# Turmeric

**ICAR - Indian Institute of Spices Research**
Kozhikode - 673 012, Kerala

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Extension Pamphlet

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# Turmeric

Turmeric of commerce is the cured and dried rhizome or underground stem of a perennial herb, *Curcuma longa* L (Family: *Zingiberaceae*). Turmeric is used as condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. India is the leading producer and exporter of turmeric in the world. The major turmeric growing states in India are Telangana, Andhra Pradesh, Tamil Nadu, Maharashtra, Madhya Pradesh, West Bengal, Assam and Orissa. The states of Telangana and Maharashtra together accounted for 37 per cent of the area and nearly half of the total turmeric output. During 2019-20, the country produced 11, 78, 750 tonnes of turmeric from an area of 2,96,181 ha.

## Climate and soil

Turmeric can be grown in diverse tropical conditions from sea level to 1500 m above sea level, at a temperature range of 20-35°C with an annual rainfall of 1500 mm or more. The crop can be grown under rain-fed or irrigated conditions. Though it can be grown on different types of soils, it thrives best in well-drained sandy or clay loam soils with a pH range of 4.5-7.5 with good organic matter status.

## Varieties

A number of cultivars are available in the country and are mostly known by the name of the locality where they are cultivated. Some of the popular cultivars are Salem, Duggirala, Mydukur, Armoor, Tekkurpet, Amalapuram, Erode, Sangli and Lakdong. The improved varieties of turmeric released from ICAR-IISR and their salient features are given below.

Table 1. Turmeric varieties released from ICAR- IISR

| Variety | Mean yield (fresh) (t/ha) | Duration (days) | Dry recovery (%) | Curcumin (%) | Characteristic features |
|---|---|---|---|---|---|
| Suvarna | 17.4 | 180-200 | 20.0 | 4.3 | Deep orange coloured rhizome |
| Suguna | 29.3 | 180-200 | 15.0 | 5.3 | Reddish yellow coloured rhizomes |
| Sudarsana | 28.8 | 180-200 | 15.0 | 5.3 | Thick plumpy rhizomes |
| IISR Prabha | 37.5 | 210-240 | 19.5 | 6.5 | Reddish yellow coloured rhizomes, developed from seedling progeny |
| IISR Prathibha | 39.1 | 210-240 | 18.5 | 6.2 | Developed from seedling progeny, plumpy and bold rhizomes |
| IISR Alleppey Supreme | 35.4 | 210-240 | 19.3 | 6.0 | Consistent in curcumin content |
| IISR Kedaram | 34.5 | 210-240 | 18.9 | 5.5 | Reddish orange rhizomes, tolerant to leaf blotch |
| IISR Pragati | **38.0** | **180-200** | **18.0** | **5.1** | Short duration, stable curcumin across locations, tolerant to root knot nematode |

Apart from these varieties, several other high yielding varieties, developed by various institutions have been recommended for different turmeric growing regions of the country. Some of the important varieties and their salient features are provided in Table 2.

Table 2. List of other promising notified/released varieties in turmeric

| Variety | Suitable for states | Yield (t ha$^{-1}$) | Salient features | Institute |
|---|---|---|---|---|
| Rashmi (2019) | Odisha<br>Tamil Nadu<br>Himachal Pradesh<br>Andhra Pradesh<br>Kerala | 31.3 | Bold rhizomes, Suitable for both rainfed and irrigated condition, early and late sown season,<br>Curcumin:6.4%,<br>Oleoresin: 13.4%,<br>Essential oil: 4.4%<br>Dry recovery: 23.0%<br>Maturity: 240 days | High Altitude Research Station, OUAT, Pottangi, Odisha |
| Roma (2019) | Odisha,<br>Tamil Nadu<br>Himachal Pradesh<br>Andhra Pradesh<br>Kerala | 20.7 | High quality variety<br>Curcumin:6.1%,<br>Oleoresin: 13.2%,<br>Essential oil: 4.2%<br>Dry recovery: 31.0%<br>Maturity: 250 days<br>Suitable for both rainfed and irrigated condition, Suitable for hilly areas and late season planting. | High Altitude Research Station, OUAT, Pottangi, Odisha |
| Surama (2019) | Odisha<br>Tamil Nadu<br>Himachal Pradesh<br>Andhra Pradesh<br>Kerala | 20.0 | High quality variety<br>Curcumin:6.1%,<br>Oleoresin: 13.1%,<br>Essential oil: 4.4%<br>Dry recovery: 26.0%,<br>Maturity: 253 days<br>Round and plumpy rhizome, field tolerance to leaf blotch, leaf spot and rhizome scale. | High Altitude Research Station, OUAT, Pottangi, Odisha |
| UBKV Turmeric 2 (TCP 64) (2019) | West Bengal | 26.16 | Bold rhizome, moderately resistant to leaf spot and leaf blotch disease.<br>Curcumin: 4.95%,<br>Oleoresin: 11.85%,<br>Essential oil: 6.74%<br>Dry recovery:23.3%<br>Maturity: 210-220 days | Uttar Banga Krishi Viswa Vidyalaya, Pundibari, West Bengal |
| UBKV Turmeric 3 (Uttar Rangini) (2021) | West Bengal<br>Bihar<br>Tamil Nadu | 28.91 | High yielding<br>Curcumin: 5.10%,<br>Oleoresin: 12.25%<br>Essential oil: 6.53% | Uttar Banga Krishi Viswa Vidyalaya, Pundibari, West Bengal |

| Variety | Suitable for states | Yield (t ha$^{-1}$) | Salient features | Institute |
|---|---|---|---|---|
| UBKV Turmeric 3 (Uttar Rangini) (2021) | West Bengal Bihar Tamil Nadu | 28.91 | High yielding Curcumin: 5.10%, Oleoresin: 12.25% Essential oil: 6.53% | Uttar Banga Krishi Viswa Vidyalaya, Pundibari, West Bengal |
| CO2 (2016) | Tamil Nadu Karnataka Maharashtra Andhra Pradesh Telangana | 43 | Bolder rhizomes Curcumin: 4.2% Dry recovery: 20 % Maturity: 280 days | Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu |
| GNT-2 (2018) | Southern Gujarat | 28.70 | Medium reddish yellow powder colour Curcumin: 4.10 % Dry recovery: 20.70 % Resistant to rhizome rot and moderately resistant to leaf blotch disease | Department of Genetics and Plant Breeding, NMCA, NAU, Navsari |
| Punjab Haldi 1 (2015) | Punjab | 27.2 | Curcumin: 3.3% Oleoresin 6.7% Maturity: 215 days | Punjab Agricultural University,Ludhiana |
| Punjab Haldi 2 (2015) | Punjab | 30.6 | Maturity:240 days Curcumin: 2.9% Oleoresin: 7.6% | Punjab Agricultural University,Ludhiana |
| Phule Swarupa (2006) | Maharashtra | 35.83 | Dark yellow core colour of fingers. Curcumin: 5.19% Dry recovery: 22% Tolerant to leaf blotch, leaf spot and rhizome fly | Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra |
| Sona (2005) | Kerala | 37.34 | Medium duration, Curcumin: 7.11% Oleoresin: 18% Essential oil: 4.4%. Tolerant to *Taphrina* leaf spot | Kerala Agricultural University, Thrissur, Kerala |
| Varna (2005) | Kerala | 33.44 | Maturity:240-270 days. Curcumin:7.87% Oleoresin: 13.88% Essential oil: 4.56% | Kerala Agricultural University, Thrissur, Kerala |

*Note: The year of release/notification given in parenthesis along with the name of the variety*

# Cultivation

## Preparation of land

- The land is prepared with the receipt of early monsoon showers. The soil is brought to a fine tilth by giving three to four deep ploughings. Hydrated lime @ 500 - 1000 kg/ha has to be applied for laterite soils based on the soil pH and thoroughly ploughed. Under irrigated conditions land preparation and sowing can be undertaken from February onwards.

- Light soils: Beds of 1.0 m width, 30 cm height and of convenient length are prepared with spacing of 50 cm between beds. Rhizomes are planted at 25 cm x 30 cm spacing.
- Loamy soils: Flat beds of 3 x 1.8 m size are prepared providing necessary irrigation channels and rhizomes are sown at 15 to 20 cm spacing.
- Heavy soils: Ridges and furrow system is adopted and rhizomes are sown in the furrows/ridges at 15 to 20 cm spacing. Spacing between ridges is maintained at 45 to 60 cm.
- In alternate method, in wet lands, rhizomes are planted on raised beds of 1.2 m width, 30 cm height and convenient length. 30 cm wide channels are provided in between. Planting is done at a spacing of 30 x 15 cm.

## Seed material

Whole or split mother rhizomes or finger rhizomes can be used as planting material.Well-developed healthy and disease-free rhizomes should be used as seed material. The seed rhizomes are treated with mancozeb 0.3% (3 g/L of water) and quinalphos @ 1.5 mL/L for 30 minutes, shade dried for 3-4 hours and planted. About 2,500 kg of seed material is required for planting one hectare of turmeric.

## Transplanting

Though transplanting in turmeric is not conventional, it is found profitable. A transplanting technique using single bud sprouts (about 5 g) has been standardized to produce good quality planting material with reduced cost.The technology has been standardized at Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The technique involves raising transplants from single sprout seed rhizomes in the pro-tray and planted in the field after 30-40 days. The advantages of this technology are production of healthy planting materials and reduction in seed rhizome quantity and eventually reduced cost on seeds.

## Pro-tray technology

- Select well grown, healthy rhizomes and treat with carbendazim @ 2g/ L + quinalphos@ 1.5 mL/L and then cut into single bud.
- Cover the buds lightly with cocopeat and spray with humic acid (0.5%).
- Place the sprouted single buds in portray, which is filled with cocopeat enriched with *P.fluorescens* (1g per 100 gram cocopeat) and cover with polythene sheets for seven days.
- Ensure that the bud portion is in contact with the cocopeat

- After sprouting, remove the polythene sheets and keep in 50% shade.
- Spray humic acid (0.5%) after the emergence of leaf.
- Seedlings will be ready for transplanting after 30-35 days


Protray technology

Single bud sprouts

Turmeric nursery

## Planting

In Kerala and other West Coast areas where the rainfall begins early, the crop can be planted during April-May (planting time vary with location and receipt of rainfall) with the receipt of pre-monsoon showers. Small pits are made with a hand hoe on the beds at a spacing of 25 cm x 30 cm. Pits are filled with well-decomposed cattle manure or compost, seed rhizomes are placed over it then covered with soil.

Different planting methods are as follows:

(a) *Flat bed method*: - Planting is done by dibbling rhizome in furrows behind the country plough. The seeds are then covered with loose soil from the ridge. The spacing is 30 x 15 cm. Flooding method of irrigation is adopted.

(b) *Ridges and Furrow method*:- In this method, ridges and furrows are prepared with tractor mounted ridger with a spacing of 45 x 20 cm. This method is better than the flat bed method.

© *Raised bed method*: In this method, raised bed with 1m width and 30 cm height is prepared. The spacing between beds is 30 cm. Four rows with spacing of 30 x 15 cm is recommended with one drip line, lengthwise at the centre.

Ridges and furrow method

Raised bed method

## Manuring and fertilizer application

Farmyard manure (FYM) or compost @ 30-40 t/ha is applied by broadcasting and incorporated into the soil at the time of preparation of land. It can also be applied as basal dressing by spreading over the beds or in to the pits at the time of planting. Organic manures like oil cakes can also be applied @ 2 t/ha. In such case, the dosage of FYM can be reduced. Integrated application of coir compost (@ 2.5 t/ha) combined with FYM and biofertilizer (*Azospirillum*) along with half the recommended dose of NPK is also recommended.

Table 3. Fertilizer requirement in different states

| State | Soil type | Fertilizer requirement in kg $ha^{-1}$ |
|---|---|---|
| Kerala | Lateritic soils (Ultisols) | 60 kg N, 50 kg $P_2O_5$ and 120 kg $K_2O$ |
| Andhra Pradesh & Telangana | Sandy Clay loams (Inceptisol), Red soils (Alfisols) and heavy clay soils (Vertisols) | 300 kg N, 125 kg $P_2O_5$ and 200 kg $K_2O$ |
| Tamil Nadu | Clay loams (Mollisols) and heavy clay soils (Vertisols) | 125 kg N, 60 Kg $P_2O_5$ and 90 kg $K_2O$ |
| Orissa | Red soils (Alfisols) | 60 kg N, 50 Kg $P_2O_5$ and 90 kg $K_2O$ |
| Karnataka | Red soils (Alfisols) | 120 kg N, 60 Kg $P_2O_5$ and 120 kg $K_2O$ |

As the soil fertility will be varying with the soil type, agro ecological conditions and management systems, site specific nutrient management based on the soil test results for major nutrient is advocated. The recommended dose of nutrients for varying soil test values of N, P and K is given in Table 4.

The fertilizers are to be applied in 2 - 3 split doses. Full dose of phosphorus is applied as basal at the time of planting. Equal split doses of N and K is top dressed at 45, 90 (and 120) DAP.

Table 4. Soil test based fertilizer recommendations for fresh rhizome yield target levels (ICAR-IISR, Kozhikode)

| Soil test value for available nutrients (kg/ha) | Fertilizer nutrient recommended (kg/ha) for yield targets | |
|---|---|---|
| | 30 t/ha | 40 t/ha |
| **Nitrogen** | | |
| < 150 | 120 | 170 |
| 150-250 | 95 | 125 |
| 250-400 | 50 | 90 |
| >400 | - | 25 |
| **Phosphorus ($P_2O_5$)** | | |
| < 10 | 60 | 90 |
| 10-30 | 18 | 50 |
| 30-50 | - | - |
| >50 | - | - |
| **Potassium ($K_2O$)** | | |
| < 110 | 275 | 325 |
| 110-300 | 230 | 300 |
| 300-500 | 150 | 235 |
| >500 | - | 140 |

Table 5. The fertilizer recommendation for Telangana State (per hectare)

| Application time | Fertilizer | Sole crop (turmeric) | Inter cropped with maize |
|---|---|---|---|
| Basal application | FYM | 10 t | 10 t |
| | Tank silt | 10 t | 10 t |
| | Neem cake | 200 kg | 250 kg |
| | SSP | 150 kg | 300 kg |
| | MOP | 25 kg | 60 kg |
| 40 DAP | Neem cake | 200 kg | 250 kg |
| | Urea | 50 kg | 90 kg |
| 80 DAP | Urea | 50 kg | 90 kg |
| | MOP | 25 kg | 30 kg |
| 120 DAP | Urea | 50 kg | 90 kg |
| | MOP | 25 kg | 30 kg |

## Fertigation

Application of fertilizer through the medium of irrigation water can be practiced in turmeric. Application of 100% recommended fertilizers with urea and potash as straight fertilizers and P as water soluble fertilizer weekly once from 30 days after planting (DAP) to 120 (DAP) gives the best yield and was found to be economically beneficial.

A complete fertigation schedule as per the recommended dose with 150:60:108 kg of NPK/ha (Tamil Nadu) has been developed by TNAU. The fertilizers are applied through irrigation water once in three days, throughout the cropping period.75 % of the recommended of phosphorous is applied as basal dose. Water soluble fertilizers like 19:19:19, Mono ammonium phosphate (12:61:0), Multi K (13:0:45) and urea are used.

Table 6. Fertigation schedule for long duration turmeric

| Crop Stage | Duration (in days) | Nutrients requirement (%) | | | Quantity applied (kg/ha) | |
|---|---|---|---|---|---|---|
| | | N | P | K | | |
| Planting to establishment stage | 15 | 10 | 20 | 10 | 19:19:19<br>Multi K<br>Urea | 15.78<br>17.33<br>21.20 |
| Vegetative stage | 60 | 40 | 30 | 20 | 19:19:19<br>Multi K<br>Urea | 9.83<br>96.00<br>100.57 |
| Rhizome initiation stage | 60 | 30 | 30 | 30 | 19:19:19<br>Multi K<br>Urea | 4.91<br>71.28<br>76.29 |
| Rhizome maturation stage | 135 | 20 | 20 | 40 | 19:19:19<br>Multi K<br>Urea | 15.78<br>40.42<br>47.06 |
| Total duration | 270 | 100 | 100 | 100 | | |

Source: https://agritech.tnau.ac.in/horticulture/horti_spice%20crops_turmeric.html

## Micronutrient application

Micronutrient application is imperative for enhanced yield. Hence, foliar application of micronutrient mixture specific to turmeric (developed and licensed by ICAR-IISR, Kozhikode, Kerala @ 5 g/L) twice at 60 and 90 days after planting ensures 15-20% higher rhizome yield. In Zinc deficient soils, basal application of Zinc fertilizer up to 5 kg Zinc/ha (25 kg of zinc sulphate/ha) also results in good yield.

## Mulching

The crop is to be mulched immediately after planting with green leaves @ 12-15 t/ha. Mulching may be repeated @ 7.5 t/ha at 45 and 90 days after planting after weeding, application of fertilizers and earthing up.

## Weeding

Weeding has to be done thrice at 60, 90 and 120 days after planting depending upon weed intensity.

- Pre-emergence application of Pendimethalin 1.0 kg/ha or Oxyfluorfen 0.12 kg/ha keeps the weeds away for 3-4 weeks from the date of sowing.
- Post-emergence application of quizalofop ethyl @ 0.05 kg/ha gives good control of most monocot weeds and slows down growth of dicot weeds.

## Irrigation

In the case of irrigated crop, depending upon the weather and the soil conditions, about 15 to 23 irrigations are required in clayey soils. In case of sandy loam soil, up to 40 irrigations might be required in conventional system of irrigation. Drip irrigation daily or on alternate days, depending on availability of water, can also be practiced.

Drip irrigation in turmeric

## Cropping systems in turmeric

### Inter cropping/companion cropping

- Turmeric is a long duration crop (9 months) in which a short duration crop can be cultivated as an intercrop to get a supplementary income before the main crop is harvested.
- Intercropping turmeric with small onion along with the practice of mulching appreciably increased the fresh rhizome yield.
- Turmeric grown with chillies as a border crop gave a maximum yield of 29.65 t/ha with additional chilli yield of 2938 kg/ha.
- Turmeric can be recommended as an intercrop in coconut and areca nut gardens. Mixed cropping can also be adopted with redgram, sunhemp, chillies, colocasia, onion, brinjal and cereals like maize and ragi.
- High economic returns can be realised from intercropping of turmeric and maize /turmeric and chillies / turmeric and castor.

### Crop rotation

- In wet lands, turmeric can be rotated with rice, sugarcane, banana, etc. once in 3 or 4 years.
- In garden lands, turmeric can be grown in rotation with sugarcane, chillies, onion, garlic, elephant's foot yam, vegetables, pulses, wheat, ragi and maize.

In order to provide shade to turmeric, castor and pigeon peas can be planted on borders and in irrigation channels

## Plant protection

### Diseases

#### *Leaf blotch*

Leaf blotch is caused by *Taphrina maculans*. The initial symptom appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown. The leaves also turn yellow. In severe cases the plants present a scorched appearance and the rhizome yield is reduced.

Leaf blotch disease

*Management:*

- Spray mancozeb 0.2% or copper oxychloride 0.25% or propiconazole 0.1%, twice at fortnightly intervals.
- Foliar spraying of combination fungicide, Azoxystrobin 18.2% + Difenoconazole 11.4% SC (1 ml litre$^{-1}$ of water) first at the initiation stage of the disease followed by two sprays at 15 days interval is recommended.

## *Leaf spot*

Leaf spot is caused by *Colletotrichum capsici. The* disease appears as brown spots of various sizes on the upper surface of the young leaves. The spots are irregular in shape and white or grey in the centre. Later, two or more spots may coalesce and form an irregular patch covering almost the whole leaf. The affected leaves eventually dry up. The rhizomes do not develop well.

Leaf spot disease

Leaf spots leading to blighting

*Management:*

- Spray with mancozeb (0.2 %) or copper oxychloride (0.2%) or propiconazole 0.1% at fortnightly intervals.
- Foliar spraying of combination fungicide, Azoxystrobin 18.2% + Difenoconazole 11.4% SC (1 ml litre$^{-1}$ of water) first at the initiation stage of the disease followed by two sprays at 15 days interval is recommended.

## *Leaf blight*

Leaf blight is caused by *Rhizoctonia solani.* The disease is characterized by the appearance of necrotic patches with papery white centre of varying sizes on the lamina which spreads on the whole surface leaving a blighted appearance. The disease occurs during the post monsoon season.

*Management:*

Spray with mancozeb 0.2% or copper oxy chloride 0.25% or propiconazole 0.1% at fortnightly intervals.

## *Rhizome rot*

The disease is caused by the fungus *Pythium aphanidermatum.* The disease starts at the collar region of the pseudostem and progresses upwards as well as downwards. The

collar region of the affected pseudostem becomes water soaked and the rotting spreads to the rhizome resulting in soft rot. At a later stage root infection is also noticed. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades. In early stages of the disease, the middle portion of the leaves remain green while the margins become yellow. Later, the yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of pseudostems.Collar region of the pseudo stem becomes soft and water soaked, resulting in collapse of the plant and decay of rhizomes. Rhizome rot affected plants will be seen as circular patches inside healthy fields. The disease is soil-borne and rhizomes borne and occurs with the onset of monsoon.

*Management:*

- Crop rotation
- Use disease free rhizome material for planting
- Provide good drainage facility
- Rhizome treatment with mancozeb (0.3%) or Copper oxychloride (COC) 0.25% for 30 minutes before planting.
- When the disease is noticed in the field, the beds should be drenched with COC (0.25%) or Metalaxyl -mancozeb (0.125%).

## Nematode pests

The important parasitic nematodes infecting turmeric are the Root-knot nematode (*Meloidogyne spp*), lesion nematode (*Pratylenchus spp*), burrowing nematode (*Radophulus similis)* and reniform nematode (*Rotylenchulus reniformis)*.The nematode usually causes damage by feeding on tender rhizomes, roots and base of pseudostemresulting instunting, chlorosis, poor tillering and necrosis of leaves. *Meloidogyne spp causes* characteristic root galls and rhizome with white creamy holes and fissured appearance. *Pratylenchus spp* infection results in the development of lesions on the surface of rhizomes with light brown to dark brownish colour . Later these lesions get infected with the fungus *Pythium spp* resulting in rotting of the inner contents. *Radopholus similis* and reniform nematodes forms lesions, mainly on the root and to a limited extent on rhizomes also. The infested rhizomes have brown, water soaked areas in the outer tissues. Generally, nematode infestation can aggravate

the rhizome rot disease in turmeric.Nematodes survive in soil and infected planting material usually acts as the source of primary inoculum. The tissues from infected crop remaining in the field serve as a reservoir of the nemtodes. It spreads through infected rhizomes or through soil. Warm, moist sandy loam soil is the most favorable condition for nematodes, except for lesion nematode, which prefers warm, moist black soil.

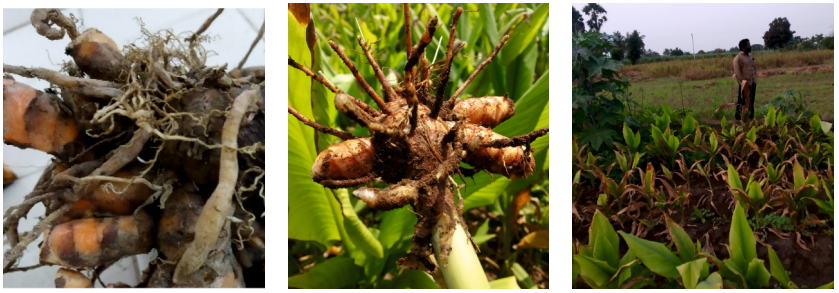
*Management:*

- Select sites free from nematodes by prior sampling and screening for nematodes. Deep summer ploughing in turmeric fields during April-May minimizes the soil population of nematodes.
- Soil solarization using transparent polythene sheets (100 gauge) during summer season for 40-50 days can also reduce nematode population in soil.
- Allelopathic effect by sunnhemp and marigold also reduces the nematode population. Avoid planting of turmeric after cultivation of banana or solanaceous vegetables.
- Use only healthy and nematode free rhizomes as planting material.
- Application of *Glyricidia* compost or neem seed cake @ 1 t/ha or FYM @ 25-30 t/ha will increase organic content, enhance beneficial microorganisms and reduce nematode population.
- *Pochonia chlamydosporia* can be applied to the beds at the time of sowing @ 20 g/bed ($10^6$cfu/g) for management of nematode problem.
- IISR turmeric variety Pragati is moderately resistant to root knot nematodes.
- Application of Carbofuran 3G @1kg a.i/ha at 3$^{rd}$ month and 5$^{th}$ month of sowing can effectively control nematodes. (Only in places where the chemical is not banned).
- Intercropping with repellent plants like marigold,G*lyricidia*, Asparagus,Dahlia etc @ 5:1 (5 rows of turmeric followed by one row of repellent plant) helps in reducing nematode problems.
- Crop rotation with Marigold, Chrysanthemum, Sesbania, Crotalaria spp.,Gaillardia, Cluster bean and Desmodium spp can be followed.

Rosetting of leaves

Galls on roots


**Brownish lesion on rhizomes (A,B,C, and D) and foliar symptom (E and F) caused by Root lesion nematode**



**Root galls (A, B) and foliar symptom (C) caused by root knot nematodes**

## Insect pests

### *Shoot borer*

The shoot borer *(Conogethes punctiferalis)* is the most serious pest of turmeric. The larvae bore into pseudo stems and feed on internal tissues. The presence of a bore-hole on the pseudo stem through which frass is extruded and the withered central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange-yellow with minute black spots. Fully-grown larvae are light brown with sparse hairs.

Bore-hole on the pseudostem

Shoot borer larvae

*Management:*

- Spray chlorantraniliprole or flubendiamide or spinosad (0.3 mL/ L) or lambda- cyhalothrin ( 2ml/L) at 15 days intervals during July to October.
- Initiate spraying when the first symptom of pest attack is seen on the inner most leaf.

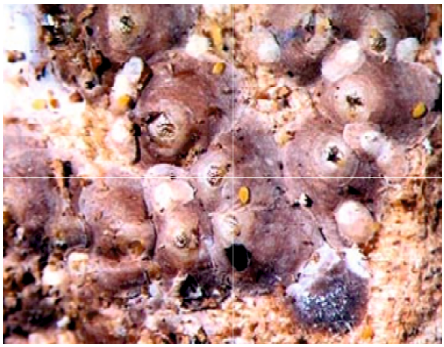
### *Rhizome scale*

The rhizome scale (*Aspidiella hartii)* infests rhizomes in the field (at later stages of the crop) and in storage. Adult (female) scales are circular (about 1mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shrivelled and desiccated affecting its germination.

*Management:*

- Adapt timely harvest of rhizomes
- Before storage, discard severely infested rhizomes
- Treat seed material with quinalphos @ 1.5 mL/L for 30 minutes, shade dried for 3-4 hours before storage and also before sowing .
- Store rhizomes in sawdust along with dried leaves of *Strychnos nuxvomica*

Affected rhizome



Encrustations on the rhizomes

**Minor pests**

**Leaf thrips**

The turmeric thrips (*Panchaetothrips indicus)* infests
turn pale and gradually dry up. The pest infestation is more common during the post monsoon period especially in drier regions of the country.

*Management*

- Set blue sticky traps (5 no./acre)
- Apply Neem seed kernal extract (5 %)

**Leaf feeding beetle**

Adults and larvae of leaf feeding beetles such as *Lema spp.* feed on leaves especially during the monsoon season and form elongated parallel feeding marks on them.

*Management*:
Sprays undertaken for the management of shoot borer is sufficient to manage this pest

**Lacewing bug (*Stephanitis typicus*)**

The pest infests the foliage causing them to turn pale and dry up. The pest infestation is more common during the post monsoon period especially in drier regions of the country.

*Management:* Spray neem oil 3.0 % or Neem Seed Kernal Extract 5.0 %

## Leaf roller (*Udaspes folus*)

In infected plants, the leaf rolled longitudinally and the larvae feed within the folded portion.

*Management:* Spray taken for shoot borer can manage leaf roller infestation

## Harvesting

Well managed turmeric crop is ready for harvest in seven to nine months depending on the variety and time of sowing. The crop is generally harvested during January to March. Early varieties mature in 7-8 months, medium varieties in 8-9 months and late varieties after 9 months. On maturity, the leaves turn dry and are light brown to yellowish in colour. In Kerala, turmeric is grown in raised beds and harvesting is done either manually or by using a tractor. In case of manual harvesting, the land is ploughed, the clumps are carefully lifted with spade and the rhizomes are gathered by hand picking. Harvesting with a tractor attached to a turmeric harvester is followed when the raised beds are taken using a tractor. Power tiller operated turmeric harvester developed by TNAU can be used for mechanized harvesting, with the capacity of 0.6 ha/day. This harvester can reduce cost of harvesting by 65 % while also reducing the time required for harvest by 90%. Only 0.5% of rhizomes are damaged during mechanical harvesting whereas, in manual harvesting about 4.2% of rhizomes are damaged. The harvested rhizomes are collected manually and all the extraneous matter adhering to them is cleared. Fingers are separated from mother rhizomes.

### Preservation of seed rhizomes

Rhizomes for seed purpose are generally stored by heaping in well ventilated rooms and covered with turmeric leaves. In Tamil Nadu, the heap is plastered over with earth mixed with cow dung. The seed rhizomes can also be stored in pits with saw dust, sand along with leaves of *Stychnosnuxvomica* (Kanjiram). The pits are to be covered with wooden planks with one or two openings for aeration. The rhizomes are to be dipped in quinalphos 25 EC (0.075%) (3 ml/L) solution for 20-30 minutes if scale infestations are observed and in mancozeb (0.3%) to avoid storage losses due to fungal growth.

## Post harvest processing

The harvested turmeric rhizomes have to be processed before they can be sold in the market. This is done through a series of post-harvest processing operations like boiling, drying and polishing. Boiling of turmeric is taken up within 3 or 4 days after harvest. The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter take a little longer to cook. The dry recovery of the different turmeric varieties vary widely, usually ranging from 15 to 20 per cent.

## Boiling

Boiling is the first post-harvest operation to be performed at the farm level which involves cooking of fresh rhizomes in water until soft before drying. By this process,

the raw odour of turmeric is avoided. The cooking also reduces the drying time and yields uniformly coloured product.

In the traditional method, a vessel made of galvanized iron sheet is used for turmeric boiling. Boiling of turmeric rhizomes is carried out till froth forms and white fumes come out of the pan with a characteristic odour. Boiling is considered complete when a pointed stick can pass through the rhizomes with application of slight pressure. The other indications of the completion of boiling process are softness and easy breaking of rhizomes when pressed between the fore finger and thumb and a uniform coloured interior. An effective cooking time of 45 to 60 minutes for fingers and 90 minutes for mother rhizomes is considered essential. Overcooking and under cooking are found to affect the quality of the rhizome.

Improved boiler using steam boiling technique is followed when large quantities of turmeric are to be cured. The TNAU model of improved steam boiler for turmeric consists of a trough, inner perforated drums and lid. The outer drum is made of 18 SWG thick mild steel to a size of 122 x 122 x 55 cm. A lid is provided with hooks for easy lifting and also provided with an inspection door. For easy draining and cleaning, an outlet is placed at the bottom of the drum. Four numbers of inner drums of 48 x 48 x 45 cm size are provided in the outer drum. The capacity of each inner drum is 25kg. The inner drums are provided with a leg for a height of 10 cm, so that the rhizomes will not come in contact with water, which is filled to a height of about 6-8 cm in the outer drum. The outer drum is placed with more than half of its depth below the ground level by digging a pit, which serves as a furnace. This furnace is provided with two openings, one for feeding the fuel and the other one for removing the ash and unburnt.

After placing the boiler in the furnace, about 75 litres of water is added (6-8 cm depth). About 25 kg of well washed rhizome is taken in each inner drum and placed in the boiler and the lid is placed in position. Using the available agricultural waste materials, mostly, the turmeric leaves, fire is put in the furnace. During the boiling process, it takes about 25 minutes to boil the water and to produce steam for the initial batch of rhizomes. Subsequent batches can be processed in 10 - 15 minutes. Through the inspection door, the stage of boiling of the rhizome is assessed by pressing the rhizomes with a hard pin / needle.

Using a long pole, the lid is removed and the inner drums are lifted one by one. For the next batch, about 20 litres of water is added to the outer drum, depending on the water lost by evaporation. The next batch of rhizomes is loaded in all the drums and heating is continued. At the end of the boiling process, all the drums need to be cleaned free of mud and soil to avoid damage and enhance the life of the equipment. The capacity of the boiler is about 100 kg per batch and the fuel requirement is 70 – 75 kg of agricultural waste materials.

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## Drying

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on the drying floor. A thin layer is not desirable, as the colour of the dried product may be adversely affected. During night the material is heaped and covered. It may take 10-12 days for the rhizome to become dry and attain a moisture content of less than 12%. The bulbs and fingers are dried separately, the former takes more time to dry. Turmeric should be dried on clean surface to ensure that the product does not get contaminated by extraneous matter. Care should be taken to avoid mould growth on the rhizomes. Rhizomes are turned intermittently to ensure uniformity in drying.

Solar tunnel driers covered with UV stabilized semi-transparent polyfilm sheet of 200 microns thickness can also be used for drying of turmeric. The solar radiation is transmitted through plastic sheet, which has a transmissivity of 90 per cent. The UV sheet is transparent to the short wave radiations and opaque to long wave radiations. During the sunshine hours the short wave radiations are entrapped through the UV sheet, heated by the black absorber at the bottom and is converted into long wave radiation. This conversion of short wave radiation to long wave radiation causes an increase in the temperature inside the drier. Heat is transferred from the absorber to the air above the absorber. The heated air from the bottom while passing over the products absorbs the moisture. Solar radiation which passes through the transparent cover of the drier, also heats the products in the drier. This enhances the temperature and drying rate of the produce inside the drier than in the ambient conditions.

The yield of the dry product varies from 15-25 per cent depending upon the variety

and the location where the crop is grown. The starch gelatinized during boiling shrink and increases the intercellular spaces during the drying process. This in turn enhances water diffusion and leads to reduced drying time.

## Polishing and colouring

Dried turmeric has poor appearance and rough dull outer surface with scales and root bits. The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing. Polishing is done till the recommended polish of 7-8% is achieved. Usually 5 to 8% of the weight of turmeric is lost as polishing wastage during full polishing. This wastage is about 2 to 3% during half polishing. Polishing of dried turmeric also helps in removing the wrinkles.

Manual polishing consists of rubbing the dried turmeric fingers on a hard surface. Manual polishing gives rough appearance and dull colour to the dried rhizome. Sometimes, undesirable colouring materials are added during polishing to improve the colour and appearance. But this is not recommended. In an improved method, polishing is done by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal screen. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against each other as they roll inside the drum. The turmeric is also polished in power operated drums.

Large scale polishing units with capacity to polish 500 to 1000 kg per batch is used for polishing turmeric rhizomes at commercial units. It takes about 45-60 minutes per batch and about 4% is wasted as dust.

The colour of the processed turmeric influences the price of the produce. Hence to obtain attractive product, turmeric powder is sprinkled during the last phase of polishing.

## Cleaning, grading, packing and Storage

Indian turmeric is considered to be the best in the world. About 90 per cent of the total produce is consumed internally and only a small portion of the production is exported. Turmeric of commerce is described in three ways:

*Fingers*: These are the lateral branches or secondary 'daughter' rhizomes which are detached from the central rhizome before curing. Fingers usually range in size from 2.5 to 7.5 cm in length and may be over 1 cm in diameter.

*Bulbs:* These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers.

*Splits*: Splits are the bulbs that have been split into halves or quarters to facilitate curing and subsequent drying.

Turmeric being a natural produce, is prone to contaminants during various stages of production and processing . The produce is cleaned to remove such foreign materials.

A sifter, destoner, and an air screen separator will help remove materials such as stones, dead insects, excreta, and other extraneous matter. Cleaned and graded material is packed generally in new double burlap gunny bags and stored over wooden pallets in a cool, dry place protected from light. The stores should be clean and free from infestation of pests and rodents. It is not recommended to apply pesticides on the dried/polished turmeric to prevent storage pests.

**Commercial requirements**

Turmeric produced in different regions exhibit quality variations due to the differences in soil, climatic conditions, and agricultural practices. The post harvest handling and processing of the commodity also add on to the quality differences. This necessitates the use of some standard specifications for trade. To ensure the quality of spices for food use, Government of India has introduced the mandatory compliance of the standards set by The Food Safety and Standards Authority of India (FSSAI).

**FSSAI standard regulations (2011) for turmeric and turmeric powder**

Turmeric whole means the primary or secondary rhizomes commercially called bulbs or fingers of *Curcuma Longa* L. The rhizomes shall be cured by soaking them in boiling water and then drying them to avoid regeneration. The rhizome be in natural state or machine polished. The product shall have characteristic odour and flavour and shall be free from mustiness or other foreign flavours. It shall be free from mould, living and dead insects, insect fragments, rodent contamination. The product shall be free from lead chromate, added starch and any other extraneous colouring matter. It shall conform to the standards as in Table 7.

Table 7. FSSAI standards for turmeric

| S.No. | Descriptions | Value |
|---|---|---|
| i. | Extraneous matter | Not more than 1.0 per cent by weight |
| ii. | Defective Rhizomes | Not more than 5.0 per cent by weight |
| iii. | Moisture | Not more than 12.0 per cent by weight |
| iv. | Insect damaged matter | Not more than 1.0 per cent by weight |
| v. | Test for lead chromate | Negative |

*Note: Defective rhizomes consist of shrivelled fingers and or bulbs internally damaged, hollow or porous rhizomes scorched by boiling and other types of damaged rhizome.*

*a. Organic extraneous matter includes chaff, stems and straw.*
*b. Inorganic extraneous matter includes dust, dirt, stones and lumps of earth. This shall not exceed 2 per cent by weight of the total extraneous matter.*

Turmeric powder means the powder obtained by grinding dried rhizomes or bulbous roots of *Curcuma Longa* L. The powder shall have characteristic odour and flavour and shall be free from mustiness or other foreign odour. It shall be free from mould,

living and dead insects, insect fragments, and rodent contamination. The powder shall be free from any added colouring matter including lead chromate and morphologically extraneous matter including foreign starch and shall conform to the standards as in Table 8.

Table 8. FSSAI standards for turmeric powder

| S.No. | Descriptions | Value |
|---|---|---|
| i. | Moisture | Not more than 1.0 per cent by weight |
| ii. | Total ash on dry basis | Not more than 9.0 per cent by weight |
| iii. | Ash insoluble in dil. HCl on dry basis | Not more than 1.5 per cent by weight |
| iv. | Colouring power expressed as curcuminoid content on dry basis | Not less than 2.0 per cent by weigh |
| v. | Total Starch | Not more than 60.0 per cent by weight |
| vi. | Test for lead chromate | Negative |

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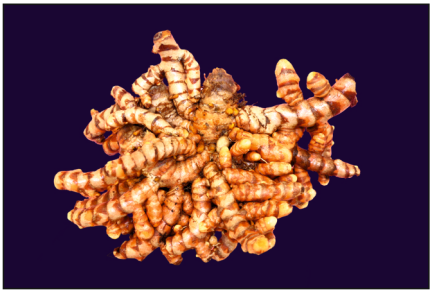

Suvarna

Suguna

Sudarshana

IISR Prabha


IISR Pratibha


IISR Alleppey Supreme


IISR Kedaram

IISR Pragati

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