Original Research Article

InvestigatingPhysicalProperties of Turmeric Seed Rhizome Varieties duringSowing StagetoDesign aMetering Mechanism fora Turmeric Planter

ABSTRACT

Aims: Turmeric production is facing the labour shortage during peak operations like planting and harvesting. The objective of the study was to investigate the physical properties of turmeric seed rhizomes and to optimize the design parameters of turmeric planter.

Place and Duration of Study: Department of Farm machinery and power engineering, Dr NTR CAE Bapatla, Andhra Pradesh during the year 2021-22

Methodology: To design a metering mechanism of a turmeric planter, information related to geometrical properties such as length, breadth, thickness and density are necessary. Frictional parameters are also measured to design hopper of the planter which facilitates free flow of seed rhizomes during sowing operation.

Results: Results concluded that the length of finger rhizome used as seed material in turmeric cultivation ranged from 3.7 to 5.5 cm. Average breadth and thickness of seed rhizomes are 2.1 and 1.7 cm respectively. Average weight of turmeric seed rhizome was found to be 15.5 g with an equivalent diameter of 2.45 cm. Bulk density and true density of seed rhizome was found to be 640 and 1040 kg m^{-3}, respectively. Angle of repose was noted as 36.80°. Coefficient of static friction on mild steel sheet for different varieties found to varied between of 0.75–0.85.

Conclusion:

By measuring all these physical properties, preparation of proper design of a turmeric planter which delivers the required seed rate at desired plant spacing is expected.

Keywords:*Turmeric seed rhizome,geometrical properties, density andfrictional parameters*

1. INTRODUCTION

India is a leading producer and exporter of turmeric in the world. Since ancient times, turmeric has been farmed in India as a significant spice. Indian turmeric is regarded as the greatest quality since it contains a lot of curcumin.Among various costs involved in turmeric cultivation, seed and labour costs account for 34.22% and 29.42%of the total cost of cultivation [1]. Due to improved industrial and urban livelihood opportunities, labour availability has decreased to great extent in agriculture sector. Increase in wage rate of human labourhas led to influence in the costof cultivation drastically reducing the net income.

Rise inthe wagerate is not specific to Turmeric cultivation alone as agricultural wages rose steeply after 2007-08. Hence,the key in reducing the cost of cultivation of turmeric is by reducing the dependence of human power which can be achieved by the advent of mechanization[2].

Most of the farmersdepend on the bullock drawn plough with manual seed dropping and semi-automatic planters for turmeric planting.Planting of turmeric crop on raised beds is more advantageous in Telangana and Andhra regions. Itsupports drip irrigation, controls rhizome rot disease, creating drainage during high rainfall times. By developing automatic turmeric planter, dependency on labour force can be reduced in planting and irrigation operations.

In view of these, a research work has been undertaken to develop a tractor drawn automatic turmeric seed rhizome plantersuitable for raised bed cultivation of differentturmeric varieties. As a part of above-mentioned research, Turmeric seed rhizome physical properties have been studied to optimize the design parameters of turmeric planter.

Comment [ME1]: introducing

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2. MATERIALS AND METHODS

The present investigation was undertaken during the year 2021-22 to study the physical parameters of the selected varieties of turmericcultivation. To design aturmeric planter that includesmetering mechanism and seed box, one should be aware of turmeric seed rhizomegeometricalproperties (length, breadth and thickness), gravimetric properties (bulk density, true density and porosity) and frictional properties (angle of repose and coefficient of friction). Geometrical properties, gravimetric properties and frictional properties combinedly termed as Physical properties seed materials.

Physical properties such as length, breadth and thickness are needed to design a suitable metering mechanism. Proper size and shape of the metering mechanism can be identified by measuring the physical properties. Gravimetric properties like bulk density and true density helps in designing the seed box dimensions and selection of seed box material. Frictional properties like angle of repose and coefficient of friction used in seed box design. These properties help in smooth movement of seeds in seed box during planting operation.

2.1 Preparation of turmeric seed rhizomes

In turmeric cultivation there is no separate seeds for plant propagation. A part of whole rhizome i.e. mother rhizome and finger rhizomes are used as seeds for plant propagation. Many farmers stopped using the mother rhizome as seed material as it is also becoming less economical on comparing with finger rhizome. Mother rhizome planted crop also facing many pest and disease problems, so all over the country only finger rhizome is using as seed material. Finger rhizomes are cut into pieces of certain length are used as planting material.Farmers select the healthy finger rhizomes and cut it into pieces by using traditional knifes. Those cut pieces is technically called as turmeric seed rhizomes. While cutting seed rhizome into pieces (i.e. seed rhizomes) care must be taken that each seed rhizome must contain two nodes.

After sowing the seed rhizome in the soil, the plant germination starts from nodes of the rhizome. The length of cut pieces i.e. seedrhizomes varies significantly which depends on the health

of the finger rhizome.The average length of finger rhizome used as seed material in turmeric cultivation is ranges from 3.7 to 5.5 cm.

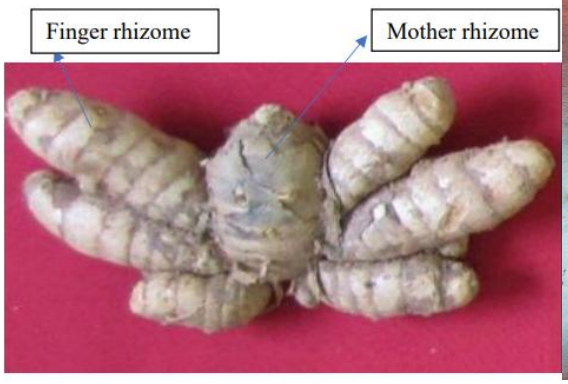


Fig. 1Whole turmeric rhizome

Fig. 2 Turmeric seed rhizomes

Size of the turmeric rhizome varies with moisture content. Moisture content of the turmeric rhizome decreases on the passage of time from the time of harvest. The moisture content of seed rhizome during sowing season is varied between 20-25 per cent. Geometrical properties like length, breadth and thickness decreases with decrease in moisture content of the rhizome. Generally turmeric crop is harvested in February and March whereas plantation takes place in the period of June to August.

2.2 Equivalent diameter

Length, breadth and thickness of the seed rhizome are measured by using Vernier caliper scale (least count 0.01 cm). Breadth is measured as the diameter of the rhizome along major axis. Thickness is measured as diameter of the rhizome along minor axis.

Equivalent diameter, also known as geometric mean diameter of seed rhizome is defined as the cubic root of length, width and thickness (not necessary that the three intercepts should intersect with each other).

$$\textbf{Equivalent diameter} = (lbt)^{1//3} \ldots.[3]$$

Where l, b and t are the length, breadth and thickness of rhizome

a. Length b. Breadth c. Thickness

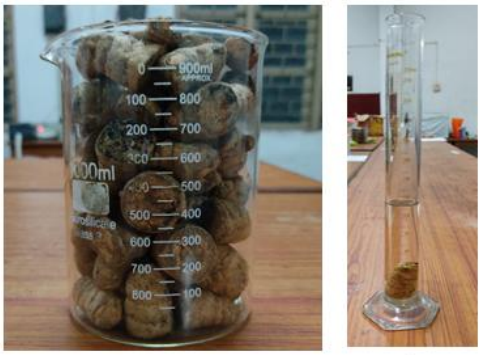
Fig. 3 Geometrical parameters of turmeric seed rhizome

2.3 Density

Density is determined as the weight of the turmeric seed rhizome divided by its volume, expressed in kg m^{-3}. Both bulk density andApparent density were measured following the similar procedure. A 1000 ml volume empty cylindricalbeaker wastaken and filled it with the seed rhizomes. By measuring the weight of the filled rhizomes bulk density was measured. To measure the Apparent density, turmeric rhizomes weregently pressed into the beaker andrefilled the empty space of beaker with rhizomes.New weight of seed rhizomes measured and apparent density was calculated. An Electronic weighting balance is used to measure the rhizome weights.

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}}$$

True density is measured using toluene solution and measuring cylinder. A 100 ml toluene solution was filled in measuring cylinder and the single turmeric rhizome of known weight was dropped in it. Change in the volume of toluene solution is the volume of turmeric rhizome.



a b

Fig. 4(a) Bulk density and (b)True density measurement

2.4 Angle of repose and coefficient of friction

Angle of repose and coefficient of friction are necessary to design a seed hopper of a planter. Properly designed hopper assures controlled free flow of seeds during sowing operation. The angle of

repose can be measured by angle of repose apparatus. Angle of repose of seeds was calculated using the following expression.

$$\theta = \tan^{-1}\frac{2H}{D} \ldots.[4]$$

Where θ, H, D areAngle of repose(^{o}),Height of rhizome heap(cm) and Diameter of circular plate (cm) respectively.

For determination of coefficient of friction of turmeric rhizomes, a tilting table top setup was used. Set up consists two levelled surfaces in which one is constant to horizontal plane and other is movable in vertical plane. Turmeric rhizomes were kept on movable surface and raised it to the point where the rhizomes start to moving by rotating screws. The angle of tilt was measured. The tangent of angle with the horizontal is called as static coefficient of friction.

2.5 Comparison of physical parameters for local grown turmeric varieties

Physical parameters of few selected local grown turmeric varieties are needed to optimize the design of turmeric planter.Different parameters considered for the study are density, geometrical properties like length, breadth and thickness andfrictional properties like angle of repose and coefficient of friction. Local grown turmeric varieties (Andhra and Telangana regions) viz., **Mydkur (Kadapa), Duggirala and Nizamabad** were selected to collect the informationduring rhizome sowing stage. Measurements were taken from 5 randomly selected seed rhizomesof each variety.

3. RESULTS AND DISCUSSION

Physicalproperties of turmeric rhizomes play an important role in the design optimization of metering mechanism. Variety of the turmeric rhizomes were not given any attention while measuring the physical properties since all rhizomes are similar in size and shape.Physical properties of the seed rhizomes were calculated and tabulated in Table. 1&2.

Comment [ME3]: The moisture content of the rhizomes should have been measured and quoted for each type.

3.1 Equivalent diameter

Equivalent diameter was calculated by measuring the major, minor and intermediate axis dimensions of a seed rhizome. It increased with the weight of the rhizome and average equivalent diameter was calculated to be 2.45cm.

3.2 Density

Density plays an important role in design of proper seed hopper. A hopper should facilitate storage of seed for longer time during sowing work on field and at a time it should not be over weighted. Bulk density and true density were found to be640 and 1040 kg m^{-3}respectively.During field work, there may be a change in seed density because of jerks and vibration. Bulk density changes are analysed by knowing Tapped density. Tapped density of seeds also measured as 680 kg m^{-3}.

Table.1Gravimetric properties of turmeric rhizomes

Comment [ME4]: An additional column to show measured moisture content of each is important in such cases

S.No.	Turmeric Variety	Bulk Density (kg m^{-3})	True Density (kg m^{-3})	Tapped Density (kg m^{-3})
1	**Mydkur (Kadapa),**	649	1057	703
2	**Duggirala**	632	1026	662
3	**Nizamabad**	639	1037	675
4	**Average**	**640**	**1040**	**680**

3.3 Physicalparameters for local grown turmericrhizome seed varieties

Investigating the physical parameters of local grown turmeric rhizome varieties during sowing stages will enable us to find a properdesign of metering mechanism and hopper. Major turmeric Varieties cultivated in Andhra Pradesh and Telangana regions are Mydkur (Kadapa), Duggirala and Nizamabad were chosen for the study. All these varieties shape is similar i.e. oblong, but there is a little difference in Lengths and breadths. Among all these varieties, Mydkur (Kadapa) variety rhizome is longer and broader than other varieties.

Table.2Geometricproperties of local grown Turmeric varieties

Parameters	Length (cm)	Breadth (cm)	Thickness (cm)	Angle of repose (^{0})	Coefficient of friction on MS sheet
			Mydkur (Kadapa)		
Minimum	3.9	1.9	1.5	31	0.75
Maximum	5.5	2.5	2	42	0.85
Mean	4.38	2.12	1.76	36.6	0.812
Median	4.1	2	1.8	36	0.82
SD dev	0.67	0.26	0.21	4.15	0.04
			Duggirala		
Minimum	3.8	1.7	1.5	31	0.76
Maximum	5.5	2.5	1.9	41	0.82
Mean	4.29	2.1	1.68	35.4	0.79
Median	4	2.2	1.6	35	0.8
SD dev	0.7	0.3	0.16	3.8	0.02
			Nizamabad		
Minimum	3.7	1.65	1.5	30	0.75
Maximum	5.4	2.4	1.9	36	0.82
Mean	4.22	2.09	1.7	32.8	0.79
Median	4	2.1	1.7	33	0.8
SD dev	0.67	0.32	0.15	2.38	0.03

Based on all these physical properties data, a turmeric planter metering mechanism which must assist all the local varieties should be designed.

4. CONCLUSION

Physical properties of turmeric seed rhizomes are investigated as a primary objective in developingAutomatic turmeric planter. Average weight of turmeric seed rhizome was found to be 15.5 g with an equivalent diameter of 2.45cm. Bulk density and tapped density of seed rhizomes found to be 640 and 680kg m^{-3}, respectively. From rigorous lab studies in various turmeric varieties, average seed rhizome length was noted tobe 4.29cm. Average breadth and thickness were noted as2.1 and 1.7 cm, respectively. By utilizing all these physical properties, preparation of proper design of a turmeric planter is expected.

RESEARCH CATEGORY

Agricultural Engineering, Farm Machinery and Power Engineering

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

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