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ICAR

GOOD Agricultural Practices

Turmeric

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ICAR-Indian Institute of Spices Research
ICAR-All India Coordinated Research Project on Spices

TURMERIC

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Good Agricultural Practices are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while consideringeconomic, social and environmental sustainability as defined by the Food and Agricultural Organization (FAO). GAP recommends addressing environmental, economic and social sustainability for on-farm production and post-production processes resulting in safe and healthy food and non-food agricultural products. A broadly accepted approach using GAP principles, generic indicators and practices will help guide debate on national policies and actions and on the preparation of strategies to ensure that all stakeholders participate in and benefit from the application of GAP in the food chain. The aim of GAP is to promote Sustainable Agriculture and Development and with effective input use, are one of the best ways to increase smallholder productivity. GAP in addition to improving the yield and quality of the products, also has environmental and social dimensions.

Practising GAP improve the safety and quality of food and other agricultural products and it helps to reduce the risk of non-compliance with national and international regulations, standards and guidelines set by Codex Alimentarius Commission, World Organisation for Animal Health and the International Plant Protection Convention IPPC regarding permitted pesticides, maximum levels of contaminants food and non-food agricultural products, as well as other chemical, microbiological and physical contamination hazards. Moreover, adopting GAP promotes sustainable agriculture and contributes to meeting national and international environment and social development objectives.Its social dimension would be to protect the agricultural workers' health from improper use of chemicals and pesticides. It is a particularly opportune time to promote GAP when second generation of reforms in agriculture which would have a Critical impact on Indian agriculture, are planned by the Indian Government. However, farmers need to be adequately informed, technically prepared and organised to meet this new challenge with governments and public agencies playing a facilitating role.

GOOD AGRICULTURAL PRACTICES FOR TURMERIC

Turmeric (*Curcuma longa*) (Family: Zingiberaceae) also known as 'Indian saffron' is used as condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. Turmeric is the dried rhizome of this herbaceous perennial which is native to South Asia particularly India. India is a leading producer and exporter of turmeric in the world. The states of Telangana, Maharashtra, Tamil Nadu, and Andhra Pradesh together contributes 63.4% of India's turmeric production, other important turmeric producers are Orissa, Karnataka, West Bengal, Gujarat, Meghalaya, Assam.

Turmeric enjoys a unique distinction among spices due to its various medicinal properties and versatality. The spice played a great role in the life of ancient people as a wound healer, as a medicine for stomach ache, flatulence, poison etc., but in recent times, the crop has gained importance of several of its documented medicinal properties including its anti-cancerous and anti-ageing properties and hence finds use in the drug and cosmetic industry.

SITE SELECTION

The information on soil condition, water logging, industrial waste and effluents, source of irrigation water and meteorological data need to be available with the farmers before starting turmeric cultivation.

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^{o}C with an annual rainfall of 1500 mm or more, under rainfed or irrigated conditions. Though it can be grown on different types of soils, it thrives best in well-drained red or clay loam soils with a pH range of 4.5-7.5 with good organic status. Soil with good drainage is essential.

SEEDS AND PROPAGATION MATERIAL

Varieties

A number of cultivars are available in the country and are known mostly by the name of locality where they are cultivated. Some of the popular cultivars are Duggirala, Tekkurpet, Sugandham, Amalapuram, Erode local, Salem, Alleppey, Moovattupuzha and Lakdong. Improved varieties of turmeric released by different research organizations are also available (Table-1).

Recently, a high yielding, short duration (180 days) turmeric variety named IISR Pragati (Acc. 48) with an average yield of 38 t/ha (fresh rhizomes) has been released by ICAR-IISR, Kozhikode and is touted as a boon to turmeric growers. It has stable and high curcumin content (5.02%) across locations and is well suited for cultivation in states of Kerala, Tamil Nadu, Andhra Pradesh, Telangana, Karnataka and Chhattisgarh.

Table 1. Improved varieties of turmeric

Variety	Mean yield(fresh) (t/ha)	Crop duration(days)	Dry recovery (%)	Curcumin (%)	Oleoresin (%)	Essential oil (%)
ICAR-Indian Institute of Spices Research, Kozhikode						
Suvarna	17.4	200	20.0	4.3	13.5	7.0
Suguna	29.3	190	12.0	7.3	13.5	6.0
Sudarsana	28.8	190	12.0	5.3	15.0	7.0
IISR Prabha	37.5	195	19.5	6.5	15.0	6.5
IISR Prathibha	39.1	188	18.5	6.2	16.2	6.2
IISR Alleppey Supreme	35.4	210	19.3	6.0	16.0	4.0
IISR Kedaram	34.5	210	18.9	5.5	13.6	3.0
IISR Pragati	38	180	15.95	5.02	15.29	6.3
Tamil Nadu Agricultural University, Coimbatore						
Co 1	30.0	285	19.5	3.2	6.7	3.2
BSR 1	30.7	285	20.5	4.2	4.0	3.7
BSR 2	32.7	245	20.0	3.8		
High Altitude Research Station, OUAT, Pottangi, Odhisa						
Roma	20.7	250	31.0	6.1	13.2	4.2
Suroma	20.0	255	26.0	6.1	13.1	4.4
Ranga	29.0	250	24.8	6.3	13.5	4.4
Rasmi	31.3	240	23.0	6.4	13.4	4.4
Surangi	23.4	180-200	28.0	4.5-6.5	12.7	4.6
Tirhut College of Agriculture, RAU, Dholi, Bihar						
Rajendra Sonia	42.0	225	18.0	8.4	10.0	5.0
ICAR Research Complex for NEH Region, Shillong, Meghalaya						

Mega Turmeric1	23.0	310	16.4	6.8		
Kerala Agricultural University, Thrissur						
Kanti	37.7	240-270	20.2	7.2	8.3	5.2
Sohba	35.9	240-270	19.4	7.4	9.7	4.2
Sona	21.3	240-270	18.9	7.1	10.3	4.2
Varna	21.9	240-270	19.1	7.9	10.8	4.6
SardarkrushinagarDantiwada Agricultural University, Jagudan						
Sugandham	15.0	210	23.3	3.1	11.0	2.7

Seed rate

A seed rate of 2,000 - 2,500 kg of rhizomes is required for planting one hectare of turmeric. Well developed healthy and disease free rhizomes are to be selected. Whole or split mother and finger rhizomes are used for planting. The mother rhizome can be used for seed material by splitting into two or three pieces with one or two healthy buds.The seed rhizomes are to be treated with mancozeb 0.3% (3 g/L of water) for 30 min, shade dried for 3-4 h and planted or seed are treated with *P. fluorescens* (10 g/kg) and *T. viride*/ *T. harzianum* (4 g/kg) and then sown.

SOIL CONDITIONS/MANAGEMENT

- The soil analysis report of the selected site and analytical report on irrigation water should be available especially with respect to heavy metals and pesticide residues contents.
- The quantity, quality and type of soil amendments used for the selected site need to be recorded.
- Soil tilth need to be maintained as per the requirement of the crop and field operations performed need to be recorded.

Preparation of land

The land is prepared with the receipt of early monsoon showers. The soil is brought to a fine tilth by giving about four deep ploughings. Hydrated lime @ 500 - 1000 kg/ha has to be applied for laterite soils based on the soil pH and thoroughly ploughed.

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.

Loamy soils : Flat beds of 3 x 1.8 m size are prepared providing necessary irrigation channels. Rhizomes are dibbled at 15 cm apart in the plough furrows spaced 30cm apart.

Heavy soils: Ridges and furrow system is adopted and rhizomes are sown 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 with 30 cm height with convenient length, 30cm wide channels are provided in between. Planting is done with 30 x 15 cm spacing.

CROP MANAGEMENT FOR CULTIVATION

- The spacing for the crop, in terms of row to row and plant to plant distance need to be adopted as per the agronomic requirement.
- Gap filling of plants to compensate mortality losses should be carried out within a reasonable timeframe.
- Based on the soil analysis and crop requirement, organic manure preferred for the crop supplemented with mineral nutrition through inorganic source need to be applied.
- Application of mineral supplements must be based on complete soil analysis in a competent laboratory.
- Specialized nutritional application for distinct needs viz., root production or enhancement of leaf bio mass need to be taken up as per the requirement of the crop.
- In order to optimize water usage and to reduce wastage of water irrigation management plan need to be prepared for the crop.
- Efficient system for irrigation need to be adopted so as to conserve water for the whole cropping season and to reduce the water usage.
- Records need to be maintained for irrigation schedules, fertigation application and water requirement.
- Depending on the nature and stage of the crop, inter-cultivation practices need to be adopted to reduce the incidence of weeds.
- Comprehensive package of pest and disease management schedules including prophylactic measures required for the crop need to be adopted to minimize the crop loss and its quality.
- In order to reduce pesticide residue in produce, correct dose of pesticides, time of application and mode of application need to be ensured and recorded correctly.
- Use of bio control agents and bio pesticides is preferred and plans for this should be available.

Transplanting

Though transplanting in turmeric is not conventional, it is found to be profitable. A transplanting technique in turmeric by 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 the production of healthy planting materials, 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 + monocrotophos @ 1.5 mL/L and then cut into single bud.
- Cover these buds with cocopeat and spray with humic acid (0.5%).
- Place the sprouted single buds in portray, which is filled with cocopeat (100g) mixed with *P. fluorescens* (1g) and cover with polythene sheets for seven days
- 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 on 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 rainfall receipt) with the receipt of pre-monsoon showers. Small pits are made with a hand hoe on the beds with 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

(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. This method has the more chances of occurrence of pest and diseases. 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.

(c) 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 in 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 ploughing at the time of preparation of land or 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.

The fertilizer application in different states is as follows:

State	Soil type	Time of planting (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 or 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 1. 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 1. Soil test based fertilizer recommendations for fresh rhizome yield target levels (ICAR-IISR, Kozhikode)

Soil test value for available nutrients (kg/ha)	Fertilizer recommended for yield targets (kg/ha)	
Nutrient	**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

The recommendation per hectare for Telangana State is as follows:

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

Note: Fertilizers should be applied at the base of the plant and covered with soil

Fertigation

Application of 100% RDF with urea and potash as straight fertilizers and P as water soluble fertilizer weekly once which gives an yield of 49.11 t/ha with BC ratio of 2.94.

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 on 60 and 90 days after planting ensures 15-20% higher rhizome 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 40 and 90 daysafter planting after weeding, application of fertilizers and earthing up. Normally, this operation is done in rainfed areas particularly in high rainfall regions and slope land.

Weed management

Weeding has to be done thrice at 60, 90 and 120 days after planting or 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 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 to be given in clayey soils and 40 irrigations in sandy loams in conventional system of irrigation. Drip irrigation daily or alternate day also useful.

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 inter crop to get a supplementary income before the main crop is harvested. Intercropping turmeric with small onion and 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 returns are realised from by adopting 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 HEALTH MANAGEMENT

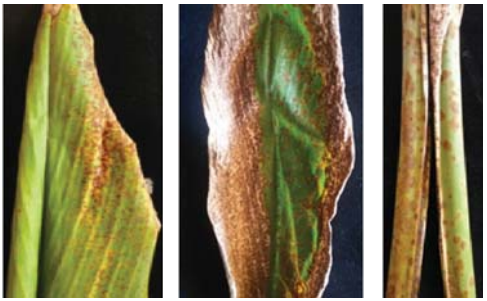
- Farmers are advised to identify the pest properly with the help of plant protection experts and to follow IPM strategies for sustainable production.
- Farmers shall keep a record of the plant protection chemicals used during the cropping season.
- Proper precautions should be taken while spraying chemicals to avoid contamination beyond the application area.
- Preparation of spray fluids should be carried out in a designated area away from any natural water bodies, drinking water sources, human dwellings etc.
- It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.
- Plant protection chemicals must be stored in a dry, well ventilated facility with displayed information on hazardous chemicals inaccessible to children and unauthorized people.
- Farmers should follow the waiting period recommended by authorized Institutes for repeated application of pesticides and advised not to mix pesticides.
- Spray should not be done during peak period of bee activity to protect bees.

- It is advised to spray pesticides in the afternoon hours avoiding strong windy condition and rains.
- Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.
- Avoid eating, drinking, smoking or chewing while preparing spray solution and the containers, buckets etc used for mixing pesticides should not be used for domestic purpose.
- Select right kind of sprayer with appropriate nozzles for spraying. It is advised not to blow/clean clogged nozzle with mouth.
- Left over spray solution and empty containers should not be disposed in ponds, water bodies etc.
- Combustible containers can be burnt if the container labels permits burning.
- Containers made of paper, cardboard & plant materials can be disposed off by burning. Non combustible containers should be broken or deformed by punching holes at several places to prevent reuse.

Disease Management

Leaf blotch

Leaf blotch is caused by *Taphrina maculans* and 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 with mancozeb 0.2% or copper oxy chloride 0.25% or propiconazole 0.1% at fortnight intervals.

Leaf spot

Leaf spot is caused by *Colletotrichum capsici* and 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 fortnight intervals.

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 spread 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 fortnight intervals.

Rhizome rot

The disease is caused by *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.

Rhizome rot infection

Management

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

Nematodes

Root knot nematodes (*Meloidogyne* spp.) and burrowing nematode (*Radopholus similis*) are the two important nematodes causing damage to turmeric. Root lesion nematodes (*Pratylenchus* spp.) are of common occurrence in Andhra Pradesh and Tamil Nadu. Root-knot nematode feed on tender rhizomes, roots and base of pseudostem causing stunting, chlorosis, poor tillering and necrosis of leaves are the common aerial symptoms. Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water soaked areas in the outer tissues. Nematode infestation aggravates rhizome rot disease. Nematodes survive in soil and infected rhizomes as primary inoculum. It spreads from infected plants or through soil

Management

- Avoid planting turmeric after Banana or solanaceous vegetables.
- Apply neem cake @150 kg/ha
- Plant marigold as inter/ border crop
- Apply biocontrol agent *Pochonia chlamydosporia* @ 20g/bed

Rosetting of leaves

Galls on roots

Pest Management

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.

Bore-hole on the pseudostem

Shoot borer larvae

Management

Spray chlorantraniliprole or flubendiamide or spinosad (0.3 mL/ 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.

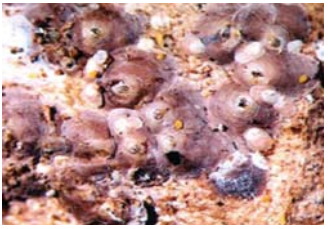
Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages of the crop) and in storage. Adult (female) scales are circular 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 insecticides for 20-30 minutes before storage and also before sowing in case the infestation persists.
- 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 the leaves causing them to roll, 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)
- Spray neem oil 3.0 % or NSKE 5.0 %

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.

Leaf feeding beetle

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 NSKE 5.0 %

Leaf roller

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

HARVEST AND POST HARVEST MANAGEMENT

- Harvesting season is determined and followed on the basis of qualitative parameters set for the end product rather than the total vegetative yield.
- Clear instruction should be available for farm worker to use proper cutting devices and avoid harvest of unwanted plants.
- A documented procedure should exist for cleaning containers and avoiding mixed up and contamination of produce.
- Washing and cleaning methods need to be ensured for the freshly harvested materials to ensure removal of soil particles adhering to the materials.
- Processing area must be clean with a proper platform and shade.
- Proper drying techniques need to be adopted for drying and storage of harvested crop produce. Drying procedure and the temperature employed should be in conformity with the quality needs of the farm produce.
- Sorting procedure need to be carried out after the completion of drying phase and before the material is packed.
- Selection of packaging material must be based on the quality requirements and possible length of storage before consumption/processing and need to be kept clean, dry and undamaged.
- Storage area must be kept clean and free from insect pests. Proper separation need to be implemented to keep different products of the crop separately.

Harvesting and on-farm processing of turmeric

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. 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. The harvested rhizomes are collected manually and all the extraneous matter adhering to them is cleared.

Preservation of seed rhizomes

Rhizomes for seed purpose are generally stored by heaping in well ventilated rooms and covered with turmeric leaves. The seed rhizomes can also be stored in pits with saw dust, sand along with leaves of *Stychnos nuxvomica* (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 (0.075%) solution for 20-30 minutes if scale infestations are observed and in mancozeb (0.3%) to avoid storage losses due to fungi.

Post harvest processing

The harvested turmeric rhizomes before entering into the market is converted into a stable commodity through a number 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 ranging from 19 to 23%.

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. Boiling destroys the vitality of fresh rhizomes, avoids the raw odour, 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 by pressing a pointed stick in to the rhizomes with 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 yellow interior instead of red one. 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 turmeric 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. 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 are provided in the outer drum. The capacity of four inner drum is 100 kg. 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. After placing the turmeric boiler in the furnace, about 75 litres of water is added (6-8 cm depth). About 55 - 70 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 produce steam and boil the initial batch of rhizomes and 10 - 15 minutes for the subsequent batches. Through the inspection door, the stage of boiling of the rhizome is assessed by pressing the rhizomes with a hard pin / needle. the next batch, about 20 litres of water is added to the outer drum, depending on the water lost by evaporation. 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 gadget. The capacity of the boiler is about 100 kg per batch and the fuel requirement is 70 – 75 kg of agricultural waste materials.

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 time, the material should be heaped or covered. It may take 10-15 days for the rhizome to become completely dry. he 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 by 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 transmits 90 percent light. 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 condition. The yield of the dry product varies from 20-25% depending upon the variety and the location where the crop is grown.

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 the polishing wastage during full polishing and 2 to 3% during half polishing. Polishing of dried turmeric also helps in removing the wrinkles.

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.To obtain attractive product, turmeric powder is sprinkled during the last phase of polishing.

Cleaning, grading, packing and storage

Although Indian turmeric is considered to be the best in the world, about 90% 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 bound to gather contaminants during various stages of processing. The spice is also 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.

IDENTIFICATION AND TRACEABILITY

The final produce need to be legibly labelled with the product name, month and year of harvest and the name of farmer/farming agency.

- If the produce was tested before, an appropriate label may be used indicating quality approval.
- The products need to be traceable back to the registered farm (and other relevant registered areas) from where it has been grown.

PERSONNEL AND EQUIPMENT

- Key resource persons engaged at the site (such as farm owner/ supervisor) must be familiar with all aspects related to the crop such as, quality requirements of the end product, crop husbandry etc.
- The personnel engaged in cultivation should have basic exposure to subject matters like safety and hygiene.

Protective clothing for workers

- The machinery used for fertilizer and pesticide application must be calibrated at prescribed schedules and calibration certificates / records should be maintained.
- Equipments must be clean and mounted whereever applicable, in an easily accessible manner. Scheduled servicing procedures must be adhered to keep them in working order. Additional care should be taken for cleaning those machine parts that get into direct contact with the harvested produce.
- Workers need to be equipped with suitable protective clothing. Complete sets of protective clothing, (e.g. rubber boots, waterproof clothing, protective overalls, rubber gloves, face masks, etc.) with label instructions and legal requirements as authorized by a competent authority need to be complied.
- All workers handling and/or administering plant protection chemicals, disinfectants, biocides or other hazardous substances and all workers operating dangerous or complex equipment should have certificates of competence .
- Permanent and legible signs indicating potential hazards, e.g. waste pits, fuel tanks, workshops, access doors of the plant protection product / fertiliser / any other chemical storage facilities as well as the treated crop etc. must be made available.

Inputs storage shed

Power tiller drawn harvester

Turmeric harvester

Boiler TNAU

Boiler - for large scale boiling

Toxicity class of fungicides/insecticides/herbicides recommended for turmeric cultivation

Mancozeb		Slightly toxic
Chlorantraniliprole		Slightly toxic
Flubendiamide		Slightly toxic
Propiconazole		Moderately toxic
Metalaxyl- mancozeb		Moderately toxic
Copper oxy chloride		Moderately toxic
Spinosad		Moderately toxic
Pendimethalin		Moderately toxic
Oxyfluorfen		Moderately toxic
Quizalofop ethyl		Moderately toxic