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Investigating the Influence of Rhizome Size and Treatment on Turmeric Crop Productivity (*Curcuma longa* L.)

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Authors' contributions

This work was carried out in collaboration among both authors. Author AVB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author YAV managed the data interpretation and manuscript preparation analyses of the study. Both author read and approved the final manuscript.

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ABSTRACT

The experiment was conducted during the Kharif season of 2021-22 at the Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University in Sardarkrushingar. It followed a Randomized Complete Block Design (Factorial concept) with three replications, utilizing the GNT 2 variety. The study aimed to investigate the effects of seven treatments and four rhizome sizes on various characteristics of turmeric. The results indicated that both the rhizome size R4 (mother rhizome) and treatment T4 (Chiller treatment at 4°C for 2 hours) significantly influenced all the measured traits. The mother rhizome (R4) exhibited the highest values for germination percentage (80.48%), plant height (64.52 cm), leaf length (36.96 cm), leaf width (13.50 cm), tillers per plant

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(3.21), mother rhizomes per plant (2.32), primary fingers per plant (7.33), secondary fingers per plant (7.94), rhizome length (14.89 cm), rhizome width (15.54 cm), and rhizome weight (185.25 g). Furthermore, among the different treatments, the chiller treatment (T4) at 4°C for 2 hours yielded significantly higher results for germination percentage (85.98%), plant height (65.35 cm), leaf length (34.51 cm), mother rhizomes per plant (2.38), primary fingers per plant (6.70), secondary fingers per plant (7.95), rhizome length (14.13 cm), rhizome width (15.58 cm), and rhizome weight (187.23 g). The sodium hypochloride treatment (T5) at 4% for 2 hours resulted in the maximum leaf width (12.96 cm) and the number of tillers per plant (3.24). In conclusion, these findings emphasize the potential benefits of pre-sowing rhizome treatment for enhancing turmeric crop cultivation, leading to improved crop performance.

Keywords: Chiller treatment; Curcuma longa; mother rhizome; sodium hypochloride.

1. INTRODUCTION

Turmeric (*Curcuma longa* L.) is a tropical perennial, underground rhizomatic crop belonging to the family Zingiberaceae. Is a cross-pollinated, triploid species (2n = 3x = 63). It is one of the ancient and sacred spices of India. It is the third most important spice crop of India next to chilli and black pepper. It is being used dates back nearly 4000 years to the Vedic culture in India as a culinary spice and dye that had a wide range of spiritual significance to the Hindu religion. Also known as “Golden Spice” as well as the “Spice of Life”. Turmeric is valued for its underground rhizome containing a yellow phenolic pigment called curcumin. Which is used as a natural coloring agent for food, cosmetics, and dye. Curcumin the main active ingredient of turmeric, functions as a medicine with anti-inflammatory, anti-mutagenic, anti-tumor, anti-bacterial, anti-oxidant, anti-fungal, anti-parasitic and detoxifying properties, due to its anti-oxidant properties, controls Alzheimer’s disease in human beings [1]. Alleppey turmeric is the world's most outstanding and demanded grade. Which is the richest source of curcumin and is extensively cultivated in Kerala.

India is the largest producer, consumer and exporter of turmeric supplying 94% of the world demand. Its crop duration is generally 7-9 months depending on the variety. In India, sowing takes place in July and harvesting commences from December to February. March-April months are the peak arrival period in the market for turmeric. Turmeric can be grown under diverse tropical conditions with temperatures ranging between 20-30°C and with an annual rainfall of 1500 mm.

The global production of turmeric is around 11 lakh tonnes per annum. India dominates the world production scenario contributing (80%) followed by China (8%), Myanmar (4%), Nigeria (3%) and Bangladesh (3%) [2]. In India, during 2021-22 about 306 ha area was covered under turmeric. The important turmeric growing states in India is Maharastra, Telangana, Odisha, Andhra Pradesh, Tamilnadu, Karnataka, West Bengal, and Assam. In Gujarat during 2021-22 about 4.28 ha area and production of 16.83 MT [3] was covered under turmeric. Major turmeric growing districts in Gujarat are Dahod, Navsari, Surat, Panchmahal and Mahisagar etc. India is the largest producer, consumer and exporter of turmeric that accounting for about 80 per cent, 90 per cent and 60 per cent share respectively of the world total.

Evaluating the effect of rhizome size on the growth and development of plants is very important for increasing yield in the plant species producing different sizes of seed [4,5]. An optimum seed root in the size of a specific root crop may develop healthy seedlings and vegetative parts, which subsequently receive higher solar energy and maximize yield in ginger, potato and turmeric plants producing different sizes of propagules. The turmeric plant propagates by the mother rhizome and finger rhizome. The finger rhizomes of the species are considered to be different in size because primary finger rhizomes developed from the shoot base have secondary and tertiary finger rhizomes which are different in size due to the differences in developing time. In addition, all the primary finger rhizomes are not developed at a time from a shoot base. Therefore, it is necessary to determine the optimum size of seed rhizomes for turmeric cultivation.

To fulfill the increasing demand of people for turmeric and improve its quality, it is essential to the production of turmeric considerably. This can be achieved by bringing more area under cultivation and increasing productivity per unit

area. The lack of a suitable cultivar for the particular agroclimatic condition is one of the constraints for low productivity. However other factors like high yielding varieties, nutrition, layout, planting material, spacing and time of planting influence the productivity of turmeri [6].

2. MATERIALS AND METHODS

The experiment "Study of Different Rhizome Size and Treatment on Turmeric (*Curcuma longa* L.)"was conducted at the Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *Kharif* 2021-22. Geographically, Sardarkrushinagar is positioned at 24° 19'26" North Latitude & 72° 18'53" East longitude with an altitude of 154.52 meters above mean sea level. The experiment was laid out in factorial randomized block design (FRBD) and replicated three times and a spacing of 45 x 30 cm. The variety used for the study was Gujarat Navsari Turmeric 2. Cultural practices were followed as per the recommended package of practices. The treatment comprised different sizes of rhizome based on weight as given below (Table 1, Fig. 1).

The data on different characters will be analyzed on the mean value of five plants for experimental design. The characters *viz.,* germination per cent, plant height, leaf length, leaf width, tillers per plant, mother rhizomes per plant, primary fingers per plant, secondary fingers per plant, rhizome length, rhizome width, fresh rhizome weight. The observed data were statistically analyzed by appropriate statistical procedures as suggested for Randomized complete block design (Factorial) by [7].

Fig. 1. Different grades of rhizomes

Table 1. Treatment details

Rhizome size (R)	Treatment (T)
R_1 = >35 g finger rhizome	T_1 = 4-second microwave treatment
R_2 = >20-25 g finger rhizome	T_2 = 8-second microwave treatment
R_3 = ≤ 5 g finger rhizome	T_3 = Deep freezer treatment (-20°C for 2 hrs.)
R_4 = Mother rhizome	T_4 = Chiller treatment (4°C for 2 hrs.)
	T_5 = Sodium hypochloride treatment (4% for 2 hrs.)
	T_6 = Tap water treatment for 2 hrs.
	T_7 = Control

Table 2. Influence of different rhizome size on germination and its attributes traits of turmeric ev. GNT 2

Rhizome size	Germination (%)	Plant height (cm)	Leaf Length (cm)	Leaf width (cm)	Tillers plant^{-1}	Mother rhizome plant^{-1}	Primary fingers plant^{-1}	Secondary fingers plant^{-1}	Rhizome length (cm)	Rhizome width (cm)	Rhizome weight (g)
R_1	80.00	62.02	33.87	12.57	3.05	2.24	6.67	7.32	14.06	14.30	162.15
R_2	79.63	60.66	32.20	11.85	2.72	2.11	5.62	5.85	12.89	13.49	153.55
R_3	73.97	54.65	29.50	10.91	2.35	2.03	4.86	5.32	12.04	13.45	137.30
R_4	80.48	64.52	36.96	13.50	3.21	2.32	7.33	7.94	14.89	15.54	185.25
S.Em ±	1.30	1.00	0.49	0.20	0.05	0.06	0.11	0.17	0.27	0.28	4.16
C.D. 5%	3.69	2.83	1.40	0.58	0.15	0.16	0.31	0.49	0.78	0.78	11.79

Table 3. Influence of different treatments on germination and its attributes traits of turmeric ev. GNT 2

Treatments	Germination (%)	Plant height (cm)	Leaf Length (cm)	Leaf width (cm)	Tillers plant^{-1}	Mother rhizome plant^{-1}	Primary fingers plant^{-1}	Secondary fingers plant^{-1}	Rhizome length (cm)	Rhizome width (cm)	Rhizome weight (g)
T_1	81.75	60.58	32.36	11.86	2.77	2.05	6.12	6.17	13.70	14.12	160.47
T_2	74.93	59.06	31.82	11.86	2.43	2.03	5.49	5.43	12.76	12.78	143.97
T_3	79.44	60.82	33.92	12.44	2.83	2.20	5.97	6.85	13.02	14.59	159.17
T_4	85.98	62.35	34.51	12.74	3.20	2.38	6.70	7.95	14.13	15.58	187.23
T_5	85 .84	60.62	34.37	12.96	3.24	2.33	6.61	7.43	14.02	14.85	167.61
T_6	83 .61	59.92	32.82	12.08	2.83	2.23	6.34	7.06	13.21	14.10	154.36
T_7	58.08	59.87	32.11	11.68	2.53	2.00	5.62	5.38	13.44	13.34	144.15
S.Em ±	1.72	1.32	0.65	0.27	0.07	0.07	0.15	0.23	0.36	0.36	5.50
C.D. 5%	4.89	NS	1.85	0.76	0.19	0.21	0.41	0.64	NS	1.03	15.60

3. RESULTS AND DISCUSSION

The analysis of variance (mean sum of the square) for four rhizome sizes and seven treatments for different characters are given in Table 2 and Table 3.

3.1 Growth Parameters, Yield, and Attribute Traits of Turmeric

The mean sum squares due to treatments and rhizome size were found to be significant for most of all the characters, indicating the existence of sufficient variability in the experimental materials uses of different rhizome sizes and treatments use under this investigation significantly effect on germination per cent as well as different plant growth parameters. The analysis of the variance of rhizome size showed significant variation. However, maximum germination per cent was found in R_4 (80.48%) and it was at par with the R_1 (80.00%) and R_2 (79.63%), while in the case of different treatments T_4 (85.98%) give significantly higher germination per cent and it was at par with T_5 (85.84%), T_6 (83.61%) and T_1 (81.75%). The results have confirmed the reports of [8,9,10].

In the turmeric crop, different growth parameters are also important to obtain a good rhizome yield. In the investigation among the different sizes of rhizome, the mother rhizome gave significant results for plant height R_4 (64.52 cm) which was at par with the R_1 (62.02 cm), leaf length R_4 (36.96 cm), leaf width R_4 (13.50 cm) and the number of tillers plant^{-1} R_4 (3.21) while different responsible traits for economic yield also found significantly due to mother rhizome maximum mother rhizome plant^{-1} R4 (2.32) and it was at par with the R_1 (2.24), primary rhizome plant^{-1} R_4 (7.33) followed by the R_1 (6.67), secondary fingers per plant^{-1} R_4 (7.94) followed the R_1 (7.32), rhizome length T_4 (14.89 cm) followed by the R_1 (14.06 cm), rhizome width R_4 (15.54 cm) followed by the R_1 (14.30 cm) and rhizome weight in R_4 (185.25 g) followed by the R_1 (162.15 g). Similar results were reported by [11,12,13,14].

The analysis of the variance of the treatments found significant except for the plant height and rhizome length. Among the different treatments used in this experiment, the chiller treatment gave maximum plant height T_4 (62.35 cm) followed by the T_3 (60.82 cm), leaf length in T_4 (34.51 cm) and it was at par with the T_5 (34.37 cm), T_3 (33.92 cm) and T_6 (32.82 cm), mother rhizome per plant^{-1} T_4 (2.38) and it was at par with the T_5 (2.33), primary fingers per plant^{-1} T_4 (6.70) and it was at par with the T_5 (6.61) and T_6 (6.34), secondary fingers per plant^{-1} T_4 (7.95) and it was at par with the T_5 (7.43), rhizome width treatment T4 (15.58 cm) and it was at par with the T_5 (14.85 cm) and T_3 (14.59 cm). Maximum leaf width found by Sodium hypochloride treatment (4% for 2 hrs.) T_5 (12.96 cm) and it was at par with the T_4 (12.74 cm) and T_3 (12.44 cm) and number of tillers per plant^{-1} T_5 (3.24) and it was at par with the T_4 (3.20). The results have confirmed the reports of [15,16,17,18,19].

4. CONCLUSION

The findings of the study indicate that seedlings derived from different sizes of finger rhizomes and mother rhizomes displayed similar levels of health. However, the mother rhizome exhibited superior performance across all parameters due to its ample food reserves, which likely stimulated robust plant growth and ultimately led to increased yield. Optimal seed root size for a specific root crop can promote the development of healthy seedlings and vegetative parts, enabling them to harness more solar energy and maximize yield. The duration of the chilling treatment played a crucial role in breaking dormancy and enhancing germination and seedling emergence in turmeric. It was found that an appropriate length of chilling treatment greatly contributed to vigor enhancement in turmeric plants. The application of the R4 rhizome (mother rhizome) and finger rhizomes weighing over 35 g resulted in significant improvements across nearly all traits. Additionally, treatments such as T4 (Chiller treatment) and sodium hypochloride treatment (4% for 2 hrs.) demonstrated significant positive effects on germination percentage and various growth attributes. In conclusion, the results highlight the potential benefits of pre-sowing rhizome treatment for optimizing turmeric crop cultivation. Such treatments can contribute to improved crop performance and yield outcomes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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