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Optimization of seed rhizome type and multiplication method of turmeric (*Curcuma longa* L.) for mid hills of North West Himalayan region

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Abstract
Turmeric is an important spice, medicinal and cosmetic crop of south Asian countries being propagated through rhizomes requiring huge quantity of seed rhizome (2500 kg ha^{-1}) which accounts for 20-22% of production cost. An experiment was conducted to optimize type of seed rhizome and method of multiplication under shade house conditions at Agronomy Research Farm, CSK HPKV, Palampur during 2017 and 2018. The experiment was laid out in completely randomized design (CRD) consisting of four treatments and five replications. Significantly higher germination percentage (92.0 and 92.8%) and germination index (2.53 and 2.21) were noticed in seedlings raised in portrays using primary rhizome during both the years. Besides, better growth attributes *viz*., seedling height (13.32 and 13.58 cm), root length (10.64 and 11.18 cm) and seedling vigor index (2204 and 2219) were also recorded during both the year in turmeric seedlings raised through primary rhizomes in portray as compared to seedlings raised using mother rhizome in portray or polybag and seedlings raised in poly bag using primary rhizome. Significantly higher total dry matter accumulation (2.59 g $plant^{-1}$), root dry weight and root to shoot ratio (0.41 and 0.51) were observed in seedlings raised in poly bags. For raising turmeric seedlings primary rhizomes and portray found to be better propagating material and method, respectively than mother rhizomes and polybag. Shifting from rhizome planting to transplanting of turmeric seedlings in mid hills of Himalayan region is expected to conserve 80% of the seed material besides saving the expenditure on weeding and irrigation. Transplanting of turmeric seedling may also help in resource conservation along with better resource use efficiency and sustainability.

Keywords: turmeric, seedlings, germination, portray, potting media, primary rhizome

Introduction

Turmeric (*Curcuma longa* L.) belongs to family Zingiberaceae is one of the important herbaceous plant grown and used as spice, medicine, cosmetic and dye in India and South Asian countries since ancient times (Ishimine *et al*., 2003) [9]. Use of turmeric can be traced back to the Vedic period, where turmeric was the principal spice, medicinal plant and also used for its religious significance. In India, turmeric is cultivated in an area of 1.89 lakh ha with production of 8.52 lakh tonnes and productivity of 4503 kg ha^{-1}. In Himachal Pradesh (HP) turmeric is cultivated in an area of 200 ha with production of 550 tonne and productivity of 550 kg ha^{-1}(Anon., 2015) [5]. Turmeric offers a good scope to diversification of cereal based cropping system in Himachal Pradesh. Intensive cultivation of turmeric in the HP state will help not only to meet its own requirements but also help the country to boost its export. Productivity levels of turmeric in Himachal Pradesh is too low compared to national average mainly because of below optimal soil and atmospheric temperature, poor nutrient and weed management practices and moisture stress during rhizome development stage. Cultivation of turmeric in mid hills of north west Himalayan region needs special attention in this aspect, as this region experiences lower soil and atmospheric temperature than optimum temperature of 30-35 ^{0}C required for germination of turmeric rhizome (Panigrahi *et al*., 1987) [12]. Due to lower atmospheric and soil temperature (Fig. I) turmeric rhizomes took 60-70 days for germination itself in this region. During this time, field will be invaded by season bound weeds which in turn pose threat for crop establishment besides adding additional burden of weeding expenses and efforts.

A shift in crop establishment technique from rhizome planting to transplanting of seedlings may offer appropriate solution for delayed germination, threat from weeds during initial phase of crop establishment and may rescue the crop from end season drought. Traditionally turmeric is being vegetatively propagated through rhizomes (primary and mother) which require large quantity of seed rhizomes (2500 kg ha^{-1}) and account for 20-22 percent of production cost. Availability of quality planting material during cropping season is low and storing the voluminous seed rhizomes from previous crop are highly prone to damage of pathogens and insect pests. To overcome these constraints, rapid multiplication of turmeric through single bud rhizome techniques has been developed by TNAU, Coimbatore. In this portray technique of turmeric, seed rhizome requirement will be reduced by 75 per cent as compared to conventional rhizome planting. As rhizome is cut and used for raising seedlings the diseased rhizome can be eliminated. So, it helps in screening of rhizomes for diseases and the planting material will be disease free (Malhotra *et al*., 2016) [11]. Timely and quicker crop establishment is possible with transplanting of seedlings in the place of planting of rhizomes. Transplanting of turmeric seedling in turn utilize available resources efficiently along with rational usage of resources as well as minimizing cultural operations without compromising productivity levels. Thereby results in efficient utilization and conservation of resources leading to higher net return. Meanwhile, scientific evidences pertaining to possibility of raising turmeric seedlings using split mother and primary rhizomes in portray with cocopeat + FYM and polybag using soil sand FYM as potting media is new option for turmeric farming with special reference to HP. In this background, the present study was undertaken to standardize the propagating material and method of rapid multiplication of turmeric for the north western Himalayan region.

Material and Methods

An experiment was conducted to standardize the propagating material and method of rapid multiplication of turmeric for north western Himalayan region under shade house conditions at Agronomy Research Farm, CSK HPKV, Palampur during 2017 and 2018. The experiment was laid out in completely randomized design (CRD) consisting of four treatments and five replications with turmeric cultivar, Suvarna. The treatment details were as follows,

T_1: Turmeric seedlings raised in portray using mother rhizome.

T_2: Turmeric seedlings raised in portray using primary rhizome.

T_3: Turmeric seedlings raised in polybag using mother rhizome.

T_4: Turmeric seedlings raised in polybag using primary rhizome.

Rhizomes of cv. Suvarna were segregated in to mother and primary rhizome. Both mother and primary rhizomes were sliced in to size weighing about 10-12 g and 5-8 g, respectively with caution of at least getting one to two eye buds per slice. For raising turmeric seedlings portray (50 cavities) and polybag (10 cm x 7.5 cm) were chosen. Portrays were filled with potting media consisting of coco peat and FYM in 1:1 proportion. Polybags were filled with soil, sand and FYM in 1:1:1 proportion. For each cavity of portray and poly bags single sliced rhizomes were placed and dually covered with respective potting media. After sowing rhizomes, portray and poly bags were drenched with water containing *Trichoderma harzianum* at the rate of 20 g/l as prophylactic measure against fungal diseases. Staked tray and poly bags were completely covered with 200 micron polyethylene film for duration of 40 days from sowing. Sliced rhizomes were planted in respective media on 08/04/2017 and 15/03/2018 during the year 2017 and 2018, respectively and 68 and 83 days old seedlings were used for field transplanting, respectively. Mean monthly maximum and minimum air and soil temperature (at 5 cm depth) recorded from April to June in both the years of experimentation were recorded and presented in Fig. I. Each treatment consisted of two portray or 100 polybags, respectively. Observation on germination percentage was recorded at 30, 60 days after planting (DAP) and at the time of transplanting. Rate of emergence (RE) was calculated according to Islam *et al.* (2009) [10] using the following formula;

$$\textbf{Rate of emergence} = \frac{\text{No. of seedlings emerged } i^{th} \text{ DAP}}{\text{No. of seedlings emerged } n^{th} \text{ DAP}} \times 100$$

i^{th}: initial stage of observation
n^{th}: subsequent stage of observation

Germination index was calculated as described in the Association of Official Seed Analysis (1983) [6] using the following formula:

$$\textbf{Germination index} = \frac{\text{(No. of germinating seeds)}}{\text{(Days of first count)}} + \frac{\text{(No. of germinating seeds)}}{\text{(Days of next count)}}$$

Seedling vigor index was calculated with the formula recommended by (Abdul baki and Anderson, 1973) [2].

Seedling Vigor Index = (Root length + shoot length) × germination percent before planting.

Plant height was measured from the base of the seedling to base of petiole of top most (youngest) leaf. Leaf area was estimated with leaf area meter 211 of Systronics make. Root length and dry weight of shoot, leaves and roots were measured as per standard procedure; destructive method of sampling. Root/shoot ratio, total dry matter per plant was calculated at the time of transplanting. The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Gomez and Gomez (1984) [7]. The level of significance used in ‘F’ and‘t’ tests was P = 0.05 and critical difference values were calculated where ‘F’ test was found significant.

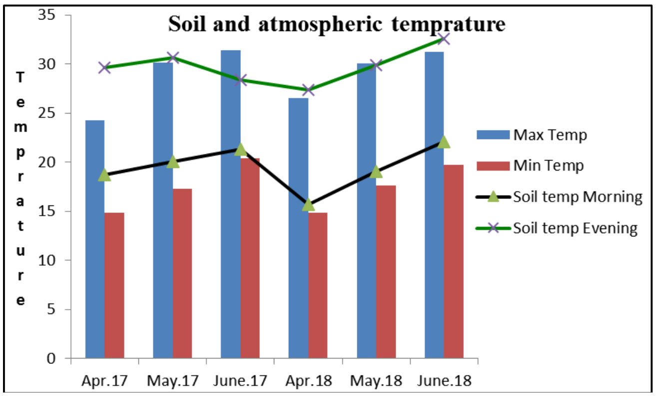

Fig I: Soil and atmospheric temperatures during the period of experimentation

Fig 2: Turmeric seedlings and root biomass raised in polybag

Fig 3: Turmeric seedlings and root biomass raised in portray

Results and Discussion

Results of the current study show that, significant variation in germination percentage of turmeric rhizomes was observed among type of propagating material and media across time lag. Mother rhizomes grow rapidly and develop well and are found to be better than finger rhizomes (Aiyadurai, 1966) [4]. Contrary to the well-established fact with conventional planting system, primary rhizomes have recorded significantly higher germination percentage as compared to mother rhizomes in the current study (Table. 1). Lower percentage of germination in mother rhizome can be attributed to meager germination observed in the slices of mother rhizome obtained from crown portion of the bulb. Reduced internodal distance with presence of scaly leaves and lower number of viable buds at apex or crown portion of mother rhizome may be the reason to lower germination as compared to primary rhizome. Higher germination percentage was noticed in portray as compared to rhizomes planted in polybag at all the stages of observation (Table 1). A good growth medium provides sufficient anchorage or support to the plant, serves as a reservoir for nutrients and water, allows oxygen diffusion to the roots and permits gaseous exchange between roots and the atmosphere outside root substrate.

Table 1: Effect of seed rhizome type and potting media on germination percentage of turmeric

Treatments	Germination percentage (%)					
	30 DAP		60 DAP		At transplanting	
	2017	2018	2017	2018	2017	2018
T_1	24.2	21.2	44.4	42.6	62.0	59.2
T_2	35.2	32.8	60.4	56.8	92.0	92.8
T_3	18.8	14.4	38.4	36.8	54.8	53.2
T_4	24.8	22.4	48.8	46.2	74.4	72.6
S. Em±	1.2	2.11	1.72	2.83	2.36	3.89
CD (P=0.05)	3.6	6.38	5.22	8.57	7.15	11.69

Cocopeat is considered as a good growth media component, with acceptable pH, electrical conductivity and other chemical attributes (Abad *et al.*, 2002) [1]. Cocopeat has good physical properties, high total pore space, high water holding capacity, low shrinkage, low bulk density all these attributes had combinedly supported for better condition for germination of turmeric rhizome as compared to conventional soil based media. Turmeric seedlings raised in portray using primary rhizome (T_2) has recorded significantly higher germination during both the years (92.0 and 92.8%, respectively) as compared to mother rhizome and primary rhizome placed in poly bag having soil, sand and FYM as potting media (Table.1). Results of the current study are in concurrence to earlier report of Abirami *et al*. (2010) [3]. Uniformity and speed of seedling emergence are important components of seed performance, thus directly affecting crop stand and establishment. Early and uniform emergence of vigorous seedlings is desired key to ensure better crop performance with ensured uniformity in development, yield and quality of the harvested produce.

Table 2: Effect of seed rhizome type and potting media on rate of emergence and Germination index of turmeric

Treatments	Rate of emergence				Germination index	
	30-60 DAP		60DAP - planting			
	2017	2018	2017	2018	2017	2018
T_1	54.4	50.1	71.7	72.4	1.72	1.42
T_2	58.7	57.7	65.7	61.2	2.53	2.21
T_3	49.2	40.2	70.7	69.4	1.43	1.12
T_4	51.2	50.1	65.7	63.8	1.92	1.62
S. Em±	2.91	5.4	2.81	2.70	0.055	0.078
CD (P=0.05)	NS	NS	NS	8.16	0.165	0.23

Rate of emergence recorded at two different stages during both the years remained unaffected by type of propagating material and as well as media. But, significant earliness in germination was noticed with mother rhizomes in both the potting medias during the year 2018 only (Table 2). This can be attributed to higher size of the propagating material (10-12 g/slice) as compared to primary rhizome (5-8 g/slice). Seeds with higher food reserve will efficiently mobilize reserves from storage tissues to the embryo axis and this capacity is reflected in seedling growth (Isely, 1957) [8]. The germination index (GI) appears to be the most comprehensive measurement parameter combining both germination percentage and rate of emergence. It magnifies the variation among seed lots in this regard with an easily compared numerical measurement.

Table 3: Effect of seed rhizome type and potting media on growth attributes and seedling vigour index of turmeric

Treatments	Seedling height (cm)		Root length (cm)		Leaf area (cm^2 $plant^{-1}$)		Seedling vigour index	
	2017	2018	2017	2018	2017	2018	2017	2018
T_1	12.90	12.72	10.26	10.50	232.00	228.40	1432	1430
T_2	13.32	13.58	10.64	11.18	237.40	233.80	2204	2219
T_3	11.20	10.70	9.08	8.30	238.00	240.00	1112	1014
T_4	12.20	11.10	9.00	8.26	241.40	238.60	1581	1400
S. Em±	0.50	0.66	0.43	0.42	4.48	5.82	67.28	95.18
CD (P=0.05)	1.5	2.0	1.30	1.29	NS	NS	203.44	287.82

In the current study significantly higher GI values (2.53 and 2.21, respectively during 2017 and 2018) were observed in T_2 during both the years followed by T_4 (1.92 and 1.62, respectively) (Table.2). This gives a complimentary evidence to support earliness and better germination with primary rhizome in coco peat as growing media. Slightly higher germination percentage and earliness in germination observed during year 2017 can be attributed to higher atmospheric and soil temperature recorded in that particular year as compared to later year (Fig.1). Trend of variations observed in germination was even continued with growth parameters of turmeric seedlings. Significantly higher plant height of 13.32 cm and 13.58 cm was recorded in T_2 and T_1 during 2017 and 2018, respectively. Among different potting media, cocopeat and FYM in 1:1 proportion supported for significantly better plant height than conventional potting media comprising soil sand and FYM (Table 3). Similarly, significantly higher root length (10.64 and 11.18 cm, resp.) was observed in T_2 and T_1 during both the years as compared to T_3 and T_4 (Table 3). Higher total pore space, low bulk density with high water holding capacity of cocopeat has facilitated for better physical condition for root development and proliferation which in turn recorded higher root length as compared conventional potting media. On the contrary leaf area remained unaffected either due to propagating material or potting media (Table 3). The seed showing the higher seed vigour index is considered to be more vigorous. Higher seedling vigour index was recorded in T_2 as compared to rest of the treatments during both the years (2204 and 2219, respectively) (Table 3)

Table 4: Effect of seed rhizome type and potting media on dry matter accumulation and root shoot ratio of turmeric

	Leaf dry weight (g plant^{-1})		**Stem dry weight (g plant^{-1})**		**Root dry weight (g plant^{-1})**		**Total dry matter (g plant^{-1})**		**Root /shoot ratio**	
Treatments	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
T_1	0.55	0.63	1.11	1.21	0.28	0.32	1.94	2.16	0.17	0.17
T_2	0.58	0.66	1.14	1.20	0.27	0.29	1.98	2.15	0.16	0.16
T_3	0.66	0.69	1.15	1.04	0.75	0.87	2.56	2.59	0.41	0.51
T_4	0.69	0.67	1.21	1.10	0.69	0.77	2.59	2.54	0.36	0.43
S. Em±	0.024	0.028	0.038	0.062	0.022	0.029	0.047	0.06	0.014	0.024
CD (P=0.05)	NS	NS	NS	NS	0.067	0.087	0.14	0.20	0.042	0.072

Differential response was noticed with respect to dry matter accumulation in leaf stem and roots of turmeric seedlings. Relative dry matter accumulation in leaf and stem remain unaffected during both the years as a response to different propagating and potting material. Significant variations were noticed with root dry weight during both the years (Table 4 and Fig. II & III). Significantly higher dry weight of root (0.75 and 0.87 g/pl, respectively) was recorded in turmeric seedlings raised in poly bag having conventional potting media during both the years as compared to seedlings raised in portray having cocopeat and FYM as potting media (Fig. II & III). This variation can be attributed to higher space availability for establishment and proliferation of roots in poly bag as compared to constrained space in portray environment. Higher available space has facilitated for formation of anchoring and storage roots along with feeding roots (Fig. II & III). Consequently it had resulted in higher total dry matter and higher root shoot ratio in T_3 during both the years.

From the results of current study it can be concluded that, primary rhizomes with one to two nodes weighing 5-8 g was found to be suitable propagating material for rapid multiplication of turmeric seedling. At the same time raising turmeric seedlings in portray having cocopeat and FYM in 1:1 proportion as potting media was observed to be better potting media compared to seedlings raised in conventional potting media. In the era of conservation agriculture, standardization and adoption of intensified planting material production technique will help in reducing quantity of seed rhizome to one fifth. Transplanting turmeric seedling will facilitate to get uniform crop stand and timely crop establishment which in turn utilize the available and applied resources efficiently. More over reduced number of weeding and irrigation activities reduces the cost of production. Modification in crop calendar with early transplanting will rescue the crop from end season drought. Above mentioned changes may combinedly help in conserving and utilizing the resources efficiently with higher productivity and helps in attaining sustainability. Apart from it, farmer will be directly benefitted by around Rs 30,000-35,000 per ha as savings against the cost of seed material (Rs 75,000/- seed rhizome 2500 kg @ Rs 30 /-kg) since each seedling will be costing around `. Rs 0.41 and 0.43 only per poly bag and portray raised seedlings respectively. Switching over to turmeric seedling production and cultivation of turmeric through transplanting not only helps on conserving inputs but also magnifies resource use efficiency along with attaining sustainability.

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