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Agrotechniques for organic turmeric production and processing

Nilima Darekar, Adinath Paslawar and Anuradha Watane

Abstract
Turmeric (*Curcuma longa* L) is the important spice crop of India known as golden spice. In India it is cultivated with an area of 2.45 lakh hectare with a production of 9.39 Lakh MT. In Maharashtra, it is cultivated with an area of 0.15 Lakh ha and production of 0.40 Lakh tonnes. India is the major producer and exporter of turmeric and earned a foreign exchange of 217.87 million $. The medicinal and cosmetic uses of turmeric are increasing significantly over the years. In the world, due to an increase in health consciousness peoples are mostly prefer organically produced products for daily consumption. Turmeric is a rhizomatous crop, requires heavy application of nutrients for boosting the yield. Being a long duration crop, it extracts lot of nutrients from the soil. After the enforcement of the green revolution in India, the use of chemical fertilizers for agriculture uses is increasing day by day. But in the present era, there is a extended use of chemical fertilizers which leads to cause of harmful effects. The use of organic manures in the agricultural plays a vital role in improving the quality of turmeric as well as improving the soil health. Turmeric is having a close relation with human health; hence demand of organically grown turmeric is increasing tremendously.
The organic manures are available in varied sources so there is a need for judicious and balanced use of these sources for improving productivity along with fertility. They have ability to improve balanced nutrition with efficient irrigation method ensures good crop growth and yield. It is important to understand that under an organic system weed will never be eliminated but only managed. Weed control in organic systems focuses on management technique designed to prevent weeds, as well as the production of crop having vigorous enough to out-compete weeds and reduce the availability of resources to the weeds. The main target of weed management in organic farming is to reduce the degree of direct control inputs and to bring about substantial yield improvement of the crop. Turmeric crop is highly prone to several fungal diseases. Eco-friendly disease management holds substantial importance in spice crop as most of them consumed as for direct spice purposes. Conventionally rhizomes were boiled in water which results less retention of curcumin content and essential oil. Processing time of turmeric rhizome is also very large in conventional system. Hence modification is done and improved system is developed for processing of turmeric. This system requires area small in size and less time required for the processing. The essential constituent of turmeric is curcumin which retain to higher value as compare to conventional system.

Keywords: turmeric, organic, production, practices, processing

1. Introduction
Turmeric is rhizomatous herbaceous plants botanically known as *Curcuma longa* and belong to family *Zingiberacea*. It is an important commercial spice crop grown in India since ancient times and is also known as Indian saffron or golden spice or spice of life. Turmeric (*Curcuma longa* L.) is one the most important and ancient spice of India, contains about 69.49 carbohydrate 6.30 protein, 5.10 oil and 3.50% mineral and other important elements in dry turmeric (Swain *et al*., 2007) [27]. Turmeric contains up to 5% essential oils and up to 5% curcumin, a polyphenol. Curcumin is the active substance of turmeric and curcumin is known as C.I. 75300, or Natural Yellow 3. The keto form is preferred in solid phase and the enol form in solution. Curcumin is a pH indicator. Turmeric has anti-inflammatory (painkiller), carminative, anti-flatulent, antimicrobial, anti-tumor, antioxidant, anti-arthritic, anti-amyloid, anti-ischemic and anti-inflammatory properties. The herb contains health benefiting essential oils such as turmerone, zingiberene, cineole, and p-cymene. This traditional herb does not contain any cholesterol; however, it is rich in antioxidants and dietary fiber, which helps to control blood LDL or "bad cholesterol" levels. It contains good amounts of minerals like calcium, iron, potassium, manganese, copper, zinc, and magnesium.
Among the organic spices exported from India, turmeric holds the most important position

next to chilli. There is a great demand for organic spice products both in domestic and foreign market. Most usage of turmeric is in the form of rhizome powder, in some regions leaves of turmeric are used to wrap and cook food. Turmeric is a nutrient exhausting crop and responds well to organic manures and fertilizers. Growing demand for natural colours in industry, fast food chains, pharmaceuticals offer a potential scope for organic production of turmeric. There is a great demand for organic turmeric in USA, Germany, France and Japan. Turmeric being a long duration crop extracts lot of the nutrients from the soil. Utilization of Farm yard manure in agriculture is recommended for retaining productivity of problem soils, reducing the usage of chemical fertilizer, improving economy in agriculture and minimizing environmental problems (Xiao, 2006) [9]. India leads in production of turmeric, but average productivity is very low owing to imbalanced and suboptimal dose of chemical fertilizers and organic manures (Kandianna and Chandaragiri, 2008; Roy and Hore, 2011) [12, 21].

It is intensively grown in the highland with sandy loam soil. Turmeric favours to grow well in partial shade to sunny conditions. Turmeric ranks 4thas foreign exchange earner among the spices. Constant use of chemical fertilizers under monoculture over a long period of time was found to impair the ecological balance in huge dimensions. Therefore, it is inevitable to adopt a strategy for judicious use of organic manures and biofertilizers. Likewise the use of bio-fertilizers have a supplementary nutritive role in productivity are ecofriendly, cost effective and enhance the soil fertility status. Importance of bio-fertilizer and organic manures in turmeric was reported by various workers in relation to quality and productivity of crop (Velmurugan *et al*., 2009) [28].

2. Origin and distribution

The genus Curcuma longa has a wide spread occurrence in the tropics of South East Asia. Turmeric has been distributed in India, South-East Asian countries and North Australia. In India, turmeric is extensively cultivated in the states of Telangana, Andhra Pradesh, Odisha, West Bengal, Tamil Nadu, Assam, Maharashtra, Karnataka, Bihar and Kerala. (Mirjanaik and Vishwanath, 2020) [15]

3. Improved varieties for turmeric cultivation

Table 1: Improved varieties for turmeric cultivation

Sr. No.	Variety	Rhizome Yield (q/acre)		Curcumin (%)
		Fresh Rhizome	Dry Rhizome	
1.	Phule Swarupa	145	32	5.19
2.	Selam	150	30	4.5
3.	Krushna	140	25	2.5
4.	Rajapuri	110	22	4.0
5.	Kadappa	150	25	3.5
6.	Waigaon	100	22	4.0
7.	IISR Prabha	150	30	6.5
8.	IISR Pratibha	155	28	6.2
9.	IISR Alleppi	140	27	5.5
10.	IISR Alleppey Supreme	142	27	6.0
11.	Suvarna	71	14	4.3
12.	Suguna	118	14	7.3
13.	Rajendra Sonia	68	25	8.4
14.	Pragati	61	19	5.02
15.	PDKV Waigaon	105	25	5.2
16.	Mega Turmeric 1	94	15	6.8
17.	Varna	88	17	7.9
18.	Sohba	145	28	7.4
19.	Sugandham	60	14	3.1
20.	Roma	84	26	6.1

4. Species

- ***Curcuma longa*:** Cultivated one referred as Longa types
- ***Curcuma aromaticum*:** Rhizomes possess pleasant unique aroma due to volatile oil popularly known as Kasthuri types
- ***Curcuma amada*:** Rhizome have odour of raw mangoes and popularly called as mango ginger. Used for preparation of pickels
- ***Curcuma angustifolia*:** Strach extracted from rhizomes, referred as Indian arrow root
- ***Curcuma zedoaria*:** Musky odour with smell of camphor and pungent bitter taste

(Mirjanaik and Vishwanath, 2020) [15]

5. Production potential of Turmeric in India

India's total area under spice crop is almost 3858 thousand ha from which turmeric occupies nearly 6% and production is 9% among spice production. India's scenario of turmeric with regard to area & production was 245 thousand ha area & 939 thousand MT of production in 2019-20. The scenario of turmeric is highly fluctuate due to various reasons such as vagaries of rainfall in major turmeric growing states, incidence of diseases, low price in last two years, etc. The productivity of turmeric is also decline in last two years due to vagaries of rainfall in major turmeric growing states, incidence of diseases. The major turmeric growing states of India are Telangana, Karnataka, Maharashtra, Assam, etc. Among which Telangana has maximum share of 37% and Maharashtra 5%.

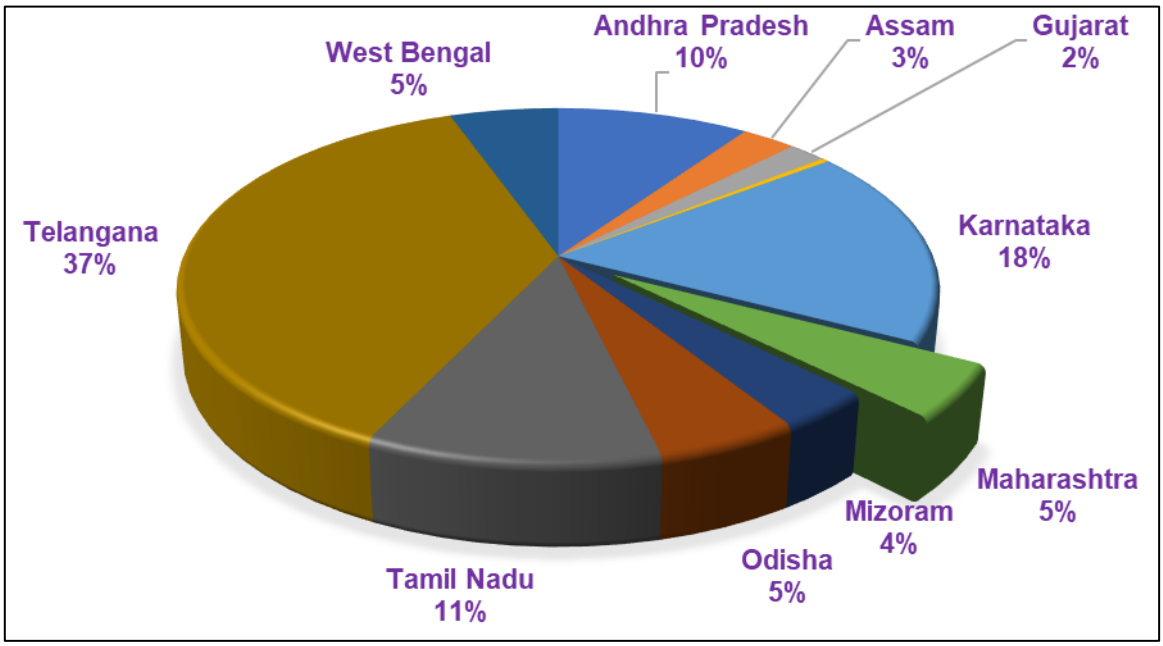
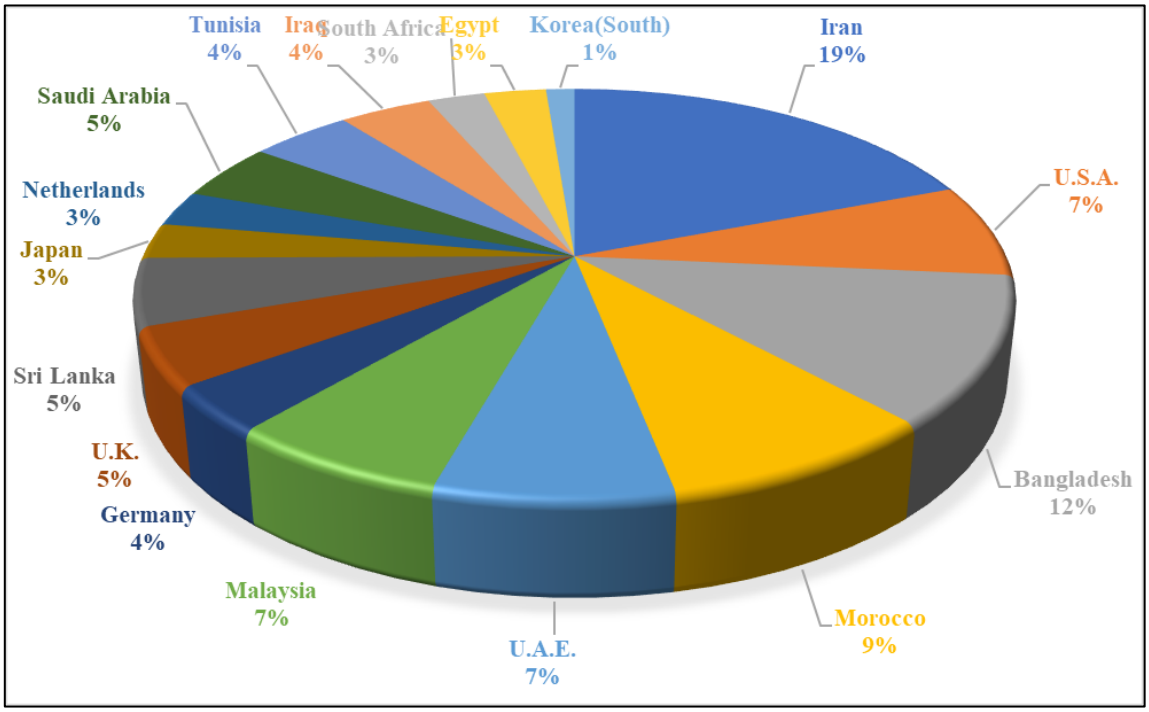


Fig 1: Turmeric Growing States in India



Anonymous, (2021)

Fig 2: India's turmeric export scenario

6. Opportunities and Strengths for Export

6.1 Domestic strengths for exporting turmeric

- India is a largest producer of turmeric in the world.
- India has improved and high yielding cultivars of turmeric.
- Potential for productivity increase at the national level (kg/ha) can be achieved through research station and progressive farmer plot.
- APEDA has sanctioned an Agri Export Zone for organic turmeric.

Small land holdings in Indian farming community may easily convert the zones into certified organic producers.

6.2 Opportunities at Global Level

- India has monopoly in turmeric trade at world level as India is the largest producer and exporter of turmeric in world.
- Also patenting of turmeric will be helpful for export.

Waigaon turmeric got Geographical Indication in 2016 as this turmeric have unique features than other it contain highest curcumin content (5.2%) and bright colour. The other varieties which has curcumin content greater than 5% have tremendous demand in global market.

7. Why Organic Turmeric?

Turmeric as super spice due to its vast array of health properties. But in conventional production there is uncontrolled use of agrochemicals make it inorganic. As we know the consumable part of turmeric is Rhizome. This

uncontrollable use of agrochemicals leads to residue stagnation both in soil as well as rhizomes. This is much harmful to health.

Exactly reverse was happened in organic farming, as we go for organic manures addition they add organic matter into soil; it leads to nutrient enrichment in soil and by activity of various beneficial soil microbiota turmeric rhizome uptake this nutrients for its development. Hence organically grown turmeric preserve its all health properties without any adverse effect. Hence best solution is grow only organic turmeric.

8. Prospects of Organic Turmeric

If farmers switch towards organic turmeric production; this organic farming offers possibility for

- Sustainable crop production
- Exploiting export opportunities
- Meets the domestic and foreign demands
- Minimization of cost of production
- Provide health benefits and nutritional security
- Maintain native soil fertility

9. Package of Practices for Organic Turmeric Production

Turmeric is long duration crop and planting done from April to June as vary from region to region. To increase production of turmeric under organic farming there is necessity to adopt various advance management practices regarding to nutrient management, weed management, irrigation management and disease management along with processing.

9.1 Conversion plan

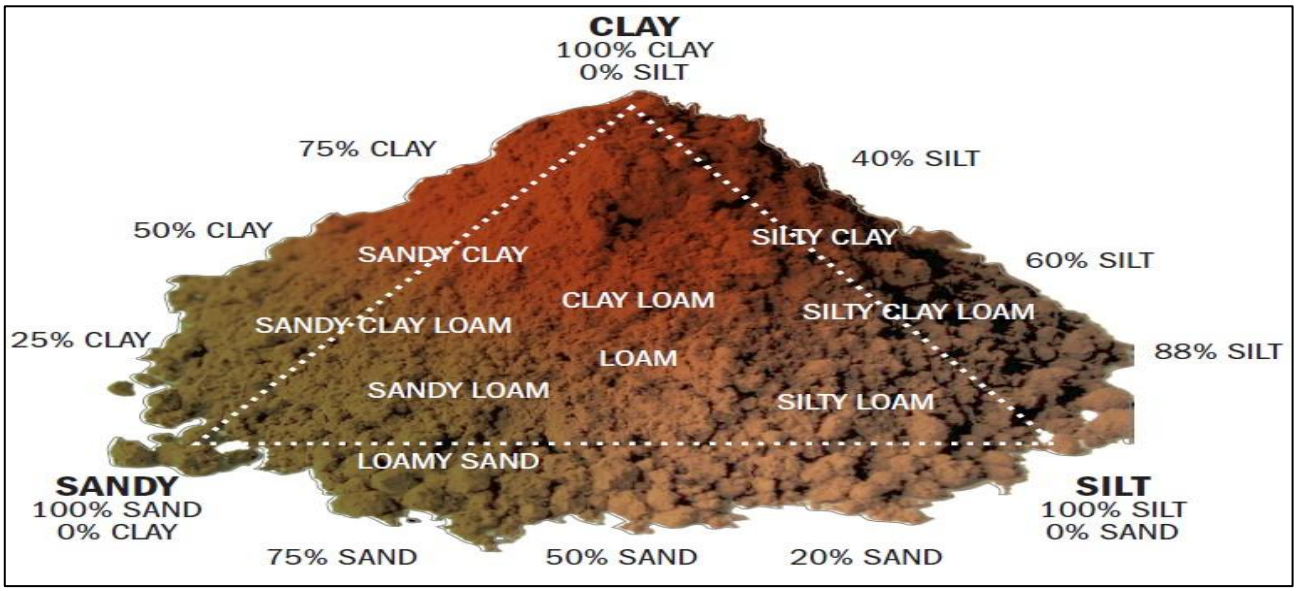
For certified organic production, at least 18 months the crop should be under organic management i.e. only the second crop of turmeric can be sold as organic. The conversion period may be relaxed if the organic farm is being established on a land where chemicals were not previously used, provided sufficient proof of history of the area is available. It is desirable that organic method of production is followed in the entire farm; but in the case of large extent of area, the transition can be done in a phased manner for which a conversion plan has to be prepared. Turmeric as a best component crop in agri-horti and silvi-horti systems, recycling of farm waste can be effectively done when grown with coconut, arecanut, mango, Leucaena, rubber etc. As a mixed crop it can also be grown or rotated with green manure/ legumes crops or trap crops enabling effective nutrient built up and pest or disease control. When grown in a mixed cultivation system, it is essential that all the crops in the field are also subjected to organic methods of production. In order to avoid contamination of organically cultivated plots from neighboring non-organic farms, a suitable buffer zone with definite border is to be maintained. Crop grown on this isolation belt cannot be treated as organic. In sloppy lands adequate precaution should be taken to avoid the entry of run off water and chemical drift from the neighboring farms. Proper soil and water conservation measures by making conservation pits in the interspaces of beds across the slope have to be followed to minimize the erosion and runoff. Water stagnation has to be avoided in the low lying fields by taking deep trenches for drainage. (Turmeric - Extension Pamphlet by ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, November 2015)

9.2 Climate requirement

Turmeric requires a warm and humid climate. It can be grown in diverse tropical conditions from sea level to 1500mm above MSL within a temperature range of 20-35°C with a rainfall of 1500 mm or more per annum or under irrigated conditions.

9.3 Soil requirement

Turmeric can be grown on different types of soils, it thrives best in well-drained clay loam soils with a pH range of 4.5-7.5 with good organic matter.



Clay

9.4 Planting

a) Method

Planting method is too much important task in case of rhizomatous crops like turmeric as it directly affect on growth and yield of crop. Dikey *et al*., (2019) results revealed that the effect of land configuration on number of tillers per plant, plant height, number of leaves plant-1, leaf area plant-1 and plant dry matter plant-1 was statistically significant during both the years of investigation. Planting of turmeric on broad bed furrow recorded the maximum number of tillers plant-1

(1.78 and 1.86), plant height (98.29 and 101.71 cm), number of leaves plant-1 (9.80 and 10.99), leaf area plant1 (44.70 and 48.77 dm^2) and plant dry matter plant-1 (78.05 and 85.64g) compared to that ridges and furrow method during the year 2014 and 2015 respectively.

Ridge & Furrow

BBF (Pair row system)

Broad bed

a) Season of Planting

May to July depending on tract. In Maharashtra, May is the best time of planting rhizomes. Karnataka and Tamil Nadu April-May sowing done. (Mirjanaik and Vishwanath, 2020) [15]

b) Seed Rate

Varies according to type of planting material, spacing and weight of rhizomes. The optimum spacing between the furrows keep as 45-60cm and two plant row with two plants as 30cm. Then the rhizome rate of planting is as mother rhizomes: 2000-2500 kg/ha and finger rhizomes: 1500-2000 kg/ha. As an intercrop in fruit garden: 400-500kg/ha. (Mirjanaik and Vishwanath, 2020) [15]

c) Rhizome Selection

Patel *et al*., (2018) [18] reported that the plants grown from mother rhizomes (35-40 g) when directly planted into field, reported the maximum plant height (128.49 cm), tillers per plant (3.18), number of leaves per plant (20.48), length of leaves (44.94 cm), leaf breath (11.67 cm) and germination percentage (99.67%) as well as weight of rhizome per plant (369.11 g) with minimum mortality percentage (0.33%) and yield of rhizome (27.14 t/ha). The economics point of view, maximum benefit: cost ratio (3.34) was observed with planting of mother rhizome pieces @ 10-15 g in pro tray and transplanting after 1 month with required minimum rate of seed rhizomes (1358 kg/ha) for planting in turmeric cv. GNT-1. It is confined that use of 50-60 g mother rhizome resulted in maximum biometric characteristics like plant height (121.33 cm), leaf size of length (62.79 cm), breadth (18.05 cm) number of leaves per plant (7.33), number of tillers per plant (4.24), and stem girth (2.20 cm) (Angami *et al*., 2017) [1].

d) Rhizome treatment

Naresh *et al*. (2015) [17] observed that technological interventions like rhizome treatment, soil application of Trichoderma (bio-control agent) in well rotten cow dung, wood ash, crop rotation, mulching, plant protection measures increased rhizomes yield by a tune of 20- 30% at farmers field.

9.5 Integrated organic nutrient management

In organic production the integration of various organic sources of nutrient are very much important for vigorous growth, higher yield and better quality of produce. Nutrients require on the basis of growth stage and the nutrient recommendations. The requirement of nutrients in turmeric under Maharashtra condition is 200: 100: 100 kg NPK and this varies from stage to stage and place to place. Nutrient requirement is maximum at vegetative stage followed by rhizome initiation stage and rhizome maturation stage & minimum at plant establishment stage. In organic turmeric management nutrients provide in split doses as its growing period is longer.

Table 1: Crop Growth Stagewise Nutrient Requirement of Turmeric

Crop Stage	Duration (in Days)	Nutrients Requirement (%)		
		N	P	K
Planting To Establishment Stage	15	10	20	10
Vegetative Stage	60	40	30	20
Rhizome Initiation Stage	60	30	30	30
Rhizome Maturation Stage	135	20	20	40

Kadam J.H. and Kamble B.M. (2020) [11] revealed that maximum dry yield (62.42 q ha^{-1}) of the turmeric was recorded by application of the general recommended dose of fertilizer (GRDF) i. e. 25 MT FYM + 200:100:100 kg N:P2O5:K2O ha^{-1} which was at par with the vermicompost (11.36 t ha^{-1}). The highest curcumin content was recorded in the GRDF, which was at par with vermicompost. The highest benefit: cost ratio (1.59) was also noticed in GRDF, which was at par with the application of vermicompost (1.54) on a nitrogen basis. The soil available nutrient status was taken

into consideration during experimentation. The application of vermicompost (11.36 t ha-1) along with Phosphate Solubilizing Bacteria and *Azospirillum* @ 5 kg ha-1, respectively at the time of planting was found superior for higher dry yield (55.45 q ha-1) and maintenance of soil fertility for organic cultivation of turmeric.

Bondre, *et al*., (2019) [3] revealed that for essential oil content of leaves and processed finger yield treatment improved with application of Neem cake @ 4 t ha-1 + *Azatobacter* (10 kg ha-1) + PSB (10 kg ha-1) + VAM (65 kg ha-1) found to be superior over other treatments. However, effect on quality parameters of rhizomes viz. curcumin, oleoresin content and recovery per cent of processed fingers were non-significant. The high essential oil content of leaves as influenced by different organic nutrient management treatments opted might be due to high available nutrients, better phosynthetic assimilates in leaves.

Datta, *et al*.,(2017) [5] results revealed that application of green leaf manure (from *Glyricidia maculata*) @ 12tonnes/ha along with rock phosphate @ 0.2 tonnes/ha, wood ash @ 1 tonnes/ha, *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha gave the significantly highest fresh (29.27 tonnes/ha) and dry yield (7.81 tonnes/ha) followed by vermicompost 5 tonnes/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (26.30 tonnes/ha and 6.99 tonnes/ha, respectively) which was statistically at par with sole application of 30 tonnes/ha farm yard manure (26.00 tonnes/ha and 6.77 tonnes/ha, respectively). This might be due to supply of all the essential mineral nutrients in a balanced amount which results better growth and development. The higher magnitude of growth parameters which ultimately provided longer and higher photosynthesis process and transfer the food material from source to sink. Organic manures improved soil productivity and fertility which in turns improved yield and quality of such long duration crop like turmeric.

Kurimella, *et al.*, (2016) [13] reported that application of FYM 15 t/ha + Vermicompost 3.8 t/ha + Neem cake 1.5 t/ha significantly enhanced the plant height, number of tillers, leaf area and stem girth followed by Vermicompost 7.5 t/ha + FYM 7.5 t/ha + Neem cake 1.5 t/ha and Neem cake 3 t/ha +FYM 7.5 t/ha + Vermicompost 3.8 t/ha. Significantly higher fresh rhizome yield (606.54 g/plant), projected dry yield (7.6 t/ha), curing (25.25%), curcumin (5.3%) and essential oil (4.2%) were also observed in FYM 15 t/ha + Vermicompost 3.8 t/ha + Neem cake 1.5 t/ha followed by Vermicompost 7.5 t/ha + FYM 7.5 t/ha + Neem cake 1.5 t/ha and Neem cake 3 t/ha +FYM 7.5 t/ha + Vermicompost 3.8 t/ha.

Singh R.P. *et al*., (2017) [26] revealed that the treatment combination of VC 5t/ha + *Azospirillum* 5kg/ha recorded maximum essential oil 4.94%. With regards to organic manures, the treatment Vermicompost 5t/ha recorded maximum essential oil 4.51% of turmeric while bio-fertilizer *Azospirillum* 5kg/ha recorded maximum essential oil 3.98% of turmeric.

Sarma, *et al*., (2015) [22] results revealed that the combined applications of FYM + vermicompost + neemcake increased plant height, number of fingers, girth of rhizome, weight of rhizome and rhizome yield. While minimum of these were observed in the absolute control. Highest rhizome yield (20.48 t ha-1) with maximum benefit- cost ratio (3.6) was obtained in the treatment combined applications of FYM + vermicompost + neemcake and the lowest yield (12.50 t ha-1) was obtained in the treatment of control with minimum benefit- cost ratio (3.1). The improvement in growth and yield parameters in the treatment combined applications of FYM + vermicompost + neemcake might be due to combined application of vermicompost and FYM that influenced the physical, chemical and biological properties of soil through supplying macro and micro nutrients leading to better plant growth and development.

9.6 Irrigation management

In turmeric production irrigation management is also important aspect as turmeric is long duration crop though there is no need of irrigation upto 1st forenight of October or may be 1 or 2 irrigation is given if dryspell occur. Then from middle of October it require regular irrigation. Irrigation provides through furrow method, sprinkler method and drip irrigation method.

Sunil A. Satyareddi* revealed that drip irrigation might have resulted in improvement of the biometric parameters resulting in better maintenance of relative water content in leaves. This might have induced progressive effect on growth attributes, extended period of greenness of crop is an indicative of profuse expansion of photosynthetic area and translocation of the absorbed nutrients as indicated by leaf area and chlorophyll content. Yield response to drip irrigation at 50 per cent soil moisture depletion was significantly higher over other methods. Drip irrigation recorded higher fresh rhizomes (25.85 t/ha), fresh mother rhizomes (5.86 t/ha) and cured finger rhizomes yield per ha (3.97 t/ha). Whereas, corresponding lower yield was recorded with furrow irrigation at 50 per cent soil moisture depletion. Furrow irrigation at 50 per cent soil moisture depletion might have resulted in the loss of added nutrients through leaching, runoff and other factors. On the contrary drip irrigation at 50 per cent soil moisture depletion might had facilitated for better development of rhizomes directly infusing higher nutrients into the rhizome resulting in increment of both rhizome volume and weight in comparison to other irrigation methods evaluated.

Satyareddi and Angadi (2014) [23] evaluated that drip irrigation applied at 50 per cent available soil moisture depletion recorded higher plant height (76.3 cm), number of tiller per plant (6.1), number of leaves per plant (21.3) in comparison to other irrigation methods. Yield response to drip irrigation was also significantly higher as exhibited by higher fresh weight of mother rhizomes (76.8 g/plant), primary rhizomes (187.6 g/plant), secondary rhizomes (63.0 g/plant) yield per ha (23.9t/ha). Whereas lower yield was recorded with furrow irrigation at 50 per cent soil moisture depletion (21.1 t/ha). Drip irrigation at 50 per cent soil moisture depletion facilitated better retention of moisture within the active root zone of turmeric which facilitated for better soil moisture regime for uptake of the nutrients. Maintenance of higher relative water content in leaves, reduced stomatal closure might have had profound effect on growth attributes. Higher LAD, an index of extended greenness of crop is an indicative of profuse expansion of photosynthetic area, translocation of the absorbed nutrients coupled with efficient resource utilization. Drip irrigation at 50 per cent soil moisture depletion facilitated for better expansion of rhizomes both in length and girth directly infusing higher nutrients into the rhizome in comparison to other irrigation methods evaluated. Furrow irrigation at 50 per cent soil moisture depletion might have contributed to the loss of added nutrients through leaching, runoff and other factors.

9.7 Weed management

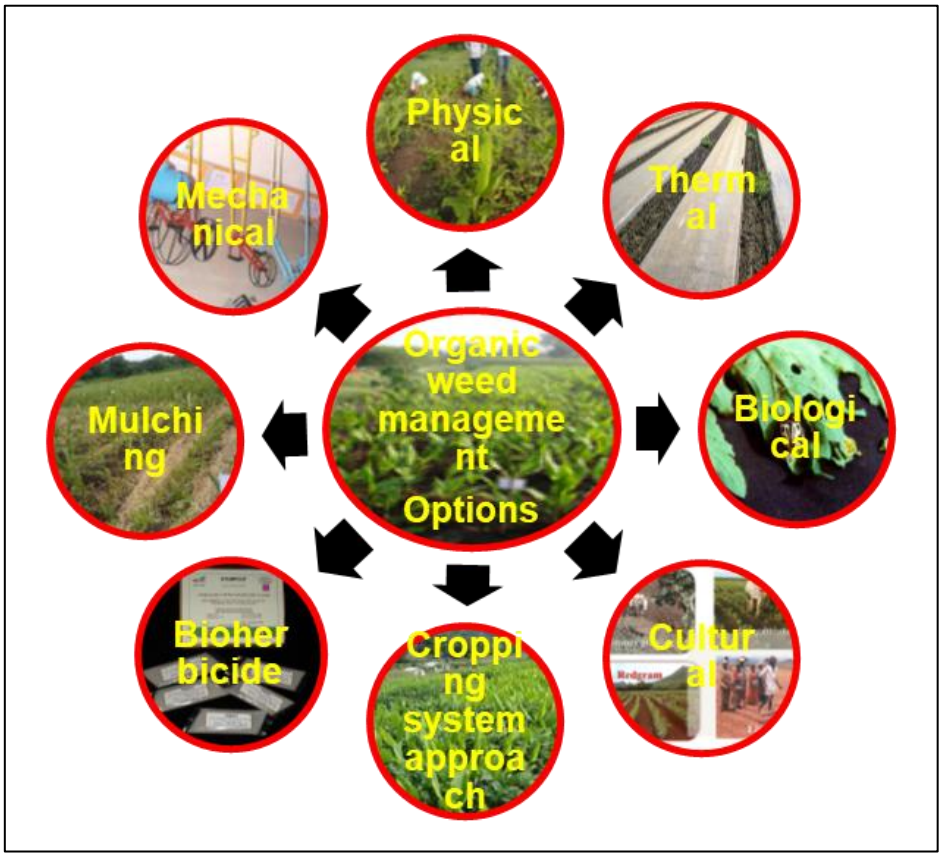
9.7.1 Why weed management is compulsory?

- Reduction in yield of crops (25- 80%).
- Depletion of nutrients from soils (30 – 50%).
- Competition for moisture with crop plants (25-40%)
- Reduction in availability of sunlight (25 -30%)

9.7.2 Need for organic weed management

- Area under certified organic farming is 2.299 Mha hectares.
- Weed management - Challenging problem in organic farming
- Extensive use of organic manures - Build up of soil seed bank
- Weed-crop competition relationships differ with organic and Conventional system.
- Organic systems tolerate a greater abundance of weeds compared to conventional systems.

A farmer who manages weeds organically must be intimately familiar with the type of weeds and their growth habits to determine which control methods to employ.



Need for organic weed management

Table 2: Effect of Different Organic Weed Management Practices On Weeds

Practice	Effect
Tillage	Kills growing weeds; damages perennial roots & rhizomes; buries seeds too deeply to emerge; brings weed seeds to surface.
Stale seedbed	Flushes weeds from the soil before planting.
Competitive cultivars	Improves competitive ability of crop against weeds.
Cover crops / Intercrops	Suppress weeds, improves soil health
Crop rotation	Disrupt the development of crop weed association
Using transplants	Competitive advantage to crop
Increase plant density	Suppress weeds by shading
Organic fertility source	Faster-growing weeds due to slow release of nutrient sources.
Post - planting cultivation	Removes weeds from the crop.
Drip irrigation	Direct water to the crops rather than to weeds.
Mulch	Smothers weeds, delays emergence of weeds
Rapid cleanup after harvest	Prevents seed set by residual weeds.

Maheshwari and Karthik (2019)

Chaudhary *et al*., (2021) [4] revealed that significantly lower dry weed biomass of total weed and weed control efficiency was observed under inter culture + hand weeding at 30 days after planting + paddy straw mulch 5 t/ha (30 days after planting) followed by hand weeding at 60 and 90 days after planting followed by inter culture + hand weeding at 30 days after planting + wheat straw mulch 5 t/ha (30 days after planting) followed by hand weeding at 60 and 90 days after

planting, paddy straw mulch 5 t/ha (0-3 days after planting) followed by hand weeding at 30, 60 and 90 days after planting and wheat straw mulch 5 t/ha (0-3 days after planting) followed by hand weeding at 30, 60 and 90 days after planting. The lowest plant stand at harvest was found in weedy check which was followed by plastic mulch (0-3 days after planting) followed by hand weeding at 20, 40 and 60 days after planting and plastic mulch (0-3 days after planting) followed by hand weeding at 30 and 60 days after planting. Significantly higher rhizome yield and B:C was registered under spreading of paddy straw mulch 5 t/ha followed by hand weeding at 30, 60 and 90 days after planting as compared to other treatment except spreading of wheat straw mulch 5 t/ha followed by hand weeding at 30, 60 and 90 days after planting. The lowest rhizome yield was registered under weedy check. Plastic mulch (0-3 days after planting) followed by hand weeding at 20, 40 and 60 days after planting and plastic mulch (0-3 days after planting) fb hand weeding at 30 and 60 days after planting remain at par with each other but inferior to other mulching treatment with respect to rhizome yield. Therefore, application of either wheat or paddy straw mulch became economical alternate method for the control of weed under organic cultivation of turmeric.

9.8 Intercultural Operation

In turmeric crops there is necessity of various intercultural operations such as weeding, earthing up and mulching for better growth of rhizomes that results into increase of size of rhizome and yield. Along with that various short duration vegetables crop taken as intercrop in turmeric. As turmeric is shade loving crop so there is grown of castor, pigeon pea for shade. Sidhu *et al*., (2016) [25] conducted experiment on effect of mulching, spacing and intercropping of green gram (*Vigna radiate*) on growth, yield and quality of turmeric (*Curcuma longa* L.) opined that maximum plant height (74.7 cm) number of tillers (2.3/plant) fresh rhizome yield (176.4 q/ha) processed rhizome yield of turmeric (48.9 q/ha) when inter row spacing of 37.5 cm provided along with mulch.

9.9 Insect pest

The important pest occurred on turmeric crop are shoot borer (*Conogethes puctiferalis*), rhizome scale (*Aspiodiotus hartii*) and nematodes (*Meloidogyne* spp) which interfere with the rhizome growth and yield also quality. The application of Neem cake + *Paecilomyces lilacinus* (3.75g/3kg soil) performed better with maximum plant height (72.00 cm), fresh rhizome weight (325 g), dry rhizome weight (65 g) and least number of galls (23.50) and lowest soil nematode population (153.25) reported by Prabu *et al*., (2018) [19].

9.10 Major Diseases on Turmeric Crop

9.10.1 Rhizome rot

- 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.

9.10.2 Leaf spot

- Symptom 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, spots may coalesce and form an irregular patch covering almost the whole leaf.

9.10.3 Leaf blotch

- Disease 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.

R. S. Mishra and J. P. Singh (2019) [16] showed that all treatments were significantly superior over control for management of Taphrina leaf spot of turmeric in field condition. Among the treatment cow urine based botanical formulation was most effective at 90 days (44.04%) in comparison to acetone based botanical formulation (37.22%) and distilled water based botanical formulation (45.61%). The plant extracts of madar, datura and botanical formulation were showed broad spectrum of activity against several diseases. Cow urine based botanical formulation and individual each plant extracts at 20% concentration were significantly minimized *Taphrina maculans* over the control. It has been shown that cow urine posses antimicrobial activity against plant pathogenic microbes especially *Taphrina maculans*. Finding of experiment showed that all treatments significantly increased the plant height and fresh rhizome yield of turmeric over the control. The maximum plant height was recorded in cow urine based botanical formulation (138.94cm) and individual plant extract because cow urine has rich contents of sodium, nitrogen, sulphur, vitamins A, B, C, D and E, minerals, manganese, iron, magnesium etc, which help to curing plant disease and increased the plant growth. Hence, Cow urine based formulation would definitely prove to be a potential medicine which in turn would reduce the pressure on the existing use of chemical and antibiotics; it could be a major step in disease management.

9.11. Harvesting and Yield

Turmeric is harvested when leaves start yellowing and ultimately the stem dries down. Starts from February and continues till April. Rhizomes are ready for harvest in 7-9 months after planting. Harvesting consists of digging of underground clumps of rhizomes with Pick axe or digging fork. Fingers are separated from mother rhizomes. Hossain (2010), conducted research on effects of harvest time on shoot biomass and yield of turmeric (*Curcuma longa* L.) in Okinawa, Japan. Results are revealed that per cent of dry yield to fresh yield was higher i.e 14−22 in December and 15−24 in January; and yield-shoot ratio in dry weight was 1.2, 0.9−2.2.

9.12 Certification

Under organic farming, processing methods also should be based on mechanized, physical and biological processes to maintain the vital quality of organic ingredient throughout each step of its processing. All the ingredients and additives used in processing should be of agriculture origin and certified organic. In cases where an ingredient of organic agriculture origin is not available in sufficient quality or quantity, the certification programme authorizes use of non organic raw materials subject to periodic re-evaluation. Labeling should clearly indicate the organic status of the product as “produce of organic agriculture” or a similar

description when the standards requirements are fulfilled. Moreover organic and non-organic products should not be stored and transported together except when labeled or physically separated. Certification and labeling is usually done by an independent body to provide a guarantee that the production standards are met. Govt. of India has taken steps to have indigenous certification system to help small and marginal growers and to issue valid organic certificates through certifying agencies accredited by APEDA and Spices Board. The inspectors appointed by the certification agencies will carry out inspection of the farm operations through records maintained and by periodic site inspections. Documentation of farm activities is must for acquiring certification especially when both conventional and organic crops are raised. Group certification programmes are also available for organized group of producers and processors with similar production systems located in geographical proximity.
(Turmeric - Extension Pamphlet by ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, November 2015)

9.13 Processing Of Turmeric & Advancements
Almost 90% turmeric of is expected for processing. Due to processing of turmeric, various products are prepare such as turmeric powder, essential oil, turmeone oil, curcumin, oleresin, etc as per market demand.
The processing of turmeric done by two methods namely
1. Conventional method-- with boiling and
2. Advance method--without boiling.

9.13.1 Processing of Turmeric by Conventional Method
- Harvesting
- Cooking- at cooking time add cowdung for curcumin spread
- Drying
- Polishing/ Colouring
- Grinding/ Powdering
- Packing
- Storage

9.13.2 Cleaning and Drying
Jose and Joy, (2009) [10] conducted experiment on solar tunnel drying of turmeric (Curcuma longa linn. Syn. C. Domestic val.) for quality improvement. The results proved that conventional processing could maintain the intrinsic quality up to a certain level, but extrinsic quality could not be achieved. Solar tunnel drying method is an effective alternative to traditional open sun drying, where retention of curcumin (5.83%) volatile oil (4.74%) and oleoresin (12.4%) was high, with less drying time. The quantitative analysis showed that the traditional drying i.e., open sun drying had taken 11 days to dry the rhizomes while solar biomass drier took only 1.5 days and produced better quality produce (Prasad *et al*., 2006) [20].

9.13.3 Curing
It involves cleaning of fresh rhizomes, boiling in water and drying in sun. Jayashree *et al*., (2016) [9] studied on processing of turmeric (Curcuma longa) by different curing methods and its effect on quality they opined that turmeric cured by cooking in boiling water for 40, 60, 90 min, took 11 days for complete drying, maximum retention of curcumin (5.91%) and essential oil (3.6%) was obtained for rhizomes cured for 40 min. While turmeric rhizomes cured by steam cooking for 30, 45 and 60 min took 24, 23 and 12 days for drying.

9.13.4 Polishing
Dried rhizomes are smoothing and polishing outer surface by manual or mechanical rubbing. Polishing drum rotates are employed.

9.13.5 Colouring
Boiled and half polished rhizomes are added with turmeric powder to give good appearance.

9.13.6 Grading
1. Fingers: Fingers usually range in size from 2.5 to 7.5 cm in length and may be over 1 cm in diameter.
2. Bulbs: These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers.
3. Splits: Splits are the bulbs that have been split into halves or quarters to facilitate curing and subsequent drying.

9.14 Advance method--without boiling
a) Advanced Mechanical Dryers & Polishers For Turmeric Drying (MPUAT, Udaipur**)**
Peeling machine, Solar dryer and Polisher have been developed to facilitate processing operations in efficient manner.
a) Plant & Machinery - Washing vessel, Peeling machine, Blanching vessel, Solar dryer/ mech. dryer, Polisher, Pulveriser, heat sealing machine
b) Power - 2 hp 3 phase power connection
c) Man power - 2 unskilled labours
d) Land - 200 Sq m
e) Initial investment = Rs 4,90,600/ (Approximately)
f) Unit cost of turmeric processing= Rs.1.55 per kg
g) Time saving - 9.33 h/q

b) Advance Method for Making Turmeric Powder Developed By Dr. PDKV, Akola.
- Intensive washing of rhizomes with tap water
- Cut the rhizomes/ fingers into 1 cm size or make chips
- Vacuum drying of cut fingers for 60 to 75 min
- Drying in solar or cabinet dryer at 55 to 60^0C

-- 6to 7 hrs for cut fingers
-- 3 to 4 hrs for chips
- Grinding through pulverizer for making powder

Features
- Fresh rhizomes are directly used for powder making.
- Boiling, drying and polishing is not performed.
- It takes about 12 hours only.
- Curcumin content of powder is 1.5 times more than traditional method i.e. more than 5%.
- 7 – 8% more recovery of powder is achieved.
- Fulfills the export standards and applicable to organic product also.

10. Organic turmeric offers
- Sustainable and cost effective production technology with high B:C ratio
- Heath benefits with no hidden adverse effects.
- Positive and stable increase in yield attributes through use of organic inputs like manures, biofertilizers, mulching etc.
- Assurance and exploitation for export opportunities through value addition.

11. Constraints

- Lack of awareness for organic products among consumers
- Lack of separate marketing channel
- Standardized, need based, time and cost effective processing methods are not developed.
- Lack of holding power of producers for storage facilities and processing.
- Loss in quality due to diseases and pests.

12. Future Perspectives of Turmeric

- The forecasted population increase is up to 1619 millions in 2050 with increased GDP and per capita food spending.
- Total demand for export and domestic markets also hastens by 2050 will be 2882.15 (000 tons) in which demand for organic turmeric will be key factor.
- Productivity to meet the total demand of turmeric by 2050 shall be 10.03 T/ha.
- Competing countries with India in production and export of organic turmeric are Malaysia, Fiji, Philippians, Jamaica, Nigeria, Sierra, Leone.

13. Conclusion

India is major player in conventional turmeric production and processed products too. Also have potential to emerge as largest Organic Producer in global market by 2050. Use of advances management in organic turmeric production can increase its sustainable productivity. Integrated organic management is viable option for increases organic turmeric production. India will have to develop very competitive edge in all aspects including competitive organic production, post harvest and value addition of turmeric, if it has to secure and increase its present position in the international trade of turmeric as in upcoming days due to increased awareness of global troops demand will be only for organic.

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