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EXPLORATION OF TURMERIC (*Curcuma longa* L.) CULTIVATION : A REVIEW

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ABSTRACT : Curcuma longa L is an important sacred and spice crop of Asia, used in several culinary purposes and also for treatment of several diseases. It is cultivated for its rhizomes for extraction of curcumin forming the principal source of drugs and colouring principle. In India, Andra Pradesh, Karnataka, Tamil Nadu are the major state producing turmeric. There is a need to standardize the production technology which may help to improve the yield, quality so as to extend the farmers' hand of reliability so that they can get high net returns per unit area. The present review is focusing on production practices of Curcuma longa L.

Key words : *Curcuma longa, turmeric, herbal medicine, production.*

Turmeric (*Curcuma longa* L.) is an important, sacred and ancient spice of India. It is a major rhizomatous spice produced and exported from India. Turmeric is a herbaceous perennial plant, native to tropical South-East Asia, belonging to the family Zingiberaceae, under the order Scitaminae. It is cultivated for its underground rhizomes which is used as spice and condiment, dye stuff and in cosmetic and drug industry, particularly in the preparation of anti-cancerous medicines. It forms an important adjuvant in Indian culinary as it imparts colour and aromatic flavour to various dishes. Turmeric is widely used as a condiment in the preparation of pickles and curries and as a colouring agent in textile, food and confectionary industries. It is also used as herbal medicine *'Amraharidra'*, which gives a cooling, aromatic effect and promotes digestion (Srivastava *et al.,* 25). Turmeric has long been used in India for the treatment of sprains and inflammatory conditions. The turmeric rhizomes contain 'curcumin' which is responsible for colouring.

India is the world's largest producer and exporter of turmeric and it produces nearly 50 per cent of global turmeric production. It is grown in an area of 1.92 lakh hectares with an average production of 8.93 lakh MT (Anon., 1) with an average production of 156.31q/ha (Deshmukh *et al.,* 6). It is cultivated extensively in tropical regions of the world, from India to Indo-China, the East Indies and parts of China. It is also cultivated in Iran, Sri Lanka, China, Pakistan, East Indies, Indonesia, Libya, Nigeria, Sudan, Persia, Taiwan, Jamaica, and Peru. In India, it is mainly grown in the states of Andhra Pradesh, Orissa, Tamil Nadu, Assam, Maharashtra, Karnataka, Kerala and North-Eastern region. In Karnataka, it is largely cultivated in Chamarajnagar, Belagavi, Mysore, Mandya, Bidar, Kodagu, and Chikamagalore districts (Lokesh and Chandrakanth, 13).

In India, Andra Pradesh, Karnataka, Tamil Nadu are the major state producing turmeric. There is a need to standardize the production technology which may help to improve the yield, quality so as to extend the farmers a hand of reliability so that they can get high net returns per unit area. The present review is focused on production practices of *Curcuma longa* L. so as to promote the production of the crop in non-traditional areas. In this regard the studies on different aspects of *Curcuma longa* L. are reviewed and presented under different headings.

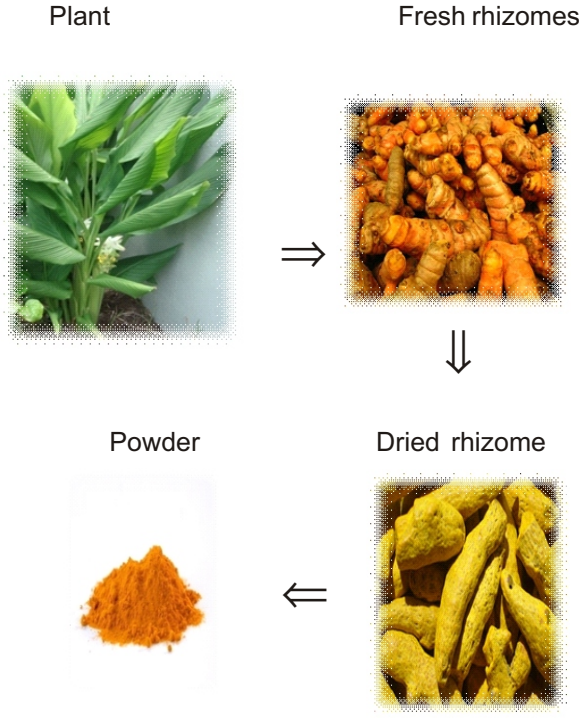

Fig. 1: Plant and plant parts of turmeric.

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Genotypic evaluation studies

Chaudhary *et al.* (5) evaluated five varieties of turmeric viz. Krishna, Suvarna, Rajendra Sonia, Suguna and Sudarshana and revealed that the variety Krishna recorded highest fresh (405.60 q/ha) and cured rhizome (65.80 q/ha) yield followed by Rajendra Sonia and Suvarna, while in curing percentage, Suvarna (20.68%) was found to be superior followed by Rajendra Sonia and Krishna. With regard to rhizome numbers and their size, Krishna produced more rhizomes (11.48), maximum length (10.20 cm) and girth (2.45 cm) followed by Rajendra Sonia. The varieties Suvarna, Rajendra Sonia, Suguna and Sudarshan were found to be early duration types (190 to 210 days) compared to Krishna, which matured relatively late (255 days). Krishna recorded significantly highest shoot dry weight (19.54 g) followed by Rajendra Sonia (17.96 g) at maturity.

Jilani *et al.* (8) conducted experiments at three different localities of Dera Ismail Khan region of Pakistan to evaluate the performance of turmeric cultivars including Duggirala, Zedory and Krishna The results showed the supremacy of Krishna over the other two cultivars in all the three localities, as Krishna took significantly least number of days (44.67, 46.00 and 48.33) to sprouting, maximum plant height (78.54, 73.64 and 75.43 cm), leaves per plant (13.74, 12.97 and 13.73), leaf width (8.733, 7.30 and 7.80 cm), maximum finger per plant (31.43, 54.44 & 37.00) in all the three localities.

In an evaluation of seven turmeric (*Curcuma longa*) varieties under irrigated condition for two crop season Chaturvedi *et al.* (4) found that varieties differed in their production potential and growth characters (plant height, number of tiller per plant, leaves per tiller, leaf length and leaf breath). Among varieties tested, Barua Sagar resulted in maximum production of fresh rhizome 33.50 t/ha (2006-07) and 30.25 t/ha (2007-08) and it was at par with the production of Azad Haldi-1 (32.60 t/ha and 29.85 t/ha) during 2006-07, 2007-08, respectively. These two varieties namely Barua Sagar and Azad Haldi-1 were significantly superior to the varieties during all the seasons and are suitable for general cultivation in the area of central Uttar Pradesh.

Rao *et al.* (18) studied the genetic divergence in fifty four turmeric (*Curcuma longa*) cultivars at Jagtial (Andhra Pradesh) by subjecting D_2 statistics to assess the genetic diversity available in the cultivars. The D^2 analysis showed wide diversity among the cultivars and they were grouped into six clusters. Inter-cluster distance values also showed wide genetic divergence among the cultivars. Based on cluster-mean values, the cultivars PTS-38 and Duggirala in cluster I (high cured yield), PCT-5 and PCT-8 in cluster III (high curcumin, essential oil and oleoresin contents) and PCT-13, PCT-14 and PCT-10 in cluster IV (short duration, medium yield with good curcumin content).

In-vitro studies

Gomathy *et al*. (7) conducted an experiment for the standardization of *in vitro* culture technique for the mass propagation of *Curcuma longa* L., Scooped rhizomatous buds were used as explants and they were cultured on MS medium supplemented with different concentrations of BAP, Kn and IAA both in individual and in combined form for shoot inductions and the best results were obtained from MS medium supplemented with BAP+IAA at the concentration of 2.0mg/l and 0.5mg/l, respectively. Best root formation of in vitro developed shoots could be achieved on half strength MS medium supplemented with IBA at concentration 1.0mg/l. The in vitro developed plantlets were transferred to pot and they were grown in greenhouse for hardening and finally they were planted in the open field. Around 90% of plants were successfully established in natural field condition.

Archana *et al.* (2) conducted an experiment to develop an efficient protocol for the development of micro rhizome and mini rhizome technology in high yielding variety of turmeric, Alleppey Supreme, using two media combinations and four types of culture vessels. Cultures in all media showed prominent basal bulging within one month of growth as an indication of micro rhizome induction irrespective of vessels used. In solid medium shoot number ranged from 1.0 to 5.55±0.71 and in liquid medium it ranged from 3.67±1.15 to 5.5±2.12. In both the medium, cultures grown in planton vessel showed higher number of shoots. Length of shoot did not exhibit any prominent difference in any of the media and vessel except for cultures grown in 350 ml bottle (B1) in solid medium where maximum shoot length (11.6±0.57) was observed. Yield was nearly three times higher in minirhizome seed material (526.67±9.5) compared to the conventional seed rhizome (183.0±8.30).

A high frequency *in vitro* plantlet regeneration method was developed for *Curcuma longa* L. (cv. Ranga) using fresh sprouting rhizome bud on semisolid culture media (Kambaska *et al.,* 10). The explants were cultured on Murashige and Skoog's (MS) medium supplemented with different concentration and combinations of BAP (6-Benzyl-amino-purine) and

NAA(α- Naphthalene acetic acid) for shoot and root induction. Explants cultured on MS basal medium supplemented with 2.0mg/l BAP+0.5gm/l NAA showed highest rate of shoot multiplication. *In vitro* shoots were rooted on to the half-strength MS basal media supplemented with 2.0 mg/l NAA and rooting was better. Rooted shoots were transplanted in the green house for hardening and their survival rate was 95% in the field condition.

Propagation studies

Singh *et al.* (24) used different planting materials of turmeric *i.e.,* mother rhizome, primary finger, secondary finger and tertiary fingers and observed data on plant growth, yield and yield contributing characters along with economics of turmeric cv. Erode. The highest number of fingers per plant (13.64), finger length (9.06 cm), finger weight (36.14g) and yield (389.47g/plant and 235.41 q/ha) were obtained by use of the mother rhizome.

In a study on the different rhizome sizes used for propagation of the turmeric, Meenakshi *et al.* (17) found that mother rhizomes recorded maximum numbers of tillers, number of leaves and plant height as compared to fingers used for propagation. Planting of mother rhizomes and fingers brought about significant variations with regard to number of tillers per plant at 150 DAP, number of leaves and plant height at 120 DAP. Leaf area was found to differ significantly both at 120 and 150 DAP, recording maximum at 150 DAP in all the cases and total dry matter production per plant differed significantly due to planting material. In all the cases mother rhizome was found to be superior than finger rhizomes. Like this, Kumar and Gill (12) also found that use of mother rhizome as planting material resulted in better emergence (86.6% and 83.1%), taller plants (49.6 and 50.0 cm) with more number of leaves and leaf area index (4.4 and 3.8), more tillers/ plant (2.7 and 3.1), higher number (17.09 and 23.89) and weight (136.96 and 227.66 g) of total rhizomes plant-1 as compared to use of primary and secondary fingers as planting material. Planting of mother rhizomes produced highest fresh (207.7q/ha), dry (46.0q/ha) and processed (44.1 q/ha) turmeric yield and it decreased significantly with decrease in seed size.

Nutritional studies

Application of different levels of S and Mg did not have any significant effect on the vegetative growth of the turmeric plants. Though maximum number of mother rhizomes and primary fingers, as well as highest length of primary fingers, was noted at 44 kg/ha of S and 22 kg Mg/ha (Bose *et al.,* 3). There was a significant increase in the weight of the mother rhizome at the above dose, which then declined with further increases in S and Mg levels. Significant variation in weight of primary fingers was observed due to S and Mg applications, also peaking with 44 kg S/ha in this study at application rates of more than 22 kg/ha of Mg, which reduced K uptake and caused losses in yield.

Kulpapangkorn and Mai-leang (11) studied the effect of plant nutrients on turmeric production with 5 treatments namely: 1) untreated check, 2) farm manure at 12 kg N/rai 3) farm manure at 12 kg N/rai plus chemical fertilizer at 5-5-5 (N-N-P_2O_5 -K_2O) kg/rai, 4) farm manure at 12 kg N/rai plus chemical fertilizer at 10-5-5 (N-P_2O_5 -K_2O) kg/rai and, 5) chemical fertilizer at 10-5-5 (N-P_2O_5 -K_2O) kg/rai. The results showed that effect of plant nutrition to yield was significant. Untreated check (1,242 kg/rai) provided lowest yield, while as, fertilizer using provided higher yield (2260.22 kg/rai). The combination of farm manure and chemical fertilizer trended to have higher yield than the single treatment. The curcuminoids and volatile oil contained in turmeric were more than 5% curcuminoids and 6% volatile oil, which were met to standard level and no significantly different in amounts of active constituents on any treatment.

Sadanandan and Hamza (21) conducted experiment on the response of four varieties of turmeric viz. Suvarna , Suguna , Sudarshana and Alleppey with four levels of NPK fertilizers and two levels of micro nutrients, under rainfed conditions . The variety Alleppey followed by Sudarshana and Suguna were superior with regard to yield of rhizome, curcumin recovery and economics and these were significantly increased due to application of NPK and micronutrients. NPK @ 60, 50, 120 kg ha^{-1} with micronutrient was optimum for the varieties Suvarna , Suguna and Alleppey, whereas 50, 40,100 kg ha^{-1} with micronutrients was optimum or Sudarshana.

Among different treatment combinations of organic manures and microbial inoculants tried, the most effective treatment was vermicompost + *Azospirillum sp.* + *Glomus sp.* (28.94 t ha1) followed by compost + *Azospirillum sp.* + *Glomus sp.* (26.93 t ha^{-1}) as compared to recommended inorganic NPK (Roy and Hore, 20). Maximum root colonisation (74%) with microbial inoculants at 180 days after planting was observed with vermicompost + *Azospirillum* sp. + *Glomus* sp. Maximum bacterial population (105.25 x 105 CFU g^{-1} soil) at harvest was noticed in compost + *Azospirillum* sp. + *Glomus* sp., as compared to lowest population with recommended NPK (56.35 x 105 CFU

g^{-1} soil). By integration of bio-fertilizers and inorganic fertilizers, Singh *et al.* (23) found that combined application of NPK (180:90:90 kg/ha) + *Azotobacter chrococcum* (2.5 kg/ha) + *Pseudomonos florescence* (2.5 kg/ha) significantly increased yield and yield attributes of turmeric.

Turmeric showed better response to the application of organic manures (Kamal and Yousuf , 9). Plants feeded with neem cake application had the taller plant (79.30 cm), maximum number of tillers per height ant (5.40), leaf number (5.40), leaf area (44.09) leaf area index (0.429), fresh weight of haulm (190.05g), fresh weight of root (49.13 g), fresh weight of rhizome per plant (256.21 g) and dry weight of haulm (15.21g), dry weight of root (7.32 g), dry weight of rhizome per plant (40.35 g), total dry matter yield (6.85 t ha^{-1}) than those received other types of manures. Moreover, yield attributes such as number of mother rhizomes $plant^{-1}$ (1.75), more number of primary rhizomes per $plant^{-1}$ (5.19), secondary rhizomes per plant (18.03) and tertiary rhizomes per plant (7.69) were also highly accelerated by neem cake application. Similarly, the same treatment expressed the best in terms of size of mother rhizome (7.69 cm), primary rhizome (21.86 cm) and secondary rhizomes (7.05 cm). All these parameters in cumulative contributed to produce the highest estimated fresh rhizomes yield & cured rhizomes yield (29.48 t ha^{-1}, 5.59 t ha^{-1} respectively). The highest curing percentage (20.28) was observed in treatment having mustard cake @ 2.0 t/ha.

Quality assessment

Lokhande *et al.* (14) carried out an investigation on the effect of curing and drying methods on the recovery, curcumin content and essential oil content in different turmeric cultivars. The Krishna cultivars were best among the three cultivars on the basis of physico-chemical analysis whereas, Salem and Tekurpeta had higher values for colour. The fingers cured with improved method loose moisture at faster rate than uncured and cured with traditional method. The fingers of Salem cultivar cured with improved method followed by shade-net drying had got higher recovery. The essential oil content of three cultivars was unaffected by the curing and drying methods.

Ratnambal (19) evaluated 184 accessions of *Curcuma* for curing (dry recovery), essential oil, oleoresin and curcumin contents. Curing percentage varied from 13.5 to 32.4. The cultivar Konni had the maximum percentage of oleoresin (19.2). The volatile oil content was more in *Curcuma aromatica* than in *Curcuma domestica*. Curcumin content varied from 2.3 % in Hahim to 10.9 % in cultivar Edapalayam. However, curcumin content was comparatively low in six exotic types as well as in 14 related species.

Economic assessment

The economics of production of turmeric was investigated by Mane *et al.* (16) in which they studied the economics of 60 cultivators with equal distribution in small, medium and large groups. The techniques like mean, percentage, ratio and cost concept of Cost-A, Cost-B and Cost-C were used to analyze the data. The results revealed that use of hired human labour was more than family human labour in turmeric production. The use of hired human labour, bullock labour and machine labour, increased with an increase in farm size. Whereas, the use of seed, FYM, nitrogen, phosphorus, potash, family human labour decreased with an increase in farm size. Per hectare net profit was ₹352053.97 in small farm followed by ₹ 344388.94 and ₹ 333662.36 on medium and large farm, respectively. The output-input ratio was 2.23 on small farm followed by that of 2.21 and 2.18 on medium and large farm, respectively. Per quintal cost of production in turmeric was ₹ 1475.75 on small farm followed by ₹1485.46 and ₹1501.09 on medium and large farm, respectively.

Singh (22) studied impact of integrated nutrient management on the economic cultivation of turmeric (*Curcuma longa* L.) in an acid alfisol of Himachal Pradesh where the pooled results of two years showed that highest mean yield (150.8q ha^{-1}), highest income over control (₹ 50,382 ha^{-1}) and highest net returns (₹ 63,566 ha^{-1}) were recorded in the treatment, 100% NPKS + 20 t FYM ha^{-1} as soil mulch. Whereas, highest benefit cost ratio (1:2.99) was recorded in treatment 100% NPKS. All the planting materials grown under juvenile guava orchard were found desirable in terms of gross return, net return and benefit :cost ratio over sole crop (Singh *et al.,* 24). In front line demonstrations (FLDs) on turmeric cv. Megha Turmeric-1, Deshmukh *et al.* (6) concluded that an attractive gross return (₹ 2,34,460/-) and net return (₹ 1,41,604/-) with higher B : C ratio (2.52) were recorded by SHGs with adoption of scientific management practices.

Mahawar and Grover (15) estimated the economics of turmeric cultivation for different categories of producers in Hoshiarpur, Nawashahar (Shaheed Bhagat Singh Nagar) and Gurdaspur districts of Punjab. The results revealed that on an overall basis the total cost incurred on use of physical input, machine labour and human labour use was ₹ 74438, ₹ 5227 and ₹ 29556 per hectare, respectively.

The total variable cost was ₹ 121720, ₹ 108357 and ₹103569 per hectare for small, medium and large producers, respectively. On an overall basis returns over variable cost per hectare was ₹ 45380 which was highest for large producers (₹ 68604) followed by medium producers (₹ 48660) and small producers (₹ 30822). Similarly, B-C ratio was also highest for large producers (1.66) followed by medium producers (1.45) and small producers (1.25). The overall benefit : cost (B : C) ratio was 1.40 denoting turmeric cultivation a profitable enterprise. The results of the study on economics of turmeric cultivation showed that the net returns per hectare received were quite high for all the categories of the farmers which clearly indicate the financial worthiness of turmeric crop.

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