation water promote late germination. Whereas, the use of a soil media combination of soil, sand and organic materials (viz., FYM, Coco peat, Vermicompost) exhibited its superiority with respect of coconut seednut germination. These media exhibit superiority with respect of early germination, total germination, and minimum days for first germination of coconut seednuts.

## 5. FUTURE SCOPE

The study of the effect of saline irrigation water and growing media on the germination of seednuts of hybrid coconut (*Cocos nucifera* L.) has promising future scope in areas in the context of nursery management, especially for coconuts in which the production of seedlings through tissue culture technique is still not successful. By considering the ever growing demand for coconut seedlings, different media combinations can increase germination as well as support good growth of seedlings and, hence, the production of better seedlings. More research can be planned with various organic materials in different nurseries for different kinds of seeds.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Languages Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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