ZINGIBERACEOUS SPICES

Technologies for sustainable production

INDIAN INSTITUTE OF SPICES RESEARCH

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Compilation of Lead Papers
National Workshop on Zingiberaceous Spices - Meeting the growing demand through sustainable production

Organised by
Indian Institute of Spices Research, Calicut

In collaboration with
Directorate of Arecanut and Spices Development, Calicut

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Accelerating production and productivity of zingiberaceous spices

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Introduction

India is known, from prehistoric times, as the land of spices. Till the seventies, India had a virtual dominance in the international trade; even with the emergence of a few countries it continues to be the largest producer, consumer, and exporter of spices in the world. The export of spices from India during April-January 2007-08 was 3,49,775 tonnes valued at Rs. 3,485.48 crore ($ 864.95 million). During the first ten months of the financial year 2007-08, export earnings from spices in dollar terms surpassed the last year's total export performance of $792.95 million and reached an all-time high of $864.95 million. Cardamom (large) and other miscellaneous spices performed better than last year. However, performance of cardamom (small), ginger and turmeric, fell short of last year's performance. This suggests that our growth in spices export though remarkable is not spectacular considering the historical importance of India as a land spices.

Our country is the global leader in exporting zingiberaceous spices like cardamom (small), ginger and turmeric. The contribution of zingiberaceous spices to total spices in area and production in India is 387 thousand ha (15%) and 1136 thousand tonnes (30%) respectively. The USA, Canada, Germany, Japan, Saudi Arabia, Kuwait, Bahrain and Israel are the main markets for Indian spices. North America (USA and Canada) and Western Europe are the most important regions having the import demand for many of the spices. Saudi Arabia, Bahrain, Kuwait and Israel are the major markets for green cardamom, ginger and turmeric. Indian spices flavour foods in over 130 countries and their intrinsic values make them distinctly superior in terms of taste, colour and fragrance. Alleppey Green Extra Bold (AGEB) cardamom, Cochin Ginger (low fibre content), Alleppey Finger Turmeric (AFT) etc. have established deep roots in the cookery of many countries. We have near monopoly in spice oils and oleoresins.

Entry of Guatemala in cardamom and China in ginger is creating stiff competition to Indian spices. India possesses many innate advantages over other spice producing countries - its large size, varied soil and climatic conditions, and skilled and relatively low cost human power. However, the productivity of many of the spice crops is low. Productivity of small cardamom (174 kg ha^{-1}) and ginger (3969 kg ha^{-1}) is very low compared to other producing countries (Table 1). Owing to global challenges like climate change, habitat destruction, pollution, species exploitation with molecular techniques, WTO and IPR issues, it was visualized that challenges are need to be addressed in the light of global demand for these group of spices and value addition.

1. Salient achievements

1.1 Ginger and turmeric

Several putative wild types of ginger and high curcumin types of turmeric have been collected and conserved in the *ex-situ* gene bank of IISR, Calicut. The institute presently has 665 ginger and 924 turmeric accessions. Emphasis was given to evolve varieties through selection and breeding for high yield, quality and resistance to biotic and abiotic stresses.

Table 1. Productivity of major spices in India vis-à-vis other countries

Spice	India (kg ha^{-1})	Highest yield (Country)
Ginger	3969	11767 kg ha^{-1} (China)
Turmeric	4446	4446 kg ha^{-1} (India)
Cardamom (S)	174	315 kg ha^{-1} (Guatemala)
Cardamom (L)	202	202 (India)

1.1.1 Varieties developed

Three ginger varieties with high yield and quality have been released by IISR

- Varada (yield -22.7 t fresh/ha),
- Rejatha (yield -22.4 t fresh/ha), and
- Mahima (yield -23.2 t fresh/ha)

Seven high curcumin and high yielding turmeric varieties have also been released by IISR.

- Suvarna (yield -17.4 t fresh/ha)
- Sudarsana (yield -28.8 t fresh/ha)
- Suguna (yield -29.3 t fresh/ha)
- Prabha (yield -37.5 t fresh/ha)
- Prathibha (yield -39.1 t fresh/ha)
- IISR Kedaram (34.5 t fresh/ha)
- IISR Alleppey Supreme (35.4 t fresh/ha)

1.1.2 *Micropropagation techniques*

Biotechnological tools involving micro propagation protocols have been standardized and are used in rapid clonal multiplication of ginger and turmeric. Direct regeneration of plantlets from pseudo stem of ginger has been achieved through tissue culture. Besides, 'synseed' technology and production of micro tubers in ginger and turmeric have become handy for production of disease-free planting material.

1.1.3 *Nutrient management*

- The nutritional requirement of improved varieties of ginger was standardized to meet the major, secondary and micro nutrient requirements. Under IPNM, dosage of organic amendments *viz.*, neem cake, groundnut cake and gingely cake (@ 1 to 2.5 t/ha) for improving the physicochemical properties of soil and increasing the yield and quality of ginger was standardized.

- As the major spice growing soils are acidic, better source (rock phosphate) and dose of application of P on incubation with FYM (10 tha^{-1}) was standardized for ginger (25 kg P_2O_5 ha^{-1}) to improve the agronomic efficiency of applied P. The optimum zinc fertilizer dose for getting maximum rhizome yield was found to be 6 kg ha^{-1}.

- The investigation on nutrient requirement for targeted production of ginger shows that in the targets with 10, 15 and 20 kg fresh yield/3 m^2 the mean yield recorded is 11.04, 11.93 and 12.2 kg/3 m^2 respectively. The deviation from the fixed targets was calculated to be +10.4, -20.4 and -39.0% respectively, stating that at targets level of 15 kg/bed, we could achieve up to 80% of the targets fixed. At 10 kg /3 m^2 target, the yield exceeded the target fixed.

- The nutritional requirement of improved varieties of turmeric was standardized to meet the major, secondary and micro nutrient requirements. Recommendation on lime requirement and NPK requirement under chemical (60: 50: 120 kg N, P_2O_5 and K_2O ha^{-1}) and integrated nutrition methods were recommended.

- Under IPNM, dosage of organic amendments *viz.*, neem cake, groundnut cake and gingely cake (@ 1 to 2.5 t/ha) for improving the physicochemical properties of soil, increasing the yield and quality of turmeric was standardized.

- The investigation on nutrient requirement for targeted production of turmeric showed that in the targets with 15, 20 and 25 kg fresh yield/3 m^2, the mean yield recorded are 26, 24.2 and 26.6 kg/3 m^2 respectively. The deviation from the fixed targets was calculated to be +73, +21 and +6.3% respectively, stating that at all targets levels the rhizome yield exceeded the target fixed.

1.1.4 Pest and disease management

- Soft rot caused by *Pythium* spp is the most destructive disease of ginger and turmeric. Seed rhizomes are to be selected from disease-free gardens, and stored suitably. Cultural practices such as selection of well-drained soils for planting is important. Application of *Trichoderma harzianum* (50 g/bed) at the time of planting and after 45 days was found to help in preventing the disease. Removal of diseased clumps and drenching the affected and surrounding beds with copper oxychloride 0.2% checks the spread of the disease.

- Bacterial wilt caused by *Ralstonia solanacearum* is also a serious soil and seed-borne disease affecting ginger. Selection of seed rhizomes from disease-free gardens, and planting in well-drained soils has been found to minimize the occurrence of this disease.

Besides, solarization of seed rhizomes on a sunny day soon before planting to attain a temperature of 46-48°C in the rhizomes for about 30 min has been found to be effective in disinfecting the rhizomes.

- Among the pests, shoot borer (*Conogethes punctiferalis*) is the most serious insect pest of ginger. An integrated schedule including pruning of freshly infested shoots at fortnightly intervals during July–August and spraying malathion (0.1%) at monthly intervals during September– October was found to be effective in controlling the pest infestation on ginger.

- Another major pest, rhizome scale (*Aspidiella hartii*) infests rhizomes of ginger and turmeric in storage. Storage of seed rhizomes in dried leaves of *Strychnos nux-vomica* + sawdust in 1:1 proportion helps in keeping the seed rhizomes free of scale infestation. In case the infestations are severe, dipping of seed rhizomes in quinalphos 0.075% before storage may be essential.

- BT (*Bacillus thuringiensis*) formulations are found effective against stem borer of ginger and turmeric. *Pasteuria penetrans*, *Paecilomyces lilacinens* and *Verticillium chlamydosperium* are effective in controlling root knot and burrowing nematodes.

1.2 Cardamom

- Collection and conservation of cardamom germplasm is a major mandate of IISR. The *ex-situ* gene bank of the institute is augmented regularly by undertaking collection programmes from the primary and secondary centres of origin. Multi branch type of cardamom and natural 'katte' resistant lines of cardamom have been collected and conserved in the *ex-situ* gene bank. The *ex-situ* gene bank presently consists of 439 collections, hybrids and disease resistant selections of cardamom.

- High production Technologies (HPT) developed through high yielding varieties and effective crop management practices in cardamom has achieved about 200% increase in yield. In cardamom it is proved that through HPT programme 460 kg/ha can be produced against 116kg/ha under average management.

1.2.1 Varieties developed

Emphasis was given to evolve varieties through selection and breeding for high yield, quality and resistance to biotic and abiotic stresses. So far IISR has released 3 cardamom varieties (Table 1).

- Suvasini, a high yielding variety suitable for high density planting (745 kg dry/ha),
- Avinash, a variety resistant to rhizome rot disease (847 kg dry/ha) and

- Vijetha, a variety resistant to *katte* disease (643 kg dry/ha) have been released.

1.2.2 Pest and disease management

- Katte disease caused by virus is the most important disease of cardamom. Roguing of disease affected clumps and replanting with katte resistant variety such as IISR-Vijetha is recommended. Katte clinics have been set up to appraise the farming community on the management of Katte disease.

- Rhizome rot disease of cardamom caused by *Pythium vexans* and *Rhizoctonia* sp. can be managed by phytosanitation, providing adequate drainage, application of *Trichoderma harzianum* (50 g/clump) twice a year during May-June and September-October and planting of the resistant variety IISR-Avinash.

- Cardamom thrips (*Sciothrips cardamomi*) are widespread and destructive pests of cardamom damaging shoots, panicles and capsules.

- Pruning of leaf sheaths during February–March, regulation of shade and removal of other herbaceous host plants around the plantation reduces the pest population in the field. Insecticides such as quinalphos 0.025%, fenthion 0.05% and phosalone 0.05% and 5–7 rounds of sprays along with the cultural operations were found to be effective against thrips.

2. The major constraints to the development of zingiberaceous spices are genetic erosion, biotic stresses, poor soil fertility, high labour cost and crop loss due to diseases, lack of resistant varieties and post harvest losses. The problems and perspectives of zingiberaceous spices and the solutions are described hereunder.

2.1 Biotic stresses

Diseases caused by biotic stresses such as fungi, viruses, bacteria, phytoplasma, nematodes and insect pests continue to be one of the major constraints in the production of many spices crops (Table 3). The Indian strains of *R. solanacearum* causing bacterial wilt of ginger were identified as biovar 3 or biovar 4 and the former one was dominant. A method was standardized for detection of the bacteria by PCR. *Curcuma amada* was found to resist infection by *R. solanacearum.* Rhizome solarization technique was developed for disinfecting rhizome before planting. On the basis of molecular studies, the pathogen causing soft rot of ginger was identified as *Pythium myriotylum.* A root-knot nematode resistant ginger germplasm accession was released as IISR Mahima. *Pythium aphanidermatum* was found to be the predominant pathogen associated with rhizome rot of turmeric.

Future thrusts should include identifying and cloning resistance genes and improving the efficiency of conventional and molecular breeding in spices, studies on mode of parasitism to develop resistant lines against nematodes, use of biotechnological interventions wherever resistance source is lacking in wild and cultivated types, development of a good certification system for all spices planting material production, keeping vigil and addressing new emerging diseases and pests in spices, identification, characterization and efficacy especially multiple efficacy of biocontrol organisms in controlling more than one pathogen and their

Table 2. Major biotic stress affecting various zingiberaceous spices

Crop	Major diseases	Major pests
Ginger	Rhizome rot (*Pythium aphanidermatum*, *Fusarium solani*), Bacterial wilt (*Ralstonia solanacearum*), Yellow disease (*Fusarium oxysporum*), Mosaic (virus)	Shoot borer (*Conogethes punctiferalis)*, Rhizome scale (*Aspidiella hartii*)
Turmeric	Rhizome rot (*Pythium graminicolum*, *P. aphanidermatum*, *Fusarium spp.*), Leaf blotch (*Taphrina maculans*), Leaf spot (*Colletotrichum capsici*)	Shoot borer (*Conogethes punctiferalis)*, Rhizome scale (*Aspidiella hartii*)Nematodes (*Meloidogyne incognita, Practylenchus sp., Radopholus similis*)
Cardamom (S)	Katte (Potyvirus), Kokke Kandu (virus), *cardamomi*) Niligiri necrosis (virus), Capsule rot (*Phytophthora meadii*, P. *nicotianae* var *nicotianae*),Clump rot and damping off (*Pythium vexans, Rhizoctonia solani*)	Thrips (*Sciothrips* Stem borer (*Conogethes punctiferalis*)
Cardamom (L)	Chirk and Foorkey (Viral diseases), *chorista* Leaf streak (*Pestalotiopsis royenae* (D.Sacc) Steyaert), Wilt (*Fusarium oxysporum*) Blight (*Colletotrichum* sp., Glomerlla Sp and *Fusarium* sp.)	Leaf eating caterpillar (*Artona* Jordon)Shoot fly (*Merochlorops dimorphus* Cherian)Stem borer (*Glypheterix* sp)Aphids (*Rhopalosiphum maidis* Fitch; *Pentalonia nigronervosa* Cog.; *Micromyzus kalimpongensis* Basu)

commercialization, residue analysis in all spice produce, development of integrated package for management of diseases and pests under organic cultivation system.

2.2. Genetic erosion

India is a country rich in spices diversity (terrestrial ecosystem). In order to conserve the valuable germplasm attempts have been made to conserve them in various institutes (Table 4). Western Ghats of India and North Eastern India are two hot spots of species diversity of *Curcuma* and

Zingiber, while cultivar diversity of spices is distributed throughout the different agro climatic zones of the country. Though based on Mansfeld's encyclopedia (2001) and IUCN Red list of threatened plants (2001) three species of *Zingiberaceae* including *Kaempferia rotunda* L. are of 'indeterminate' status (not clear whether extinct, endangered, rare or vulnerable) there is no room for much complacency.

Table 3. Germplasm conserved by various institutes

Crop	No of germplasm	Institute
Ginger	665	IISR, Calicut
Turmeric	924	IISR, Calicut
Cardamom (S)	416	CRC (IISR), Appangala

Species diversity of spices are threatened due to the ever increasing encroachment of forests and depletion of forest area besides a whole lot of other biodiversity loss indicators listed by the 188 parties to Convention on Biological Diversity plus climate change. The later ones are equally applicable to intra-specific (cultivar diversity) loss of biodiversity of spices. In a workshop recently organized by the Dept. of Biotechnology, New Delhi, 19-20 July 2005 at Bannerghatta, a preliminary list of endangered plants for immediate recovery prepared includes *Syzygium palghatense* Gamble, *S. trancoricum* Gamble and *Kaempferia rotunda* L. Though the criteria for enlisting these species for prioritization is not clear, the fact remains that species diversity of spices is under threat.

Loss of diversity at intra-specific level with valuable genes for important quality and resistance characters, an offshoot of scientific breeding of new varieties, is dubbed as 'Breeder's paradox'. The spread of high yielding varieties though very important, it adds to the erosion of land races. Such a scenario calls for immediate biodiversity conservation activities in spices. Currently, *ex situ* genebank, in vitro repositories, cryo-conservation and *in situ* conservation strategies are adopted to conserve the biodiversity of spices. While various Research Institution in the country are involved in the *ex situ* and *in vitro* conservation of spices, the biosphere reserves such as Nanda Devi, Nokrek, Manas, Sundarbans, Nilgiri and Great Nicobar, besides the different wild life national parks and wild life sancturaries are main *in situ* gene banks of spices and medicinal plants.

2.3. Climate change

It has been observed since 1750 that earth's surface is warming due to substantial increase in concentrations of greenhouse gases such as CO_2, CH_4, N_2O, and tropospheric O_3. The global average surface temperature increase over the 20th century has been 0.6 ± 0.2°C. Hot days and heat waves would increase while cold days and cold waves would decrease. Increased summer drying leading to drought risk in mid latitude continental interiors, increased global average precipitation with intense precipitation events in some parts and rise in sea level are predicted.

Global and in particular, mid-to high latitudes crop productivity is projected to increase slightly for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions. Crop productivity is projected to decrease for even small local temperature increases (1-2°C) in seasonally dry and tropical lower latitude regions resulting in increased risk of hunger. The warmer temperature and wet conditions may provide congenial humidity for widespread of some diseases such as wheat scab, rice blast etc along with increased pest population in temperate and tropical regions of Asia.

The Hadlee Climate Centre has worked out regional climate model for the entire globe which predicts future climate of a region using a base line. As per this model, the spices growing region in India may experience 2-3 degree increase in temperature and also increase in precipitation by 2050. In turmeric, rain fall, minimum temperature and rainy days were positively correlated with productivity indicating that increase in precipitation and minimum temperature may have positive influence on rhizome yield. Maximum temperature and solar radiation though showed negative correlation, it was non-significant. But it suggests that increase in these two parameters may hamper the productivity. Climatic requirement for zingiberaceous spices is given in Table 4.

Table 4. Optimum climatic parameters for various zingiberaceous spice crops

Crop	Temperature (°C)		Rainfall (mm)
	Minimum	Maximum	
Ginger	19	28	1500-3000
Turmeric	18.2	27.4	640-4290
Cardamom (s)	10	35	1500-5750
Cardamom (L)	6	25	3000-3500

More directed studies are required to assess the impact of climate change on spice crops. Since spices are grown both in plains and high altitudes, it is important to assess the long term climatic changes within a region and its influence on productivity. Also there exists varietal variation and it is important to study the behavior of a variety under these conditions. Temperature effect can be studied by growing the same variety under different agro climatic conditions by keeping all other inputs constant. Also, it is important to study the combined effect of increased temperature and elevated CO_2 on productivity in spices.

2.4. Nutrient use efficiency

Nutrient or fertilizer use efficiency concepts generally describe how well plants or a production system use nutrients. Efficiency can be viewed from the short-term or from the long-term, and can be based on yield, recovery, or removal (Stewart, 2007). It has been reported that fertilizer utilization rate (crop recovery efficiency) under favorable conditions for N in mineral fertilizer is about 50-70%, for P fertilizer about 10-25% (15% average), and K about 50-60%. It was also pointed-out that the efficiency of P and K over time (multiple growing seasons) must be taken into account. Furthermore, interaction among nutrients can have a significant impact on efficiency measures for individual nutrients.

The nature and behavior of a particular nutrient in soils is important in determining how efficiency is viewed. Nutrients with soil build-up potential, such as P and K, can certainly be viewed over the short term. On the other hand, N efficiency analysis is usually viewed on the short term, or single season because of the transient nature of inorganic soil N, i.e., potential for volatilization, denitrification, and leaching. The nutrient uptake by different zingiberaceous spice crops is given in Table 5.

Nutrient use efficiency can be optimized through best management practices (BMP), which involves applying nutrients at the right rate, right time, and in the right place and are critical to achieving optimum nutrient efficiency. It is critical that realistic yield goals are established and that the right rate of nutrients is applied to meet the target yield. Over- or under-application will result in suboptimal nutrient use efficiency or losses in yield and crop quality. Soil testing remains one of the best tools available for determining the nutrient supplying capacity of the soil. But to be useful for making appropriate fertilizer recommendations good calibration data is necessary. As technology and cropping systems change and improve it is important that soil test recommendations be periodically evaluated. Interactions among nutrients are important because a deficiency of one restricts the uptake and use of another.

Table 5. Nutrient uptake by zingiberaceous spices

Crop	Yield (dry) kg ha^{-1}	Uptake (kg/ha)								
		N	P_2O_5	K_2O	Ca	Mg	Fe	Mn	Zn	Cu
Cardamom (S)	450	6.0	2.1	16.8	3.4	1.2	0.10	0.16	0.03	0.006
Cardamom (L)*	200	20.7	4.0	52.5	38.2	24.0	-	-	-	-
Ginger	3900	70.0	17.0	117.0	8.6	9.1	1.8	0.5	0.13	0.04
Turmeric	5503	91.0	16.9	245.0	10.1	16.0	1.2	0.8	0.24	0.05

* Robust type

Greater synchrony between crop demand and nutrient supply is necessary to improve nutrient use efficiency, especially for N. Split applications of N during the growing season, rather than a single, large application are known to be effective in increasing N use efficiency. Tissue testing is a well known method used to assess N status of growing crops, but other diagnostic tools such as chlorophyll meters and leaf color charts are also available. On-the-go N sensors are now commercially available that can be coupled with variable rate fertilizer applicators to automatically correct crop N deficiencies on a site-specific basis.

Another approach to improving synchrony between application and uptake is the use of enhanced efficiency (EE) fertilizers. These are fertilizer products with characteristics that minimize the potential of nutrient losses to the environment. This class of fertilizer products includes slowly soluble synthetic organic compounds containing N, soluble N fertilizer surrounded by a physical barrier or coating that impedes release, and stabilized N fertilizer (i.e., N fertilizer treated with urease and/or nitrification inhibitors). For high-value and specialty crops like spices slow release fertilizers could be very effective. Among the most promising for widespread agricultural use are polymer-coated products which release nutrients in a predictable and controlled manner with the aim of more closely matching release with crop demand. Nutrient release rates can be manipulated by adjusting the polymer coating thickness and/or properties. We also have the N stabilizer technology used in commercial agriculture like those that either inhibit nitrification (e.g. nitrapyrin, DCD [dicyandiamide]) or urease activity (e.g., NBPT) thereby slowing the conversion of the fertilizer to nitrate, and in the case of NBPT and urea, reducing the risk of ammonia volatilization.

Fertilizer placement has always been an important nutrient management consideration. Determining the right placement can be as important as determining the right application rate. Of course, numerous placement options are available, but most generally involve surface or sub-surface applications, either banded or broadcast before or after planting. Placement decisions depend on the crop and soil conditions, not to mention equipment and product availability issues.

Overall, it is clear that higher nutrient use efficiency can often be achieved by reducing rates and sacrificing yield, but that is not usually economically sound or sustainable. It is apparent that nutrient use efficiency, land use efficiency, economic return, and environmental protection are components that define and determine sustainability now and for the future. Therefore, improving nutrient efficiency is a worthy goal and fundamental challenge facing agriculture in general. The opportunities are there and tools are available to accomplish the task of improving the efficiency of applied nutrients. However, we must be cautious that improvements in efficiency do not come at the expense of the farmers' economic viability or the environment. Also, there is a need for breeding programs to focus on developing cultivars with high NUE by identifying traits such as nutrient absorption, transport, utilization, and mobilization in plant. This coupled with BMPs, i.e. right rate, right time and right place targeting both high yields and nutrient efficiency will benefit farmers, society, and the environment alike.

2.5. Quality planting material and plant health management

The X Plan had targeted gross domestic product (GDP) growth in agriculture and allied sectors at 4% per annum. Actual growth of agricultural GDP, including forestry and fishing, was only 1% per annum in the first three years of 10th Plan. The challenge during XI plan would be to accelerate the agricultural growth by doubling the rate achieved in the X Plan. Accelerated agricultural growth will require diversification into horticulture. India Vision 2020 document prepared by the Planning Commission also emphasizes on rapid diversification from low value to high value crops such as spices for domestic consumption, processing and export so as to sustain an agricultural growth rate of 4.0 to 4.5 per cent per annum. To achieve that the minimum target should be to double or triple the average yields of major spice, medicinal, and aromatic crops. The National Commission on Farmers in their Draft National Policy for Farmers also suggested that crop diversification is necessary for increasing net income of farm families.

India has been considered as treasure house of valuable medicinal and aromatic plant species. Ministry of environment and forest have identified and documented over 9,500 plant species considering their importance in the pharmaceutical industry. In the present context of "back to nature" in health care it is relevant that these valuable plant species are not only preserved but also their cultivation developed in order to meet the entire demand of the domestic industries as also to exploit the bright prospect of export. Cultivation of medicinal and aromatic plants will also ensure purity, authenticity and sustainable supply of raw materials required for herbal drug, including polyherbals. Our foreign exchange earning potential from these groups of plants is estimated to be over 3,000 million US dollars per annum.

Seeds and planting materials with only assured quality can be expected to respond to other inputs. Any lax in this pursuit will turn our seeds of hope to seeds of frustration. The X plan had proposed to focus on those areas to double horticulture production by 2011-12 through a National Horticulture Mission (NHM) and the ongoing Technology Mission for the North East including Sikkim, J&K, Uttaranchal and Himachal Pradesh. In addition, ICAR also launched an ambitious "Mega Seed Project on Seed Production in Agricultural Crops and Fisheries" during 10^{th} Plan. This project continues in 11^{th} Plan also. During 10^{th} Plan ICAR allotted Rs. 58.00 Lakhs to IISR, Calicut, Rs 45.75 Lakhs to NRCSS, Ajmer, Rs 129.30 Lakhs to NRCM & AP, Anand, and SAU's for strengthening and create infrastructure to produce quality seed / planting materials. The project made considerable impact and it is widely appreciated. The target for spices crops are as given in Table 6.

Table 6. Planting materials requirement of spice crops projected for the XI plan

Crop	Units	Total
Ginger @ 1.4 t ha^{-1}	Tonnes	12740
Turmeric @ 2.0 t ha^{-1}	Tonnes	31320
Small cardamom @ 1100 ha^{-1}	'000 Nos.	2034.26
Large cardamom @ 3000 ha^{-1}	'000 Nos.	33795.0

(Note: Projection is based on annual growth of 2.0% area in ginger and turmeric and 0.5% in area of cardamom; 7.5% in area of replanting in large cardamom.)

2.6. Intellectual Property Rights

Intellectual property means the legal rights which result from intellectual activity in the indus trial, scientific, literary and artistic fields. Examples of intellectual properties include inventions, computer software, publications, videotapes, music, and plant varieties intellectual property. Developing such products usually requires a great deal of time and financial investment. Therefore, the inventor usually seeks a return on his effort by acquiring IPRs.

Patents are the most critical form of protection for agricultural and considered to be the most powerful in the IP system. Patents are temporary, generally about 20 years, and are country specific. Patent is an exclusive right given to an inventor to exclude all others from making, using, selling or offering to sell the invention in the country that granted the patent right, and importing it into that country.

Farmers are granted the legal ability to reuse the IPR protected seed known as the "Farmer's privilege". To be eligible for protection the variety must conform to DUS i.e. they need to be Distinct (It must be clearly distinguishable from all other varieties known at the date of application for protection), Uniform (all plants of the variety must be sufficiently uniform to allow it to be distinguished from other varieties taking into account the method of reproduction of the species and Stable (It must be possible for the variety to be reproduced unchanged). Through Plant Breeders Rights (PBR), the plant breeder who developed a variety enjoys the exclusive right for marketing the variety, although use of the variety for further breeding or for replantation of seed saved by a farmer (farmer's exemption) is permissible. DUS guidelines for ginger, turmeric and cardamom are being finalized by IISR under the task force constituted by Protection of Plant Varieties and Farmers Right (PPV & FR) Authority. More recently, utility patents for genetic materials, both plants and animals, have also been allowed in some countries, so that the patented material can neither be used for further breeding, nor will the farmers be allowed to save and use the seed for cultivation, without paying a fee to the patent holder.

Under the UPOV Convention, however, a plant breeder generally does not need breeder authorization to use protected plant varieties for non-commercial or experimental acts or acts done for the purposes of breeding new plant varieties. The UPOV Convention also allows each member nation to restrict the breeder's right in relation to any variety to allow farmers to use part of their harvest for subsequent plantings in their own land. These restrictions, however, must be within reasonable limits and subject to the safeguarding of the legitimate interests of the breeder.

IPR related activities undertaken in spices include a project on Strengthening the cause of geographical indication appellation of major spice using molecular and quality profiling techniques. This project involves characterizing and comparing reputed Indian commodities such as cardamom (Alleppey green extra bold), ginger (Cochin) and turmeric (Alleppey, Rajapuri) vis-à-vis the produces from other producing countries with a view to get GI protection for the Indian commodities.

2.7. Post harvest technology and value addition

There are several factors which affect the quality of processed spice products. These include pests and micro-organisms which infest the product from the plantation, foreign matter and impurities from materials used in processing which contaminate the products, micro-organisms and dirt which are introduced through unhygienic practices of people who handle the produce, and loss of quality that results from short-comings in storage practices. Thus the quality of the product depends on the quality of raw materials, the methods used in processing, the packaging methods and materials and marketing practices. Therefore, to ensure quality of the product, constant care should be maintained from the time it reaches the consumer.

Mechanization is getting wide acceptance in post harvest operations. Most spices possess an initial moisture of about 6- 70 % which has to be brought down to a safer level of about 10 % during drying. Mechanical dryers are of great help in achieving this in a short time. This is especially important in the case of cardamom where sun light cannot be employed as this brings down the marketable appearance of cardamom. Now diesel, kerosene, LPG and electrical dryers are getting popularity among cardamom growers. As our forests are getting eroded dryers using fire wood is no more a good choice. However agricultural waste is an apt choice as fuel source in dryers for many spices like turmeric, ginger etc.

Grading is also very important in spices. Cochin or Calicut Ginger, Coorg Cardamom, Rajapuri turmeric, Duggirala turmeric all these brands are of special grades. This brings more remuneration to farmers also. All over the world consumer packs are getting wide acceptance. A garbled clean produce in a suitable consumer pack is acceptable everywhere. Now mechanical processing units which can clean, garble, grade and make dispensers of different quantities to consumer packs are available.

Good quality packaging in laminated poly propylene prevents volatile oil loss and preserve the aroma and taste of the spice for a long period. Storage atmospheres like nitrogen and vacuum is essential for the long term sustenance of the intrinsic quality. Value addition also assumes great significance in spices. Products such as ginger candy, ginger muraba, ginger paste, spice oils, oleoresins, decoctions, extracts, spice blends, spice based jam jelly etc need more attention from researchers and entrepreneurs. Many other countries which do not possess the genetic diversity like India had made great strides in these sectors. That should be an eye opener for us. In most of these spices we have the genetic wealth which will enable us to produce the kind of products which a consumer demands.

The aroma, flavour and medicinal property of all the spices are attributed to the volatile oils present in it. The oil contains a range of organic compounds, which belong to the group of terpenes and hydrocarbons. These oils possess anti oxidant, anti cancerous, anticonvulsant, anti ulcerogenic, anti inflammatory, anti allergic and .expectorant properties. This is again an integral part of our traditional medicine systems like ayurveda, unani, sidha etc. Many of these products are also used in perfumes and other cosmetic products.

2.8. Transfer of technology

In spite of strides in the research front. there is yawning yield gap between potential yield realized in research stations and yield under farmers conditions. The low productivity of spice crops is not only a threat to economic security of millions of small and marginal farmers but also to the world trade of spices hither to our country had the domination. Indian spice trade in the international market is facing stiff challenges in the post WTO era, with many new entrants in to the production and trade sector. The National Agricultural Extension System should be revitalized by adopting innovative extension approaches. These innovative initiatives should emphasize on organizing farmers groups through self help groups, women stake holder empowerment and synergizing media extension services through the use of Information and Communication Technologies (ICT).

3.0 Conclusion

India will need to make concerted efforts for producing clean products at competitive prices and withstand competition by increasing productivity and reducing cost of cultivation of zingiberaceous spices. Higher productivity, clean spices through improved post harvest techniques and reasonable threshold price affordable to food industry are the keys to future trade and promotion of zingiberaceous spices.

The extreme focus on quality imposed by ISO 9000 series of specifications and stringent regulations imposed by ASTA, FDA, USDA, EPA and American Customs calls for upgradation of the whole system of pre and post farming activities including growing, processing, grading, packing, pelleting, shipping and quality control. Brand promotion schemes, Indian spices logo and spices house certifications are a few schemes initiated by the Spices Board of India to ensure standards specified in ISO 9000 series. As the international trade barriers are steadily coming down, India will have to develop very competitive edge in all respects, if it has to retain and increase its present position in the international trade of zingiberaceous spices.

A well coordinated agricultural research can play a significant role in improving the zingiberaceous spices industry by deploying promising new technologies as well as adapting those with well-established impact. In addition to the genetic challenges of crop improvement, we need to embrace the problems associated with a highly heterogeneous and unpredictable environment. Not only are new genetic tools becoming more accessible, but a new generation of quantitative tools is available to enable better definition of agro-ecosystems, of cultivar by environment interactions, and of socio-economic issues.. Identifying areas of low genetic diversity is an important aspect of reducing vulnerability to disease epidemics. Cutting edge strategies for incorporating durable disease resistance genes into a wider genetic background, as well as participatory approaches that deliver a fuller range of options to farmers are being implemented to increase cultivar diversity.

The unpredictable effects of environment on productivity can be buffered somewhat by crop management practices that maintain healthy soils, while reversing the consequences of rapid agricultural intensification on soil degradation. Conservation agriculture is an alternative strategy that is especially pertinent for resource-poor farmers.

The demand forecast of zingiberaceous spices for the period 2006-07 to 2026-27 is given in Table 7. Export figures indicate that the Indian spice and aromatic crop industry has begun its march on the path of development. For the first time, many of the changes are happening at a fundamental level which is setting in motion a positive feedback that is expected to sustain growth at high levels and increase incomes for the next many years to come. A spices board press release indicates spice exports from India have touched an all time high. During the first ten months of the financial year 2007-08, export earnings from spices in dollar terms surpassed the last year's total export performance of $792.95 million and reached an all-time high of $864.95 million. The export of spices from India during April-January 2007-08 was 3,49,775 tonnes valued at Rs. 3,485.48 crore ($ 864.95 million) as against 2,92,185 tonnes valued at Rs. 2850.45 crore ($626.71 million) exported during the same period last year. Compared to the export performance of April-January 2006-07, the achievement during the year is higher by 20 per cent in volume and 22 per cent in terms of rupee value. In dollar terms of value, the growth is 38 per cent. Against the target of 3,80,000 tonnes valued Rs. 3,600 crore ($875 million) fixed for the year, 99 per cent of the dollar value (97 per cent in rupee value) and 92 per cent of the volume have been achieved during the first ten months of the current financial year.

Table 7. Demand forecast for the period 2006-07 to 2026-27

Five YearPlan period ending	Ginger			Turmeric			Cardamom		
	Qty. to be produced (t)	Area under the crop (ha)	Targeted yield (t/ha) (t)	Qty. to be produced	Area underthe crop(ha)	Targeted yield (t/ha) (t)*	Qty. to be produced	Area under the crop (ha)	Targetedyield (t/ha)**
2006-07	391537	87430	4.5	672478	150460	4.5	19423	87430	0.22
2011-12	500558	87430	5.7	776905	150460	5.2	36159	87430	0.41
2016-17	640934	87430	7.3	897816	150460	6.0	67535	87430	0.77
2021-22	819999	87430	9.4	1037830	150460	6.9	126330	87430	1.45
2026-27	1051128	87430	12	1200210	150460	8.0	236580	87430	2.71

* With current ratio of import & export

** Estimated yield target to meet the quantity required with present trend of export and import

However, to consolidate our country's hegemony in production and export of zingiberaceous spices, a lot more needs to be done. The challenge is both to make India as a whole richer, faster, and to find better ways of distributing the benefits of more rapid growth. As India's population expands, that challenge will become ever more urgent, and ever harder. The year 2025 signals emergence of India as a global power in spices production. Our Perspective Plan 2025 contemplates realization of the above objectives envisaged by the Planning Commission of India.

Ginger - Technologies for sustainable production

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Introduction

Ginger (*Zingiber officinale* Rosc.) is cultivated as an annual for its underground stem called 'rhizome' which is used as a spice. The crop originated as a native of tropical South-East Asia and was introduced into the West Indies, African countries and other tropical countries. It is sold as fresh ginger or, more frequently, in a peeled and split dried form. Ginger is widely used in pickles, candies and such other preparations and as a medicinal herb. Dry ginger is used for preparing ginger powder, extracting ginger oil, oleoresin etc.

The major ginger producing countries are India, China, Nigeria, Indonesia, Bangladesh, Thailand, Philippines, and Jamaica. Nigeria ranks first with respect to area under ginger covering about 56.23 percent of total world area followed by India (23.60%), China (4.47%), Indonesia (3.37%) and Bangladesh (2.32%). India ranks first with respect to ginger production contributing about 32.75 percent of world's production followed by China (21.41%), Nigeria (12.54%) and Bangladesh (10.80%). Ginger production in India during 2004-05 was at 3.98 lakh tons from an area of around one lakh ha. The production scenario in India from 1990-91 to 2004-05 is depicted in Fig. 1. World average ginger productivity is 3025 kg/ha. In India, Kerala, Karnataka, Sikkim, Himachal Pradesh, Meghalaya, Assam and other north eastern states cultivate ginger extensively. United Kingdom, United States and Saudi Arabia import large quantities of ginger. High global demand for Indian ginger is due to its lemony flavour. India has capabilities to meet the quality and quantity demands of importing countries matching to international standards (Tamil Selvan and Manoj, 2002; Peter and Nybe, 2002). India earned a foreign exchange of around Rs.40 crores during 2005-06 through ginger export. The export scenario of ginger from India from 1990-91 to 2005-06 is depicted in Fig. 2. The crop exhibited an annual growth rate of 4.6 per cent in area, 7.4 per cent in production and 2.7 per cent in productivity (Manjunath, 2004). Finest quality of ginger *i.e.* Cochin Ginger which has extensive demand in world market is cultivated in Kerala. In this paper an attempt has been made to analyse problems of ginger cultivation in India such as genetic diversity, climate, planting material, input use efficiency, pests and diseases, global trade and value addition along with the future thrust.

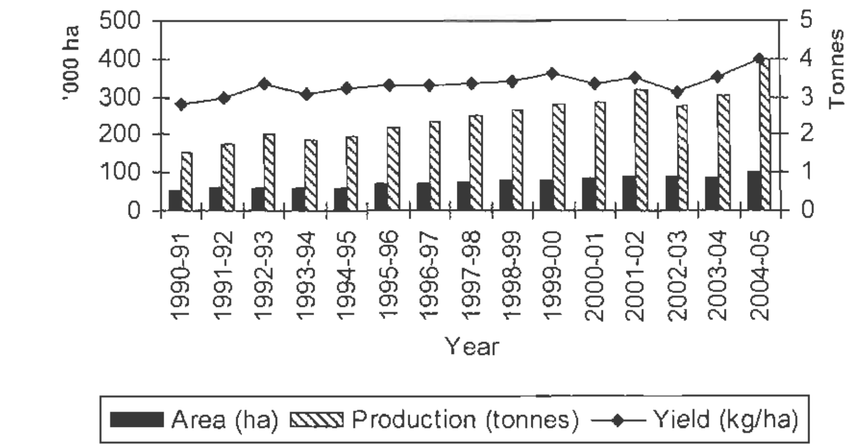

Fig. 1. Production scenario of ginger in India

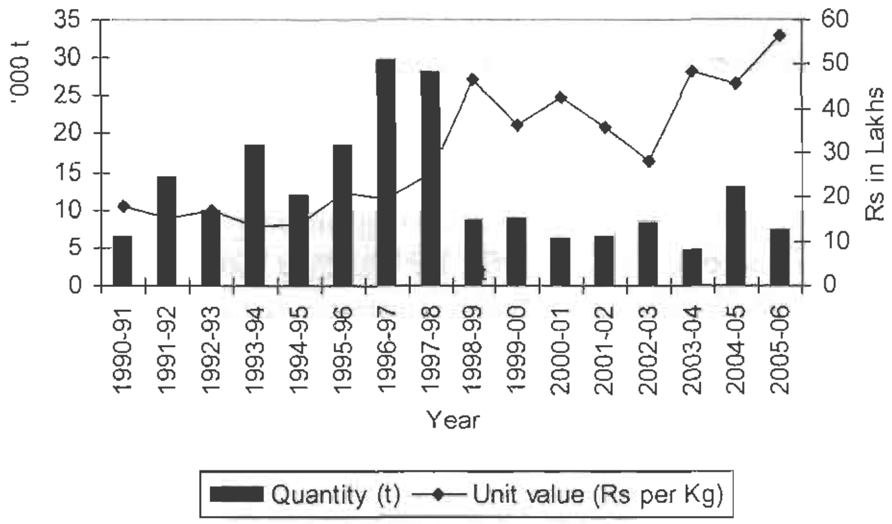

Fig. 2. Export of ginger from India

Genetic improvement and varieties

There are several indigenous cultivars specific to certain regions like Maran, Kuruppampadi, Jorhat, Bajpai, Karakal, Wayanad, Himachal & Nadia and cultivar Rio-de-Janeiro is popular in entire India. Improved varieties for high quality and yield have been developed and released from the rich source of germplasm conserved at the Indian Institute of Spices Research. IISR Varada released by IISR under ICAR has gained popularity in the ginger growing regions of the country owing to its high quality and yield. Varieties Mahima and Rejatha are also high yielders (fresh ginger). Salient features of some of the improved varieties are depicted in Fig. 3..

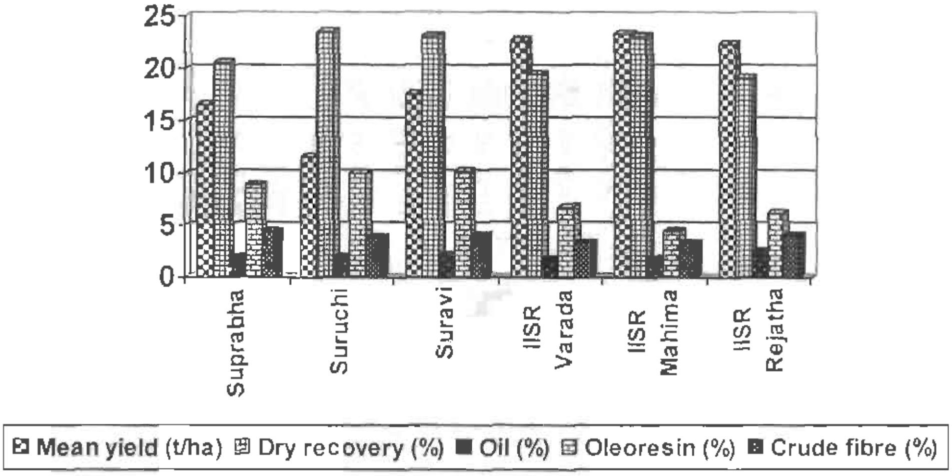

Fig. 3. Yield and quality characters of improved varieties of ginger

Future research should focus on the following

Conservation of genetic resources and genetic improvement

Though enrichment of germplasm is one of the ongoing programmes in public funded research organisations, this need to be accelerated for widening the genetic stock. Conservation of germplasm need to be done to safeguard the germplasm. Bar coding of genotypes, introduction of exotic germplasm, characterization of genotypes, chemical profiling for zingiberene, citral and limonene, identifying ginger types for value addition and low fiber types are among the scientific requirements for ginger improvement

Increasing productivity of ginger through crop improvement and biotechnology

Locating resistance source and evolving high yielding and rhizome rot/bacterial wilt resistant lines through selection, mutation, polyploidy breeding and biotechnological methods are among the important programmes for ginger improvement. Understanding the reasons for zero seed set in ginger so as to make inter varietal hybridization a reality. Multi location testing of varieties for adaptation and quality. Evaluation of lines suited to organic production (breeding for early initial vigour, more tillers and low input responsive lines). Scaling up the direct regeneration protocol as a means to produce nucleus planting material of elite lines.

Effect of climate change on ginger productivity

Climatic conditions of India, especially southern India, Orissa and north eastern states are suitable for ginger cultivation. Ginger requires a partially shaded, tropical or subtropical climate with a well distributed annual mean rainfall of 1500-3000 mm and the temperature range of 28-35°C for better growth and development of rhizomes. India can utilize this opportunity to push more of its products in to the world market. Prevalence of congenial climate for multiplication and spread of soft rot and bacterial wilt pathogens resulting in severe economic loss in heavy rainfall areas is the major concern. Though the climate of north east India is congenial for ginger cultivation, low temperature prevailing during the crop growth and rhizome development results in very plumpy rhizomes with less dry recovery with high fibre content, making them unfit for dry ginger or ginger powder. This can be used only as fresh ginger.

Climate change may pose a threat for ginger cultivation. Climate change is likely to bring about 2-3 degree increase in temperature by 2050. High rainfall in north eastern states is already causing heavy incidence of pathogens and pests, weeds and leaching of nutrients. Ginger growing areas of Himachal Pradesh and north eastern parts of the country may be benefited by increased temperature and CO_2 but these beneficial effects could be offset by increased floods and frost. Light intensity of 1290 micro moles m^{-2} s^{-1} was optimum for single leaf photosynthesis while 1950 moles m^{-2} s^{-1} was optimum for the canopy. This suggests that climate change in terms of increase in temperature and associated increase in light intensity may reduce the yield of ginger in southern states. Studies may be oriented towards varietal responses to climate change, identification of varieties which can adapt to climate change and also management strategies to mitigate the ill effects of climate change.

Role of planting material for successful ginger cultivation

Availability of good quality planting material is the key to the success of ginger cultivation as it accounts for about 40% of total cost of production. Hence selection of quality material for planting and its storage till the planting season is very important. Selected material can be cleaned and treated with Mancozeb or Carbendazim (0.3%) and Malathion (0.05%) for 30 minutes, shade dried and stored. Storage structures like Zero energy cool chamber (ZECC) is ideal for storing fresh ginger. Covering the seed material with a layer of *Glycosmix pentaphylla* leaves is also beneficial (Nybe and Miniraj, 2005). Though laborious and costly, transplanting keeps rhizome borne diseases at minimal, resulting in high net returns. Micropropagation technology is available for the production of disease free planting material.

Loss of planting material during storage due to improper storage and infection is the major concern. Difficulty in identifying the partially infected rhizomes in the lot stored for seed purpose is one of the problems. Non adoption of pre storage and pre planting treatment leads to loss of germination. Transplanting can be tried to eliminate and check the infection in the main field subject to the availability of labour. Supply of micropropagated seed material at reasonable rates by the government/agencies can contain the disease.

Input use efficiency

Irrigation

Irrigation scheduling is available for ginger. First irrigation is given to ginger immediately after planting and subsequent irrigations at an interval of 10 days in order to meet a total water requirement of 90-100cm in 16-18 irrigations. Polyethylene mulch cuts down the irrigation requirement by 50% (Pawar, 1990). *Glyricidia* mulch enhances the rain water use efficiency. As rainfed cultivation is predominant, rainfall deficit greatly affects productivity and also quality. No varieties are available which can respond to different levels of irrigation. Thrust may be given for construction of farm ponds to harvest rain water to irrigate the crop during critical stages of growth. Studies should be aimed at development of cost effective and high efficiency irrigation systems. Identification of high yielding varieties for irrigated and rainfed cultivation must be given priority.

Radiation

Ginger can be grown under open condition with full sunlight. But a partial shade of around 25 % results in better yield and quality compared to those grown under full sunlight or heavy shade. Studies report that photosynthesis attains saturation between 400-900 μ mole light intensity (Yun *et al* 1998; Ai *et al* 1998). Besides providing suitable microclimate, shading helps to minimize water loss. Ginger can be an ideal intercrop under perennial crop systems such as coconut, arecanut, pepper, clove, nutmeg etc. which are very common in ginger growing tracts. Filtered light can be effectively utilized by ginger crop. Excess sunlight in open areas results in lower yields. Ginger grown under the canopy of perennial crops may perform far below its potential due to excessive shade. Therefore identification of varieties suited to different light intensities and selection of varieties based on light availability can provide higher returns.

Nutrients

Ginger responds well to the applied fertilizers. Fertilizer requirement varies with soil type, agroclimatic conditions, varieties etc. and accordingly fertilizer requirement has been worked out for different ginger growing states of the country (Table 1). These is a wide variation in N, P and K requirement of ginger grown in different agro climatic conditions of India and uniform dose cannot be adopted. Split application of potassium, 20 % at planting, 40 % two months after planting and remaining 40 % again two months later is recommended to obtain high yields. Lime application is recommended for acid soils. In micronutrients deficient areas, combined spraying of Zn (0.3%), Fe (0.2%) and B (0.2%), twice, at 45 and 75 DAP enhances the rhizome yield. All the micronutrient treatments produced higher yields than the control (Singh and Dwivedi, 2007).

Table 1. Manures and fertilizers recommendations for various agro-climatic zones of India

State	Recommendation
Kerala	FYM 30 t ha^{-1}; NPK 70:50:50 kg ha^{-1}. Full dose of P and 50% K may be applied as basal dose. Half of N applied at 60 DAP. The remaining quantity of N and K applied at 90 DAP.
Karnataka	FYM/compost 25 t ha^{-1}; NPK 100:50:50 kg ha^{-1}. Apply the entire dose of P and K at planting. Half of N applied at 30-40 DAP and other half at 60-70 DAP.
Orissa	FYM 25 t ha^{-1}; NPK 125:100:100 kg ha^{-1}. Full P and half K applied as basal dose in furrows before planting and N and K in 2 splits at 45 and 90 DAP.
Himachal Pradesh	FYM 20-30 t ha^{-1}; CAN @ 400 kg ha^{-1}, NPK 100:50:60 kg ha^{-1}. Apply P as basal and N in 3 equal splits, first at the time of planting and subsequently at monthly intervals. K_2O also in two splits, half at sowing and remaining at rhizome initiation.
Andhra Pradesh	FYM 20-30 t ha^{-1}; NPK @ 75:50:50 kg ha^{-1}
Meghalaya	FYM 10 t ha^{-1}; NPK @ 60:90:60 kg ha^{-1}
Tamil Nadu	FYM 20-25 t ha^{-1}; 2 t ha^{-1} neem cake; 50 kg P_2O_5 + 25 kg K_2O as basal; 2 splits of 75 kg N at 45 & 90 DAS
Sikkim	FYM 40-60 t ha^{-1} + 20-25 kg Diammonium Phosphate ha^{-1}

Being N and K exhaustive, ginger removes lot of N and K from the soil leading to soil degradation and calls for fresh area for cultivation each year. An average dry yield of 4.0 t ha^{-1} ginger rhizomes removes 70 kg nitrogen and 117 kg K_2O. Excess use of N fertilizers and use of straight fertilizers, which are generally free from micronutrients, result in imbalance of other nutrients and create wide spread deficiencies of micronutrients especially Zn in major spice growing soils. Technologies for location specific integrated plant nutrient management (IPNM) are lacking. Studies should be aimed at identification of cheaper and efficient sources of nutrients and low input technologies to alleviate macro and micro nutrient deficiencies in location specific soil-crop systems. Identification of efficient location specific strains of bio fertilizers and developing IPNM through conjoint use of organics, to meet the plant nutrient requirement may be thought of. Use of micronutrients should be encouraged especially in deficient areas.

Increasing productivity of ginger through crop management

Effective IPNM, early planting of ginger and scientific crop management would augment ginger production and productivity. Nutrient requirements have been worked out for targeted yield level of 10-12 t/ha based on soil fertility levels. Use of micronutrients such as Zn, Mn, and B as IPNM component can be encouraged. Biofertilizers, cropping method, shade, manures and varieties suitable for organic production need to be developed. Crop simulation models for yield prediction and pest forecast can be developed.

Increasing productivity of ginger through pest and disease management

Among diseases, soft rot and bacterial wilt result in 50-80% economic losses. *Fusarium* yellows causes up to 60% crop loss. *Phyllosticta* leaf spot, root knot nematodes and storage rots further economic losses up to 30%. The major insects infesting ginger are shoot borer, rhizome scales and root grub. Identification of variability in the pathogen and their long term survival in soil and rhizome need to be addressed to develop location specific management strategies. Though chemicals have been found for management of soft rot use of newer method of disease control by integrating the cultural, chemical and biological approach assume significance. Biocontrol agents can be identified against major diseases of ginger as currently no biocontrol agent is available for disease management. Developing diagnostic kits to index planting material (bacteria and viruses) is very important. Latest technologies in the crop improvement can be exploited for developing transgenic ginger resistant to major biotic stress. Ecofriendly rhizome treatment method can be popularized to ensure disease free nucleus material. Foliar pathogens of ginger need further attention. Development of ideal storage conditions is vital for ensuring healthy rhizomes for planting. Considering the safety, efficiency and cost, ethylene dibromide (EDB) and methyl bromide (MB) fumigations are recommended for control of *Stegobium paniceum* L, the main storage pest. Other storage pests *i.e. Lasioderma sericorne*, F. and *Areaeceus fasciculatus* Deg., can be controlled by the application of lindane (1%) followed by malathion (2%) and pyrethrum (0.5%) as dust on the outer surface of the bag.

Processing and value addition of ginger

Though traditionally ginger processing was restricted to dry ginger and ginger powder, Australia has plenty of value added products such as ginger candy, crystalline ginger, ginger biscuits, ginger marmalade, ginger sauce, ginger beverages, ginger conserves, sugar preserved ginger, ginger beer, ginger ale etc. China also has products such as ginger flakes, ginger puree, salted ginger, ginger tea, sushi ginger, ginger pickles, dry ginger, ginger powder etc. India has only a few value added products and it exports ginger mainly in the form of dry ginger, whole ginger, and ginger powder. Australian ginger has very high levels of citral which gives lemony flavour and hence has very high consumer preference. Superiority of Jamican ginger over other gingers is also due to its lemony flavour imparted during a unique processing technique.

Improper processing and drying leads to quality deterioration. Mechanical dryers are available for quick drying of ginger without compromising in quality. Ginger cultivated in north eastern states is very plumpy and on drying becomes very shriveled with high fibre and not suitable for value addition as dry ginger or ginger powder. India has no ginger confectioneries to offer which is in great demand in the world market and fetches high returns. Farmers should be educated on proper drying and storage techniques. Use of mechanical dryers should be encouraged which leads to uniform drying and retention of better quality. Establishment of community processing units and cryopreservation facility for storage are essential for small and marginal farmers to process and store their produce without quality loss. Processing technologies should be modified/ upgraded to meet global standards and consumer preferences. Studies should be aimed at producing newer valued added products keeping in view the quality and consumer preferences to enhance our global trade. Government/agencies should promote farmers to cultivate varieties suited for specific processing/value addition with ensured buyback at a reasonably high price. Value addition in terms of ginger confectioneries such as ginger candy, jams, syrups, biscuits etc. can be attempted as there is high value and increased demand in the world market for these products.

Post harvest technology in ginger and bioprospecting of specific flavoring principles

Biogenesis of fiber, citral, limonene and zingiberene and identification of pharmacologically important bioactive principles can lead to newer molecules. Flavour development in relation to crop maturity, agronomic practices and post harvest processing need attention. Biosynthesis of fibre in ginger and secondary metabolites needs to be investigated as it is mainly related to climatic factors and agronomic practices. Pharmacological evaluation and pharmacodynamics of the bioactive principles of ginger needs attention. Standardizing cryo-grinding methods for dry ginger and dryers for ginger is necessary. Labour saving devices can be developed for easy processing and storage of ginger. Cottage industries can be promoted to produce value added ginger. Supercritical extraction system and microencapsulation of ginger oil can be developed. Effect of monoherbal/multiherbal preparation of ginger on identified human ailments can be established.

Global trade

India ranks first in ginger production. High domestic demand exists for the produce. Asian countries lead in the supply of ginger in the world market. Japan and USA are the major importers. China has the major export share. India exports mainly in the form of whole and dry ginger. Indian dry ginger is known in the global market as 'Cochin Ginger' and 'Calicut Ginger'. Cochin ginger is considered as one of the best in the world and has good export market potential. China, Nigeria and Thailand are competing with India in the recent past in the world market. Australia and China are the world leaders in value added products and Australia is very famous for confectionery ginger. India has 50% share in oil and oleoresin trade. In India, most of the ginger produced goes for domestic consumption and only a small quantity is exported. But in other producing countries domestic consumption is less and export is more. There is a lot of demand for organic ginger internationally and India has a good scope for organic cultivation.

Unregulated marketing, lack of market access and information, limited number of procurement centres, non-existence of cooperative societies and low price apart from lack of technical expertise and huge transportation cost are the major weaknesses in the domestic sector. In the international sector, the major lacuna is limited number of value added products. Heavy domestic consumption has lead to low export potential. Though there is a great scope for organic ginger production, management of diseases and pests through organic means is very difficult which affects overall production. India has the potential to increase the export through introduction of more value added products in to the world market. Shrewd marketing strategies such as marketing based on consumer preferences in different countries, offering competitive prices, quality enhancement, introduction of organic products etc. can enhance the demand for Indian products. Aggressive marketing through publicity such as advertisements, web-based marketing etc. can increase our trade. Characterization of the reputed Cochin ginger and Wayanadan ginger based on tangible and intangible properties for GI appellation can boost ginger export. IT based market intelligence, price prediction and future trade., factors affecting trade and price fluctuation in ginger and its impact on ginger production etc. should be given attention.

Scientific advancement and technologies available for ginger production

- Availability of improved high yielding varieties namely, IISR Varada, IISR Mahima and IISR Rejatha as well as nematode resistant, low fibre and high oil types
- Micropropagation technique for in vitro production of ginger
- RAPD based DNA finger printing has been done and molecular method for varietal identification
- Methodology for transgenic development in ginger
- Application of coir compost (Terra care) @ 2.5t/ha increased ginger yield by 37.5% over check.
- A technique for crude fiber extraction using dosi fiber apparatus and salted ginger preparation from fresh ginger is available
- An integrated pest and disease management strategy for soft rot and insect pests of ginger is available
- A technique for solarization of ginger seed rhizomes for elimination of bacterial wilt is available
- Spraying of bio-pesticides such as dipel 0.3% during July-October or adoption of cultural practices such as pruning of infested shoots during July – August and spraying malathion 0.1% during September-October was effective for the management of shoot borer on ginger and resulted in pesticide residue levels that were below permissible levels.
- Dipping of seed rhizomes in quinalphos 0.075% and storage in dried leaves of *Strychnos nuxovomica* was effective for the management of rhizome scale.

Conclusion

Good diversity coupled with scientific advancement in ginger would augment the ginger production to meet the projected demand. High yielding types have been well accepted by farmers across the states and ginger growing regions. The challenging task in future ginger research would be on development of varieties with high yield, bacterial wilt & soft rot resistance and high quality besides suitable to all major ginger growing areas of the country. Location specific soft rot and bacterial wilt diseases integrated disease management strategy need to be developed. Biocontrol research needs to be strengthened. Technology should be developed for repeated cultivation of ginger in the same field. Indian dry ginger (Cochin ginger) is highly valued in world market. GI registration would boost the ginger trade at international level. Though India is the major producer of ginger, the quantity exported is very less. Export earnings can be enhanced through innovative value addition mainly as ginger confectioneries, soups, beverages, syrups and marmalades etc.

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Present status and future prospects of ginger production in Kerala

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Introduction

Ginger (*Zingiber officinale* Rosc.), one of the oldest known spices is highly esteemed for its pleasant aroma and warm and pungent taste. It is cultivated widely in tropical and subtropical countries. In ancient India, China and Japan it was more valued for its medicinal properties and played an important role in primary health care. Due to its carminative, stimulant and digestive properties, ginger is used for the treatment of fever, cough, vomiting, constipation, flatulence, colic, swelling, asthma and cough in traditional medicines. In the nutraceutical and healthy food industry, ginger is gaining importance owing to its health beneficial effects like anti-hyper cholesterolemic, anti-inflammatory and anti-diabetic properties.

Ginger is grown mainly in countries like Nigeria, India, China, Thailand, Indonesia, Bangladesh, Philippines etc. with a global area of 3.78 lakh ha and production of 12.83 lakh tons. India is the largest producer and exporter of ginger producing 3.98 lakh tons of cured ginger from an area of 1.00 lakh ha, contributing nearly 30 per cent of global area and production. In India, 95 per cent of the total production is domestically consumed and only 5 per cent is exported to different countries. During 2006-07, India earned a foreign exchange of Rs. 40 crores by way of export of ginger (www.indianspices.com). The items exported include fresh and dry ginger, ginger powder, ginger oil and ginger oleoresin. The major export markets for dry ginger are Saudi Arabia, USA, Yemen, Morocco, UAE and Netherlands. Fresh ginger is mainly exported to Pakistan and Bangladesh.

The crop occupies the highest area in Assam (17.2%), followed by Orissa (14.98%) and Kerala (11.59%). Kerala is the major state in India producing quality ginger. The Cochin and Calicut ginger traded from Kerala have high reputation in the international market owing to its lemon like aroma. But Indian ginger is considered second only to Jamaican ginger due to its high fibre content.

Ginger is cultivated in an area of 12,226 ha in Kerala with a production of 56, 288 tons and productivity of 4.6 tons of cured ginger per ha. Major production centre in the state is Wayanad, contributing 59 per cent of area and 69 per cent of production recording the highest productivity of 5.34 tons of cured ginger/ha in the state (Table 1). Palakkad and Idukki districts are the other major centres of production.

Table 1. District-wise area, production and productivity of ginger in Kerala

District	Area (ha)	Production (t)	Productivity cured ginger (t/ha)
Thiruvananthapuram	127	298	2.35
Kollam	676	1999	2.96
Pathanamthitta	632	1908	3.02
Alappuzha	34	73	2.15
Kottayam	225	772	3.43
Idukki	900	3103	3.45
Ernakulam	372	1181	3.17
Thrissur	157	467	2.97
Palakkad	1362	6350	4.66
Malappuram	175	336	1.92
Kozhikode	165	504	3.05
Wayanad	7269	38,823	5.34
Kannur	76	279	3.67
Kasargod	56	195	3.48
Total	12,226	56,288	4.60

(Source: Department of Economics and Statistics, Govt. of Kerala, 2005-06)

Table 2. Trends in area, production and productivity of ginger in Kerala

Year	Area (ha)	Production (tonnes)	Productivity (kg/ha)
1995-96	12925	46455	3594
1996-97	13199	46371	3513
1997-98	12352	43617	3531
1998-99	11107	39362	3544
1999-00	11264	41344	3670
2000-01	11612	42699	3677
2001-02	10706	40181	3753
2002-03	8998	32412	3602
2003-04	8516	32972	3872
2004-05	9991	45305	4535

(Source: Department of Economics and Statistics, Govt. of Kerala, 2005-06)

The strengths of ginger industry in Kerala, major constraints in production and trade of ginger and future prospects are dealt briefly in this article.

Strengths of ginger industry in Kerala

Climatic and soil suitability

Ginger requires tropical and subtropical climate with a well distributed annual mean rainfall of 1500-3000 mm and temperature within the range of 28-35°C for better growth and development of rhizomes. Being a shade loving plant, partial shade increases the rhizome yield in ginger. The plant adapts widely to different soil types. But loose friable soil rich in organic matter with a pH of 6-7 is found ideal for ginger cultivation. Dry spells with moderate showers at the time of planting, heavy showers during growing period and a dry period of one month prior to harvest are congenial for better production in ginger. The climatic and soil conditions of Kerala are highly suitable for ginger cultivation meeting the above mentioned requirements.

Prevalence of traditional cultivars with high intrinsic qualities

Ginger has been under cultivation since time immemorial in Kerala and hence there exists high variability for yield and quality attributes in the cultivated ginger types. Geographical spread accompanied by genetic differentiation into locally adapted populations caused by mutation could be the main factor responsible for the diversity in this clonally propagated crop (Ravindran *et al.*, 2005). The early movement of settlers across the state might have contributed to the spread of cultivated types and for the wider diversity. Table 3 illustrates the traditional cultivars of Kerala and their quality attributes (Nybe, 1978).

Table 3. Yield and quality attributes of traditional cultivars of Kerala

Cultivar	Yield / bed (3x1m) kg	Driage	Oleoresin (%)	Volatile oil (%)	Crude fibre (%)
Valluvanad	11.02	18.60	8.78	2.2	4.21
Vengara	6.56	19.60	5.85	2.3	4.45
Ernad Chernad	10.52	20.00	5.98	1.72	5.60
Ernad Manjeri	11.49	21.60	8.09	1.75	4.74
Wayanad Local	11.25	18.40	9.14	1.60	5.75
Wayanad Kunnamangalam	10.40	22.40	6.52	1.49	6.00
Thodupuzha	4.88	25.20	6.38	1.62	4.46
Wayanad Mananthody	7.06	19.40	4.91	1.94	4.28
Kuruppampady	5.51	23.00	8.00	1.79	6.47

(Source: Nybe, 1978)

Improved production and processing technologies

Improved production and processing technologies were standardized for the crop by the concerted efforts of Kerala Agricultural University (KAU), Thrissur and Indian Institute of Spices Research (IISR), Kozhikode. Introduction of exotic and indigenous types from other states to Kerala has substantially improved the production and productivity of the crop. Techniques are now available for production of quality planting material, nutrient management, pest and disease management, organic ginger production, primary and secondary processing techniques and value addition in ginger. The details of high yielding varieties developed from IISR, Kozhikode are presented in Table 4.

Table 4. Released varieties of ginger suited for cultivation in Kerala

Variety maturity	Mean yield (per ha)	Dry recovery (%)	Volatile oil (%)	Oleoresin (%)	Crude fibre (%)	Days to maturity
IISR Varada	22.6	19.5	1.7	6.7	3.3	200
IISR Mahima	23.2	23.0	1.7	4.5	3.3	200
IISR Rejatha	22.4	19.0	2.4	6.2	4.0	200

(Source: Parthasarathy *et al.*, 2007)

Efforts of developmental agencies

The efforts taken by Spices Board, Cochin and Directorate of Arecanut and Spices Development, Calicut for production of quality planting material and financial assistance extended by National and State Horticultural Mission for cultivation of ginger and organic ginger production are beneficial to Kerala farmers.

Constraints in production and trade of ginger

High incidence of pests and diseases

Ginger is seriously affected by soft rot (*Pythium aphanidermatum*) and bacterial wilt (*Ralstonia solanacearum*) diseases causing severe economic loss of 50 to 80 per cent. Even the high yield potential of elite types/HYV is masked by the occurrence of these devastating diseases. The major insects infesting ginger are shoot borer and rhizome scales. Rhizome maggot is also causing severe damage in recent years.

Non availability of good planting material

Quality planting material is the key factor for obtaining high yield in ginger and seed material alone accounts for 30-35 per cent of total cost of production. Utmost care should be exercised in selection of seed material, seed treatment and storage to protect seed rhizomes from desiccation and disease and pest infestation. Good quality planting material is not available to farmers in sufficient quantities as the distribution of seed rhizomes by SAUs and other agencies is not meeting the requirement fully. Also, farmers are not fully aware of the technique of seed treatment and detection of presence of pathogens in the seed material.

Non adoption of improved package of practices and production technologies

Even though improved production technologies are available, non adoption of improved technologies is a major lacuna in cultivation. There is a wide gap in realized yield in farmer's field and experimental plots at research stations. Ginger is a soil exhaustive crop and responds well to added organic manures and leafy mulch materials. Due to non availability of enough organic manures and mulch materials farmers are unable to apply organic manures and mulches as per recommendations.

High cost of cultivation and unstable prices

In Kerala, the cost of production is generally high due to high cost of labour. Table 5 explains the cost of production of ginger and returns from one hectare of area. It is evident from data presented in Table 5 that the cultivation of crop is not profitable due to high cost of production and low prices realized for the produce (www.ecostatkerala.org).

Table 5. Cost of cultivation per hectare of ginger (2004-05)

Components of cost	Cost per hectare (Rs.)
Hired human labour	18954
Machine labour	233
Seed rhizome	13858
Farmyard manure and Chemical fertilizers	9375
Plant protection	452
Land tax and irrigation cess	64
Repair and maintenance charges of implements, machinery and buildings	211
Interest on working capital	5287
Other expenses	-
Interest on fixed capital	1194
Imputed value of household labour	1607
Total cost	61235
Value of output received (Rs./ha)	61356

(Source: Department of Economics and Statistics, Govt. of Kerala, 2005-06)

The average farm gate price of ginger is presented in Table 6. Wide fluctuations in prices and high incidence of pests and diseases have brought down the total area under ginger in Kerala. Limited credit facilities, high risk and absence of crop insurance coverage force the farmers to shift from ginger to other crops.

Table 6. Average farm wholesale prices (Rs/q) of ginger in Kerala for the year 2005-06

Month & year	Ginger (dry)	Ginger (fresh)
July 2005	9135	-
August ,,	8718	-
September ,,	9534	-
October ,,	9123	-
November ,,	9027	-
December ,,	7379	-
January 2006	5680	1383
February ,,	4837	1296
March ,,	4169	1210
April ,,	3965	1195
May ,,	3810	1229
June ,,	3975	1313

(Source: Department of Economics and Statistics, Govt. of Kerala, 2005-06)

Climate change and related problems

In Kerala, ginger is mainly grown as a rainfed crop. Absence or late summer showers, very high temperature at the time of planting and very high precipitation during crop growth period affect the growth and yield of the crop. As per POP recommendations of KAU, the ideal time for planting ginger is first fortnight of April. Absence or late summer showers force the farmers to take up the land preparation and planting only by May-June reducing the crop growth period to 210 to 220 days. The high temperature prevailing in the month of April affects the germination of rhizomes. Very high precipitation during the growth period of the crop is highly congenial for multiplication and spread of rhizome rot and bacterial wilt pathogens resulting in severe economic losses. Also, possibilities of minor pest becoming major causing severe losses could not be ruled out. Increase in temperature by 2-3 degrees, increase in precipitation, solar radiation and CO_2 concentration are predicted as after effects of climate change (Parthasarathy *et al.*, 2007).

Future prospects and strategies

Developing low cost production technologies

The cost of production of ginger in India is very high as compared to other producing countries. The high price of Indian ginger in the international market is the main reason for decline in export. Farm mechanization, *in situ* green manure production, *in situ* composting using vermitechnology, use of biocontrol agents and biofertilizers are some of the measures to reduce cost of cultivation. Research efforts should be focused in developing machineries for taking beds, planting, earthing up and harvesting of ginger.

Conservation of genetic resources, isolation of HYV with tolerance/resistance to pests and diseases and good quality attributes

With the commercial cultivation of high yielding varieties/types, the traditional cultivars with high intrinsic qualities erode naturally from the natural gene pool. These traditional cultivars are to be conserved, characterized and utilized in further breeding programmes. Release of varieties with tolerance/resistance to diseases and pests with good quality attributes and wide adaptability to climate change could boost ginger production.

Quality ginger production following GAP

Production of good quality ginger without pesticide and chemical residues is important as people are more health conscious now-a-days. The adoption of Good Agricultural Practices will help to maintain quality and reduce chemical and pesticide residues. The production system should cater the export needs and meet the specifications laid out by international agencies. There are many value added products based on immature/fresh ginger, the residues of PP chemicals are a major concern in the processing of these items.

Organic ginger production

Organic spices are getting great momentum now-a-days and premium price is assured in the international market for the organically produced ginger. Research efforts should be focused on developing control measures against pests and diseases in organic ginger production.

Remunerative steady prices and assured market

Initiatives by Government for fixing a remunerative floor price for the produce will encourage the cultivation of ginger. Direct industry linkage with farmer's group/co-operatives will also help to reduce the exploitation by middle men ensuring better prices. Also provision should be made to get remunerative prices to farmers based on the quality of produce. Being a perishable commodity, processing units have to be established under Govt. sector in major areas of production so as to protect the farmers from price fall during the period of glut in the market.

Production of value added products

Ginger is traded mainly as dry ginger and small quantities are marketed as ginger oil and oleoresin and ginger powder. Technologies are available for the production of many value added items like encapsulated ginger, salted ginger, preserved ginger, crystallized ginger, ginger cocktail, ginger ale ginger beer etc. which are not commercially exploited.

Protection of Cochin ginger under GI registration

Ginger exported from India is extensively used for flavouring beverages. The highly popular ginger ale and ginger beer owe their predominant flavour and pleasant warm taste due to ginger. Cochin ginger with its lemon like flavour imparted by citral is highly preferred for flavouring these beverages. Registering Cochin Ginger as GI will help for better marketing and export of ginger produced in the State. Registration will also help to provide legal protection to Cochin ginger and prevent unauthorized use of registered GI. Documentation of morphological and quality attributes of Cochin ginger, developing geographical indicators for Cochin ginger for registration are the areas which need immediate attention.

Exploitation of diversified uses of ginger other than flavouring properties

Ginger is referred as Mahaoushada in Ayurvedic system of medicine and the immense medicinal properties of ginger with proven effectiveness should be exploited further on a commercial scale.

Ginger is a carminative and stimulant to the gastro-intestinal tract. It is a house hold remedy for flatulence and colic. Extract of ginger is used as an adjunct to many toxic and stimulating remedies. Externally, ginger is used as a local stimulant and rubefacient. Ginger is reported to contain an antihistaminic factor. It is an anti-depressant and forms part of some anti-narcotic preparations.

Ginger rhizome is a source of proteolytic enzyme. The recovery of the enzyme from fresh rhizome is 2.26 per cent, which is found to be very high as compared to 0.013 per cent in papaya fruit. Ginger is valued for its nutritional properties also.

The anti-oxidant, anti-inflammatory and anti-diabetic properties could be utilized in the nutraceutical and health food industry. Shogaol and Zingerone are as potent as allyl sulphide or allyl disulphide in preventing lipid oxidation. The efficacy of ginger extracts or active principles like gingerol and shogaol in lowering serum cholesterol level in relation to atherosclerosis and coronary heart diseases was well established by several workers. Anti-inflammatory properties of ginger could be utilized for the treatment of arthritis and ulcers in digestive tract. The ethanolic extract of ginger and gingerol is found effective for diabetes.

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Present status and future prospects of ginger production in north eastern states

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Introduction

The north eastern region produces a variety of spices including chillies, ginger, turmeric, large cardamoms, black pepper, tejpatta etc. Ginger is prominent among them and its cultivation is undertaken as a cash crop mostly in "jhum" fields spread over the hills and tribal areas of the entire region. Ginger is grown in almost all the states of the region but the leading states are Meghalaya, Mizoram, Arunachal Pradesh and Sikkim. Apart from improved varieties like Nadia, China, Varada, etc., a number of local cultivars exist in northeastern region. These varieties are high yielder of rhizomes as compared to standard cultivars like Nadia and Rio-De-Janeiro but have more fibre content. The ginger produced in higher altitude contains high oleoresin and gives higher oil recovery.

The region as a whole produces over 207 thousand tonnes of raw ginger every year. The product is mostly marketed in the fresh form. The local demand being very limited, roughly 70-80% of the total production is reportedly available as marketable surplus from the region. A sizeable quantity of ginger is wasted in transit because of the perishable nature of the commodity. The post harvest loss is estimated to be about 10.5 % during handling and transportation. As it is abundantly available in the region, different products like ginger oil, ginger olcoresin can be prepared for export, which are very common in developed countries. Dried ginger can also be prepared and it may be either sold as such or in the form of an off white to very light brown powder. The dried ginger or ginger powder is generally used in manufacturing of ginger brandy, wine and beer in many western countries. Ginger oil is primarily used as a flavouring agent in confectionary and for soft drinks.

Present status of ginger production in north eastern region

The area under ginger in NE region is 30.84 thousands ha which gives total production of 209.15 thousand tonnes at an average yield of 6.78 t/ha against the national productivity of 3.56 t/ha. Meghalaya is the major producer of ginger in the region, which is also second largest producer in the country with total share of 19.59 % after Kerala, which contributes 23.08 % to the total production of the country. The production of ginger is highest in Meghalaya followed by Mizoram and Arunachal Pradesh. However, the productivity is highest in Manipur (9.86 t/ ha) followed by Nagaland (9.05 t/ ha) and Arunachal Pradesh (Table 1). Meghalaya is having higher per capita availability of ginger than national availability per annum. Moreover, the farmers are interested to increase the area under cultivation of ginger as soil, climate and other ecological factors favour the growth and development of the crop and there is a tremendous scope to increase the yield per unit area and thereby the total production of ginger in north east region.

Table 1. State-wise area, production and productivity of ginger in north eastern region (2004-05)

State	Area ('000 ha)	Production ('000 t)	Productivity (t/ha)
Arunachal Pradesh	4.61	38.02	8.25
Assam	4.20	32.10	7.64
Manipur	1.27	12.52	9.86
Meghalaya	8.40	46.59	5.55
Mizoram	4.53	38.07	8.40
Nagaland	1.37	12.40	9.05
Sikkim	5.10	24.00	4.71
Tripura	1.36	5.45	4.01
North eastern region	*30.84*	*209.15*	*6.78*
India	*86.32*	*307.09*	*3.56*

The farmers of the region cultivate a number of indigenous varieties, which are ideal for dehydration and preparation of other value added products. The most popular cultivated variety in the region is Nadia that possess low fibre (4.10 %) and has maximum demand for culinary purposes (Table 2). Although it is said that Nadia is popular among the farmers on productivity aspect, the local medium sized varieties are still grown in larger area in the region.

Table 2. Promising varieties of ginger grown commercially in north eastern region

Adapted variety	Crude fibre content (%)	Dry matter content (%)	Gingerol (%)	Oil (%)	Yield (t/ha)
Nadia	4.56	22.25	0.64	1.45	30.00
Poona	6.24	19.76	0.93	1.17	25.10
Varada	5.93	21.38	0.96	1.75	22.00
Thingpui (local)	5.74	22.47	1.25	1.80	19.30

Diversity of ginger in the region

In ginger, the region can be considered as treasure house of germplasm. There are several cultivated types of ginger available in the region, which are generally named after the localities they are being grown. Certain indigenous types namely Maran, Bhola and Jorhat Local of Assam have been reported to be equally good in rhizome yield as well as in size. Dry ginger recovery of these varieties has been found to be even better than exotic type Rio-de-Janeiro. The pungency in ginger is due to gingerol, which is found highest in Meghalaya Local genotype (medium size) and very suitable for export purposes. In Arunachal Pradesh, Basar Local is very much popular due to high yield and its adaptability to the area (Table 3). In Mizoram, local types 'Thingpui', 'Thingaria' and 'Thinglaidum' are grown at large scale. Among these cultivars, the farmers mostly prefer 'Thinglaidum' (medium in size) as it contains less fibre having blakish ring. 'Thingaria' is no. 2 cultivar in area and production in Mizoram. Black ginger having rhizomes with bluish black tinge inside is reported to have medicinal properties and is grown by the inhabitants of Mizoram for commercial as well as their own use. Moreover, it is sold at very high price probably due to high medicinal value.

In Tripura also a local selection, 'Tripura Local' performed better in comparison to other types. In Manipur, 'Thingpui' type (medium size) is commonly preferred in the hills out of 4-5 local cultivars grown in the state. In Nagaland, mainly two improved varieties, viz., Nadia, Rio-De-Generio and two local cultivars 'Viishii/Sungrosung' (small sized rhizome having medicinal properties) and 'Osung' (bigger sized rhizome) are grown. In Sikkim, local types 'Bhainse' and 'Gorubathan' are grown commercially due to their high yield potential and big size rhizomes. In Meghalaya, in addition to local types namely 'Meghalaya Local' and 'Tura Local', considerable area has been brought under selected type Nadia (Table 3).

Table 3. Promising local genotypes of ginger of north east region

Genotype	Crude fibre content (%)	Dry matter content (%)	Gingerol (%)	Oil (%)	Yield (q/ha)
Manipuri No. 1	6.77	21.18	1.14	1.45	171.26
Basar	7.02	22.54	1.12	1.30	209.40
Tura Local	5.50	21.9	1.32	1.55	178.26
Thingpui	5.74	22.47	1.25	1.80	193.41
Maran	6.25	24.02	1.10	1.75	198.15
Meghalaya Local	6.02	20.12	1.71	2.10	147.65
Thinglaidum	5.86	22.38	1.23	1.45	154.25
Kachai Ginger	5.72	24.87	1.20	1.70	200.97
Nagaland Local	6.93	19.8	1.18	1.85	191.80
Nadia	4.56	22.25	0.64	1.45	300.00

(Source : Sanwal *et al*, 2007)

Commercial qualities

Ginger is generally sold as raw ginger in local markets but there are several other products of ginger like dry ginger, ginger powder, ginger oil, and oleoresin. The oleoresin and oil are known as high value and low volume products, which have great demand in western countries. The varieties with less fibre, high dry matter recovery, and high oil and oleoresin contents are having great export potential in international markets. Therefore, more emphasis may be given to develop those varieties, which are having the above qualities. The Indian Institute of Spices Research, Calicut has evolved Varada, a new variety of ginger, which is being multiplied at Ginger Development Station, Umsning, Meghalaya and the performance of the variety is quite encouraging. The local varieties of ginger contain higher quantity of gingerol compared to the variety like Nadia and Varada.

In International market several grades are available and on the basis of that ginger has been categorized in different grades (Table 4). The ginger produced in the region is at par to this grade for outside export and getting higher prices because the prices vary as per the grades.

Table 4. The quality characteristics of different grades in ginger

Quality characters	Limits		
	Grade I	Grade II	Grade III
Extraneous matter % by mass (max.)	2.0	3.0	5.0
Insect damaged matter, % by mass (max.)	1.0	3.0	5.0
Pieces less than 25 mm, % by mass (max.)	0.5	1.0	2.0
Decayed pieces, % by mass (max.)	nil	0.5	1.0
Dry matter, % by mass (min.)	22.0	20.0	18.0
Volatile oil as ml/100 gm (min.)	0.7	0.5	0.3
Crude fibre content of the dry matter % by mass (max.)	8.0	10.0	12.0
Non-volatile ether extract content of the dry matter % by mass (min.)	5.0	3.0	2.0

(Source: Spice India, 2004)

Ginger based industry in north eastern region

A few ginger processing plants have been established in the region in last couple of years for preparation and marketing of different value added products. Besides, a number of self help groups (SHG) of the region have started producing different products like dried ginger, ginger candy, powder etc. at cottage level.

Table 5. Ginger processing plant in the north eastern region

Location	Public/ Private	Products prepared
Byrnihat, Meghalaya	Public sector	Oil, powder and waxed fresh ginger
Chaigaon, Kamrup, Assam	Private	Dried ginger, powder
Bijni, Bongaigaon, Assam	Private	Dried ginger, powder
Ukhrul, Manipur	Private	Oil, powder
Mangaldai, Assam	Private (Proposed)	Ginger candy, ready to use fresh ginger slices

Production and marketing constraints

Abiotic factors

Ginger is mostly grown in sub-tropical hill zones where soil is acidic in nature. Cultivation is being practised on steep slopes under jhum/ bun (raised beds) system in rainfed conditions without adoption of soil and water conservation. Deep virgin soils of forest brought under jhum system are giving higher yields in first and second year of cultivation even under zero nutrient management conditions. But heavy rains and earthing works associated with the cultural operations and harvesting accelerate the erosion reducing the fertile soils into abandoned wasteland. In second cycle of cultivation on such fields after a gap of 3-5 years very low yields (5-8 t/ha) are obtained. Farmers apply only FYM at planting and no other nutrient application strategies are followed. These factors lead to low productivity. Research on soil water conservation technologies, sustainable production system etc is being carried out by the Institute.

Biotic factors

Non-availability of quality planting material is another important factor attributing to low productivity. The serious diseases of ginger are seed rhizome borne viz., soft rot (*Pythium sp, Rhizoctonia sp and Sclerotium rolfsii*), dry rot (*Fusarium oxysporum*) and bacterial wilt (*Ralstonia solanacearum*). Some of these, particularly bacterial wilt once introduced into cultivated fields it is very difficult to eradicate. The supply of quality planting material free from diseases can contribute enormously to enhance the productivity. Ginger stem borer (*Dichochrosis punctiferalis*), Shoot borer weevil (*Prodiotes halmaticus*) causes crop damage between 30-40 % during July-September. There is a need for the establishment of seed agencies to supply certified seed rhizome in north-eastern region. Farmers / Farmers' clubs / NGOs could be trained to develop technical skill to produce home grown quality seed to meet their own seed requirements. Further, bio-organic/ botanical extracts developed by the Institute controls serious diseases and increases ginger yield. Such materials at low cost are technically feasible in slope areas and are eco friendly substances.

Socio-economic factors

Ginger cultivators in northeastern regions are resource poor and have low produce holding capacity. Lack of storage facilities at farm, non-existence of organised marketing system/ growers association etc force the growers to sell their produce just after harvesting through commission agents. Sale in village markets (weekly markets), city markets are very limited. Ginger is cultivated in sloppy, arable, rainfed areas and productivity is determined by distribution of rainfall during the growing season. Favourable rainfall distribution in certain years helps in increased productivity / marketable surplus.

Absence of adequate number of post harvest processing units to absorb marketable surplus (which is nearly 70%) forces the cultivators to sell the produce as fresh ginger only. Unorganised marketing system is another constraint determining the low adoption of improved production packages and enhancing the productivity system. Establishment of processing units in the region is needed to absorb the market surplus and produce value added products that have longer shelf life. The region has tremendous potential for organic ginger production because of existing practices of zero chemical input, which could be identified with least conversion period for certification of organic ginger production.

Future thrust

The followings are the areas where more intensive research is needed so that overall scenario of the ginger production can be changed by increasing production and productivity of ginger in the northeastern region.

Post harvest management

There is need to develop quality control measures, adequate packaging, transportation and storage techniques. Oil, oleoresin and fibre content at different stages of maturity should be determined in order to maximize the oil and oleoresin production in the region. Varieties suitable for extraction of oil and oleoresin should also be identified for better return per unit area and once they are identified, they should be popularized among the growers. Intensive research for protocol development of different value added products like candy, dehydrated product, ready to use ginger slices etc may be taken up. Low cost storage structure for long-term storage of ginger is the need of the hour. Sprouting inhibition after harvesting for a minimum period of 2-3 months using organic sources will increase the volume of export of fresh ginger.

Introduction, evaluation and improvement

Introduction of indigenous and exotic high yielding strains of ginger suitable for the state may help in increasing the total production of the region. Breeding with local germplasms should be done for high yielding and better quality varieties with resistance to biotic and abiotic stress. DNA finger printing of the local germplasm should be done immediately to safe gourd the interest of the farmers.

Quality planting materials

Since there is inadequate supply of quality planting materials and true to the type varieties are not maintained properly, a mechanism may be devised for regulating the production and supply of disease free planting materials to the growers. Micro propagation techniques may help in rapid multiplication of quality planting material.

Emphasis on organic farming

The ginger production in the northeastern region is organic by default. Bio-organics, bio-pesticides, integrated approach for pest and disease control and strategies for each farming systems has to be worked out. The need of the hour is to have a simplified and affordable organic certification system.

Cropping pattern/ crop sequences for sustainable production and productivity

Since quality and productivity of ginger largely depend on agro-climatic conditions, varieties, soil fertility, locations etc, location specific cropping pattern/ sequences has to be identified/ evaluated/ refined state-wise in the region.

Economics and technology transfer

The cost benefit analysis of different farming systems is required. There is immense need to strengthen the extension system for transfer of technologies and to provide training to the farmers.

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Present status and prospects of ginger production in Orissa

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Introduction

Ginger is one of the important spices all over the world. Ginger of commerce is the dried rhizome. It is marketed in different forms such as raw ginger, bleached dry ginger, ginger powder, ginger oil, ginger oleoresin, ginger ale, ginger candy, ginger beer, ginger wine, ginger squash, ginger paste, ginger flakes etc. Ginger (*Zingiber officinale* Rosc.) is native to South East Asia. India is the largest producer, consumer and exporter of ginger in the world. Besides India ginger is cultivated in other tropical and subtropical countries like China, Nigeria Sierra Leon, Indonesia, Malaysia, Brazil, Coast Rica, Thailand, Bangladesh, Fiji Island, Jamaica, Philippines and Australia. Ginger rhizome contains a wide variety of biologically active principles and has a long and well documented history in both culinary use as a spice to add taste and flavour to the food and medicine with antithromotic, anti-inflammatory, antidepressant, antioxidant antibacterial, antidiarrhoeal, anticancerous properties used in Ayurvedic, Unani, Chinese and tribal medicines. The pungency principle in ginger is due to the presence of monoterpines like gingerol, shogoal zingerone and flavour is due to sesquiterpenes like zingeberene, zingiberneol present in the volatile oil. The chemical composition of ginger varies due to variety, soil and climatic differences.

Global scenario

The highest area under ginger cultivation was in Nigeria, which was about 55 percent of the total world ginger area under cultivation (2001). India has a predominant position in ginger production contributing 36% of total global production. The estimated world import of ginger is around 35000 tons valued US $30 million. Jamaican ginger and Cochin ginger are the well-known and preferred grades of ginger traded across the world. During 2006-07, about 7500 tons of ginger valued at Rs. 39.75 cr was exported from India, which is 3.5% of total Indian production. Global ginger cultivation area is 3,17,055 ha with total world ginger production of 7,70,778 tons.

Indian scenario

Ginger grows well in warm and humid climate and is cultivated in tropical and subtropical regions from sea level to an altitude of 1500 M MSL in all most all states of India. During 2002-2003, the estimated production of ginger was 3,07,370 tons from an area of 85,930 ha with a productivity of 3577 kg/ha. If we compare it with 1993-94, there has been an increase in production having a growth rate of 5.79 percent. The trend in area production and productivity of ginger for a decade since 1993-94 crop seasons are given in Table 1.

Table 1. Area and production of ginger in India

Year	Area (Ha)	Production (tones)	Productivity (kg/ha)
1993-94	60,580	186,200	3074
1995-96	61,090 (0.84)	197.650 (6.15)	3235 (5.24)
1995-96	66,8902 (9.49)	219,300 (10.95)	3279 (1.36)
1996-97	702,290 (5.08)	232,510 (6.02)	3308 (0.88)
1997-98	75,750 (7.51)	252,110 (8.42)	3336 (0.85)
1998-99	77,830 (2.99)	265,290 (5.23)	3409 (2.19)
1999-00	77,500 (-0.42)	281,530 (6.21)	3633 (6.57)
2000-01	83,420 (7.64)	303,420 (7.77)	3637 (0.11)
2001-02	84,570 (1.38)	317,860 (4.76)	3759 (3.35)
2002-03	85,930 (1.61)	307,370 (-3.30)	3577 (-4.84)

(The values in the parenthesis indicate the changes from the previous year in percentage)
(Source: Spice India, 2006)

Ginger is grown in almost all states. However Arunachal Pradesh, Kerala, Meghalaya, Mizoram and Orissa together contribute over 55.63 percent of total production. During 2002-03 highest area under ginger cultivation was in Orissa (1,53,402 ha).

Table 2. State wise production of ginger (2002-03)

State	Area (%)	Production (%)
Kerala	10.5	10.5
Meghalaya	9.2	14.9
Orissa	17.9	9.6
Arunachal Pradesh	5.2	10.5
Mizoram	5.9	10.1
Other states	17.3	44.4
Total area	*85,930 ha*	*3,07,370 t*

The productivity in Indian ginger is increased from 3074 kg/ha during 1993-94 to 3577 kg/ha in 2002-2003 due to adoption of improved variety and improved production techniques and a positive growth rate of 5.4% is achieved.

Production scenario of ginger in Orissa

In Orissa ginger is grown mostly by the tribal farmers remaining in the eastern ghat hills following traditional methods of cultivation practices using their own local seed or seeds purchased from local market mostly under rainfed conditions in the low organic matter rich soil without adoption of improved varieties or crop rotation or scientific crop management practices and sailing ginger as fresh ginger just after harvesting without any processing or value addition.

About 70% area and production is from Koraput, Kandhamal, Keonjhar, Gajapati and Rayagada district of Orissa. During 2006-07 ginger was cultivated in 16,073 ha with total production of 3,13,97 tons covering all the districts of Orissa.

Table 3. District wise area and production of ginger (fresh) in Orissa (2005-2006)

District	Area (ha)	Production (tons)	District	Area (ha)	Production (tons)
Balasore	680	1400	Koraput	2200	4426
Bhadrak	100	206	Malkanagiri	243	459
Bolangir	46	57	Nawarangpur	128	237
Sonepur	20	24	Rayagada	293	553
Cuttack	460	850	Phulbani	3865	7960
J.S. Pur	311	580	Boudh	134	273
Jajpur	247	463	Mayurbhanj	584	1039
Kendrapara	317	588	Puri	32	55
Dhenkanal	294	529	Khurda	366	666
Angul	451	576	Nayagarh	485	887
Ganjam	112	231	Sambalpur	696	1315
Gajapati	440	885	Deogarh	163	230
Keonjhar	1094	2230	Bargarh	668	1362
Kalahandi	70	128	Jharsuguda	634	1173
Khariar	123	221	Sundargarh	550	1040
			Total	*15806*	*30643*

Export scenario of organic value added products and ginger from Orissa

The Government of Orissa has signed a MOU with APEDA (Govt. of India) for setting of an Agro Export Zone for ginger in the district of Koraput and Kandhamal in Orissa. Under this AEZ scheme, organised production, certification and value addition of ginger is done involving 12000 tribal farmers under one federation KASAM in an organised way.

Export of organic ginger and ginger products such as dry ginger, ginger powder and sliced ginger from Orissa to USA, Germany, Netherlands and Australia through KASAM has started since 2004-2005.

Out of total fresh ginger produced in Orissa, about 30% of fresh ginger is used for seed and 68% is sold as table ginger in vegetable market and only about 2% fresh ginger is converted to ginger flakes or dry ginger by the local spices powder industries and ayurvedic medicine manufacturers.

In spite of all these, the ginger productivity is very low. The reasons for low productivity are

- Lack of awareness among the farmers about the use of high yielding varieties of ginger. Farmers use either own seed or purchase spurious seed ginger from the local vegetable market, which are less productive and susceptible to many diseases.
- More than 50% of area and production of ginger in Orissa is concentrated in districts with tribal farmers. Most of these tribal farmers are resource poor marginal farmers and cultivate ginger in traditional methods under rainfed conditions in the podu cultivated, eroded hill areas without any improved cultivation practices (organic and inorganic nutrients, mulching, crop rotation).
- In Orissa most of the tribal farmers cultivated ginger under rainfed conditions without any irrigation facilities lead to calamities of adverse weather conditions like drought and flood causing huge crop loss and low productivity.
- In the plain areas many farmers cultivate ginger in paddy fields under ridges and furrow method and rendering to crop loss during heavy rain or flood conditions due to water logging.
- Most of the tribal farmers never follow the standard plant protection practices viz., selection of healthy seed ginger, seed treatment, prophylactic control measures against soft rot, bacterial wilt or leaf spot disease causing crop loss and low productivity.
- The practice of removal of seed rhizomes three months after planting from the ginger plant causing spread of soft rot disease through the wound created resulting huge crop loss. The farmers are not aware of applying any disease control measures like soil drenching after removed of seed ginger during rainy season.
- Mulching the ginger beds with dry leaves or dry straw improves the yield but the farmers never mulch the fields, causing low yield.
- Lack of knowledge in proper storage methods causes crop loss during storage of ginger.
- Being long duration crop, cost of cultivation is high and the tribal farmers mostly sell as raw ginger for very low price. Due to lack of value addition and lack of organized marketing network, the commercial value is not fully exploited and with very less profit, this discourages farmers to adopt any improved package of practices causing low yield of ginger in Orissa.

Table 4. Production, area and productivity of ginger in India and Orissa

Year	India			Orissa		
	Area (ha)	Produ ction (ton)	Produc tivity(q/ha)	Area (ha)	Production (ton)	Produc tivity(q/ha)
1989-90	58020	152890	28.80	8800	13350	15.20
1994-95	62090	186050	29.90	10900	16680	15.30
2004-05	95300	359000	37.67	15674	30368	19.40
2005-06	110600	391200	35.37	15806	30648	19.40

(Source: HARS, QRT Report)

During 2005-06 in Orissa ginger was grown in an area of 15,806 ha with estimated yield of 30,648 tons with 1940 kg/ha productivity. Whereas in the same year in India, ginger was grown in 1,10,600 ha with an estimated production of 3,91,200 tons with 3537 kg/ha. If we compare the productivity of ginger in Orissa during 1994-95 with 2005-06, there was increase in area, production and productivity of ginger due to adoption of improved high yielding varieties (HYV) and adoption of scientific crop management practices.

- The gap in productivity of ginger in Orissa as compared to all India average is almost 85% during 2005-06. This gap in productivity can be minimized by adoption of HYV and other standardized agro practices as indicated in Table 5.
- There are many high yielding varieties of ginger released from HARS, Pottangi Orissa and other research institutions with very high yield and moderate disease tolerance as mentioned in Table 6, the productivity average in Orissa can be increased by planting high yielding varieties.

Table 5. Contribution of different agro practices in ginger production

Agro practices	Increase in yield (%)
Use of HYV (Suprabha, Suruchi, Varada)	60-80
Timely planting (1st week of April)	15-20
Optimum seed size (15-20 gm rhizomes)	15
Application of Fertilizer (125:100:100 kg NPK/ha	12.4
Application of FYM @ 25 t/ha	14.6
Application of both FYM + Fertilizer	46.0
Application of mulching 20 T/ha	50 .0
Raised bed method of planting with mulching	105.0
Seed treatment and PP measures	12.5

Table 6. Important characteristics of high yielding and good quality ginger cultivars

Variety	Avg. yield (t/ha)	Maturity (Days)	Dry recovery (%)	Crude fibre (%)	Oleoresin (%)	Essential oil (%)
Suprabha	16.60	229	20.50	4.40	8.90	1.90
Suruchi	11.60	218	23.50	3.80	10.00	2.0
Suravi	17.50	225	23.50	4.00	10.20	2.10
IISR-Varada	22.60	200	20.70	4.50	6.70	1.75
Himagiri	13.14	230	20.62	6.05	4.29	1.63

HARS, Pottangi is supplying healthy and good quality planting material of the released varieties of ginger to the farmers for improving the productivity in Orissa. Also in Orissa, many farmers are engaged in Truthfully Label seed production of released ginger varieties of HARS (OUAT), Pottangi and supplying to other needy farmers as indicated in the Table 7.

Table 7. Quality planting material production and distribution in Orissa (2002-2006)

Year	Ginger (Ql)		Distribution to States
	Research Station	Farmer	
2002	148	1800	Orissa, A.P., Karnataka
2003	130	1200	Orissa, W.B., C.G
2004	155	2000	Orissa, A.P. M.H, C.G. M.P.
2005	205	4000	Orissa, W.B., M.H., C.G. A.P.
2006	200	3000	Orissa, A.P., C.G.
Total	*838*	*12000*	

(Source: QRT Report of HARS, Pottangi)

- By intensive cultivation and popularization of the HYV of ginger and the adoption of improved agro practices there is ample scope in Orissa to increase both area and productivity of ginger and can be grown as inter crop in fruit orchards.
- Making good quality planting material of ginger available to the farmers in an affordable price and in time is also an important step to increase productivity of ginger in Orissa.
- Many farmers are now successfully cultivating HYV ginger and adopting standardized agro practices of ginger developed by HARS with this high productivity can able to be achieved.
- There should be continuous production and distribution of good quality planting materials starting from nucleus seed to certified seed production by research station, government farm and advanced farmers fields and proper mechanism of certification should be established for quality of seed production and distribution to the farmers before planting season.
- Majority of the farmers are not adopting agro practices standardized by research stations due to lack of awareness, through large-scale demonstrations in farmers fields, improved package of practices can be adopted by farmers.
- Evolving short duration ginger varieties, standardization of mixed, inter cropping systems and evolving suitable crop management techniques would confer greater benefits to the ginger farmers of Orissa.
- There is an increasing demand in the export of various value added products of ginger. Establishment of processing facility and quality testing facility in the ginger producing areas of Orissa will increase the production and export of oil and oleoresin from fresh ginger by making the cultivation profitable.

- In Orissa, by default most of the ginger produced by tribals are grown under traditional organic way which can be further encouraged if certified as organic by accreditation agencies.
- Strengthening of Agricultural Research Information System and linking scientist with the farmers through Institute Village Linkage Programme, Seed Village Programme would also give major boost to ginger production in Orissa.
- The scope for processing of fresh ginger into various preserved product for export, and their packaging storage should be standardized by research for enhancing the export of fresh ginger from Orissa.
- Providing finance to the entrepreneurs for establishment of processing facilities for production of spices power, dry ginger, ginger flakes and for packaging in Orissa will also increase the utilization of raw ginger into dried form and by increasing export.

Table 8. Success stories from progressive farmers of Orissa during 2005-06

Name and address	Variety grown	Area (ha)	Yield (q)
R.K. Choudhury, Pottangi, Koraput	Suprabha	2.0	200.0
G.K. Rao, Pottangi, Koraput	Suprabha	5.0	540.0
Surendra Pangi, Pottangi, Koraput	Suprabha	2.0	180.0

(Source: QRT Report of HARS, Pottangi)

Conclusion

It is concluded that there is great scope to increase the ginger productivity in Orissa by adopting HYV and standardized agro practices. The economy of the tribal farmers can also be increased by adopting proper processing and development of value added products viz., dry ginger, powdered ginger, oleoresin and oil. Also there is a great scope to increase export by organic ginger from Orissa.

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Performance of ginger varieties in Maharashtra

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Introduction

Ginger (*Zingiber officinale* Rosc.) is one of the most important commercial spice crops characterized by its distinct flavour, aroma and pungency with medicinal properties and uses. It is traditionally grown in Maharashtra State for production of both the green ginger and dry ginger, popularly known as 'Ale' (green ginger) and 'Suntha' (dry ginger).

It is mainly cultivated in Satara, Sangli, Pune, Ahamadnagar, Kolhapur and Solapur districts and on small scale in 'Konkan region', in an area of 1243 ha with annual production of 1182 tons (Anonymous, 2006). Konkan region is characterized by laterite and loamy type of soils, having pH 5.5 to 6.5 and light to medium in fertility which are suitable for cultivation of ginger. The low lying and paddy fields are not suitable. The climate is hot and humid. The rainfall is high which ranges from 3000 to 4000 mm. during the period of June to September. The soils of other regions of Maharashtra are fertile, loamy to heavy types, also suitable for ginger production.

An experiment on growth and yield performance of ginger varieties (Rajput, 2007) was carried out at Dapoli. The results of the investigation are presented in Table 1.

Ginger was grown as a 'sole crop' and planted during 4^{th} week of May, 2006 on raised beds, adopting the spacing of 30 x 15 cm. A fertilizer dose of NPK @ 150: 80: 60 kg/ ha and FYM @ 25 t/ha were applied. The recommended cultivation practices for the crop were adopted (Anonymous, 2005). After rainy season, the crop was supplemented with irrigation water by use of micro sprinkler. The crop was harvested at 180 days for green ginger and at 220 days after planting for dry ginger production.

The yield of green ginger varied from 9.71 to 29.51 t/ha (Table 1). The variety Mahima produced the highest green ginger yield of 29.51 t/ha and also highest dry ginger yield of 6.43 t/ha followed by Rejatha (25.81 t/ha green ginger and 5.86 t/ha dry ginger) and Varada (25.16 t/ha green ginger and 6.19 t/ha dry ginger). These varieties were significantly superior over local varieties. The rhizome weight varied from 223.30 to 471.75 g in different varieties. Mahima variety recorded maximum rhizome weight (471.75 g) followed by Rejatha (422.54 g) and Varada (386.66 g). The ginger oil and fibre content varied from 1.85 to 4.14 per cent and 3.35 to 5.38 per cent respectively. Mahima, Rejatha and Varada varieties recorded 2.05 to 2.68 per cent ginger oil and 3.35 to 4.63 per cent fibre.

The varieties viz. Mahima followed by Rejatha and Varada were found to be suitable for ginger cultivation. The ginger crop could also be grown as an inter crop under coconut plantation. The higher yield could be obtained in loamy and fertile soils than light and laterite soils. The crop can be harvested 180 to 220 days after planting for green and dry ginger production respectively. It is necessary to sow (planting) the crop before onset of rainy season preferably in May. After rainy season, the crop should be supplemented with irrigation water.

Table 1. Growth, yield and quality performance of ginger varieties

Variety	Source of variety	Green yield (t/ha)	Dry yield (t/ha)	Plant height (cm)	No. of tillers/ plant	Wt. of green rhizome (g)	Oil (%)	Fibre (%)
Mahima	IISR, Calicut	29.51	6.43	79.58	13.42	471.75	2.68	4.63
Rejatha	IISR, Calicut	25.81	5.86	74.02	14.02	422.54	2.05	3.35
Varada	IISR, Calicut	25.16	6.19	84.60	15.26	386.66	2.43	4.42
Jawade Local	BSKKV, Dapoli	15.99	3.58	56.77	14.42	290.66	3.25	4.21
Kelshi Local	BSKKV, Dapoli	15.69	3.44	69.31	19.76	265.25	1.85	4.19
Satare Bambar	BSKKV, Dapoli	9.71	2.12	52.86	16.68	223.30	4.14	5.38
Local								
S.E. ±		1.32	0.03	1.85	0.59	22.78	0.12	0.06
C.D. 5%		3.96	0.89	5.58	1.77	68.63	0.35	0.18

Ginger crop should not be grown in the same field year after year. The crop yield could be enhanced by adopting optimum spacing, organic cultivation, judicious management cultivation and practices, proper harvesting, post harvest storage and curing processes and adopting crop protection measures.

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Technologies for sustainable production of turmeric

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Introduction

Turmeric (*Curcuma longa* L. Syn. *C. domestica*) belonging to the family zingiberaceae is an important spice crops of India grown in 24 states under various climatic conditions both as rain fed and irrigated crop. Turmeric is cultivated for its rhizome that is processed, dried and used. Turmeric is available as whole, ground, oleoresin and oil. Oleoresin is a mixture of compounds viz., curcumin, volatile oil and other active ingredients, non-volatile fatty and resinous material. Cured turmeric is sorted as fingers, round, split and non specified and marketed under various names, usually based on the place of production as Alleppey, Erode, Duggirala, Nizamabad, Rajapuri, Cuddapah.

It is cultivated in an area of 1,61,200 ha with a production of 7, 16, 800 tones during 2004-05. India is the largest producer and occupies fifth place next to chillies, cumin, coriander, and black pepper in terms of area among spices and in production it ranks second, next to chillies. Andhra Pradesh alone occupies 38.0% of area and 58.5% of production. The national productivity of the crop is 4446 kg per hectare and wide variations in productivity is seen among the states. In terms of quantity and value of export, among spices it ranks second, next to chillies during 2004-05. Even it pushed the pepper to third place, implicating that there is a lot of scope to export this spice. In terms of quantity and value of export of spices, it shares 13.9% and 7.0%, respectively. India exports only 6.48% of it's production of turmeric to more than 50 countries. During 2004-05, India exported 43,000 tons valued Rs. 15,650 lakhs. It is exported mainly in two forms, dry produce (63%) and powder form (37%).

Climate and soil

Turmeric is a crop grown in diverse tropical conditions, requires good drainage and grows in warm humid climate from sea level to 1500 m above MSL, with an annual rainfall of 1500 mm or above, grown under rainfed or irrigated condition with a temperature range from 20°- 30°C. In Tamil Nadu and Andhra Pradesh it is grown mostly as irrigated crop. Turmeric is adapted to different soil types, but thrives best in loose and friable fertile loam or clay loam with good organic matter status or sandy loam soils, red loamy soils are also good for growing turmeric wth a pH range of 5. 0 to7.5.

Cultivars

Many local cultivars of turmeric are available and they are known mostly by the names of the locality. Moderate genetic variability exists in crop and the cultivars vary in yield, duration and quality. The region specific varieties are given in Table 1. Moderate genetic variability exists in crop and the cultivars vary in yield, duration and quality.

Table 1. Popular traditional cultivars grown in different states of India

State	Cultivar
Kerala	Alleppey, Moovattupuzha, Wayanad Local, Tekurpetta, Armoor, Duggirula
Karnataka	Kasturi, Mundaga, Balaga, Cuddapah, Rajapuri, Amalapuram, Shillong.
Andhra Pradesh	Duggirala, Mydukkur, Armoor Local, Cuddapah, Kodur, Tekurpet Kasturi, Chayapasupu, Armoor, Amdapuram
Maharashtra	Krishna, Rajapuri, Sugandham.
Tamil Nadu	Erode, Salem
Orissa	Dindigam
Madhya Pradesh	Raigarh, Jangir, Bilaspur
North East India	Lakadong

Turmeric research

Besides the Indian Institute of Spices Research, Calicut, research is done at the national level through the All India Coordinated Research Project on Spices (AICRPS), which was initiated in 1971 and presently has eight centres located at different State Agricultural Universities (Table 2). Considerable headway has been achieved in the development of high yielding varieties of turmeric specifically suitable to different agro-climatic regions of the country, input technologies, standardization of agro technologies and distribution of elite seed/planting material of high yielding varieties of turmeric.

Table 2. Turmeric centres under AICRP Spices

State	Name of Centre/ location	Year of start
Andhra Pradesh	Jagtial (ANGRAU)	1986 (VII Plan)
Bihar	Dholi (RAU)	1993(VIII Plan)
Chattisgarh	Raigarh (IGKV)	1996(VIII Plan)
Himachal Pradesh	Solan (YSPHUF)	1971 (IV Plan)
Orissa	Pottangi (OUAT)	1975 (V Plan)
Tamil Nadu	Coimbatore (TNAU)	1975 (V Plan)
Uttar Pradesh	Kumarganj (NDUAT)	1995(VIII Plan)
West Bengal	Pundibari (UBKVV)	1996(VIII Plan)

The turmeric centers under AICRPS maintain about 1250 turmeric germplasm accessions (Table 3). By utilizing these germplasm, 22 varieties have been developed and released for cultivation at various agro-climatic regions of the country through AICRPS with high yield, pest/disease resistance and quality attributes (Table 4). Besides, some of the lines are under pipeline for release and several lines have been identified for yield, quality and pest/disease and drought resistance or tolerance from the germplasm of spices.

Table 3. Turmeric genetic resources at AICRPS centres

Centre	Cultivated	Wild and related sp	Total
Pottangi	171	22	193
Jagtial	273	-	273
Dholi	78	2	80
Raigarh	42	-	42
Kumarganj	108	-	108
Pundibari	116	14	130
Solan	171	-	171
Coimbatore	255	-	255
Total	*1214*	*38*	*1252*

Improved varieties

Efforts were made to evolve improved cultivars either through selection and mutation breeding. So far about 24 improved cultivars are released for cultivation to suit various regions of the country (Table 4).

Table 4. Improved turmeric cultivars

Sl. No.	Variety	Pedigree/ parentage	Institution	Yield*	Salient features
1	CO.1	Vegetative mutant by x-ray irradiation of Erode local	Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu	30.5	Bold and orange yellow rhizomes, suitable for drought prone, water logged, hilly areas saline and alkaline areas
2	Krishna	Clonal selection from Tekurpeta collection	Maharastra Agrl University, Kasba, Digraj, Maharastra	9.2	Plumpy rhizomes, moderately resistant to pests and diseases

3	Sugan-dham	Clonal selection from germplasm of Gujarat	Spices Research Station (GAU), Jagudan, Gujarat	15.0	Thick, round rhizomes with short internodes. Moderately tolerant to pest and diseases
4	BSR.1	Clonal selection from Erode Local with irra diated x rays	Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu	30.7	Bright yellow rhizome suitable for problematic soils and drought prone areas of Tamil Nadu.
5	Roma	Clonal selection from T.Sunder	High Altitude Research Station OUAT, Pottangi, Orissa	20.7	Suitable for both rainfed and irrigated condition. Ideal for hilly areas and late sown season.
6	Suroma	Clonal selectionfrom T. Sunder by x-ray irradiation	High Altitude Research Station OUAT, Pottangi, Orissa	20.0	Round and plumpy rhizome, field tolerance to leaf blotch, leaf spot and rhizome scales.
7	Rajendra Sonia	Selection from local germplasm	Dept. of Hort., Tirhut College of Agril., RAU, Dholi, Bihar	4.8	Bold and plumpy rhizome
8	Suguna	Selection from germplasm	IISR, Calicut, Kerala	29.3	Short duration type, high yield potential, field tolerance to rhizome rot
9	Suvarna	Selection from germplasm	IISR, Calicut, Kerala	17.4	Bright orange coloured rhizome with good yield
10	Sudhar-sana	Selection from germplasm	IISR, Calicut, Kerala	28.8	High yielding variety, short duration type
11	Ranga	Clonal selection from Rajpuri local	High Altitude Research Station OUAT, Pottangi, Orissa	29.0	Bold and spindle shaped mother rhizome, suitable for late sown condition and low lying areas. Moderately resistant to leaf blotch and scales

12	Rasmi	Clonal selection from Rajpuri Local	High Altitude Research Station OUAT, Pottangi, Orissa	32.0	Bold rhizomes, suitable for both rainfed and irrigated condition, early and late sown season
13	BSR 2	Induced mutant from Erode	Tamil Nadu Agricultural University, Local Coimbatore, Tamil Nadu	32.7	A high yielding short duration variety (245 days) with bigger rhizomes, resistant to scale insects
14	IISR Prabha	Open pollinated progeny selection	IISR, Calicut, Kerala	37.47	High yielding variety with high curcumin content (6.2%)
15	IISR Prathibha	*Open pollinated progeny selection*	IISR, Calicut, Kerala	39.12	High quality line (6.5% curcumin) with high yield
16	Megha Turmeric-1	Selection form Lakadong type	ICAR R.C. NEH Region, Shillong, Meghalaya	25.80	High curcumin content and bold rhizomes
17	Kanthi	Clonal selection from Kerala Mydukur variety of Andhra Pradesh	Kerala Agricultural University, Trichur,	37.65	HYV with high curcumin content (7.18%), big mother rhizomes with medium bold fingers.
18	Sobha	Clonal selection from local type	Kerala Agricultural University, Trichur, Kerala	35.88	Mother rhizome big with medium bold fingers with high curcumin (7.3%) content.
19	Sona	Clonal selection from local germplasm	Kerala Agricultural University, Trichur, Kerala	4.02 (dry)	Best suited for central zone of Kerala. Rhizome medium bold, field tolerant to leaf blotch. Curcumin 7.12.
20	Varna	Clonal selection from local germplasm	Kerala Agricultural University, Trichur, Kerala	4.16 (dry)	. Suited to central zone of Kerala.Field tolerant to leaf blotch, curcumin 7.87%.

21	Surangana	Clonal selection from local type of West Bengal	Uttar Banga Krishi Viswa Vidyalaya, Pundibari, West Bengal	29.2	Tolerant to leaf blotch and rhizome rot, suitable for open and shaded condition, can be grown in sole or inter crop in orchard garden.
22	Pant peetabh	Clonal selection from local types	G.B.P University of Agriculture and Technology, Pantnagar	20.0	Resistant to rhizome rot. Long attractive fingers.
23	IISR Alleppey Supreme	A clonal selection from Alleppy turmeric	IISR, Calicut, Kerala	35.4	Shows tolerance to leaf blotch disease. Rhizomes contain 5.55% curcumin.
24	IISR Kedaram	Clonal selection from germplasm	IISR, Calicut, Kerala	34.5	Tolerant to leaf blotch disease, Rhizomes contain 5.5% curcumin.

* Mean yield (fresh) t/ha

The production of turmeric depends on suitable cultivars for a given area and cultural condition and the genetic potential of the variety. The Rajendra sonia is resistant to leaf blotch and Sonali is resistant to rhizome rot. CO-1 is suitable for drought prone areas as well as saline and alkaline soils. Krishna is tolerant to leaf diseases and BSR-1 is suitable to drought prone areas. The characters of the major improved turmeric varieties are given in Table 5.

Table 5. Characteristics of turmeric varieties

Sl. No	Variety	Mean yield (fresh) (t/ha)	Crop duration (days)	Dry recovery (%)	Curcumin(%)	Oleoresin (%)	Essential oil (%)
1.	Suvarna	17.4	200	20.0	4.3	13.5	7.0
2.	Suguna	29.3	190	12.0	7.3	13.5	6.0
3.	Sudharsana	28.8	190	12.0	5.3	15.0	7.0
4.	IISR Prabha	37.5	195	19.5	6.5	15.0	6.5
5.	IISR Prathibha	39.1	188	18.5	6.2	16.2	6.2
6.	Co-1	30.0	285	19.5	3.2	6.70	3.2
7.	BSR-1	30.7	285	20.5	4.2	4.00	3.7
8.	Krishna	9.20	240	16.4	2.8	3.80	2.0
9.	Sugandham	15.0	210	23.3	3.1	11.0	2.7
10.	Roma	20.7	250	31.0	9.3	13.2	4.2
11.	Suroma	20.0	255	26.0	9.3	13.1	4.4

12.	Ranga	29.0	250	24.8	6.3	13.5	4.4
13.	Rasmi	31.3	240	23.0	6.4	13.4	4.4
14	Rajendra Sonia	4.80	225	18.0	8.4		5.0
15.	Krishna	9.20	240	16.5	2.8	3.8	2.0
16.	BSR-2	32.7	245				
17.	Megha Turmeric-1	25.8	305	16.4	6.8		
18.	Kanthi	37.8	255	18.1	7.1	12.1	5.2
19.	Sobha	35.9	255	18.1	7.3	15.9	4.2
20.	Suranjana	29.2	235	21.2	5.7	10.9	4.1
21.	Pant Peetabh	20.0	210	18.5	7.5		1.0
22.	IISR Alleppey Supreme	5.88	220	19.0	5.5	14.0	-
23.	IISR Kedaram	5.28	210	18.9	5.7	14.0	-

Agro techniques

Research work carried under AICRP on spices located at Pottangi (OUAT, Orissa), Coimbatore (TNAU, Tamil Nadu), Solan (YSPHUF, Himachal Pradesh) and Vellanikkara (KAU, Kerala) developed several agronomic practices / technologies to increase the productivity of turmeric.

Land preparation

Land preparation is taken up with the receipt of the first monsoon showers. Soil is made to a fine tilth by deep and repeated ploughing. Hydrated lime @ 400 kg /ha has to be applied in laterite soils and thoroughly ploughed. Immediately after receipt of pre-monsoon shower, beds of size 1.0–1.5m width, 15-30cm height and of convenient length are prepared with a spacing of 50cm between beds. In Tamil Nadu and Andhra Pradesh the ridge and furrow system of planting is followed, mainly because of the easiness to irrigate by flood irrigation. It is also easy to prepare the land using tractor drawn ploughs. Flat bed system (flat land planting) is also adopted by farmers in Tamil Nadu and Andhra Pradesh.

Planting time

Turmeric is planted with the onset of south west monsoon (May-June to July-August). The best time for planting is first week of June that result in highest establishment and higher yield. The crop planted from May 15th –June 15th was found to be less susceptible to thrips in Tamil Nadu. In a trial to determine the optimum season for planting turmeric revealed that planting on 1st June recorded the highest establishment of 86% as well as highest yield of 31,225 kg/ha followed by planting in 15th June with an yield of 30,500 kg/ha. In Andhra Pradesh turmeric is usually planted in July if it is rainfed, or May / June if the crop is irrigated.

Seed material

Use of well developed, healthy, disease free, large rhizome bits of whole or split mother rhizome is a common practice among the farmers. 2000-2500 kg rhizome is required for planting one hectare. Whole or split mother rhizomes or primary fingers are the best for planting. In Orissa and Bihar, primary fingers are used for planting. Studies made at Solan indicated that mother rhizomes of 25-30 g weight and having 2 to 3 viable buds are good planting material. Studies at Pottangi on the comparative performance of the plants raised from mother and finger rhizomes showed that mother as well as cut mother rhizomes followed by bold primaries in that order are better planting material than fingers. Studies at TNAU revealed that overnight soaking of seed rhizomes in 0.01% potassium nitrate solution results in early sprouting of rhizomes (18-22 days).

Pretreatment of seed rhizome

Rhizomes are pretreated with 0.3% mancozeb M-45 and 0.05% malathion for 30 minutes and dried in shade before planting. The Solan centre recommended dipping seed rhizome in a mixture mancozeb M-45 (250 g) and bavastin 50-WP (100 g) in 100 l of water for 60 minutes and drying in shade for 48 hours. Similarly dipping of scale infected rhizomes in dichlorophos (0.1%) or phosalone (0.07%) or monocrotophos (0.07%) for 10 minutes and planting after shade drying resulted in higher germination, better plant growth and higher yield.

Spacing / population density

Rhizomes are planted in raised beds of 1 m width and 15-30 cm height and of convenient length with interspaces of 30 cm between beds. The spacing usually used is 30 x 20 cm / 25 x 25 cm. Planting is done at a depth of 5 to 7.5 cm. Optimum spacing for turmeric for getting high yield was also standardized for different regions. Studies at Vellanikkara indicated that spacing of 25 x 25 cm recorded higher yield (10.64 kg/ 3 m^2 beds). Considering the economy of the seed material, the best spacing is 25 x 25 cm(Table 6). The broad ridge system of planting at 50 x 15 cm was found to be best as against the common ridge and furrow and flat bed system in Tamil Nadu. The ridge and furrow system is amenable for easy irrigation. Jagtial centre also worked out optimum plant population of maize in turmeric + maize intercropping system.

Table 6. Spacing recommended for turmeric

State	Recommended spacing
Karnataka/ Maharashtra	30 x 30 cm or 45 x 30 cm
Orissa	*25 x 25 cm or 20 x 25 cm*
Tamil Nadu	25 x 25 cm in ridge, furrow and flat bed system
KumarganjBihar and Andhra Pradesh	30 x 20 cm30 x 20 cm/45 x 15 cm

Mulching and manuring

Basal dose of FYM @ 10t/ha is applied and ploughed together with soil. Just after planting, the beds are to be mulched with green leaves or straw at the rate of 12-15 tons/ ha and, again with 7.5 and 5 tons/ha between 40^{th} – 60^{th} day and 90^{th} –120^{th} day. The beds are also earthed up after each top dressing. The organic and manurial requirements are FYM @ 7.5 tons/ha (basal), and green mulch @ 7.5 tons/ha in 3 splits. Studies at Orissa confirmed that any organic mulch material can be used for turmeric. Use of dry leaves 0.4 tons/ha or green leaves 12.5 tons/ha as mulch + 15 tons/ha FYM is recommended. Intercropping studies to substitute mulching indicated that pure crop with three mulching is better than intercropping with one row of horse gram in between each alternate inter-row space of turmeric. The experiment involving different types of mulch material had shown that maize straw is better, followed by banana pseudostem (Coimbatore). In Kerala 30-40 tons of FYM/ha supplemented with 30: 40: 60 kg NPK is recommended. The general organic manure recommendation is 10-25 tons/ha. The state wise recommendations are 10-15 tons for Andhra Pradesh, 10 tons FYM + 200 kg neem cake or groundnut cake for Tamil Nadu, 25 tons for Orissa, 25-40 tons for Kerala and 25 tons for Bihar.

Fertilizer recommendation

Fertilizer recommendation differs in different regions. In general, application of higher levels of nitrogen @ 140 kg/ha along with 190 kg K and 60 kg P /ha recorded the highest yield. Studies on split application of 140 kg N/ha in 5 splits also gave a high yield of 36.3 tons/ha in Tamil Nadu. Similarly application of 90 kg K/ha in three equal splits registered high fresh rhizome yield (44 tons/ha) in Tamil Nadu. Studies at Bhavanisagar indicated that 120 kg N is the optimum dose with five splits and 90 kg K/ha in three split applications (one at basal, second at 60^{th} day and another at 120^{th} day). Studies on potassium application @ 90 kg/ha in four splits (basal 60, 90 and 120 days) recorded a rhizome yield of 30 tons/ha. Soil application of 30 kg/ha ferrous sulphate promotes higher yield (24%) in Tamil Nadu. Maximum yield of turmeric was obtained in plots where application of inorganic N 100%+*Azospirillum* 5kg/ha+ FYM 5t/ha at Kumarganj, Raigarh and Pottangi, inorganic N 50%+ *Azospirillum* 5kg/ha+ FYM 5t/ha at Coimbatore and inorganic N 75%+ *Azospirillum* 5kg/ha+ FYM 5t/ha at Pundibari. At Pundibari, all organic inputs (FYM 10kg, neem cake 250 g, stera meal 250g, rock phosphate 500g, wood ash 250 g/3m^2) recorded maximum yield (20.67 t/ha) in turmeric. The fertilizer recommendations for turmeric in different states are provided in Table 7.

Table 7. The fertilizer recommendations for turmeric in different states

Andhra Pradesh	200-300kg N, 125-150 kg P_2O_5, 100-150 kg K_2O in 3 splits. 60 N, 60 P and 60 K kg/ha as basal dose.60 N, 65 K kg/ha at 60 DAP. 60 kg N /ha at 120 DAP.
Tamil Nadu	150 N+60 P+108 K kg/ha. P and K as basal and top dressing N at 30, 60, 90th and 120th days
Orissa	N60 P30 K90 kg/ha and N and K in 2 split dose as basal. Full dose FYM and half K on furrows before planting (7.2 kg/m^2 and green mulch 2.5 kg/m^2). Half N at 45 DAP, half N and half K at 90 DAP.
Kerala	30:30:60 kg NPK/ha. Full P_2O_5 and half K_2O applied as basal dose, 2/3rd after 30 days and rest N and K_2O at 60 DAP.
Bihar	100 kg N, 50 kg P_2O_5, 150 kg K_2O. Application of 15 kg/ha iron sulphate and 20 kg/ha of zinc sulphate is also recommended.
Chattisgarh	150:125:125 kg NPK/ha.
West Bengal	60:60:120 NPK kg/ha and 20-25 q FYM/ha
Madhya Pradesh	175:150:150 kg NPK

Irrigation and weeding

Turmeric is grown both as rainfed as well as irrigated crop. Under irrigation 8-10 irrigations are given at 15 days interval in Andhra Pradesh, seven irrigations in Orissa and irrigation once during last week of October and first week of November in Bihar. Weeding has to be done thrice at 60, 120 and 150 days after planting depending upon the weed growth and intensity. In the case of irrigated crop, depending upon the weather and the soil moisture conditions, 8-10 irrigations are given at 15 days interval in Andhra Pradesh. Irrigation should be scheduled depending upon the moisture level. Seven irrigations depending on water requirement in Orissa. Irrigation once during last week of October and first week of November is given in Bihar. Drip irrigation is also followed by farmers in Tamil Nadu and Maharashtra.

Weed management is essential during 50-60 days after planting (DAP). There after weed growth is affected due to mutual shading with turmeric canopy. Application of Pendimethalin and oxyfluorfen, each followed by hand weeding at 80 DAP resulted in 45 and 39% more fresh rhizome yields and pendimethalin @ 1.0 kg/ha application resulted in significantly lower weed dry matter (WDM) as compared to atrazine @ 1.0 kg/ha or fluchloralin 1.0 kg/ha and glyphosate 0.5 kg/ha.

Crop rotation / intercropping

Turmeric comes up well under partial shade conditions hence it is recommended as an intercrop in coconut and arecanut gardens. Intercropping with short duration crops is remunerative in the early growth phase, and does not affect turmeric yield. Bhendi, small onion, black gram and green gram were tried and it was found that planting small onion on either side of the ridge increased the net income per unit area without affecting turmeric yield. Turmeric + onion combination yielded an additional income of Rs. 3,491 / ha. It is possible to increase the cropping intensity by introducing other crops after harvest of short duration turmeric cultivars. The effect of different populations of maize as an intercrop in turmeric with and without fertilizer application revealed that sowing of maize after every two rows of turmeric with extra fertilizer to maize resulted in better returns. Experiments conducted at Jagtial identified maize as a profitable intercrop in turmeric. Similarly, turmeric grown with K-2 chillies as a border crop gave an yield of 29.65 tons/ha with an additional chilli yield of 2,938 kg/ha (TNAU). In Orissa, turmeric is rotated with paddy and maize. It can be intercropped in orchards of fruit plants. Turmeric intercropped with soybean gave 16.988 tons turmeric and 0.296 tons soybean/ha at Pottangi. Maximum benefit also was acquired from this treatment as evident from cost benefit analysis. In Tamil Nadu the crop sequence recommended for Periyar region (Tamil Nadu) is turmeric – banana – sugarcane, turmeric – banana – paddy and turmeric – paddy.

Crop protection

The important pests and diseases of turmeric are rhizome rot, leaf spot, rhizome scale, stem borer, rhizome fly etc. The management measures developed against the major pests and diseases are given in Table 8. Rhizome rot is the most serious menace on all the turmeric growing tracts of north Telengana zone of Andhra Pradesh, causing partial or total loss of yield due to the causal agent *Pythium* spp. This disease is seed-borne. It has been observed that no chemical is effective against rhizome rot. Rhizome fly and soft rot are associated with the disease. A study conducted on the influence of time of planting on turmeric thrips incidence, indicated only low level of infestation in the early planted crops. But turmeric planting by 15th June gave higher yields than the other days of planting though the incidence of thrips at that time was higher. The survey conducted by Dholi revealed that leaf blotch disease caused by *T. maculans* was more severe compared with leaf spot caused by *C. Capsici.* Rhizome scales infects rhizomes in field and storage. In field, infection is severe and the plant wither and dry and in storage, infection results in shriveling of buds and rhizomes. The Bhavanisagar centre (TNAU) developed a package for plant protection in turmeric. This includes seed treatment with monocrotophos @ 2 ml/l of water for 15 minutes and drying under shade for 24 hours against the scale insects and seed treatment with bavistin (2.0%) against rhizome rot. Studies on the integrated management of scale insects by application of poultry manure/ sheep manure at 15 tons /ha in 2 equal splits once at sowing and again on 12th day reduces the disease incidence and is better than the application of FYM @ 25 tons/ha and drenching with 0.06% phosalone or 0.03% dimethoate during rhizome formation at 7th month. Studies at TNAU with different sowing times at weekly intervals (from 15th May- 15th August) indicated that sowing up to mid June makes the crop escape from thrips infestation without the need of insecticides. Sowing after July 15th leads to heavy incidence and is recommended only for Periyar district of Tamil Nadu. Under the biocontrol studies at Jagtial, *T. viride* + *P. flurosecens* seed and soil treatment along with recommended NPK + FYM was found to be effective in the management of rhizome rot. The present recommendation resulted in the control of rhizome rot to 53% with an increase in fresh rhizome yield of 20%. Seed treatment as well as spraying with mancozeb + carbendazim (0.2% each) is the best treatment against leaf blotch and leaf spot of turmeric. Seed treatment as well as soil application of *Trichoderma viride* & *Pseudomonas fluorescens* @ 12.5 kg/ha and 25 kg/ha as basal and top dressing respectively along with application of recommended NPK + FYM is the best treatment against rhizome rot of turmeric.

Table 8. Recommendation for management of major disease and insect pests of turmeric

Disease / pest and causative organism	Management schedule
Leaf blotch (*Tapering maculans*)	Spray 1% Bordeaux mixture or copper oxychloride or carbendazim (0.1%) or mancozeb (2.5 g/l) at 500 l/ha or captan (0.2 ml) at monthly interval. Treat seed rhizome with bavistin (60 minutes) and shade dry before planting.
Leaf spot (*Colletotrichum capsici*)	Spray 1% dithane M-45 (2.5 g/l of water) at 15-20 days interval spray any one of the following fungicides or copper oxychloride (0.25%) / bavistin (0.1%) / chlorothalonil (0.2%) / zineb 0.3% or Bordeaux mixture 1%.
Rhizome rot and wilt (*Pythium graminicolum*)	Treat seed rhizome with dithane M-45 (0.25%) or bavistin (1.0%) for 30 minutes prior to storage and at the time of planting. Drenching of infected plants beds with blitox-50 (0.3%), or 1% Bordeaux mixture or copper oxychloride (0.25%). Incorporate biocontrol agents such as Trichoderma; or dip rhizome in Trichoderma slurry before planting.
Storage rot (*Pythium* sp. and *Rhizoctonia* sp.)	Rhizome treatment with dithane M-45 (0.25%) or bavistin (1.0%) before storing and dipping seed rhizome in copper oxychloride (0.2%) for 30 minutes and shade drying before planting
Nematodes: Root knot nematode (*Meloidogyne* spp.), Burrowing nematode (*Radopholus similis*), Root lesion nematode (*Pratylenchus* spp.)	Use healthy nematode free planting material, soil application of aldicarb at one kg/ha twice (3rd and 5th month after planting) followed by irrigation. Incorporation of VAM.

Rhizome scale (*Aspidiella hartii*)	Seed dressing with quinalphos (0.075%) (for 30 minutes) before storage and also before sowing + spraying of phosphamidon (0.05%) in field.
Shoot borer(*Conogethes punctiferalis*)	Spray malathion (0.1%) or monocrotophos (0.075%) or rogor or ekalux (0.05%) or dimethoate or quinalphos during July to October at monthly interval.
Thrips (*Panchaetothrips indicus*)	Spray dimethoate (0.05%) or methyl dimethion (750 ml/ha).
Caterpillar (*Lema* spp.)	Spray malathion (20 ml/l water).
Rhizome fly and maggot (*Mimegrella coerulifrous*)	Spray quinalphos (0.02%) at 60 DAP.

Harvesting

The turmeric crop is ready for harvesting in about 7 to 9 months after sowing depending upon the variety. In. India, sowing takes place between June and July and harvesting is done from February to April. Before harvest, the dry leaves and stem are cut close to the ground. The land is irrigated, if necessary, to facilitate digging out the rhizomes, and ploughed in between the rows if the crop is planted on ridges. Otherwise a crowbar is used. The rhizome bunches are carefully lifted and adhering soil removed by soaking in water and further cleaned of roots and scales before they are collected in the curing yard. The curing quality and the proportion of the cured and dried produce to the green produce depend mainly on the variety. Mother rhizomes give a higher curing percentage than the fingers. The mother rhizomes and fingers are separated. If need be, the former is kept for seed and the latter is cured for selling.

Preservation of seed rhizomes

Fresh rhizomes for seed purpose are to be stored for planting in the next season. Seed rhizomes are generally stored loosely heaped and covered with leaves in well ventilated store. Seed rhizome can also be stored in pits mixed with sawdust. Pits have to be covered with wooden planks with one or two holes for aeration. Studies on storage of seed rhizomes at TNAU revealed that rhizomes stored in open sand pits with partially closed pandal is satisfactory, and recorded the highest percentage of germination (96%), less weight loss (4.1%) and high seedling vigour when compared to other methods of storage such as the pit method under Coimbatore situation. However, the storage method should depend on local situations and any one method may not be suitable to all areas. In Kerala, seed rhizomes are stored in pits lined with sand and protected from sun and rains. Fresh rhizomes for seed purpose are to be stored for planting in the next season using special methods. Studies on storage of seed rhizomes at TNAU revealed that rhizomes are stored in open sand pits with partially closed pandal is ideal, which recorded the highest percentage of germination (96%), less weight loss (4.1%) and high seedling vigour when compared other methods of storge such as pit method, cowdung method, mulch and cowdung planting method or pandal method.

Present status and future prospects of turmeric production in north eastern states

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Introduction

In north eastern region, turmeric is grown in almost all the states of the region but the leading states are Meghalaya, Assam, Tripura and Nagaland. Its cultivation is undertaken as a cash crop mostly in slope areas after "jhum" spread over the hills and tribal areas of the entire region. Apart from improved varieties like Lakadong and Megha Turmeric-1, a number of local cultivars exist in north eastern region. The turmeric produced in this region contains high oleoresin and curcumion content. The product is mostly marketed in the fresh form. The local demand being very limited, roughly 70-80% of the total production is reportedly available as marketable surplus from the region. As it is abundantly available in the region, different products like turmerones (turmeric oil), oleoresin, and powder can be prepared for export, which are very common in developed countries.

Present status of turmeric production in north eastern region

The area under turmeric in the region is 17.27 thousand ha with a total production of 32.36 thousand tons. The productivity of the crop is much lower (1.87t/ha) compared to the national productivity of 3.47 t/ha (Spices Statistics, Spices Board, 2004). The production of turmeric is highest in Meghalaya followed by Assam, Tripura and Nagaland. However, the productivity is highest in Mizoram (Table 1). This shows that farmers are interested in the cultivation of turmeric as soil, climate and other ecological factors favour the growth and development of the crop and there is a tremendous scope to increase the yield per unit area and thereby the total production of turmeric in north east region.

Table 1. State-wise area, production and productivity of turmeric in north eastern region

State	Area ('000 ha)	Production ('000 t)	Productivity (t/ha)
Arunachal Pradesh	0.40	1.50	3.75
Assam	12.00	8.00	0.67
Manipur	0.37	2.09	5.69
Meghalaya	1.60	8.70	5.44
Mizoram	0.30	2.97	9.9
Nagaland	0.60	3.10	5.17
Sikkim	0.50	1.70	3.40
Tripura	1.50	4.30	2.87
North eastern region	17.27	32.36	1.87
India	150.5	521.9	3.47

The farmers of the region grow a number of indigenous varieties, which are ideal for oleoresin and powder making and preparation of other value added products. The most popular cultivated variety in the region is Lakadong (7.5 %) and Megha Turmeric-1 (6.8%) that possess higher curcumin content and has maximum demand (Table 2).

Table 2. Promising varieties of turmeric in north eastern region

Adapted variety	Dry matter (%)	Curcumin (%)	Yield (t/ha)
Lakadong	21.1	7.5	20
Megha Turmeric -1	19.5	**6.8**	30

Diversity of turmeric in the region

There are several cultivated types of turmeric available in the region, which are generally named after the localities they are being grown (Table 3). Certain indigenous types namely Manipur Local, Nagaland Local, Sikkim Local and Jorhat Local of Assam have been reported to be equally good in rhizome yield. Dry matter recovery of these varieties has been found to be even equal or better than certain improved types. In Meghalaya, Lakadong is the main variety and more than 50% area is under this variety.

Table 3. Promising local genotypes of turmeric of north east region

Genotype	Dry matter (%)	Curcumin (%)	Yield (t/ha)
Manipur Local	22.50	4.91	24.10
Jorhat Local	21.10	4.30	22.03
Meghalaya Local	20.25	6.10	17.24
Arunachal Local	22.25	4.23	23.60
Megha Turmeric -1	19.5	6.8	30

(Source : Sanwal *et al,* 2007)

Analysis of different local varieties for curcumin contents in Manipur with Megha Turmeric-1 as check indicated variability in the percentage of curcumin depending on the location/ climate (Table 4). Almost all the varieties are found to be thermo-sensitive. However, many varieties including 'Lakadong' and Megha Turmeric-1 are successfully grown under shade in agro-forestry systems. Out of 22 different germplasms/ varieties tested in Manipur centre (Imphal), Megha Turmeric-1, Lakadong and 6.L. Puram performed satisfactorily with an average yield of 5-7 tons under different farming systems.

Table 4. Curcumin content of turmeric across locations of Manipur

District	Place of collection/ Variety	Curcumin (%)
Chandel	Khengiang	5.40
	H. Mongjang, Moreh	9.11
	Mongjang	5.58
Churachandpur	Churachandpur (Local)	3.69
	Singhat (Local)	6.48
	Tipaimukh (Local)	6.89
Tamenglong	Tupul (Noney)	8.97
	Megha Turmeric-1	8.36
Senapati	Megha Turmeric-1	7.99
	Makhan (Local)	1.44
	Guite	5.86
	Purul	5.04
Imphal West	Megha Turmeric-1	6.80
Ukhrul	Megha Turmeric-1	6.60

In Arunachal Pradesh and Nagaland some cultivars are exclusively cultivated in backyards for medicinal purposes. However, these varieties contain less quantity of curcumin.

Growing pattern of turmeric in north eastern region

In north east region turmeric is grown as rainfed crop while in other parts of the country it is grown both as rainfed and irrigated crop. In north east region, it is rotated with French bean or soybean, which not only improves the physical condition of the soil but also give additional income to the farmers.

In Meghalaya, turmeric is generally cultivated on raised bed (called bun) and in the jhum fields. Under this, large tracts of hills are demarcated and burning clears the forest in the region. The land thus available is utilized for cultivation. Raised beds (called bun) of about one meter width are made along the slope and again covered with farm wastes, dried leaves, etc., which are being burnt before sowing of seed rhizomes. In Churachandpur district of Manipur and Paren district of Nagaland, turmeric is grown in fallow land after 'jhum' as a single crop or inter crop with timber/ fodder etc. The burning of field helps in reducing the weed growth, soft rot disease and increase the availability of certain plant nutrients, particularly the potash. In the region usually the seed rhizomes are stored in the pit under soil cover after harvest. By March-April when the rhizomes start sprouting, they are taken out and planted in the field.

Production constraints of turmeric in the region

Abiotic and biotic factors

Most of the turmeric growing area is inaccessible. Many of the turmeric growing areas are not connected with motorable roads. Farmers do not get remunerative returns from their crop due to poor market linkage, transportation facilities and other logistic supports. Heavy rainfall, soil erosion, soil acidity, pest and diseases are some of the important factors that affect the production and productivity of turmeric.

Socio-economic factors

Turmeric cultivators in north eastern region are resource poor and have low produce holding capacity. Due to lack of storage facilities at farm, cultivators are forced to sell their produce just after harvesting through commission agents. Sale in local markets is very limited. Unorganised marketing system is a major constraint that leads to non-adoption of improved production packages for higher productivity. Absence of large scale post harvest processing units to absorb marketable surplus (which is nearly 70%) forces the cultivators to sell the produce as fresh turmeric only.

Future thrust

The following are the areas where more intensive research is needed so that overall scenario of the turmeric production can be changed by increasing production and productivity of turmeric in the north eastern region.

Area expansion and higher productivity

There is a great scope for increasing the area under this high value crop in all the north eastern states. Increase in productivity to at least 4.0-4.5 t/ ha with simultaneous attempt to increase the area to raise the production up to 100 thousand tons from the present level of 32.36 thousand tons is possible. There is need for survey and diagnosis of lands suitable for turmeric and development of area specific farming system model in cluster approach. Systematic study on nutrient and water requirement at different growth stages may help in identifying the critical stage of nutrient and water requirement. By scheduling the nutrient and water requirement, the yield of the crop could be increased considerably. Package of practices for different locations of the region have to be standardized for varieties which are well adopted by the growers.

Evaluation of genetic resources

All the north eastern states have different type of turmeric genotypes that are in cultivation for years in some pockets. Systematic studies have not yet been done for their yield and quality parameters including curcumin content. There may be variation within the same cultivar at different stages of maturity. DNA finger printing of the local genotypes is another area to be taken up immediately. Introduction of high yielding varieties of turmeric suitable for the region can be explored. Breeding programmes should aim at developing high yielding and better quality varieties with resistance to biotic and abiotic stresses.

Organic turmeric production

With the increasing awareness of pollution hazards, people are very conscious about quality food and demand for organic food is increasing in the market. By and large, the farmers do not use chemical fertilizers as nutrient input in turmeric. The pesticide application for disease and pest management is totally nil indicating the possibility of producing organic turmeric. The need of the hour is to have a simplified and affordable organic certification system.

Post- harvest management

Use of appropriate pre and post harvest practices for turmeric is vital for the success of the crop and to provide good return to the growers. No systematic study has so far been made utilizing the local cultivars of the region. Megha Turmeric-1, being the most popular variety among the growers in the region, has not yet been systematically evaluated for preparation of different value added products including cosmetic paste. Technology for low cost drying is essential for the region as the existing solar drying technology does not function properly in the region due to cloud cover and high humidity.

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Present status and future prospects of turmeric production in Tamil Nadu

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Introduction

Turmeric (*Curcuma longa* L.) the ancient and sacred spice of India, popularly known as "Indian Saffron" is a major rhizomatous perennial crop by nature but cultivated as an annual for its manifold uses. Tamil Nadu has all along been one of the states with a creditable performance in turmeric production with the farmers relatively more responsive and receptive to the changing technologies and market forces. Tamil Nadu accounts for nearly 17 per cent of the country's output. The area under turmeric in the state is 20,383 hectares with a production of 85,432 tons as on 2006-07 (Table 1). Erode is the important market for turmeric and is considered as the biggest market for south India. The major producing centres in Tamil Nadu are Coimbatore, Dharmapuri, Salem (Athur, Omaloor and Tiruchengodu), Erode (Bhavani, Gopichettipalayam, Sathyamangalam and Kodumudi), Namakkal and Villupuram (Table 2).

Table 1. Year wise area, production and productivity of turmeric in Tamil Nadu

Year	Area (ha)	Production (tons)	Productivity (kg/ha)
2004-2005	17475	72880	4.17
2005-2006	18874	78907	4.18
2006-2007	20383	85432	4.19

(Source: Hort Stat, Dept. of Horticulture and Plantation Crops, 2004)

Genetic diversity

Research efforts taken up by various State Agricultural Universities and Indian Institute of Spices Research, Calicut have resulted in several superior selections through screening of germplasm and also in certain cases by induction of mutation. As on date, there are more than 25 released varieties in turmeric from various institutes with improved traits viz., suitability to drought prone and hilly areas, resistance to pest and diseases, high curcumin and high yielding cultivars. In Tamil Nadu, the important varieties cultivated are Erode Local, BSR-1, BSR-2, PTS-10, Roma, Suguna, Sudharsana and Salem local. Among these varieties, 70 to 75% of area in the state is occupied by the local varieties.

Table 2. District-wise area, production and productivity of turmeric in Tamil Nadu (2003-2004)

District	Area (ha)	Production (tons)	Productivity (kg/ha)
Coimbatore	1786	7945	4.45
Dharmapuri	1659	4114	2.48
Erode	5862	32566	5.56
Krishnagiri	448	1111	2.48
Namakkal	1161	5105	4.40
Perambalur	302	1255	4.16
Salem	2768	7243	2.62
Thiruchirapalli	267	1110	4.16
Thiruvannamalai	288	1197	4.16
Villupuram	1112	3918	3.52
Other districts	15653	65564	37.99
Total	16181	67250	4.16

(Source: Hort Stat 2004, Dept. of Horticulture and Plantation Crops)

Co-1

It is a vegetative mutant selection from Erode Local turmeric. The crop duration is 270 days with a yield potential of 35 t/ha. The rhizomes are bigger in size, bright orange coloured better than Erode Local type. The curcumin content is 3.2 percent with 20% processing recovery.

BSR-1

It is a selection from mutant population irradiated with X-rays. The crop duration is 280 days with an yield of 31 t/ha of fresh and 6 t/ha of dried rhizomes. The processing percentage is 20 with 4.2% of curcumin content which is higher than Co.1 and Erode Local.

BSR-2

It is a induced mutant from Erode Local type. The crop yields about 32 t/ha with a duration 240-250 days. The plants are medium statured, high yielding and tolerant to scale insects. The variety is adaptable to Erode, Coimbatore, Salem, Dharmapuri, Thiruchirappali, North Arcot and South Arcot districts.

Promising cultures of TNAU

a) The accession CL 101 was identified as high yielding accession with an yield of 45.9 t/ha with curcumin content of 4.07 per cent.

b) Two accessions viz., CL 206 and CL 219 were identified for high curcumin content of 6.2 and 6.0 percent with an yield of 37.7 t/ha and 34.9 t/ha respectively.

Fertilizers

Turmeric is considered as a nutrient exhaustive crop. It is a heavy feeder of N and K nutrients and comparatively, K uptake is higher than N. The uptake of nutrients increases with the increase in dry matter production and generally the phase of active vegetative growth is the period during which there is maximum uptake of nutrients. Further, it was evident from studies that the uptake of nutrients was higher up to third month for potassium, fourth month for nitrogen and up to fifth month for P indicating the need for earlier application of N, P and K fertilizers for improving the plant growth.

Nitrogen

Studies taken up at Coimbatore, on the effect of nitrogen on turmeric (Table 3) revealed that the response was higher at 100 to 140 kg/ha (Ahmed Shah and Muthuswamy, 1981; Balashanmugam and Chezhiyan, 1986).

Table 3. Yield and yield components of turmeric as influenced by nitrogen levels

Treatment	Yield of fresh rhizomes (t/ha)	Per cent increase over control
No nitrogen (control)	14.60	-
N at 100 kg/ha	22.32	52.88
N at 120 kg/ha	21.98	50.55
N at 140 kg/ha	22.91	56.92
N at 160 kg/ha	21.92	50.14

(Source: Ahmed Shah and Muthuswami,1981)

On the contrary, in another study taken up at Bhavanisagar, Erode district, Muthuvel *et al.* (1989) found no significant response to higher nitrogen levels of 120 or 150kg/ha when compared to 90 kg/ha (Table 4). The differences in these two studies reflect the probable influence of soil conditions and varieties involved in nutrient uptake.

Table 4. Influence of varied doses of N and K on turmeric at Bhavanisagar

N level	Fresh rhizome yield (t/ha)			Mean
	84-85	85-86	86-87	
N90 kg/ha	51.1	33.4	34.9	39.8
N120 kg/ha	51.1	33.2	38.2	40.8
N150 kg/ha	53.4	33.6	**38.4**	41.8
K level				
K90 kg/ha	50.9	33.1	36.3	40.1
K120 kg/ha	52.8	33.8	38.1	41.6
SE	2.7	1.25	3.38	
CD	NS	NS	NS	

(Source: Muthuvel *et al.*, 1989)

In a pot culture study involving labeled ^{15}N, Jagadeeswaran *et al.* (2004) demonstrated that split application of nitrogen keeps the nutrient availability throughout the active growth stages. Maximum crop recovery and soil retention coupled with minimal loss of N could be achieved with the application of N in four splits.

Phosphorus

In general, the response to applied phosphorus seems to be lesser compared to N and K nutrients. The requirements of phosphorus in Tamil Nadu seem to be lesser and in general (60 kg/ha is recommended).

Potassium

Potassium application in turmeric significanty increased plant height, number of tillers, number of leaves and number of primary and secondary rhizomes (Rathinavel,1983). Field experiments conducted at ARS, Bhavanisagar to study the effect of potash fertilization on growth and yield attributes of BSR 1 variety showed that the application of 90 kg/ha in four splits resulted in higher uptake and yield of 28.9 t/ha (Table 5).

Table 5. Influence of K levels on yield of BSR 1 turmeric and K uptake

K level	Yield/ ha (t)	Total uptake of K by whole rhizomes (kg/ha)	Total uptake of K by whole plant (kg/ha)
30 kg/ha	23.5	226.3	421.5
60 kg/ha	24.9	299.2	387.2
90 kg/ha	29.7	262.1	320.9

(Source: Balashanmugam and Subramanian, 1991)

Micronutrients

Micronutrients such as iron, zinc and boron are required in sufficient levels for proper growth and development of turmeric and very often the crop suffers when these nutrients are limiting. A general recommendation for correcting deficiency of micronutrients especially boron, iron and zinc has been prescribed (TNAU, 2004). This involves application of 375g ferrous sulphate, 375g zinc sulphate, 375g borax, 375g urea dissolved in super phosphate slurry solution (15 kg super phosphate dissolved in 25litres of water stored overnight and the supernatant solution is made up to 250 l). Spraying of the above solution twice at 25 days interval is recommended. In a study to find out the effect of Zn enriched organic manures on yield and curcumin content of turmeric at ARS, Bhavanisagar, it was found that the application of $ZnSO_4$ at 50kg/ha and $FeSO_4$ at 100kg/ha as zinc and iron enriched coir pith (1 t/ha) as basal dressing along with recommended dose of NPK + FYM and a zinc solubilizing bacteria (ZSB-Bacillus) resulted in high rhizome yield and better soil and plant nutrient status (Table 6).

Table 6. Effect of FYM and Zn in turmeric

Treatment	Rhizome yield (t/ha)	Curcumin content (%)
Control	23.5	4.04
NPK+FYM	25.6	4.38
NPK+FYM+Zn	28.6	4.53

(Source: Senthil Kumar *et al.*, 2004)

Integrated nutrient management

Selvarajan and Chezhiyan (2001) studied the effect of azospirillum along with graded doses of nitrogen on growth and yield of turmeric cultivar BSR 2 and indicated that 40% of nitrogenous inorganic fertilizer could be saved by application of *Azospirillum* @25kg/ha. Addition of biofertilizers viz., *Azospirillum* (10 kg/ha) and *Phosphobacteria* (10 kg/ha) along with FYM 15 t/ha and digested coir compost (10 t/ha) and 125:60:90 kg/ha of NPK was reported to enhance the uptake of nutrients and physiological parameters in turmeric accession CL 147 leading to higher yields (Padmapriya, 2004).

Evaluation of fertigation on yield and water use efficiency (WUE) in turmeric

Experiment conducted in ARS, Bhavanisagar indicated that at even 50% of the recommended dosage of N & K when supplied through drip resulted in higher yields compared to application of 100% recommended NPK dosage through soil application of fertilizers and surface irrigation (Table 7).

Table 7. Influence of irrigation and fertigation levels on turmeric yield (t/ha)

Irrigation & fertigation level	100% N&K	75% N&K	50% N&K	Mean
Irrigation at 80% PE	32.91	34.76	33.62	33.76
Irrigation at 60% PE	33.26	33.69	34.12	33.69
Irrigation at 40% PE	29.70	29.98	29.49	29.72
Mean	31.96	32.81	32.41	
Surface irrigation 5cm, 0.90 IW/CPE, 100% of N & K through soil.	22.50	CD-3.54		

This study reveals that it is possible to enhance nutrient and water use efficiency and improve the yield by adopting fertigation in turmeric.

Precision farming practices

TNAU standardized the precision farming practices for turmeric through demonstrations in Dharmapuri and Krishnagiri districts. The precision farming model which was standardized at farmer's field, Dharmapuri is presented as follows.

Drip irrigation system

- Installation of drip system was done with main, sub-main pipes and the inline lateral tubes were placed at an interval of 1.5 meter (5 feet).
- The drippers in lateral tubes were placed at an interval of 60cm and 50cm spacing with 4LPH capacities respectively.

Field preparation

- The main field was ploughed 4 times with chisel and disc plough each one time and cultivator once.
- FYM@ 25 t/ha was applied before the last ploughing.
- 75% of the total recommended dose of super phosphate i.e., 281 kg/ha was applied as basal dose.
- Azospirillum and phosphobacteria each @ 2kg/ha along with FYM 50kg and neem cake @100kg were applied before last ploughing.
- Raised beds of 20cm width (4 feet) were formed at an interval of 30cm (1 feet) and the laterals were placed at the centre of each bed.

- The beds were wetted for 8-12 hrs through drip irrigation depending upon the soil moisture level.

Rhizome treatment and planting

- Mother rhizome of about 2000kg of rhizomes was required for 1ha.
- The rhizomes were treated with 10kg each of *azospirillum* and *phosphobacteria*.
- The rhizomes were treated with carbendazim for 30minutes before planting.
- The treated rhizomes were planted in the raised beds in three rows spaced at 45cm. The spacing between the plants within the row was 15cm.

Fertigation

- Fertigation was done for the recommended dose of 150:60:108 kg/ha of NPK and was applied throughout the cropping period once in three days (Table 8).
- 75% of the recommended dose of phosphorus (281 kg/ha) was applied as basal dose.

  The Fertigation schedule was fixed based on the recommended dose of fertilizers for turmeric and tested in cv Sudharshana (Table 8).

Intercultivation

- Weeding was done at 30 days after planting and then whenever necessary.
- The raised beds were earthed up twice on 60th and 120th DAP.
- Micronutrients of 375g each $FeSO_4$, $ZnSO_4$, borax and urea dissolved in 250 litres of water and sprayed twice, at 60 and 90 DAP.

Harvesting

- The rhizomes were pulled out without any damage and stored under partial shade. The yield of dry rhizomes obtained by following the precision farming model was about 6.5 t/acre compared to the control (3 t/acre).

Management of rhizome rot

For the management of rhizome rot of turmeric, seed and soil application of *Trichoderma viride* and *Pseudomonas fluorescens* @ 4 g/kg of seed and 2.5 kg as basal and top dressing at 150 DAP was found to be effective which recorded the least disease incidence of 0.79% with the maximum yield of 60.19 t/ha (Table 9). The same treatment also recorded the maximum C:B ratio of 1:3.3.

Table 8. Fertigation schedule for turmeric through precision farming

Recommended Dose: 150:60:108 kg/ha 100% of TRD: 150:150:108 kg/ha

Sl. No	Crop stage	Duration in days	Fertilizer grade	Total fertilizer (kg/ha)	Nutrient supplied			% Requirement		
					N	P	K	N	P	K
1	Planting to establishment stage	15	19-19-19+MN13-0-45 Urea	15 78 17 33 21.20	3.00 2 25 9 75	3 00 - -	3.00 7 80 -	10.00	20 00	10.00
				Subtotal	15.00	3 00	10 80			
2.	Vegetative stage	60	12-61-0 13-0-45 Urea	9 83 96.00 100.57	1.18 12.48 46.23	6 00 —	43.20 —	40.00	30 00	20.00
				Subtotal	59 85	6 00	43.20			
3.	Rhizome initiation stage	60	12-61-0 13-0-45 Urea	4 91 71.28 76.29	0.59 9 27 35.09	3 00 —	3.00 18 19 -	20.00	20.00	40 00
				Subtotal	44.95	3 00	32.08			
4.	Rhizome maturation stage	135	19-19-19+MN 13-0-45 Urea	15 78 40.42 47.06	3 00 5 25 21.65	3 00 —	3.00 18.19 -	20 00	20.00	40.00
	Total duration	270		Subtotal	29 90	3 00	21 19	100	100	100
	Total duration		Total		149.75 (or) 150.00	15.00	107.27 (or) 108 00			

*75%RD of phosphorus applied as super phosphate = 45.00 x 6.25 = 281.25 kg/ha

1). 19:19:19 32 kg/ha; 2). 13:0:45 225 kg/ha; 3). 12.:61:0 15 kg/ha; 4). Urea 245 kg/ha

DEMIC (Domestic and Export Market Intelligence Cell)

TNAU has a market intelligence cell, which makes regular market surveys in turmeric. Based on the survey, price forecasting of turmeric is periodically made for the benefit of farmers. Turmeric trade is the lifeline of farming community, which has raised the standard of hundreds of farmers in Erode district. Erode turmeric market is the second biggest markets in the country. Now the turmeric marketing is done by the Regulated Marketing Committee, Erode Cooperative Marketing Society, Gobichettipalayam Cooperative Marketing Society and private traders. The arrival in the private market is high as they are granting advance money for the crop to the farmers and also providing space for stocking the produce. On the other hand, the quality of Salem turmeric is comparatively better and has acceptance in the international market for grinding and blending purposes. The Spices Board has identified Salem and Erode regions of Tamil Nadu as potential areas for setting up an agri-export zone for turmeric. Primary objective of setting up an agri-export zone would be to export turmeric and processed products. Other objectives, included moving up of the value chain by promoting processed and value added form of turmeric exports, to introduce high yielding and disease resistance varieties of turmeric having high curcumin content, to provide adequate and better facilities for proper storing and packing, to introduce scientific cleaning and processing facilities and to set up quality control laboratory for upgrading the quality, and to establish backward linkage between farmers, exporters and processing units for promoting exports and better value realization.

Research studies conducted at DEMIC of Tamil Nadu Agricultural University confirmed that there exists five-year cyclic behaviour of turmeric prices. Erode regulated market is the only regulated market functioning throughout the year whereas the turmeric markets in Andhra Pradesh, Maharashtra and in other states of India are seasonal in nature.

Fresh turmeric arrival in Erode regulated market starts from mid January to June and stored product is available throughout the year. During January to April, turmeric from Mysore region comes to Erode market regularly. March-April months are peak arrival period and the price will be less by 8 to 10 per cent than the normal price during this period. Recent market survey results confirmed that there was a reduction in the area under turmeric in main turmeric belt (Kodumudi region) of Erode district due to shift to sugarcane cultivation. This reduction in area was compensated by increased area under turmeric in Salem district. The adequate ground water level and expectation of remunerative price for turmeric in the forthcoming months might be the reasons for upward swing in area in this region.

In Erode regulated market there is no cost for storage of turmeric up to 15 days. Thereafter only ten paise per quintal/day is charged. Farmers can also store in State/Central Ware Housing Corporation and the storage cost is around Rs. 6 per quintal/month.

Table 9. Effect of bio control agents for the management of turmeric rhizome rot

Treatment details	Disease incidence (%)	Yield t/ha	C:B ratio
T1 - Recommended NPK (control)	27.22	29.57	1:1.56
T2 - Recommended NPK + FYM 12.5 t/ha	11.00	35.84	1:1.66
T3 - Recommended NPK + *T. viride* + *P. fluorescens* seed treatment @ 4g/kg of seed	3.00	38.65	1:2.18
T4 - Recommended NPK + *T. viride* + *P. fluorescens* as soil application	3.55	46.23	1:2.56
$T_2 + T_3$	3.11	38.40	1:2.07
$T_3 + T_4$	2.00	46.90	1:2.45
$T_2 + T_3 + T_4$	0.79	60.19	1:3.58
T_2 + *Bacillus subtilis* @ 1ml /l of water (500 l/ha)	2.00	54.70	1:3.12
CD (0.05%)	3.94	13.13	
SEd	1.52	6.12	
CV	13.59	17.11	

Future outlook

- Replacement of low yielding, susceptible local cultivars with high yielding types.
- Increase of area under high curcumin cultivars to cater the needs of cosmetics and pharmaceutical industry.
- Tapping the niche market viz., organic turmeric both in India and abroad.
- Introduction of precision farming, fertigation and bio-control for disease management.
- Better value addition in turmeric for increased market value for the produce.
- Market forecast to help the growers predict the price.

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Present status and future prospects of turmeric production in Andhra Pradesh

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Introduction

Turmeric is essentially a tropical crop, cultivated for the underground rhizomes which are used as condiment, dye stuff, drug and cosmetic. India is the world's largest producer of turmeric. In India, it is grown in an area of about 1,72,000 ha with a production of 8,51,700 tons (2005-06). Andhra Pradesh ranks first in the country with an area of 71,488 ha and production of 4,43,226 tons (2005-06).

In Andhra Pradesh, turmeric cultivation can be seen in three different regions, with distinct variations in area, productivity, varietal choice and production practices. In coastal region, it is mainly grown in the districts of Guntur, Krishna, Vishakhapatnam and to a lesser extent in other districts. It is an important crop of Cudapah and Kurnool districts in Rayalaseema. Major area of turmeric lies in Telangana. Important districts cultivating turmeric in the descending order based on area are Karimnagar, Adilabad, Nizamabad, Warangal, Rangareddy and Medak (2005-06). The regional differences with respect to area, production and productivity are illustrated through the data pertaining to 2000-01 as given in Table 1.

Table 1. Turmeric in Andhra Pradesh (2000-2001)

Region	Area (ha)	Production (tons)	Productivity (kg/ha)
Coast	10692	48013	4490
Rayalaseema	5025	34995	6964
Telangana	58212	292749	5029
Andhra Pradesh	73929	375757	5083
India	*191700*	*714300*	*3726*

Large area exists in Telangana, while the productivity is higher in Rayalaseema. Andhra Pradesh accounts for 41 per cent of the area and 52 per cent of production in India. The productivity level in Andhra Pradesh is much above the national average.

In India, area has increased considerably over the years thereby the production too. However, the productivity figures clearly indicated wide fluctuations that could be due to numerous factors connected with climate, genotypes, changes in management practices, etc. The mean yield of more than 4.5 t/ha was realized in the years 1993-94; 1999-2000; 2004-05 and 2005-06. The mean yield during 2005-06 was 4952 kg/ha. Similar trend was also noticed in Andhra Pradesh.

Never the less, turmeric occupies a unique place in the culture and life style of Indians and no day passes without the use of turmeric. Major share of the total production is domestically consumed, while turmeric is also exported to other countries in Asia (UAE, Malaysia, Bangladesh, Japan, etc), Europe (United Kingdom, Netherlands, Germany, etc.), USA and Australia. UEA followed by USA are the major importers. Turmeric occupies about 12-13 per cent share of the total spices exported from India.

Ground turmeric *i.e.*, the turmeric powder is used world wide as a seasoning, to make curry and for its medicinal properties. Curcumin, composing 2-4 per cent of turmeric is the most biologically active phytochemical compound. It is extracted and researched for its renowned range of therapeutic effects.

The important cultivars grown in Andhra Pradesh, the management practices adopted and the issues related to the prospects of turmeric cultivation are presented below.

Cultivars

Among 40 species of curcuma, only two species viz., *C. longa* L. and *C. aromatica* Salisb. are commercially cultivated for the production of turmeric. Most of the high yielding cultivars are *C. longa* and have a prolonged maturation period of 8-9 months. The rhizomes of *C. aromatica* possess pleasant aroma and hence this turmeric is called "Kasturi" in Andhra Pradesh. Cultivars of this species mature early, within 6-7 months (Table 2).

Presently variety Armoor is replaced by variety Duggirala in the districts of Northern Telangana. Two short duration varieties namely Suguna (PCT 13) and Sudarshana (PCT 14) also occupy a small area in these Telangana districts. Laxminarayana Reddy (1998) reported that, of all the short duration cultures studied at Jagtial centre, genotypes PCT 13 and PCT 14 gave higher fresh rhizome yields as well as cured yields and were free from rhizome rot disease. PCT 13 was also found to be suitable for the southern zone of Andhra Pradesh (Ramakrishna *et.al,*, 1994). Studies made by Subbarayadu *et.al.* (1998) at Anantharajupeta indicated that Dindrigam under short duration group, Amruthapani Kothapeta under medium duration group and Duggirala and Mydukuru under long duration group were high yielders and suitable for Cudapah tract.

Soils

Turmeric can be grown on sandy loams, clay loams, light black soils with good drainage facility and good water holding capacity. Soils should contain good amount of organic matter. Soil pH of 5.0 to 7.5 is ideal. Soils should be rich in available nutrients. Saline and alkaline soils and low lying areas with the problem of water logging are not suitable for turmeric cultivation.

Vijaya Kumar *et.al.* (1997) studied the status of turmeric growing soils of Northern Telangana. Most of the soils were sandy clay loam in nature, neutral to alkaline in reaction (6.7 to 8.6 pH), non-saline (EC <1.1 dSm^{-1}), and the organic carbon content ranged between 0.5 and 0.85 per cent. These soils were low to medium in available nitrogen and phosphorus and high in available potassium. The micro nutrients were above critical limits in all the soils studied.

Table 2. Cultivars / types of Andhra Pradesh

Type	Area of cultivation
Short duration Kasturi types (7 months)	
Kasturi Kothapeta	East Godavari
Kasturi Tanuku	West Godavari
Kasturi Amalapuram	Central delta in East Godavari
Chayapasupu	Agency areas (of Godavari, Vizag, Srikakulam)
Gummalaxmipuram	Srikakulam
Medium duration Kesari types (Bontha) (8 months)	
Kesari Duvvur	Cudapah
Amrutapani Kothapeta	East Godavari
Types	Area of cultivation
Long duration types (9 months)	
Duggirala	Krishna, Guntur districts
Tekurpet	Rayalaseema
Mydukur	Cudapah district
Armoor	Northern Telangana
Sugandham	Cudapah district
Vontimitta	Cudapah district
Nandyal	Kunrool district
Avanigadda	Krishna district

(Source: Rama Rao and Rao, 1994)

Seed material

Turmeric is multiplied by using fingers or mother rhizomes. Generally fingers are used for planting in Andhra Pradesh. The seed rate adopted is 2.5 t/ha. The fingers are treated with a fungicide, mostly mancozeb or redomil MZ @ 3 g/l of water by soaking them for about one hour followed by shade drying.

Planting

In Andhra Pradesh, turmeric is planted in three different systems viz., raised beds, ridges and furrows and flat beds. In all the systems, facilities for irrigation and drainage are created. A spacing of 30 cm x 10-15 cm is usually adopted.

Intercrops and cropping systems

In Northern Telangana, turmeric is intercropped with maize. It is recommended to adopt 2:1 row ratio i.e., one row of maize for every two rows of turmeric. However, most farmers do not adopt distinct rows. Maize and turmeric are put in the same row. For every 12-15 rows of turmeric, one row of castor is also grown. In addition, red gram is sown as border crop around the turmeric field. Studies made at Jagtial indicated that turmeric + maize intercropping was more beneficial than sole crop of turmeric (Manohar Rao and Laxminarayana Reddy, 1990). One row of maize in every second and third inter row space of turmeric (maintaining 100% population of both the crops) with additional fertilizer to maize resulted in higher yields of turmeric and maize, better land equivalent ratio and higher net returns.

In other parts of Andhra Pradesh, turmeric is mostly grown as sole crop. In coastal districts, turmeric is grown as intercrop in coconut. A three tier system of turmeric, cocoa and coconut is recommended. In some areas, it is also grown in mango orchards. In all these systems, additional doses of fertilizers are applied. Two years of crop rotation is invariably followed in all the turmeric growing areas. Turmeric is followed by sesame or hybrid seed production of sorghum or bajra. Next year, other crops are grown such as maize, chillies, etc.

In certain areas, mulching is practiced soon after planting. The green material of dhaincha (Sesbania), sunnhemp, tephrosia, neem, glyricidia or that from forest tree species is uniformly spread on the soil surface. In some places, paddy straw or sesamum stalks are also used for mulching.

Weed management

Weeds are controlled by pre-emergence application of atrazine @ 1.0 kg a.i./ha. After removal of the maize intercrop, the interspaces are manually turned with spades to keep the soil loose.

Nutrient management

Turmeric requires good nutrition. In most parts tank silt is applied to the soil @ 40-50 tractor loads/ha. In addition to it, FYM or poultry manure @ 25 t/ha is also applied. It is recommended to apply *Trichoderma viride* @ 5 kg/ha after incubating with 250 kg FYM. It is also recommended to apply 1 t/ha of neem cake or castor cake in two equal splits (basal and 40 DAP). For sole crop of turmeric, the recommended dose of fertilizers is 150:60:100 kg NPK/ha. Entire dose of P is applied as basal, while N and K are applied in three equal splits, up to 120 DAP. When turmeric is intercropped with maize, the recommended dose of fertilizers for maize is applied in addition to the dose recommended for turmeric.

Raghava Rao and Swamy (1984) made studies at Tirupati and reported that a fertilizer dose of 187.5:62.5:125 kg NPK/ha over 25 t/ha of FYM would be beneficial under light soil conditions for obtaining higher yields in turmeric.

The fertilizers recommended for turmeric in Northern Telangana are 188:70:120 kg NPK/ha in addition to the use of organics. Manohar Rao *et.al.* (2005) tested the use of organics viz., FYM, neem cake, groundnut cake, vermicompost and sugarcane press-mud and recommended the use of 12.5 t/ha of FYM and 1.25 t/ha of neem cake in addition to the recommended dose of fertilizers to realize higher yield as also higher curcumin from Duggirala variety of turmeric. Essential oils and oleoresins were more with the use of 1.0 t/ha of vermicompost.

Water management

This crop requires good amount of water. Care should be taken to avoid water logging, or else, it favours development of rhizome rot. On an average 15-20 irrigations are required on heavy soils, while nearly 40 irrigations are required on light soils. In a study made by Gopalakirshna *et.al.* (1993) at Jagtial, turmeric crop (cr. Armoor) produced fresh rhizome yield of 3.3 t/ha with 14 irrigations scheduled based on IW/CPE of 1.3 and was on par with those of farmers practice (3.4 t/ha), wherein, the crop received 20 irrigations (each with 5 cm depth). Of late, it is recommended to irrigate turmeric adopting drip system, which saves nearly 30 per cent of water and water use efficiency (WUE) is also higher.

Plant protection

Two types of leaf spots are commonly noticed in turmeric namely *Colletotrichum* leaf spot and *Taphrina* leaf blotch. Rhizome treatment at the time of planting and chemical control with carbendazim 1 g/l or mancozeb 2.5 g/l is recommended. Regular sprays at 15 days interval are required (2-4 sprayings) to keep the leaf spot under check. Most importantly turmeric crop suffers heavily from rhizome rot and rhizome fly. There are many pre-disposing factors for the occurrence of rhizome rot. They include deep planting, water logging and ill drained conditions especially during periods of heavy rainfall, non-adoption of seed treatment, etc. Apart from other management practices, it is recommended to drench the soil around the affected plants by using redomil MZ @ 1 g/l or captan @ 2 g/l or COC @ 3 g/l. Rhizome fly, which is closely associated with rhizome rot badly damages the rhizomes. Use of carbofuran 3 G @ 25 kg/ha is recommended to arrest the spread of rhizome fly damage.

Harvesting and processing

Crop is harvested slightly above ground level when it reaches maturity. Maturity can be decided by complete drying of above ground portion. Harvesting is done manually by digging with the help of hand held pick-axes. A country plough is run to loose the soil in black soils if the crop is planted in ridge and furrow system. It should be processed (cooked) within a week for marketing.

Post-harvest processing

All precautions are taken while cooking, drying and polishing. Cooking is done in iron pans with a carrying capacity of 100 kg. Water is added to the pan till the produce is immersed in it and boiling is continued for 45-60 minutes till froathing is seen. There will be good aroma and the rhizomes become very soft. Over cooking or under cooking should be avoided.

There is another system of cooking, where the produce is put in pans and the pans are placed into another big galvanized iron pan. The size of smaller pan carrying produce is 90 x 55 x 40 cm. Four such small pans can be arranged in one bigger pan. The bottom of smaller pans is perforated for free movement of water. Water is boiled in the larger pan and turmeric is cooked in the small pans that are placed into the larger pan and removed after cooking. This system is more convenient and rapid compared to direct cooking in bigger pans as stated earlier.

Recently a steam cooking unit is introduced in Nizamabad district, where a central steam generating unit is present and cooking units are on all four corners. Produce after cooking is dropped on to the ground. Loading and unloading is easy. This system is working well and many prototype units are locally fabricated and put to use. The district administration has come forward to encourage the system and is considering it for subsidies.

After cooking, the produce is spread on a tarpaulin or concrete platform uniformly into 2-3" layer. The produce is turned upside down during day time. Gradually the thickness of layer is brought down and the produce gets dried in 10-15 days. Drying is stopped when the rhizomes give a metallic sound when broken and the moisture content reaches about 8 per cent level.

After drying, the produce is subjected to polishing. The dried produce is placed into polishing drums that are operated either manually or mechanically through electric power. When the drum is rotated, there is rapid contact between drum and rhizomes and also among rhizomes, due to which, the surface looses the dirt and other impurities; minute scraping takes place and rhizomes become bright and shiny. Even turmeric powder is added during the last stage of rotation to improve the colour and brightness. Grading and packing are very important to fetch good price in the market.

Marketing

Farmers sell their produce in the local market. Cudapah and Nizamabad are two important markets for turmeric in Andhra Pradesh. Some farmers of Northern Telangana districts especially those bordering Maharashtra take their produce to Sangli market, where the market price is usually higher compared to that of Nizamabad. Certain observations of sales in the local markets indicated that some farmers bring produce without proper drying after cooking and this appears to be one of the factors for lower price in the market.

The whole sale price of turmeric (Rs./q) in different markets of south India during the period 1996 to 2000 is indicated in Table 3. It is obvious that higher price for turmeric is seen in Sangli (Maharashtra) and Erode (Tamil Nadu) compared to the markets of Andhra Pradesh.

Table 3. Market price per quintal

Year	Cudapah	Nizamabad	Sangli	Erode
1996	1828	1486	2084	2574
1997	2217	1923	2783	2691
1998	2596	2427	3093	3729
1999	2486	2437	2925	3541
2000	1538	1555	2269	2608

The model price for turmeric in Nizamabad market in the recent past is given in Table 4. There is a clear cut indication of decline in the market price for turmeric from 2003-04 onwards despite the fact that the cultivation costs are on the increase from year to year.

Table 4. Model price for turmeric in Nizamabad (Rs./q during March)

2002-03	2003-04	2004-05	2005-06	2006-07
2458	2575	2315	2270	1850

The Ministry of Agriculture, Government of Andhra Pradesh has published the harvest price of turmeric in Andhra Pradesh during different years based on the cultivation expenses and average yields. Harvest price in other words is the cost of production per quintal. As per the report, the following are the harvest prices for turmeric in Andhra Pradesh (Table 5).

Table 5. Harvest price (Rs./q) for turmeric in Andhra Pradesh

2001-02	2002-03	2003-04	2004-05	2005-06
1723	2194	2268	1878	1922

The decrease in harvest price during 2004-05 and 2005-06 could be due to good average yields during these years and definitely not because of any reduction in cost of cultivation. Comparison of harvest price i.e., production cost and model price clearly indicates that the profit to the farmer is not really encouraging. The prices trend could be seen by perusing the whole sale price index values given below (Table 6). Turmeric cultivation appears to be non remunerative to the farmers, especially during the years when the market prices are low.

Table 6. Whole sale price index of turmeric in India (during March)

Base year 1993-94 = 100

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
85.4	106	144	230	205	173	119	138	226	228	212	197	172

Government support to turmeric farmers

There are different programmes of State and Central Government to support the turmeric farmers; *mainly in the form of providing subsidy. The following equipments are supplied on subsidy by* the Department of Horticulture, Government of Andhra Pradesh.

Item	Total cost (Rs.)	Subsidy (%)
Cooking pans (set of 6 pans)	7956	50
Concrete drying platform	50000	25
Tarpaulin sheets	1596	33
Polishing drums	30160	50
Drip system (for 1 acre)	50000	70 (through APMIP)

In addition to the above subsidies, Department of Horticulture has taken an initiative to promote the cultivation of new and promising turmeric cultures by organizing demonstrations on large scale. In the Northern Telangana districts of Karimnagar and Nizamabad, demonstrations are organized with varieties such as Prabha, Prathibha, Roma, Suroma, Ranga and Rashmi. Seed is supplied free of cost for an area of 50 cents (2000 m^2) and the required fertilizers and pesticides are supplied on 50 per cent subsidy.

Issues that need to be addressed

1. The varieties grown by farmers are not true to type and got mixed up as the farmer is using his own seed material year after year. There is need to purify the seed material of elite varieties to replace the one with the farmers.

2. In some areas farmers harvest the turmeric crop prematurely by 7 months, especially varieties like Duggirala, which need to remain on the field for 9 months. It is done primarily to take up the sowings of succeeding crop within the right time e.g.: hybrid seed production of bajra or sorghum. The farmers are incurring loss either due to ignorance or due to over ambitious nature. There is need to educate the farmers to cultivate short duration types during such situations where they can realise quality turmeric by the end of 7 months.

3. Continuous efforts are required to evolve or identify turmeric varieties tolerant or resistant to rhizome rot and rhizome fly.

4. Due to the escalation of cultivation costs as well as non-availability of labour of timely operations, farmers demand improved systems of mechanization, especially for the field operations such as digging and cooking.

5. The role of quality i.e., curcumin content for payments to the farmers in the markets is not seen. Other criteria such as moisture content, colour, pest damage, etc., are taken into account, but not the curcumin content. There is need to evolve a mechanism, wherein quality also plays an important role in deciding the market price. This can motivate the farmers to take up the cultivation of curcumin rich varieties.

6. The market prices are widely fluctuating and are influenced by various factors that are not under the control of farmer. As majority of the produce is consumed within our country, the influence of international markets would be minimum. The farmers unitedly demand for minimum support price for turmeric, similar to the support given for good grains. This remains to be attended carefully and realistically after necessary deliberations and governmental interventions.

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Turmeric – Harvesting, processing and marketing

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Introduction

India is the land of spices and turmeric is an important spice. Besides India, Sri Lanka, China, and Pakistan are the other tropical countries cultivating turmeric. India is the largest producer and exporter of turmeric. Andra Pradesh, Maharastra, Orissa, Tamil Nadu, Karnataka and West Bengal are the states extensively cultivating turmeric. USA, Germany, UK, Japan and Middle East are the important importers of Indian turmeric in various forms. India ranks 4th in turmeric export and contributing 4% of world's production. In India, turmeric shares 11% of the spices exported and earns about Rs. 90 crores by export.

In turmeric production, about 90% is consumed locally. Per capita consumption of turmeric in India varies between 0.16 and 0.44 kg per annum in different states. The consumption pattern being, 17-20% of fresh turmeric rhizomes are retained for seed purposes, 1% is used by farmer and 70% is marketed as cured and dried turmeric.

Harvesting

Harvesting of turmeric rhizomes is done by manual digging using a specially designed hoe type hand tool and collecting the rhizomes. By this method harvesting is done by a group of labourers as a team. Power tiller operated digger is available for efficient digging of rhizomes (Fig. 1).

Fig.1. Power tiller and tractor operated turmeric digger

Using the power tiller operated digger 1.5 acre can be covered in a day. The cost of the digger is Rs.15,000/-. Compared to manual digging, 65 % saving in cost and 90% saving in time can be achieved. The damage caused to the rhizomes is 0.5% as compared to 4.2% in manual harvesting. The undug rhizomes left in the field are 0.8% as compared to 4.8% in manual harvesting. Tractor drawn turmeric digger can harvest turmeric rhizomes from 0.5 acre in one hour (Fig. 1). The cost of the digger attachment is Rs. 15,000/-. This digger results in 70% saving in cost and 90% in time when compared to manual digging. Extent of damage caused to the rhizomes is very much less (2.83%).

Processing

Curing of turmeric is the term used to indicate processing of turmeric rhizomes. Curing process involves boiling of rhizomes, drying and polishing. Boiling of rhizomes results in uniform distribution of colouring pigments and quick drying.

Traditional method of turmeric boiling

In the conventional method, a vessel made of galvanised iron sheet as shown in Fig. 2 is used. Farmers cultivating turmeric will have such boiling vessels on their own to boil the produce at farm level. Cow dung slurry was used traditionally and discontinued nowadays. However, sodium bicarbonate, 0.1% (100 g /100 litre) was recommended for getting bright colour for the turmeric rhizomes. Nowadays only water is used for boiling turmeric rhizome. Also tins were used for boiling of rhizomes. In the traditional turmeric boiler, 50-60 kg per batch can be boiled in 45–60 minutes. The major disadvantage of using this boiler is higher fuel requirement.

Large scale steamer

For boiling turmeric at farm level in large quantities, turmeric rhizomes are boiled using steam (Fig. 3). Both farm level units owned by the farmers and for custom hiring are available. It takes about 12-15 minutes for a batch of about 100 kg. Steam is produced using farm wastes and requires about 0.5 kg per kg of rhizome. The boilers owned by the farmers for use at farm level are stationary and the units available for custom hiring are mobile units. The cost of the units range Rs.1 lakh to 3 Lakhs. The major advantages of this unit are less boiling time, less fuel requirement, less drying time and no need for skilled labourer.

Farm level improved turmeric boiler

The improved farm level turmeric boiler is a steam boiling type (Fig. 4) and consists of a trough (outer drum), inner perforated drums and lid. The outer drum is made of 18 SWG thick mild steel to a size of 1.2 x 1.2 x 0.55 m with four numbers of inner drums of 48 x 48

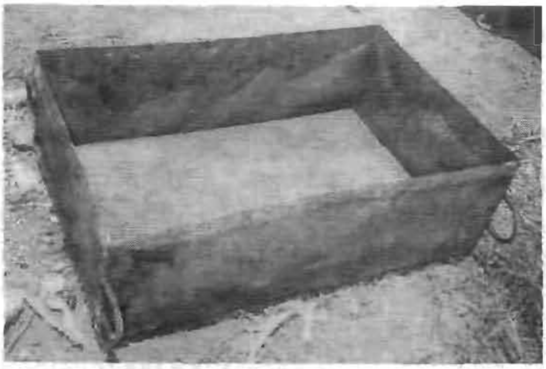

Fig. 2. Conventional turmeric boiling tan

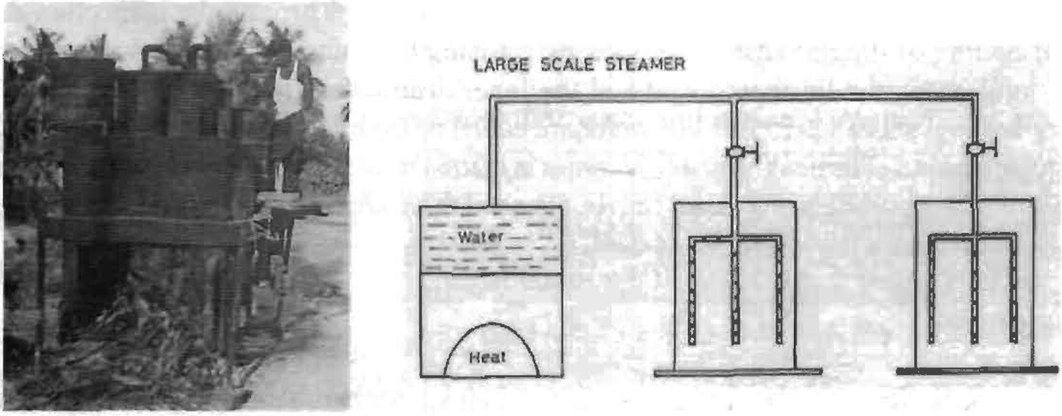

Fig. 3. Large scale turmeric boiling unit using steam

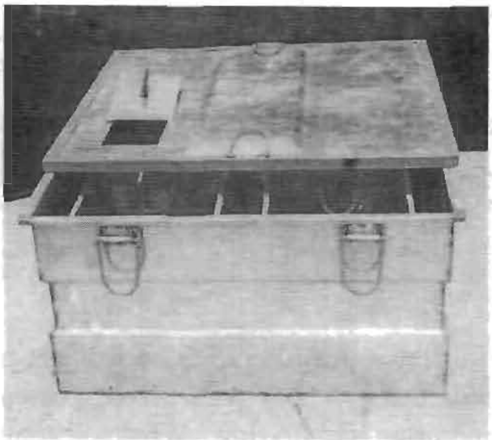

Fig. 4. Improved farm level turmeric boiling unit

x 45 cm size, made of perforated sheet and provided in the outer drum. Also the outer drum is made of 18 SWG thick mild steel to a size of 1.85 x 1.2 x 0.55 m with three numbers of inner drums of 90 x 40 x 40 cm size, made of perforated sheet and provided in the outer drum. Also the drum can be made to any size to suit the requirement of the farmer with any capacity. 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. The inner drums are provided with a leg for a height of 10 cm, so that the rhizomes will not have contact with water filled in the outer drum for about 6-8 cm. depth. The outer drum is placed with more than half of its depth below the ground level by digging a pit, which serves as a furnace. This furnace is provided with two openings, one for feeding the fuel and the other one for removing the ash and unburnt. After placing the turmeric boiler in the furnace, about 60 litres of water is added (6-8 cm depth) to the outer drum and about 50 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, removed while harvesting the rhizomes will be adequate as fuel for turmeric boiling. During the boiling process, it takes about 25 minutes to produce steam and boil the 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 using a hard pin / needle. Using long poles, the lid is removed and the inner drums are lifted one by one. For the next batch of boiling, about 12-15 litres of water are added to the outer drum, depending on the water lost by evaporation. The next batch of rhizomes is loaded in all the drums and heating is continued. At the end of the boiling process, all the drums need to be cleaned free of mud and soil to avoid damage and enhance the life of the gadget.

Salient features:

- Capacity of the boiler is about 200 – 240 kg per batch and 50 quintals per day for 8 hours.
- Fuel requirement is 25-30 kg of agricultural waste materials (turmeric leaves/sheath) per batch of 200 or 240 kg of rhizomes.
- The cost of the unit (with 200 or 240 kg per batch capacity) is about Rs.8,000/-
- Cost of boiling of turmeric rhizomes is Rs.10 per quintal.

Drying and cleaning

The cured produce is dried in thin layers for 10 to 15 days. Rounds and fingers are dried separately. The rounds take a longer time for drying. The rhizomes have some adhering roots which ordinarily drop off during the process of curing and dry-ing. Whatever remains is finally removed along with the scales by manual labour.

The cooked fingers are dried in the sun by spreading in 5 cm thick layers on bamboo mat or drying floor. A thinner layer is not desirable, as the colour of the dried product may be adverse-ly affected. During night time, the material should be heaped or covered. Artificial drying, usually cross-flow hot air at a maximum temperature of 60°C is also found to provide a satisfac-tory product. In the case of sliced turmeric, artificial drying has clear advantages in giving brighter coloured product than sun drying which tends to suffer surface bleaching. When fully dried, the turmeric rhizomes become hard, stiff and brittle. Dried turmeric usually has a low moisture content of 6%.

The effect of different processing conditions on the drying rate was found by conducting studies. The processing conditions like boiling, steaming, peeling and slicing showed no significant difference in the volatile oil or total colour after drying. Boiling or steaming the rhizome, however, reduces the drying time and gives better appearance to the dried product. Slicing con-siderably reduces the drying time. As a method of processing this may have an advantage over the conventional drying of fingers, especially for making into powder or for oleoresin production. The control sample dried without any treatment was wrinkled in appearance and was difficult to polish. Boiling also ensures even distribution of colour in the rhizomes.

Comparative study of improved turmeric boiler with conventional method

Details	TNAU Improved method	Conventional method
Method	Steaming	Immersed in water
Capacity, kg	4 boxes x 80 kg	2 boxes x 100 kg
Size of box, m	0.48 x 0.48 x 0.15	0.90x 0.60 x 0.40
Weight of the container, kg (each)	10	15.5
Water required for boiling, litres	60	30 x 2
Water used, litres	12-15	60
Time taken for boiling, minutes	12-15	35
Fuel required, kg per batch	25-30	35
Gross weight handled after boiling	90	145
Moisture content, %(w.b) before boiling	72	72
Moisture content, % (w.b) after boiling	80	84
Savings in time, %	200	-
Savings in fuel, %	300	-

Polishing

Manually the dried turmeric rhizomes are rubbed against the hard surface of the drying floor or trampled under feet covered with pieces of gunny bags. The scales and root bases are sepa-rated by winnowing. The cleaned big pieces are separated as they fetch a premium price.

Power operated polisher is popular among the farmers and polishing is done before marketing. Normally these type of polishers are operated by a suitable power source, either an engine or motor. Polishing cleans the surface and improves colour and appearance. Also colouring is done using turmeric powder. After polishing and colouring, the turmeric will be in lemon yellow to orange colour. The capacity of the polishing units is 500 to 1000 kg per batch. It takes about 45 - 60 minutes per batch and 4% will be wasted as dust. The yield after polishing will be 15 - 25% on fresh basis.

Colouring and grading

Colouring the produce with a yellow colour before exporting to some places to make it more attractive is practiced in some areas of the country. This is done in turn ways, dry colouring and wet colouring. In dry colouring, a yellow dry product, called "Middle chrome' is lightly dusted over a small heap of cured turmeric and thoroughly mixed with it. Wet colouring is done by adding the colour in water and sprinkling the coloured water on half polished, cured turmeric. The product is well stirred and then left to dry for sometime, usually a week, before it is bagged for export. The wet colouring gives a better finish than the dry colouring.

In some areas of the country, a special treatment is given to turmeric to improve the appearance of the product by soaking the material in an aqueous extract of tamarind for 10 minutes to which a paste of turmeric is added. For giving a brighter colour, the boiled, dried and half polished fingers are taken in baskets which are shaken continuous-ly when an emulsion is poured in. When the fingers are uniformly coated with the emulsion, they are dried in the sun. The composition of the emulsion required for coating 100 kg of half boiled turmeric is: alum 0.04 kg, turmeric powder 2 kg, castor seed oil 0.14 kg, sodium bisulphate 30 g and concentrated hydro-chloric acid 30 ml. This is a harmless method of colouring, dispensing with the chemicals which are injurious to health. This method deserves to be encouraged for use in all turmeric processing centres in the country.

Grading is an important operation in processing of turmeric. Turmeric is graded into bulbs and fingers in different fractions based on their size. Manual grading consumes more time and la-bour.

Extraction of curcumin and turmeric oil

Curcumin is the principal colouring constituent which imparts the characteristic yellow colour to turmeric. Curcumin present in turmeric is responsible for considerable quantities of it being converted to 'kum-kum' a dye used in cosmetics. Use of curcumin is also reported in paint and varnish industries.

Curcumin has the molecular formula, $C_{21}H_{20}O_6$ and separates as an orange yellow crystalline powder having a melting part of 180, 183°C, insoluble in water, slightly soluble in either, soluble in alcohol and in glacial acetic acid, its structure was shown to be 1-7 bis (4-hydroxy-3-methoxy-phenyl)-1, 6-heptadiene-3, 5-dione existing in the exolic state. Of the different solvents suggested for isolation of curcumin from turmeric, alcohol, ethylene dichloride, benzene and acetone have been used by many workers. It is not extractable by petroleum solvents. In fact hexane has been suggested as a solvent for removing the bitter principles of turmeric without affecting the curcumin content. The curcumin content of ten common cultivars has been summarized in Table 1.

Table 1. Curcumin content of leading turmeric varieties

Variety	Curcumin content, %	Variety	Curcumin content, %
Waigon	3.5	Miraj	2.87
Tekurpeta	1.82	Sugandham	3.62
Erode	3.00	Rajapuri	3.45
Alleppey	5.44	Duggirala	2.22
Gadhri	3.49	Cudduppah	2.46

Marketing

In marketing and export of turmeric and turmeric products, many important factors related to food safety are required to be considered. Some of them are as follows:

- Good Cultivation Practices
- Good Manufacturing Practices
- Following the principles of Hazard Analysis and Critical Control Points (HACCP) in processing of turmeric products
- Minimum levels of residues of pesticides / chemicals
- Use of good source of water - lead/ chromium / Iron free
- Selection of vessel used for boiling – to avoid copper vessel
- Drying on clean surfaces and avoid – soil, dust/ dirt surfaces and avoid infestation. Cement floors may be preferred.

The American Spice Traders Association has laid the following ASTA specification for turmeric products for their imports which is presented in Table 2.

Table 2. ASTA specifications for turmeric

Extraneous / foreign matter, %	0.5
Excreta, mammalian, mg/pound	5
Excreta, other, mg/ pound	5
Whole insect dead, numbers	3
Insect defiled, % weight	2.5
Mould, % weight	3

The following are some of the standards available for the turmeric products.
Turmeric Whole: IS: 3576-1991; Turmeric powder: IS:2446-1980; Turmeric Oleorsin: IS:10925-1984; ISO – Turmeric whole and ground: ISO 5562-1983.

Summary

Turmeric an important spice crop plays a vital role in the Indian trade and export. Number of industries is functioning on the pre harvest and post harvest activities related to turmeric. Use of improved methods of processing and practices to adopt food safety will further increase the trade activities of turmeric and the profit to the farmers and export earning will increase.

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Status and prospects of cardamom cultivation in Karnataka

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Introduction

In India, cardamom cultivation is mainly concentrated in the evergreen forests of Western Ghats, which is also the place of cardamom origin and diversity. To a lesser extent it is also cultivated in deciduous forests. Out of the estimated 73228 ha (2006 – 07) in India, Karnataka occupies 26611 ha with lowest productivity of 65 kg per ha. It is grown as monocrop and intercrop in arecanut and coffee plantations. In the moderate rainfall areas, its cultivation is confined to small marshy pockets in coffee plantations. The smaller type of cardamom (Malabar) with leafy stems which rarely exceeds 3 m height is grown. In Karnataka, this type is characterized by prostrate panicles and mostly pubescent leaves. This Malabar type is grown in Kodagu, Hassan, Chickmagalur, North Canara and hilly regions of South Canara. Small pockets of cardamom plantations are also raised in Shimoga and Mysore districts as an intercrop in arecanut plantations.

Cropping conditions

Cardamom is mainly grown as monocrop in most of the cardamom growing zones in Kodagu, Hassan and Chickmagalur districts. In parts of Chickmagalur and Shimoga and most of the arecanut plantations located above 500 MSL, cardamom is a popular intercrop under arecanut shade. Only in negligible area under coconut plantation, cardamom is grown as an intercrop by giving more space (above 8 m between coconut palms). In moderate rainfall area, cardamom has become a small component in whole farm in which, it is confined to less than 10 % area in marshy valley bottom. During 1990 to 2000 period, sizable coffee area was mix cropped with cardamom both under Arabica and Robusta coffee systems. The sharp decline in the market price experienced during 2002 to 2005 and drought conditions experienced during 2002 to 2004 influenced growers to neglect cardamom. Presently, growers are concentrating more on the intensive cultivation in small area than extensive cultivation and realizing crop level from an average of 200 to 672 kg per ha. A few farmers in Kerala obtained 1 to 2.3 kg dry cardamom per plant by adopting intensive crop production package and using improved selections like IISR Suvasini, ICRI-3 and Njallani Gold.

Varieties grown

For long time the preferred varieties in Karnataka were the Malabar types. The seedlings raised from local cultivars like Kodagu Local, Malai, Manjirabad and Sirsi Local were used for large scale planting and clones of respective cultivars were used for gap filling. During 1985 to 2000 periods, seedlings obtained from selections like Mudigere - 1, Mudigere - 2, ICRI - 3, Clone - 37 and CCS - 1 were used for large scale planting. Thus, in all the new plantations the seedlings of improved selections monopolized over traditional Manjirabad, Kodagu Local and other cultivars. Advent of improved grower's selection (Njallani Gold) and its large scale multiplication and massive replanting with clones in the last two decades has revolutionized cardamom production in cardamom hills in Kerala. Only in about 5% of new plantations, few interested growers have planted this grower's selection and obtained crop level upto 2.3 kg per plant in Karnataka. However it produced only 230 kg dry from 4 ha of very high rainfall area of Kodagu (Madenadu).

Rainfall pattern

Unlike other cardamom area in South India, Malanad region in Karnataka experiences very long dry period lasting for over 142 days. The lack of moisture during critical periods of panicle initiation, growth and flowering, adversely affect setting and further productivity. The change in ecology and large scale destruction of forest cover also affected the cardamom area. Many lush green productive small and large plantations were lost during 2002 to 2004 periods as most of the natural streams were dried up due to prevailing dry spell. Many growers were unable to provide even life saving irrigation during February to April periods.

Suitable agro-practices

Many crop management trials in research stations, on-farm research cum demonstration trials and large-scale demonstration trials were conducted to refine the production packages suitable to different management systems. Following are the minimum agronomic practices to be followed for increasing productivity of cardamom in Karnataka (Table 1).

Table 1. Minimum agronomic practices for cardamom production in Karnataka

Sl. No.	Agronomic operations		
	Rainfed cultivation	Need based cultivation	Intensive cultivation
1	Sowing of seeds in September	Sowing of seeds in September	Sowing of seeds in September
2	Raise nursery in polybag/ secondary nursery in February	Raise nursery in polybag/ secondary nursery in February	Raise nursery in polybag in February

3	Clearing land in new areas and removal of old plants in identified replanting area in March/April	Clearing land in new areas and removal of old plants in identified replanting area in March/April	Clearing land in new areas and removal of old plants in identified replanting area in March/April
4	Shade regulation to get one umbrella canopy	Shade regulation to get one umbrella canopy	Shade regulation to get one umbrella canopy
5	Marking the pits at 1.8 x 1.8 m spacing	Marking the pits at 2 x 2 m spacing	Marking of pits at 2.5 x 2.5 m
6	Opening of pits 45 x 45 x 45 cm size	Opening of pits 45 x 45 x 45 cm size	Opening of pits 60 x 60 x 60 or 90 x 90 x 90 cm size
7	Fill the pits with top soil and 1 basket compost	Fill the pits with top soil, 1 basket compost, add 15 g carbofuran and 40 g rock phosphate to pit	Fill the pits with debris of shade trees, top soil, 2 basket compost and raise above the ground, add 15 g carbofuran and 40 g rock phosphate to pit at the time of planting
8	Planting of 10 months old nursery plants in June in main field	Planting of 10 months old nursery plants/ clones in June to September in main field	Planting of 10 months old nursery plants or clones of high yielding selections in June to September in main field
9	Application of first dose of fertilizer in September to boost growth	Application of first dose of fertilizer in September to boost growth	Application of 30g, 60g, 90g mixed fertilizer (19:19:19) at 30, 60, 90 days after planting respectively. Apply 15-20g carbofuran once in 45 days interval to control nematode and shoot fly
10	Clean the drains in marshy area during rain in new and in old plantation, trashing in May-June and September	Clean the drains in marshy area during rain in new plantation and in old plantation, clean in May-June and September, trashing in May-June and September	Provide drains for every two rows for better aeration and good drainage to avoid rhizome rot, Clean the drains in marshy area during rain in new plantation and in old plantation, clean in May-June and September, trashing in May-June and September

11	Weeding in September	Weeding in September	Weeding in September
12		Give protective irrigation from December onwards for new planting	Give protective irrigation from December onwards for new planting and also old plantations
13		Start giving normal irrigation with sprinkler (4-6 hours, 25mm rainfall) from second week of February once in 12-15 days upto commencement of regular monsoon.	Start giving normal irrigation with sprinkler (4-6 hours, 25mm rainfall) from second week of February or mini sprinkler irrigation 40 litre per plant twice in week and sprinkler irrigation once in 20 days upto commencement of regular monsoon.
14	*Katte* infected plants if found must be rouged and destroyed once in three months	*Katte* infected plants if found must be rouged and destroyed every month	*Katte* infected plants if found must be rouged and destroyed every month
15	Fertilizer dose of 75:75:150 kg/ha may be given in two splits during June and September	Fertilizer dose of 125:125:250 kg/ha may be given in two splits during June and September	Fertilizer dose of 125:125:250 kg/ha may be given in three-four splits for every three months based on soil moisture
16	Farm yard manure may be applied at 5 kg per clump in September followed by earthing up	Farm yard manure may be applied at 10 kg per clump in June and September followed by earthing up and mulching	Farm yard manure may be applied at 10 kg per clump in June and September followed by earthing up and mulching
17	Insecticide such as quinalphos (0.05%)/ chlorpyriphos/ phosalone may be sprayed in March-April, May –June and September-October to control shoot borer and thrips	Insecticide such quinalphos (0/05%)/ chlorpyriphos/ phosalone may be sprayed in March-April, May –June and September- October to control shoot borer and thrips	Insecticide such as quinalphos(0.05%)/ chlorpyriphos/ phosalone may be sprayed in March-April, May – June and September- October to control shoot borer and thrips

		Drench with copper oxy chloride 0.02% for clumps infected with rhizome rot disease and spray 1% Bordeaux mixture to control capsule rot and leaf spot	Drench with copper oxy chloride 0.02% for clumps infected with rhizome rot, spray 1% Bordeaux mixture to control capsule rot and spots infected where rhizome rot disease is noticed
18	Trashing during May-June, September	Trashing during May-June, September	Trashing during May-June, September and October
19			Loosening of soil up to 50 cm radius around base during May and September
20			Demulching upto 30 cm from the base and cleaning of bearing area and spreading of overlapping panicles
21	Harvesting at the interval of 15-20 days	Harvesting at the interval of 15-20 days	Harvesting at the interval of 15-20 days

Major pests and diseases

Major pests and diseases affecting cardamom and their management measures are presented in Table 2 and Table 3. Out of the major diseases, high incidence of *katte* (0.01 to 99%) in all the plantations, most destructive *kokke kandu* disease (0.1 to 82 %) in many endemic area of North Kodagu, Hassan, Chickmagalur and North Canara districts and mixed infections of *kokke kandu* and *katte* (47%) has drastically reduced the productivity and affected plantations were totally lost during 1995 to 2005 period. However, many on-farm disease management trials conducted in farmer's fields under mono- and mixed crop conditions have shown leads to contain the secondary spread of viruses to manageable level.

Table 2. Major diseases and their management measures

Disease	Pathogen	Management measures
Nursery leaf spot	*Phyllosticta elettariae*	Early sowing; Provision of 50 % shade; Alternate spraying of fungicides like Bordeaux mixture (1%)/ Mancozeb (0.2%)/ Carbendazim (0.2%)
Damping off and rhizome rot	*Pythium vexans, Rhizoctonia solani*	Shifting of nursery site; Incorporation of *Trichoderma* at sowing, emergence and rapid tillering stage
Panicle and capsule rot	*Phytophthora meadii, P. nicotianae* var. *nicotianae*	Thrashing thrice a year; Shade regulation; Incorporation of *Trichoderma viride* and *T. harzianum* with 500 g of neem oil cake per clump; Phytosanitation; Two rounds of Bordeaux mixture (1%) spraying during July and August months
Rhizome rot/ clump rot	*Pythium vexans, Rhizoctonia solani*	Thrashing thrice a year; Shade regulation; Incorporation of *Trichoderma viride* and *T. harzianum* with 500 g of neem oil cake per clump; Phytosanitation; Two rounds of Bordeaux mixture (1%) spraying during July and August months; Spot drenching with 0.2% copper oxy chloride during July/August; Earthing up; Remove excess mulch during monsoon; Prevention of water stagnation by providing leading drains/staggered trenches
Leaf blotch Leaf blight	*Phaeodactylium alpiniae, Colletotrichum gloeosporiodes*	Shade regulation; Raising fast growing shade trees in exposed areas; Application of organic fertilizers
Katte *Kokke kandu* Nilgiri necrosis Infectious variegation BBrMV	*Macluravirus* (+ssRNA) ? *Carlavirus* (+ssRNA) ? *Potyvirus* (+ssRNA)	Locate nurseries in isolated places keeping a minimum distance of 200 mts from plantation; Maintain moderate to higher shade around plantation to protect from in migrating viruliferous aphidsPlant only healthy seedlings/ suckers; Avoid planting of voluntary plants and clones collected from infected plantations; Periodical inspection of all plants should be undertaken to detect and destroy virus infected plants; Inspection at shorter intervals (15-30 days) in the infected pockets should be undertaken for effectively checking secondary spread; Insecticide spraying to control vectors should be avoided. Instead removal of senile tillers and leaf sheaths (breeding sites of vectors) should be under taken at quarterly interval

Integrated pest management in cardamom

Pest infestation in varying degrees at various stages of crop is an important factor which contributes to the high cost of cultivation and low yield realization in cardamom. As many 60 insect and non-insect pests attack cardamom, but only 5 or 6 are the major problems (Table 3).

Table 3. Major pests of cardamom in Karnataka

Pests in nurseries		
Common name	Scientific name	Specific spots of high infestation
Shot borer plantations	*Conogethes punctiferalis*	Nurseries raised adjacent to old
Root grub	*Basilepta fulvicorne*	Secondary nurseries raised in sandy loam soilsTwo season nurseries Clonal nurse-rs raised adjacent to old plantations
Pests in main plantations		
a) Pre-bearing period		
Shoot borer	*C. punctiferalis* plantations	New plantations raised adjacent to old
Shoot fly	*Formosina flavipes*	New plantations raised adjacent to old plantations
Root grub	*B. fulvicorne*	New plantations raised adjacent to old plantationsPlantations raised in sandy loam soils with *Erythrina* and Jack as shade trees
b) Bearing period		
Thrips persistent	*Sciothrips cardamomi*	All valley bottoms and areas with soil moisture All plantations raised with Mysore and Vazhukka types
Shoot, panicle and capsule borer	*C. punctiferalis*	All plantations raised adjacent to old plantations
Capsule borer	*Thamurgides cardamomi*	All isolated plantations

Pest management in nurseries

In nursery stage seedlings are affected by cut worm, shoot borer, root grub, leaf thrips and root knot nematode. Root grubs and leaf thrips pose more problems in two season nurseries. To manage whole pest complex the following measures are to be followed at various stages of nursery.

Prebearing stage

Shoot fly, root grubs and root knot nematode are the main trouble shooters in the prebearing stage which lasts for 18-30 months. Response of plants, tillering, vegetative vigour and uptake of nutritional inputs depend on the health of the root system. The maiden peak harvest totally depends on the proper management of three main insect pests. To manage these pests,

1. Apply granular insecticides during initial establishment and tillering stage @ 20-40 gm per plant.

2. Catch root grub beetles through insect nets and destroy.

3. Trace the maggots and larvae of shoot borer from the small tillers showing dead heart symptoms and destroy.

4. Spray with insecticide quinolphos (0.05%), Fenthion (0.075%) and Dimethoate (0.05%) during early monsoon and late monsoon periods.

Bearing stage

Thrips, shoot and capsule borers, root grubs, root knot nematodes and occasionally defoliators are the main pest problems in the nursery. To manage the complex pest problems, integration of cultural and insecticide package is essential. It is always advisable to apply insecticides during afternoon hours and during flowering period select only insecticides, which are less toxic to honey bees. Apply insecticides only after trashing to reduce quantity of insecticide (ii) Provide better coverage (iii) increase efficiency. Heavy (more than 60 mm) over lapping rain is detrimental to most of the pests. In periods of successive over lapping rains, insecticide application may be deferred.

Cultural practices

Undertake earthing up upto collar region immediately after last rain to protect active exposed feeder roots.

Undertake trashing thrice a year during early monsoon, mid-monsoon and late monsoon periods to remove pest breeding sites.Provide adequate mulch to protect feeder zone.

Remove the weeds and other herbaceous cover which act as hosts for many potential pests.

Collect the adult beetles of root grubs during the peak periods of emergence i.e. April-May and September-October using hand nets and kill them. The beetles, which are brightly coloured in metallic shades, could be easily spotted during day time. Being weak fliers, they could be easily caught using sweep nets. In the same way the adult moths of shoot and capsule borer, which are found resting on the lower surface of cardamom leaves could be collected by net and killed.

Cardamom tillers harbouring the live larvae and pupae of shoot and capsule borers as indicated by the presence of fresh excreta should be cut and destroyed. This will greatly reduce the emergence of the subsequent generation offsprings.

The hairy caterpillars are gregarious in habit and they congregate on the trunk of shade trees during daytime. These congregations should be traced, collected and killed mechanically.

The adults of hairy caterpillars can be lured and captivated by operating light traps at night. These can be collected later and killed.

Chemical control

Following holistic schedule may be followed to manage shoot and panicle borer, capsule borer, thrips, defoliators and sapling feeders under intensive production technology. By adopting this schedule pest damage is reduced to less than 3% in all varieties of cardamom grown in Karnataka including Njallanil Gold.

Spray	Stage of crop	Insecticide	Concentration	Qualtity/100 litres of water
1.	Panicle elongation	Quinolphos/	0.05% a.i.	200 ml.
		Fenthion	0.05% a.i.	60 ml.
2.	Stray flowering	Quinolphos or	0.025% a.i.	100 ml.
		Chlorpyriphos or	0.04% a.i.	200 ml.
		Phosalone	0.07% a.i.	200 ml.
3.	Flowering stage	Phosalone	0.07% a.i.	200 ml.
4.	Fruit development and stray flowering	Chlorpyriphos	0.06% a.i.	300 ml.
5.	Fruit development, ripening and production of new tillers (for erect/ semi erect types)	-do-	-do-	-do-

A gap of 30-40 days may be given between thc sprays

Since highest bee activity is seen in morning hours, spraying may be undertaken in the afternoon hours.

Spraying aftcr trashing increases efficiency and reduces the quantity of pesticide solution.

Post harvest technology

Cardamom plants start bearing two years after planting of suckers/ seedlings. Duc to extended staggered flowering habit harvesting has to be done in five to seven rounds. Fruits mature in about 120 days of pollination and on maturity the fruit colour changes from green to yellow, which is characteristic feature of Malabar types. Harvesting is carried out at an interval of 15 to 30 days and completed in 5 to 7 rounds. In Karnataka, either fully ripened fruits or fruits along with physiologically matured (*karikai*) fruits are harvested and dried in specially constructed kilns. In some parts, it is dried under sun. The process gives golden yellow capsules. From the kiln dried capsules, after grading, two types of cardamom namely, green and golden yellow are obtained. The latter is popularly sold with distinct Agmark grade "Coorg Green". Sun drying is commonly practiced many cardamom pockets in Hassan, Chickmagalur and entire North Canara. The dried fruits with uneven colour arc bleached to produce white cardamom. For kiln drying, flue pipe drier is commonly used. Electrical drier and bin driers are also used by many cardamom growers.

In the licensed auctioning system, presently the green cardamom and Njallani cardamom are fetching better price compared to yellow and white cardamom (Table 4).

Table 4. Mean auction price of cardamom (Rs./kg) at Sakleshpur and Vandanmedu auction centres

Year	Place of auction	2003	2004	2005	2006	2007
Mean auction pricc(Rs./kg)	Sakleshpur	436.12	280.76	229.82	190.96	223.64
	Vandanmedu	438.37	339.77	269.29	247.14	393.64

Prospects

Increased labour management expenditure, input costs, recurring drought, prolonged dry period experienced in Karnataka irregular power supply and increased irrigation costs are real constraints to growers to manage large holdings. By restricting the area to only suitable pockets within the plantation, they can harvest the same quantity by adopting improved production package. Already many growers have shown leads to harvest an average crop of 200 to 1000 kg per hectare by confining the area to 10 to 25% of the original area. This approach helps them to overcome all the management problems and the same can be popularized in all the cardamom producing zones of Karnataka.

Viral diseases are the real constraints for sustained productivity in traditional cardamom zones of Karnataka. The contiguous small holdings, ignorance and inter-plot interference put constant pressure on disease management techniques. By adopting rejuvenation package and disease management through self-help groups, the damage caused due to secondary spread of viruses can be minimized. Opening a disease clinic to create awareness on disease identification and management methodology through a group of trained workers or by training a group of skilled workers from each participating plantations will certainly help to contain viral diseases.

Change in agroclimatic conditions caused due to deforestation or conversion of major area to grow other crops is one of the major causes for decline in productivity. The cardamom plantations act as natural rain harvesting structures, which do not allow run-off even under heavy rainfall conditions. The natural streams go dry during summer hence; there are no water resources to save cardamom and other crops. In such situation, by adopting drought management package and by creating water harvesting structures minimum life saving irrigation has to be given to save the plantation during dry period. All the promotional schemes should be concentrated to promote water harvesting and utilization infrastructure.

In the past two decades, there is a phenomenal shift in the focus of planters towards other remunerative crops. This lead to negligence towards management of viral diseases of cardamom as a result the plantations became unproductive and all the old varieties like Malai, Coorg Local, Manjirabad and Sirsi Local have disappeared from cardamom growing zones. These materials conserved in the gene bank of research stations have to be multiplied and re-introduced to the respective zones along with other improved varieties. This approach helps to restore the genetic diversity. Only certified clones are to be multiplied clonally and instead of planting one clone many high yielding clones can be multiplied and planted to overcome inbreeding depression and self compatibility problems which affects productivity and quality of the produce.

Many leads have been shown by research stations for growing cardamom under varied cropping systems like cardamom under controlled shade suitable for homestead garden, cardamom + Arabica coffee + pepper, cardamom + Robusta coffee + pepper, arecanut + cardamom + cocoa + banana + pepper, arecanut + cardamom + pepper, coconut + cardamom + pepper and silviculture + cardamom + pepper. Out of these arecanut and silviculture systems are more remunerative compared to other cropping systems. By popularizing the planting plan and approach all the arecanut plantations can be converted into cardamom plantations.

Pesticide abuse in cardamom zones particularly, the pesticides used to control root grub and thrips have affected the underground water, pollinators, quality of produce besides increasing the production costs. By adopting need-based production packages suitable to different conditions the pesticide use can be minimized which helps to reduce pollution.

The short flowering phase, wider adaptability, field tolerance to major pests like thrips and borers makes Malabar varieties as the better options for organic cultivation. The phenology of Malabar types synchronizes with progress of monsoon and 90% of the crop can be harvested before November and the last harvest is completed before first week of January. Because of short flowering phase, the capsules are less prone to natural attack by thrips and capsule borers. Only 30% of capsules are damaged due to thrips and capsule borer infestation as against 100% infestation in Njallani Gold under pesticide free growing conditions. In the traditional high rainfall areas of Karnataka even with adopting of all intensive production packages an average of 200 kg per hectare can be produced as against over 500 kg per hectare in other moderate rainfall zones. Hence, these areas are the best places to promote organic cultivation of cardamom as pests are very minimum during flowering and fruit development stages. Earlier, these areas (Birunani, Bagamandala, Madenadu, Galibeedu, Surlabi, Shantalli, Hongadahalla, Kottegehara, Basarikatte etc.) used to produce cardamom without chemical fertilizers and pesticides. With active support from development agencies and group approach, the entire high rainfall zone can be brought to organic cultivation by providing infrastructure for life saving irrigation and viral disease management.

Traditionally the produce is either kiln dried to get green/ pale green / golden yellow cardamom or sun dried to get creamy white cardamom or bleached to get white cardamom. The green colour and bold size are preferred quality parameters of cardamom in the market. Green colour on the dried produce alone fetches Rs. 80 to 140 more price compared to pale green/ sun dried capsules. Many growers in Kerala and Tamil Nadu have taken care to produce green cardamom by integrating improved pre and post harvest methods like harvesting at shorter interval, immediate drying using improved driers (bin type, cardi driers etc.) which removes moisture quickly by blowing hot air and drying within 24 hours of harvest. This process helps them to retain the green colour and also reduces the percentage of splits which is a normal feature seen while drying over matured/ stored harvested capsules or during the process of slow drying. By popularizing these driers alone the confidence of the growers can be boosted in major cardamom producing zones of Karnataka.

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Cardamom - Technologies for sustainable production

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Small cardamom *(Elettaria cardamomum* Maton) the 'Queen of Spices' is one of the important economic species of the zingiberaceae family. It is cultivated in the tropical evergreen forests of Western Ghats in India covering Kerala, Karnataka and Tamil Nadu in an area of 73,228 ha with a production of 11, 235 MT (2006-07, Spices Board). Indian cardamom, in the geographical trade brands of Alleppey Green Bold and Coorg Cardamom, was a commodity of international trade from time immemorial and during the 4^{th} century B.C, it was an item of Greek trade. It was listed among the Indian spices liable for duty at Alexandria in AD 176 (Rosengarten, 1969) indicating that international trade barriers and regulations were not a post-WTO event. Between 16^{th} and 18^{th} century, cardamom was considered as a minor forest produce. The erstwhile Travancore Government had taken up its cultivation in A.D. 1823 (Suresh, 1980) and subsequently established plantations in the hilly terrains of Kerala. In early 1970s, India contributed for nearly 65% of the world production but its export share declined to less than 6 percent at present, completely surrendering its monopoly to Guatemala with its production of about 22,000 MT.

Cardamom is one outstanding example of agriculture crops, which recorded impressive increase in production and productivity since last 10 years in its heart of cultivation in Idukki district of Kerala. The introduction of high yielding land races like Njallanil Green Gold and other location specific varieties by various research organizations, farmers and its large scale scientific cultivation under suitable agro - ecological conditions contributed to the increased yield. However, it has brought out an array of negative impacts on the cardamom ecosystem, thus making the sustainability of cardamom cultivation a million dollar question. Signs of fatigue have set in on the crop and on the soil. The quality deterioration in forest eco-system is noticeable in terms of reduction with respect to tree density, canopy shade, and change in tree species. The weather that supports cardamom growth is changing on a faster pace than the global climatic change.

Negative impact of intensive cultivation in cardamom

Intensive crop husbandry practices were carried out in the plantations at the cost of deforestation and large scale pruning of tree branches for more light for encouraging tillering, panicle production and increasing green colour of cardamom capsules. The mild filtered light for cardamom under a 50% shade cover gave way to a more direct sunlight with less than 25% shade. This has resulted in variation in the rhizosphere and microclimate. Soil pH showed considerable reduction over a period of last 14 years that resulted in poor uptake of major nutrients like nitrogen, phosphorus and potassium. Jose *et al.* (2006) studied the relative variation in soil property and fertility status of soils under the cardamom eco system in the "Cardamom Hill Reserve" (CHR) with soils of adjoining natural forest. The organic carbon, available N, P, K and sulphur and exchangeable calcium and magnesium were higher in the natural forest compared to the cardamom growing soils.

Murugan (2007) reported significant changes in the daily weather parameters such as maximum-minimum air temperature, sun shine hours, wind velocity, soil temperature, relative humidity, rainfall pattern and number of rainy days over the last ten years compared to normal period (1967 - 1996) in the CHR. Meteorological data showed that there has been an increase of atmospheric temperature by 0.6°C with the passage of last decade but at the same time number of rainy days decreased. Rainfall during summer months and the number of rainy days will have pronounced effect on cardamom production. An average summer rain (366 mm) followed by a normal southwest monsoon (1162 mm) influenced the cardamom yield substantially (Anonymous, 2007). Studies undertaken by the Indian Cardamom Research Institute on the rainfall pattern and number of rainy days for 10 years between 1992 and 2001 revealed that there was a reduction in rainfall and rainy days over the period and the variation was to the tune of 30 and 35 percent respectively during the year 2001 (Thomas, 2003). Drought became a recurring phenomenon in the cardamom hills. An increase in soil temperature, humidity and light intensity favour the outbreak of pests in the plantation. Excessive use of insecticides caused pests out-break and resurgence of minor pests such as white fly, red spider mite, scale insects etc. (Varadarasan, 2003). For the management of various pests and diseases, many insecticides and fungicides are employed in addition to dumping of fertilizers of organic and inorganic sources to upkeep soil fertility and plant health. This resulted in high unit cost of production and presently it is in the range of Rs.200 to 250 per kilogram of dried capsules. The irreversible deterioration to the eco-system is unmeasurable. The major share of the cost is labour that ranges from 60-70 per cent and is on the increase. Labour availability in the plantation sector is the concern that the industry is struggling to cope up with. Considering the forest ecosystem, topography and nature of the crop, mechanization is not an easy proposition in the near future.

Cardamom is a unique crop characterized with non- synchronized flowering and its yield performance totally depends on favorable climate and adoption of management practices at the right time through out the growth phase. Any variations in the climate or in the crop husbandry practices affect the yield and quality of capsules. Conservation of evergreen forests is very essential to preserve nature and climate in the cardamom eco- system, for which technologies for sustainable cardamom production is the only option rather than aiming at maximizing production and productivity. The Indian Cardamom Research Institute has evolved sustainable production technologies with a targeted average productivity of 600kg/ha with least negative impact on eco-system.

Technologies for sustainable production

a) ***Selection of location specific varieties or cultivars***

The crop improvement programmes undertaken in cardamom at various research centers have resulted in the identification and release of a few high yielding varieties/clones having superior quality capsules. Hybrids were also produced with an objective to incorporate desirable characters (both qualitative and quantitative). A few hybrids such as MHC-10, MHC-13, MHC-18, MHC-23, MHC-24, MHC-26 and MHC-28 are promising with respect to yield. The hybrids, MHC-10 and MHC-13 are tolerant to thrips and Azukal (capsule rot disease) respectively. Cardamom hybrids are highly heterogeneous and may exhibit an array of variability in the population. Hence these hybrids are to be multiplied adopting vegetative methods for field planting. The first hybrid in cardamom, MHC-26 (ICRI 5) was released for cultivation by ICRI during 2006.

The research institutes empowered the enterprising farmers to locate and isolate the high yielding cardamom clones in their plantations without affecting the richness of genetic diversity. In recent years, a few improved 'land races' in cardamom have been located by farmers. Among them, 'Njallanil green gold' identified by Shri. Sebastin Joseph, Njallanil, Kattappana is the ruling cardamom variety cultivated in the cardamom tract of Kerala. Besides, Panikulangara, Palakudi, Elarani, Kalarikkal white cardamom and PNS Vaigai are also getting popular as location specific varieties.

The performance of the improved varieties/hybrids and landraces is location specific and this necessitates the need for developing varieties for each agro- ecological situations of the cardamom-growing tract. Monoculturing of a single high variety/cultivar like *Njallanil* will lead to loss of diversity resulting in gene erosion. Crop improvement programme in participatory mode in the farmer's field in respective areas would help to identify location specific varieties for that particular micro-ecosystem. Establishment of poly-clonal plots in various locations is another approach which could be considered not only for evolving new clones in future but also to prevent the loss of valuable genes.

b) Quality planting material production in nursery

The crop is propagated through seeds in Karnataka or through suckers in Kerala and Tamil Nadu. Cardamom seedlings exhibit segregation in the population, but are free from *katte* and other viral diseases. Plants raised from rhizomes come to yield earlier than seedling progenies or tissue cultured plants by reducing the longevity of juvenile phase. Rhizome multiplication may be taken up from the first week of May immediately after the receipt of rains. Eight to nine months' old suckers having one or two vegetative buds may be used for propagation. Fertilizers may be given at doses 100:50:200 kg/ha NPK in six splits at an interval of two months. Applications of DAP and MOP for first two rounds enables better establishment and growth. Suckers treated with bio agents like *Pseudomonas* (1%), *Bacillus* (1 %) and *VAM* (@ 50 g/ sucker) favour better shoot emergence and growth. Organic manures such as farm yard manure/

compost @ 1 kg, neem cake @ 100 – 150 gm per sucker, vermiwash (foliar spray 5 %) and other inorganic fertilizers in recommended dosage may be applied. On an average of 15-20 planting units could be obtained within a year of planting with the above practices.

c) Sustainable crop management strategies

Spacing and Planting : Clonally propagated planting materials (sucker) of locally adapted varieties may be used for planting in pits opened at various zones of the tract in the spacing stipulated. Early planting with the onset of monsoon during May/June is ideal as it augments the field establishment and further growth of plants. Suckers should be planted in pits filled with organic materials/compost/farmyard manure. For the cultivars of mysore and vazukka, the spacing can be 2.4 x 2.4 m or 3 x 3 m in high rainfall or irrigated areas. Immediately after planting, the plant base should be mulched well with available litter to protect soil from erosion and moisture conservation. Planting should be done on contour across the slopes. While planting, rock phosphate (100 g/per pit) may be mixed with soil. VAM @ 50g per plant can also be mixed with top- soil prior to mulch application.

Shading : Two tier canopies should be maintained for providing filtered shade condition to plants. In the absence adequate shade, suitable shade trees may be planted. Trees like *Jack* and *Erythrina* sps. may be avoided as they act as hosts for root grub beetles and nematodes. The disease viz. *Chenthal* (Leaf blight) caused by *Colletrotricum* sps. invariably appears in the open condition and it can be managed with adequate shade.

Weeding : Weeds are potential competitors for cardamom in the consumption of water and nutrients. At the initial stage, if cardamom clump development is not enough, weed's growth will be luxuriant. Two or three rounds of hand weeding at the plant base during May, September and December/January and slash weeding in the inter space are advisable. Spade weeding is to be avoided as it will loosen the soil and cause soil erosion. The weeded materials may be used for mulching in the appropriate time.

Irrigation : Judicious irrigation during summer months ensures increase in yield by at least 50%. Irrigation is required generally from February to April but at times from January to May depending upon rainfall. But in Tamil Nadu, where the south-west monsoon is not very effective, irrigation during March- August is advisable. This is the critical period in which development of young tillers and panicles takes place. If plant suffers during this stage, yield will be reduced. Water may be stored during rainy season wherever possible by constructing check dams, ponds without causing much damage to the environment. This water can be used for irrigation, which can be done through different methods such as pot irrigation, hose irrigation, sprinkler irrigation and drip irrigation depending on the facilities available in the plantation. Pot irrigation or hose irrigation can be done at weekly intervals at the rate of 20-30 litre per clump depending upon the clump size. A rose can nozzle may be fitted to hose tip for effective irrigation. In case of sprinkler, irrigation with amount of water equivalent to 35 to 45 mm rain at fortnightly intervals is recommended under average conditions. In case of drip irrigation / micro sprinkler water at the rate of 4-6 litre per clump per day can be given. The micro-sprinkler irrigation, apart from watering will create conducive microclimate for flower induction. Under no circumstances, irrigation should result in splashing of top soil for which thick mulching is a pre-requisite.

Cultural practices: Intensive soil works like digging and forking would loosen and expose the soil and would contribute to increased soil erosion. Cardamom planting in trenches across the slope on contours, mulching of soil, diagonal planting and opening of silt pits (1.0 x 0.5 x 0.6 m) in between four plants will help in soil and water conservation in gentle slopes. If slope is very steep, construction of stone pitching walls at 10-20 m intervals across the slope and also making water-collecting trenches along the wall will be helpful depending upon the nature of soil. It is recommended to open fifty to hundred water conservation pits per hectare. In sloppy areas, water conservation pits may be avoided as it may cause landslide in rainy season. Harvesting of rainwater in polythene sheet lined pond is advocated for water conservation.

Forking the plant base to a distance up to 90 cm and to a depth of 9-12 cm is found to enhance root proliferation and better growth of plants. As far as possible, the entire plantation and particularly the plant base are to be kept under mulch. It is very essential to keep the plant base mulched (5-10 cm thick) except during June to September period to reduce the ill effects of drought, evaporation loss and to maintain optimum temperature. Forking is recommended in the month of November – December.

Trashing : Trashing consists of removing old tillers and dry leaves and leaf sheaths. This operation may be carried out once in a year preferably after receiving a few rains in May/June periods. However pruning may be practiced three times a year in December, March and October months. The pruned/trashed material can be used as mulch and it enables to reduce pests/diseases occurrence, especially thrips; so also result in substantial savings in spray volume.

Earthing up: Earthing up of the plant base with top-soil is recommended during December-January. While carrying out this operation, care should be exercised to ensure that only topsoil is used, and it is evenly spread at the base covering only half the bulb portion of the rhizome. This operation helps to keep the top soil 10 to 15 cm loose and friable enabling easy root penetration and water percolation.

Fertilizer application and Manuring: A fertilizer dose of 75:75:150 kg N, P_2O_5 and K_2O/ha is recommended under rain fed while that for irrigated condition, it is @ 125:125:250 kg/ha to soil in three splits (Anonymous, 1997). Cardamom roots are generally confined to surface soil and nearly 70% of the roots are within 5 cm depth. Only 10 % of the roots forage horizontally an area of 120 cm away from the clump. Therefore, for the maximum efficiency of the applied fertilizers it would be appropriate to apply fertilizers at a radius within 50 cm (Krishna Kumar and Potty, 2002). Fertilizers may be applied around the plant base in a circular band of 15 cm width leaving about 30 cm from the plant base after removing the mulch spread on the surface.

Organic manures are considered essential for improving physical characteristics of soil, apart from their nutritional values. They are indispensable for cardamom irrespective of whether fertilizers are applied or not. Application of organic manures such as neem cake (1-2 kg/plant) or farmyard manure @ 5-10kg /plant may be made once in a year in May-June along with rock phosphate and muriate of potash (Anonymous, 1997). Thimmarayappa *et al.* (2000) suggested an integrated nutrient management to meet the 25 per cent of requirement of nitrogen through FYM and the balance 75 percent through inorganic nitrogen source for sustained production of cardamom over a period of time. The manures should be mixed with surface soil after application and ensure adequate moisture in the soil.

Micronutrient application: Zinc application (foliar) @ 500 ppm enhances growth, yield and quality of the produce in cardamom. Based on the studies, it is recommended that zinc may be applied as a foliar spray as zinc sulphate @ 250 gm/ 100 litres of water during April/May (pre-monsoon) and September/October (post monsoon). Zinc should be applied alone and not to be mixed with any insecticide / fungicide / fertilizers. Soil application of boron in the form of commercial grade borax at the rate of 7.5 kg/ha is recommended in boron deficient areas. It may be applied in 2 doses along with NPK fertilizers.

Recent studies at Indian Cardamom Research Institute, Myladumpara indicated that, application of *Azospirillum* and *Phosphobacteria* @ 50 g each per plant along with recommended dose of fertilizers and FYM (5Kg) significantly increased the cardamom yield. In Regional Research Station, Sakleshpur, Karnataka, application of 75:37.5:150 kg NPK per ha per year + *Phosphobacterium* + 5 kg FYM per plant gave highest cardamom yield when compared to fertilizer application alone. The role of FYM in increasing the yield of cardamom in combination with biofertilizer, *Azospirillum* has been ascertained (Anonymous, 2007 a).

d) Sustainable disease management

Cardamom is susceptible to a number of diseases caused by various pathogenic organisms. As many as 25 different types of fungal diseases affect at various stages of its growth (Joseph Thomas and Bhai, 2002). The major fungal pathogens affect the entire plant parts resulting in severe damages; others cause specific infections on selected plant parts causing only partial damage. "Azhukal" or capsule rot and rhizome rot are the major diseases encountered in the plantations. Timely detection and suitable control measures are to be taken to manage the spread of these diseases. With the change in climate, a drastic shift to diseases caused by *Fusarium* species is noticed compared to the conventional diseases caused by *Phytophthora* and *Pythium*. Proper shade management, phytosanitary measures combined with prophylactic application of cardamom soil specific bioagents like *Pseudomonas*, *Trichoderma*, *Bacillus* etc., needs to be undertaken. Bordeaux mixture remains the best fungicide, provided it is correctly prepared and applied.

e) Sustainable pest management

Cardamom is infested with an array of insect pests right from the nursery stage to the processed cardamom in storage. As many as 60 insect pests have been reported for cardamom (Kumersan and Varadarasan, 1987). These pests were categorized depending on the severity of infestation as major and minor pests. Among these thrips, borer, root grubs and root-knot nematodes are more destructive than others.

All the pests can be brought under control effectively by integrating different control measures. Removal of dry drooping leaf sheaths and old panicles (cultural control) not only reduces the thrips population but also enhances accessibility of insecticides to the pests. Further, it reduces the quantity of spray fluid required for controlling them. Mechanical collection and destruction of root grub beetles using insect nets prevent massive egg laying and reduce the population of grubs. Also this operation minimizes the use of insecticides for the control of grubs. Use of bio-agents against this pest shall further help to reduce the requirement of insecticides. Chemical control measures need be taken only when the pest population exceeds the threshold level.

Insecticides shall be applied using a high volume sprayer. Spray fluid in the form of fine droplets should fall on panicles and on the lower one-third portion of the tillers for the management of thrips. Approximately 400 -700 ml of spray fluid may be required for a plant depending on clump size. Since all chemicals recommended for management of thrips are also effective against borer, no separate insecticide spray against borer is required during February, May and September. Thus a total of seven to nine rounds of insecticide sprays a year will control both thrips and borers in Kerala region. For Karnataka only four rounds are sufficient (January, March, May and September/October). For Tamil Nadu five rounds are required. Phasalone, being a less toxic insecticide to bees (pollinators) may be chosen for spraying during peak periods of flowering. To protect honey bees, the major pollinator of cardamom it would be better if insecticide sprayings were conducted during afternoon hours, so that the foraging bees may not get direct contact with insecticides to a great extent.

f) Harvest and Post harvest processing

Quality of the produce can be achieved through timely harvest and adoption of scientific post harvest operations. At farm level cardamom should be harvested at correct maturity stage without physical damage followed by the employment of proper processing techniques involving various unit operations such as washing, drying, cleaning, grading and packaging till marketing of the produce.

Lack of synchronized flowering necessitates several rounds of harvest in cardamom. Capsules are picked at an interval of 25 to 30 days in Kerala and Tamil Nadu and in Karnataka 20 to 25 days interval is adopted depending upon the environmental conditions. By and large, harvesting starts from July-August and continues till January-February in Kerala and Tamil Nadu whereas in Karnataka it commences in August and continues till December/January.

Cardamom curing may be defined as the process in which moisture of freshly harvested capsules is reduced from 80 percent to 10-12 percent at an optimum temperature 50°C so as to retain green colour to maximum extent. The moisture content of the capsules husk is around 80 per cent and this has to be removed completely during the process of drying. Drying is the most important unit operation that determines the colour of end product. Apart from quality in terms of colour, flavour components such as 1-8 cineole, terpenyl acetate, and linalool etc. are also retained.

Recently private entrepreneurs have developed cardamom driers using alternate source of fuel viz. LPG, diesel, kerosene etc. Evaluation of these systems revealed that all the systems are technologically advanced and are viable and farmer friendly. However, among the fuel sources, firewood became cost effective but indiscriminate use of firewood in the plantations will cause ecological impacts in the cardamom ecosystem. Therefore without comprising on the quality of produce alternate fuel sources are to be advocated for curing, safe guarding the nature.
The cured cardamom capsule requires cleaning to remove stalk and dried remains of the floral parts. Conventionally, rubbing capsules over a coarse surface of wire mesh is practiced. Recently a cost effective and farmers friendly machine, carpol was developed for the cleaning and polishing of cardamom. The processed cardamom having large size, bold, round and deep green colour fetches premium price in the market. The capsules should be compact with full of seeds and it adds to the litre weight (quality) of capsules. True cardamom is normally marketed on the basis of their geographical origin and on their physical form.

The Government of India and the Indian Standards Institution (ISI) have prescribed well defined grades known as 'Agmark' grades and Indian specifications or standards on the basis of important quality characters such as colour, weight per unit volume, size and percentage of empties, malformed, shriveled and immature capsules.

Cardamom can be stored for long period in double lined polythene bags. Cardamom dried and maintained at or below 10 percent moisture retains the original colour and avoids mould growth. Use of black polythene lined gunny bags helps to retain the capsules colour during storage.

g) Cardamom based cropping systems

Cardamom based cropping system involving cultivation of compatible crops in the interspaces of the plants would fetch sustainable income in the event of low price for cardamom. Intercropping is feasible in the initial years of its growth before the canopy become thick in the plantations. With the formation of dense cover, the crops grown as intercrop will not be able to utilize efficiently the resources like sunlight, soil and water resources from the third year onwards in the cardamom ecosystem.

A large number of trees are cultivated as a source of shade in the cardamom ecosystem. Planting of trees which have medicinal properties would provide economic returns to farmers apart from providing adequate shade to plants. Hither to, trees having medicinal importance in the cardamom ecosystem were given least priority and the existing forest trees are mainly seen as a fuel source for cardamom processing.

Climbing medicinal and spice species could be trailed on the shade trees. Shade tolerant varieties of black pepper (*Piper nigrum*), Thippali (*Piper longum*) vanilla (*Vanilla planifolia*), *Holostema* sps. etc. can be cultivated as intercrop in the plantations. Selection of varieties is very important particularly in the case of black pepper. Shade tolerant varieties like Karimunda, Neelamundi etc. may be preferred for intercropping. The flower and berry formation is vigorous in the upper foliages of pepper above cardamom canopy. Planting of these crops should be done prior to or along the planting of cardamom suckers '. Malimulaku', *Capsicum chinense* is grown in some parts of Idukki in the first after planting of cardamom. Robusta coffee can be successfully intercropped with cardamom under appropriate spacing between the cardamom plants. Robusta coffee not only acts as shade but also maintains cool humid microclimate congenial for cardamom growth. The comparative performance of mixed cropping of robusta coffee, cardamom, black pepper and Coorg mandarin and the intercropping of robusta coffee reveals that an incremental gain of 269.21 % in mixed cropping over the mono crop. Rubber (*Hevea brasiliensis*) and areca (*Areca catechu*) can be successfully cultivated as shade trees in the plantations These cropping systems can perform better only under assured irrigation with compatible varieties of cardamom and rubber. Introduction of these crops will fetch added income from the plantations and it will be a boon to farmers in the event of price crisis in cardamom.

h) Apiculture (Bee keeping)

The role of honey bees in augmenting the productivity levels of agricultural, horticultural and fodder crops has been well documented. It has been estimated the value of honey bees as producers of honey and bee wax is only a small fraction of its value as crop pollinators. Apiculture in the cardamom plantations offers effective pollination leading to increased capsule formation with superior quality due to formation of large number of seeds. Two species of honey bees, Apis *cerana* and *Apis dorsata* contribute over 90 % of pollination in the plantation. Flower morphology, plant architecture and flowering phenology are closely suited to foraging behavior of honey bees. Inadequate pollination in cardamom might be due to low populations of honey bees and hence warrants introduction of bee colonies in cardamom gardens (Belavadi *et al.*, 2002). Installation of three to four bee colonies per hectare enhance the yield to the tune of over 20% in the plantation. Four to five visits of bees on a flower assures quality capsule formation. The floristic flora in the cardamom hills is very rich and is quite capable of providing nectar and pollen bees through out the year.

All the commonly used pesticides in the plantations are fatal to honey bees. The forage behavior of bees though commences in the early morning hours, the peak is between 8 - 11 am depending on the weather conditions. The percentage of capsule set is high during morning hours and it declines gradually towards afternoon mainly due to low forage. Recommended measures may be practiced to safeguard bee colonies from the ill effects of insecticide application and inclement weather conditions. Promoting use of bee keeping in the cardamom plantations will ensure increased productivity levels and enhance the livelihood of bee keepers and farmers. It will also helps in the conservation of floristic wealth and sustainable cardamom production.

Conclusion

The variation in yield is a regular phenomenon noticed in the plantations. In the event of price crisis, farmers are forced to opt for intensive cultivation for increasing the productivity The on farm utilization of locally adapted proven planting material, integrated management practices and other technologies for sustainable production developed by various research organizations would provide sustainable yield and superior quality capsules with respect colour and size of 7mm and above. Sustainable cultivation will be economically viable with reduced cost of cultivation and ecologically sound produce by minimizing the ill effects caused by intensive cultivation with respect to pollution and variation in the climate in the cardamom ecosystem.

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Mechanization in production, processing and value addition of ginger and cardamom

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Introduction

Spices are high value export oriented crops extensively used for flavoring food and beverages, medicines, cosmetics, perfumery etc. Spices constitute a significant and indispensable segment of culinary art and essentially add flavour, color and taste to the food preparations. The farm level processing operations are the most important for value addition and product diversification of spices. Like all the other agricultural commodities spices invariably contain high moisture content (75 to 85 per cent) at the time of harvest, which has to be brought down to 10 to 12 per cent. After harvest the produce is subjected to different types of operations like washing, curing, drying, cleaning, grading, storing and packaging. It is essential that these operations ensure proper conservation of the basic qualities like aroma, flavour, pungency, colour etc. Each of these operations enhances the quality of the produce and the value of spice. The clean raw materials form the basis for diversified value added products. The processing and value addition of ginger and cardamom are discussed herewith.

Ginger

India accounts for about 50 per cent of the dry ginger output in the world. In India, domestic market prefers fresh green ginger for culinary use, while two types of dried ginger i.e. bleached and unbleached are also produced for export purpose. Various post harvest operations involved in obtaining value added ginger are discussed. Most of these operations are done manually at farm level and only very little mechanization for these processes are practiced at farm level.

Post harvest processing

Washing: For preparing dry ginger, the produce is harvested after 8 months of planting. After harvest, the rhizome is washed to remove dirt, spray residues and other foreign materials. In this process ginger is soaked in still water overnight and in the next day water is sprayed at high pressure on to the rhizomes, which forcefully remove the firmly attached dirt on the rhizomes. In some cases drum type washer is also used as commercial device.

Peeling: Peeling of ginger is the most important unit operation, which is done to remove the skin. Peeling hastens the process of drying and maintains the epidermal cells of the rhizomes, which contain essential oil responsible for aroma of ginger. Indigenously, peeling is performed by rubbing the ginger pawns soaked in water over night against jute bags or by scraping with sharpened bamboo splinters. Abrasive brush type ginger peeling machine consisting of two continuous brush belts being driven in the opposite directions was developed by Rajasthan Agricultural University, Udaipur for mechanical peeling of ginger. The spacing between the belts and the belt velocity could be varied (Agarwal *et al.*, 1983). The optimized operational parameters of the abrasive brush type ginger peeling machine of capacity 20 kg/h were brush belt spacing (1 cm) and belt speed (65 rpm) of the driving brush belt resulting in the belt relative velocity of 199 cm/s. Number of passes required were 4-5. When operated at its full capacity, the machine had a peeling efficiency of 71 per cent with ginger meat loss of 1.6 per cent (Agarwal *et al.*, 1987).

Peeling of ginger skin was associated with the loss of ginger meat from underneath the skin. The epidermal cells in ginger contain most of the essential oil which imparts the ginger it's characteristic aroma and is perhaps the most important factor in determining its market price (Jaiswal, 1980). Therefore the loss of ginger meat from underneath the skin would result in the loss of ginger weight as well as heavy loss of economic value of ginger.

An abrasive brush type ginger peeling machine of capacity 200 kg/h. have also been developed by Rajastan Agricultural University, Udaipur. The machine essentially consist of two continuous mvertical abrasive belts with brush of 32 SWG thick steel wires, 2 cm long and spacing of 1.90 cm. The peeling zone of the ginger-peeling machine was 30 x 135 cm. The number of passes was three. The peeling efficiency and material loss were 83.46 and 4.33 per cent respectively (Ali *et al.*, 1991).

A small manually operated ginger peeling machine, which utilizes locally available material for its construction has been developed for farm level application (Charan *et al.*, 1993). The moving abrasive surface was made of coconut fibre brushes (30 mm length) mounted on two endless canvas belts of 40 mm width and 5 mm thick. The stationary abrasive surface was also developed with the same abrasive brushes arranged side by side on a wooden plank of 780 x 240 x15 mm in size. The capacity of the machine to peel untreated ginger was 24 kg/h. The peeling efficiency and meat loss were 71 per cent and 1.3 per cent respectively.

The effects of lye pretreatment on the peeling efficiency and ginger meat loss before mechanical peeling have been studied. Lye treatment of ginger in 7.5 per cent solution for 5 minutes before machine peeling indicated that the peeling efficiency of the machine could be increased and the meat loss reduced. Peeling efficiency of the machine operating in 3 and 4 passes increased from 73 to 83 per cent and from 75 to 86 per cent respectively by lye pretreatment where as the corresponding meat loss was reduced from 3.3 to 1.9 per cent and 3.8 to 2.4 per cent. However the application of this unit in large scale needs to be further studied and optimized (Charan *et al.*, 1993).

Drying: The cleaned and peeled ginger with moisture content of about 80 to 93 per cent is spread thinly under sun and the moisture content is brought down to 10 to 12 per cent or even less for safe storage. It takes about 10 -15 days for complete drying. Ginger can be mechanically dried in drying chamber over which hot air at 80°C is passed using electric heating coil and a blower. But it is reported that the quality of dry ginger cured in bright sun light is better than the one cured in closed chamber with artificial heat. The dry ginger so obtained is known as rough or unbleached ginger.

Drying of peeled ginger at different temperatures for different moisture content has been studied. Peeled ginger dried at two stages, i.e., up to 50 per cent moisture content (w.b) at 85°C and then to the required moisture content at 65°C gave best organoleptic and biochemical qualities (Charan, 1995).

A tray type drier for drying ginger was reported (Philip *et al.*, 1996). The main parts were a drying chamber, plenum chamber and a chimney with butterfly valve. Trays of wiremesh were provided in the drying chamber to keep the materials to be dried. The plenum chamber encloses the burning-cum-heat exchanging unit. Preliminary tests showed that 10 hours of drying at 60°C reduced the moisture content of ginger from 90 percent to 11 per cent. The product obtained was also of high quality.

Bleaching: The peeled ginger is soaked in thick lime water for some time and it is then fumigated with sulphur fumes for 12 hours and sun dried for a day. The process is repeated once or twice to obtain a fully bleached white produce which is thoroughly dried and stored.

Grading: The dried ginger rhizomes are manually graded. The grade designation and quality of garbled, ungarbled, bleached and non bleached Calicut and Cochin ginger as per AGMARK specifications are given in the Table1.

Packing: The graded ginger is packed separately in polythene lined jute bags or in multilayered paper bags.

Table 1. Agmark grade specifications of ginger

Grade Designation	Trade name	Size of rhizome	Extraneous matter, (% w/w), max	Very light pieces, (% w/w), max	Lime as CaO, (% w),max
Calicut Ginger- Non Bleached					
NGK	Garbled, Non Bleached Calicut	Not less than 15mm	2.0	-	-
NUCK Calicut	Ungarbled Non bleached Not less than 15mm	3.0	4.0	-	
NUGK	Ungarbled Non-bleached Calicut Good	Not less than 15mm	4.0	6.0	-
Calicut Ginger- Bleached					
BGK	Garbled Bleached Calicut	Not less than 15mm in length	2.0	-	3.5
BUGK	Ungarbled, Bleached Calicut special	Not less than 15mm in length	3.0	4.0	4.0
BUGC	Ungarbled, Bleached Calicut Good	Not less than 15mm in length	4.0	6.0	6.0
Cochin Ginger-Non Bleached					
NGC	Garbled Non Bleached Cochin	Not less than 15mm	2.0	-	-
NUGC	Ungarbled Non-bleached Cochin special	Not less than 15mm	3.0	4.0	-
NUGC	Ungarbled Non-bleached Cochin Good	Not less than 15mm	4.0	6.0	-
Cochin Ginger-Bleached					
BGK	Garbled,Bleached Calicut	Not less than 15mm in length	2.0	-	3.5
BUGK	Ungarbled, Bleached Calicut) special	Not less than 15mm in length	3.0	4.0	4.0
BUGC	Ungarbled, Bleached` Calicut Good	Not less than 15mm in length	4.0	6.0	6.0

(Source: Agmark grade specifications for spices, Spices Board, 2001)

Value added products of ginger
Ginger powder

Dried ginger is powdered to a fine mesh-60 (250 microns) to be used in various end products.

Salted ginger

Fresh ginger (with relatively low fibre) harvested at 170 -180 days after planting can be used for preparing salted ginger. Tender rhizomes with portion of the pseudo stem is washed thoroughly and soaked in 30 % salt solution containing 1 % citric acid. After 14 days it is ready for use and can be stored under refrigeration.

Crude fibre

In fully matured ginger crude fibre varies from 3-8 per cent. It is estimated by acid and alkali digestion of ginger powder and what ever remains is considered as fibre.

Ginger oil

Dry ginger on distillation yield 1.5 to 2.5 per cent volatile oil. The main constituent in the oil is zingiberene and contributes to the aroma of the oil.

Ginger oleoresin

Dry ginger powder on treating with organic solvents like acetone, alcohol, ethyl acetate etc. yield a viscous mass that attribute the total taste and smell of the spice. The major non volatile principal in oleoresin is gingerol. The oleoresin content varies from 4 -10 per cent.

Others

Sweet and salty products can be prepared from fresh ginger like ginger candy, ginger paste, salted ginger, salted ginger, crystallized ginger.

Cardamom

Cardamom plants take about two years to bear capsules and takes about 3 months after flowering for fruit maturity. Green cardamom and white cardamom are the two important products obtained from fresh cardamom. The harvesting index and post harvest operations involved in the value addition of cardamom are discussed.

Maturity index and harvesting

Harvesting of cardamom is taken up at a time when the seeds inside the capsules have become black in colour or reached the maturity stage. The pericarp at this stage is still green in colour and the capsules are individually picked manually according to the colour.

Green cardamom

Freshly harvested cardamom capsules are subjected to the following unit operations for the production of green cardamom.

Washing and alkali treatment

Immediately after harvesting on each day, the capsules are to be pooled and brought to the drying kilns. The capsules are treated with 2 per cent washing soda (sodium carbonate) for 10 minutes, which enables to retain green colour and prevent growth of mould. In bigger estates two RCC tanks are constructed side by side, one for initial washing of capsules to get rid of dirt / soil and the other for washing with washing soda. After washing, capsules are spread in a single layer on portable drying trays for draining of water. Later the trays are arranged in kilns for drying

Curing (drying)

Cardamom curing (drying) may be defined as the process in which the moisture content of green cardamom is reduced from 80 percent to 8-12 percent (wet basis) at an optimum drying temperature of (50°C) so as to retain its green colour to maximum extent. There are mainly two types of drying viz. natural i.e. sun drying and artificial drying by using fire wood fuel or electrical current. Sun drying requires 5-6 days or more depending up on the availability of sun light and it does not impart good green colour to the produce. Splitting of capsules is more as they have to be subjected to turning during the drying process. This method is normally followed in small holdings in Karnataka. Artificial dryer may be either electrical or conventional flue pipe dryer.

Cross flow electrical drier: This type of drier is installed by Cardamom Board at central locations to facilitate drying of cardamom by small farmers. These are tray type cross flow driers and the capacity of these driers vary from 25 to 400 kg. The air is heated by 15 kW air heaters and circulated over the material by fan operated by 0.5 hp motor. The temperature of the drying air is kept at 40^0 C. At full loading capacity, the drying time required is about 18 to 20 h. After completing the drying at 50^0 C, the drier is run at 60^0 C for easy removal of stalk. The trays are then cooled for I h and the stalks are removed by wire mesh cleaner (Patil, 1987).

Kiln drier or flue pipe drier: The pipe curing method of drying is one of the best methods of drying from which high quality green cardamom can be obtained. The structure usually consists of walls made of bricks or stones and tiled roof with ceiling. A furnace is situated on one side of the chamber; heat is produced by burning firewood from farm waste in the furnace. A pipe made of iron or zinc sheet starting from the furnace passes through the chamber and opens outside the roof. The heated air current generated in the furnace passes through the pipe and increases the temperature of the room. The fans located on either sides of the wall uniformly spread the temperature. Inside the room wooden/ aluminium trays are to be piled one over the other with spacing of 20 to 22.5 cm between the trays. The fire in the furnace has to be regulated so as to maintain 45-50^0 C. It takes 18-22h to obtain high quality green cardamom. A drying chamber of the dimension 4.5m length and 4.5m breadth is sufficient for a plantation producing 1800 to 2000 kg of raw cardamom. A direct type solar drier developed for copra can also be used to obtain green cardamom (Patil, 1987).

Garbling

The dried cardamom is then subjected to garbling. Traditionally this is achieved by rubbing the cardamom capsules against coir mat or wire mesh and winnowed to remove any foreign matter. Semi mechanical garbling unit - oscillatory type TNAU garbler consisting of a concave, oscillating unit, perforated bottom, handle and outlet for flower stalks and cardamom. The capacity of the unit is 2-3 kg per batch. The rotary type garbler consists of a feed hopper, rotting drum, discharge chute and handle. It takes about 2-3 minutes to garble one batch of about 5 kg. Its capacity is 100kg/h and the efficiency was 98 per cent (Sreenarayanan *et al.*, 2003).

Grading

The partly cleaned cardamom by garbling is to be further cleaned and graded according to size, mostly manually. It can also be done mechanically using hand operated cleaner cum grader. The grades as per AGMARK specifications are given in the Table 2.

Bleaching

Sulphur bleaching of dry cardamom capsules is widely practiced to obtain white cardamom. Here the capsules are soaked in 2 per cent bleaching powder solution (20 g/l of water) for one hour and spread on wooden trays, which are arranged inside airtight chambers. Sulphur dioxide is produced by burning sulphur (15 g/ kg of capsules) and made to pass over the trays. The process of soaking and drying is to be carried out for 3-4 times depending up on the intensity of white colour required. The bleached cardamom is creamy white or golden yellow in colour.

Packing

Cardamom capsules are packed in jute bags or wooden containers suitably lined with polythene or craft paper.

Table 2. Agmark grade specifications of cardamom

Grade Designation	Trade name	Colour	Unclipped capsules (% by count), max	Empty and malformed capsules, (% by count), max	Immature and shriveled capsules, (% w/w), max	Blacks and splits, (% by count), max	Size, diameter of the sieve hole on which retained, mm	Weight in G/L by wt., max
Aleppey Green Cardamom								
AGEB	Cardamom extra bold	Deep green, green or light green	-	2.0	2.0	0.0	7.0	435
AGB	Cardamom bold	Deep green, green or light green	-	2.0	2.0	0.0	6.0	415
AGS	Cardamom Superior	Deep green, green or light green	-	3.0	5.0	0.0	5.0	385
AGS-1	Shipment green-1	Deep green, green or light green	-	5.0	7.0	10.0	4.0	350
AGS-2	Shipment green-2	Deep green, green or l ight green	-	7.0	9.0	12.0	4.0	320
AGL	Light	-	-	-	-	15.0	3.5	260
Coorg Green Cardamom								
CGEB	Extra bold	-	0.0	0.0	0.0	0.0	8.0	450
CGB	Bold	-	0.0	2.0	3.0	0.0	7.5	435
CG 1	Superior	-	0.0	3.0	5.0	0.0	6.5	415
CG 2	Coorg green or Motta green	-	3.0	5.0	10.0	0.0	6.0	385
CG 3	Shipment	-	5.0	10.0	15.0	10.0	5.0	350
CG 4	Light	-	-	-	-	15.0	3.5	280
Bleached or half bleached cardamom								
BL 1	-	-	-	0.0	0.0	-	8.5	340
BL 2	-	-	-	0.0	0.0	-	7.0	340
BL 3	-	-	-	0.0	0.0	-	5.0	300

(Source: Agmark grade specifications for spices, Spices Board, 2001)

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Large cardamom- Technologies for sustainable production

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Introduction

Large cardamom is a principal commercial crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal. The area under this crop is about 26,000ha with an annual production of 4500 to 5000 metric tons (Anonymous, 2007). The area, production and productivity of large cardamom are given in the Table 1. This crop is cultivated successfully under forest tree cover in hilly areas from 1000m to 2000m above mean sea level, under sub-humid cold climate and thrives well at 6°C to 25°C with well distributed annual rainfall of 300-350 cm. It is well adapted to the hilly forest ecosystem where the fertility status is high due to natural nutrient recycling. However, the area and production of large cardamom has been decreasing in the recent years and the production in Sikkim, according to Horticulture and Cash Crops Development Department, Government of Sikkim, during 2004-05 was 24,000 ha with an annual production of 6500 MT has come down to 12,500ha with an annual production of 3000MT during 2006-07 (Anonymous, 2007a). The reasons given for this decrease are, i.)The economic life span of the large cardamom is 12-15 years and most of the gardens are very old and senile, ii.) The diseases and pests have devastated the gardens, iii.) The Sikkim state has about 80,000 ha of cultivable land with an average size holding of 1.17 ha. There is continuous pressure on land with gradual diversion to other non-agricultural purposes.

Table 1. Area and production of large cardamom in India

Year	Sikkim			West Bengal		
	Area (ha)	Production (MT)	Productivity (kg/ha)	Area (ha)	Production (MT)	Productivity (kg/ha)
2002-03	26,734	4650	205	3274	650	241
2003-04	26,734	5401	242	3305	753	279
2004-05	26,734	4980	223	3305	793	292
2005-06	26,734	4477	200	3305	708	261
2006-07	26,734	3910	202	3305	510	188

(Source: Spices Board's Annual Reports)

Cultivars

There are mainly five cultivars of large cardamom viz., Ramsey, Sawney, Golsey, Varlangey (Bharlangey) and Bebo (Gyatso *et al.*, 1980). Some other sub-cultivars of the above ones (Ramnag, Ramla, Madhusey, Mongney etc.) are also seen in cultivation in small areas in Sikkim. Another cultivar Seremna or Lephrakey (a Golsey type) is also getting importance and is spreading to more areas in lower altitudes (Upadhyaya and Ghosh, 1983).

Ramsey

This cultivar is well suited for higher altitudes, even above 1500 m. on steep slopes. Grown up clumps of 8-10 years age group possesses 60-140 tillers. The tillers colour is maroonish green to maroon. Peak bearing of capsules is noticed in alternate years. This cultivar is more susceptible to viral diseases like foorkey and chirke especially if planted at lower altitudes. It occupies a major area under large cardamom in Sikkim and Darjeeling district of West Bengal.

Sawney

This cultivar is widely adaptable, especially suited for mid and high altitudes i.e. around 1300-1500 m. It is robust in nature and consists of 60-90 tillers in each clump. Colour of tillers is similar to Ramsey. This cultivar is susceptible to both chirke and foorkey viral diseases. Cultivars such as Red sawney and Green Sawney derived their names from capsule colour.

Golsey (Dzongu Golsey)

This cultivar is suitable to low altitude areas below 1300 m especially in Dzongu area in north Sikkim. Plants are not robust like other cultivars. Tillers are green in colour. Golsey is tolerant to chirke and susceptible to foorkey and leaf streak diseases. The cultivar is known for its consistent performance though not a heavy yielder. Many local cultivars are known in different locations such as Ramnag from north Sikkim. Ram meaning 'mother' and nag for black, which refers to its dark pink capsules. Seto-Golsey is from west district of Sikkim with robust leafy stems/tillers and green capsules. Madhusey has pink coloured capsules and has sweet seeds compared to other cultivars (Rao *et al.*, 1993).

Varlangey

This cultivar grows in medium and high altitude areas in South Regu (east Sikkim) and at high altitudes at Gortak (Kalimpong sub-division in Darjeeling district of West Bengal). Its yield performance is exceptionally high at higher altitude areas i.e.1500 m and above. Colour of tillers is maroonish-green to maroon towards collar zone. This cultivar is also susceptible to foorkey and chirke diseases.

Bebo

This cultivar is grown in Basar area of Arunachal Pradesh. The plant has unique features of rhizome and tillering. The rhizome rises above the ground level with roots penetrating deep into the soil and the young tillers are covered under thick leafy sheath. It is supposed to be tolerant to foorkey disease.

Seremna (Sharmney or Lephrakey)

This cultivar is grown in a small pocket at Hee-Gaon in west Sikkim at low altitude and is known for its high yield potential. Plant features are almost similar to Dzongu Golsey but the leaves are mostly dropping, hence named as Sharmney.

Technologies for sustainable production

One of the major constraints in sustainable production system is lack of quality, disease free planting material. Propagation of large cardamom is done through seeds, rhizomes (sucker multiplication) and tissue culture techniques. Cultivars suitable for specific areas, altitudes, agro-climatic conditions and mother plant/clump of known performance are selected for collection of seed, rhizome and vegetative bud.

Propagation through seeds

Nursery practices: Healthy plantation, free from viral disease in particular, is selected for seed capsules. Gardens with productivity of 1000 kg/ha or more during the past 3 years are considered. Higher number of spike bearing (reproductive) tillers per plant (bush), higher number of spikes and capsules, bold capsules, higher number of seeds per capsule etc. are some of the criteria looked into for selecting a plot for collection of seed capsule.

Spikes are harvested at maturity and seed capsules are collected from the lowest two circles in the spike. After dehusking, the seeds are washed well with water to remove mucilage covering of seeds, mixed with wood ash and dried under shade.

The dried seeds are treated with 25 per cent nitric acid for 10 min. The acid-treated seeds are washed thoroughly in running water to remove the acid residue and are surface dried under shade, these acid treated seeds are kept soaked in 10 ppm GA_3 solution for five days and sown for early and higher percentage of germination (Gupta, 1989). Large cardamom nursery is raised in two stages viz., primary nursery and secondary nursery. Seedlings raised in primary nursery (by seeds) are transplanted to the secondary nursery beds or to polybags. It has been established that the viral diseases of large cardamom are not transmitted through seeds. However the seedlings come to full bearing only after 4th year, and due to cross pollination there will be variability in the seedling population. Hence to get uniform and sustainable production, the propagation through suckers/rhizome and tissue culture method are preferred.

Propagation through rhizome

High yielding, disease free planting materials are selected for multiplication. Trenches of 60 cm width, 60 cm depth and convenient length are made across the slopes. Trenches are filled with topsoil, leaf mold and decomposed leaf litter. Rhizomes with one mature tiller and two young shoots or vegetative buds are planted at a spacing of 90 cm in the trenches during June-July. Thick mulching with dry leaf/grass is applied at the base of the rhizome and watering if required, is done regularly to keep the soil moist.

Once fresh vegetative buds appear, well decomposed cattle manure is applied 30 cm around the rhizome and incorporated to the soil. The rhizome multiplication plot is maintained with 50 per cent shade, either under shade trees or under agro shade net. When the rhizomes are planted in June/July, about 8-10 tillers are produced from each of the rhizome within 6 to 10 months. Each such clump is split into units of two to three tillers and are used for planting in the main field during June/July or used for further multiplication. Large scale planting of single clone may succumb to out break of pests and diseases, hence it is advisable to plant poly clonal material of same cultivar/variety to maintain minimum variability in the population.

Micro propagation

Large cardamom can be multiplied on a large scale through micro propagation. Protocols for micro propagation have been developed at Indian Institute of Spices Research (Sajina *et al.*, 1997: Nirmal Babu *et al.*, 1997). Many commercial firms are engaged in the production of tissue-cultured plants for commercial use. Axillary buds of 0.5-2 cm lengths from promising, virus disease free mother plants are used as explants. Large-scale field demonstration-cum trials with tissue cultured plants have indicated that there is early vigour in these plants and they come to bearing in the third year of planting compared to seedlings, which come to bearing in the fourth year of planting (Anonymous, 2007b). Hence, in the sustainable production systems, tissue culture technology could be used well for the production of disease free, high quality planting material in a large scale, for the replanting of senile and unproductive gardens.

Crop management

Soil, land and shade

Large cardamom is grown in forest loamy soils having soil depth a few centimeters to several meters. Texture is sandy, sandy loam, silty loam or clay. In general, soil is acidic having pH ranging from 5 to 5.5 or more, and with 1 per cent or more organic carbon (Bhutia *et al.*, 1985; Biswas *et al.*, 1986). On an average, these soils are high in available nitrogen and medium in phosphorous and potassium. Adequate drainage is quite essential for better stand of the crop (Singh *et al.*, 1998).

Large cardamom is a shade-loving crop. It grows well under dense shade (60-70 percent of full day light interception) to light shade (about 30 per cent full day light interception) condition. The day light intensity required for optimum growth of large cardamom ranges from 5000 to 20,000 lux. Therefore, in virgin forests shade regulation is necessary.

The most common shade trees are Utis (*Alnus nepalensis*), at 600-2000 m above mean sea level (amsl): Chilaune (*Schima wallichi*, at 550 – 1515 m amsl): Panisaj (*Terminalia myriocarpa*, at 400 – 1000 m amsl): Pipli (*Exbucklandia populnea* at 900-2000 m amsl) Malato (*Macaranga denticulate* at 670 – 1515 m amsl): Asarey (*Cole brookianum* at 850-2000 m amsl): Gogun (*Saurauvia nepalensis* at 1400 – 2000 m amsl): Karane (*Symplocos ramosissima* Wall at 1500-2400 m amsl): and Bilaune (*Maesa chesia*) etc. It is advisable to plant more than one species of shade trees commonly grown in a particular locality. In case of bare land utis is the first choice as it is quick growing, capable of fixing atmospheric nitrogen and has faster rates of nutrient cycling. Roots of *Alnus* species are nodulated with *Frankia* as an endophyte, and are efficient in biological N_2 fixation. Monoculture plantation of *A.nepalensis* is known to fix 29-117 kg N/ha/ year. The large cardamom based agro-forestry system under the influence of alnus was more productive with faster rate of nutrient cycling (Sharma and Ambasht, 1988). Ideal spacing is 9-10M between shade trees.

Planting

For planting of large cardamom, pits are opened at spacing suitable for the variety/cultivar. In case of robust variety/cultivar such as Sawney, Varlangey, Ramsey etc., spacing followed is 150 x 150 cm while a spacing of 120 x 120 cm is used for Golsey (Dzongu). Pits are opened in April-May. The size of pits usually is 30x30x30 cm. After the receipt of a few showers, pits are filled at least 15-20 days before planting, with top soil, decomposed cattle manure or compost or leaf mold mixed well with the top soil along with 100 g rock phosphate. The ideal season for planting is June-August depending on rains. Shallow planting is advocated to avoid covering the base of seedling, which may lead to rotting. After planting the base is mulched well. Staking is very essential for better anchorage during the initial stage of establishment.

Mulching

The plant base should be mulched with dried leaves, weeds and trashes. Mulching is done immediately after planting as well as in October-December in the existing plantation. This practice helps to cover the exposed roots, to conserve soil moisture in the ensuing dry months and helps in recycling of nutrients.

Plant nutrition

It is estimated that for producing about 100 kg dry large cardamom, the robust types like Ramsey, Sawney and varlangey remove (in kg) 10.33 N: 1.95 P: 26.24K: 19.10 Ca and 11.9 Mg: whereas Dzongu Golsey removes only about 5.74N :0.99P :3.54K :9.18Ca and 5.86Mg respectively. In organic production systems, recycling of the organic agriculture waste as compost, vermi-compost, etc. are recommended. Application of cattle dung, farmyard manure, poultry manure, Sheep/ goat manure, de-oiled mustard cake and neem case are recommended as nutrient suppliments.

However, studies on the use of fertilizers have indicated that judicious use of chemical fertilizers in conventional production system is beneficial. Application of NPK fertilizer in three splits, once in April-May after the first summer showers and second split in June and third in September-October before monsoon ceases, increases yield.

Weeding

Depending on the intensity of weed growth, two to three rounds of weeding are required in a year.

Irrigation

Watering during November-March is found essential to maintain a sustainable good yield in the plantation (Biswas *et al.*. 2003). Water from natural springs and streams is tapped through pipes and is provided to plants through surface channel/hose in different directions. Due to highly undulating terrain, other methods of irrigation like sprinkler and drip are difficult. Rainwater harvesting is also gaining importance.

Crop protection

Pests

Leaf caterpillar: Leaf eating caterpillar (*Artona chorista* Jordon, Lepidoptera:Zygaenidae), is a major pest of large cardamom in Sikkim and West Bengal (Yadava *et al.*, 1992: Singh and Varadarasan,1998). *Artona chorista* occurs sporadically in epidemic form in Sikkim and West Bengal every year. Usually the incidence of the pest is observed from June to July and October-March in the field.

Mechanical control: The larvae are gregarious in nature and feed underneath the cardamom leaf: the infested leaf can easily be identified from a distance and these can be collected along with larvae and destroyed in June-July and October-December. Group approaches of mechanical control by all the farmers of the locality, totally suppresses this pest in an area within a few years (Varadarasan & Biswas 1992; Deka and Gopakumar 2008).

Chemical control: Even though insecticides like quinalphos and endosulfan (0.05 per cent) are effective, growers are advised to avoid use of such chemicals which kill the natural enemies also. Only when there is an outbreak and needs chemical intervention, then any one of the following insecticides can be sprayed.

If caterpillars are in early stage spray (skeletonization of the leaves), quinalphos 25 EC 0.05 per cent (200 ml/100 l of water) or endosulfan 35 EC 0.05 per cent (143 ml/100 l of water). If the caterpillars are in the later stage, spray (defoliation of the plant), quinalphos 25 EC 0.1 per cent (400 ml/100 l of water) or endosulfan 35 EC 0.1 per cent (286 ml/100 l of water). If the infestation is very severe, second round of insecticide spray after 1 month can be given. During rainy season, 50-100 ml wetting agent per 100 l of water is added with insecticide solution.

Shoot fly: Shoot fly, *Merochlorops dimorphus* Cherian (Diptera: Chloropidae), recorded as a major pest of large cardamom damaging young shoots. Low to moderate damage by shoot fly is recorded in large cardamom plantation in Sikkim and West Bengal. In the main field, more damage is recorded at higher than in the lower altitudes. The tip of the shoot becomes brown and later whole shoot dries up causing 'dead heart' symptom. Single, pale glossy white larva bores the young shoot and feeds on the central core of pseudo-stem from the top to the bottom resulting in its death. For managing this pest, infested young shoots should be removed at ground level and destroyed.

Stem borer: Stem borer, *Glypheterix* sp. (Lepidoptera:Glyphiperidae) is recorded as a minor pest. Stem borer is recorded from March to November at Ghotak (West Bengal), Pangthang, Khasay, Gamdong (east Sikkim), Kabi and Mangan (north Sikkim). The larvae feed on the central portion of the shoot and as a result the terminal leaf of the plant gets dried up and this symptom is known as 'dead heart'. Infestation of this pest is also indicated by the presence of entry holes plugged with excreta. The intensity of infestation has been found higher at lower altitudes (about 5 per cent) in Sikkim on seedlings and main plantations. It can be controlled by removing infested shoots along with caterpillars.

Aphids: Aphids cause more damage as a vector rather than as a pest. The aphids are associated with the transmission of viral diseases of large cardamom. The aphid population is recorded high during summer months at lower altitudes. The removal and destruction of diseased plants is helpful in control of further spread of disease and in reduction of aphid population. In conventional production systems, spraying of 0.03 per cent Dimethoate or Phosphomidon after removal of foorkey and chirke affected clumps in March-April, gives adequate control of aphids.

Diseases

Chirke and foorkey are two viral diseases on large cardamom causing severe damage to the plantations. Chirke spreads fast where as foorkey causes severe yield loss. Among fungal diseases, flower rot, clump rot, leaf streak and wilt were known to cause damage to the plant and ultimately reduce the crop yield. However of late, a blight disease of large cardamom has become very serious and is causing considerable damage to the plantation resulting in the decrease of production in Sikkim and Darjeeling district of West Bengal.

Chirke: This virus disease is characterized by mosaic with pale streak on the leaves. The streaks turn pale brown resulting in drying and withering of leaves and plants. The flowering in diseased plants is extensively reduced and only one to five flowers develop in one inflorescence, as against 16-20 in an inflorescence of healthy plants (Raychaudhary and Chatterjee, 1965) and by the end of third year of crop the loss is around 85 per cent. Primary spread of the disease from one area to another area is through infected rhizomes and further spread within the field is by aphids (Raychaudhary and Ganguly, 1965).

Foorkey: This disease is characterized by dwarf tillers with small, slightly curled pale green leaves. The virus (spherical particles of 37 nm diameter, Alhwat *et al.,* 1981) induces remarkable reduction in size of leafy shoots and leaves of the infected plants and also stimulates proliferation of large number of stunted shoots arising from the rhizome. The spikes/inflorescence is transformed into leafy vegetative parts. The diseased plants remain unproductive and gradually degenerate. Foorkey symptom appears both on seedlings and grown up plants (Varma and Capoor, 1964).

The primary spread of disease from one area to another is through infected rhizomes and further spread within the plantation by aphids.

Management of chirke and foorkey:

(i) Regular rouging of diseased plants and burying in deep pits.
(ii) Use of healthy disease free planting material to prevent the disease.

Leaf streak disease: It is a fungal disease caused by *Pestalotiopsis royenae*(D.Sacc) Steyaert., and is a serious disease among foliar diseases and is prevalent round the year. The disease symptom is the formation of numerous translucent streaks on young leaves along the veins. Three rounds of 0.2 per cent spray of copper oxychloride at 15 days interval, during February-March and September-October can control this disease.

Wilt: A fungal disease caused by *Fusarium oxysporum* is prevalent in swampy and open areas. Early symptom is chlorosis of the older leaves commencing from the petiole region and progressing inwardly towards the young leaves. As the infection progresses, the pseudostem also get rotten, collapses and the plant dries up. Drenching 0.5 per cent dithane M-45 or thiram checks further spread of disease.

Blight: This is a new devastating disease affecting large cardamom. Major symptoms of the disease include yellowing and severe blighting of leaves, rotting, drying and lodging of bearing tillers in the middle. The affected plantations exhibit a dried up (blight) appearance from a distance. The infection mostly affects the bearing and mature tillers in a clump and young and newly emerging tillers remain healthy. However late in the season, the young emerging leaves of the new tillers in the diseased clump show pale yellow discoloration in the interveinal areas, and in some cases the emerging leaves are whitish in colour and droop without opening properly. The affected rhizomes of such tillers showed brown lesion –brown rot.

Harvest and post harvest technology

First crop comes to harvest about 2-3 years after planting of sucker or seedling. However stabilized yields are obtained only from the 4th year up to 10-12 years. Harvesting season starts in August/ September in low altitudes and continues up to December at high altitudes. Usually harvesting is done in one round and hence the harvested produce often contains capsules of varying maturity. Harvesting is done when the seeds of top capsules in the spike attain dark gray colour. After harvest, individual capsules are separated manually and cured. The traditional curing is called bhatti curing system (direct heat drying), where the cured product has black colour and smoky smell due to direct heating. For getting better quality produce, large cardamom is cured by flue pipe curing system (indirect heat drying)developed by the Indian Cardamom Research Institute, Regional station, Spices Board, Gangtok. Curing time was found to be 17.25 hours for 200kg batch capacity and firewood consumption per kilogram of raw capsule cured was 1.8kg. The cured capsules have pleasant aroma, unique flavour and original colour of capsules are retained (Anonymous 2004; Deka *et.al.*, 2003).

Conclusion

Even though technologies are available for the sustainable production of large cardamom, the unusual and prolonged dry weather, climate change in recent years coupled with the outbreak of new fungal blight disease, conversion of land to non-agriculture purposes, blooming of tourism, eco-tourism which has diverted the rural man power from cardamom cultivation resulting in the neglect of cardamom plantations has resulted in the decline of area and production of large cardamom, which is a cause of concern. To counter these, increase in productivity of existing gardens is imperative for sustained production. Evolving superior genotypes combining high yield and quality, developing resistant or tolerant lines against the virus diseases, management of blight disease, periodic replanting of old, senile and unproductive plantations with disease free superior planting material is essential for sustainable production.

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Other economically important zingiberaceous species

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Introduction

Though turmeric (*Curcuma longa* L.) and ginger (*Zingiber officinale* Rosc.) are the most widely known zingiberaceous crops apart from the cardamoms, there are other members as well, used to a varying extent for different uses ranging from medicine to floriculture (Table1 and Fig.1).

Table 1. Emerging species of economic importance of family Zingiberaceae

Species	Use
Curcuma amada Roxb.	Spice, medicine, pickles, salads
C. zedoaria Rosc.	Folk medicine, arrow root industry
C. ochrorhiza Val. & Van Zijip.	Traditionall medicine of Malaysia
C. pierreana Gagnep.	Traditional medicine of Vietnam
C. kwangsensis S.G.Lee & G.F.Liang	Traditional medicine of China
C. caesia Roxb.	Spice and medicine
C .comosa Roxb.	Thai traditional medicine
C. aromatica Salisb.	Toiletry articles, Perfumery
C. angustifolia Roxb., *C. zedoaria* Roxb., *C. caulina* F.Graham, *C. montana* Roxb., *C. psuedomontana* Roxb., *C. xanthorrhiza* Roxb., *C. decipiens* Dalz., *C. malabarica* Vel.*et al.*, *C. raktakanta* Mangaly & Sabu, *C. haritha* Mangaly & Sabu, *C. aeruginosa* Roxb.	Arrow root industry

C. alismatifolia Gagnep., *C. roscoeana* Wall., *C. thorelli* Gagnep., *C. rhabdota* Sirirugsa & F. Newman, *C. sparganifloia* Gagnep., *C. rhomba* Mood & K. Larsen, *C. latifolia* Rosc., *C. petiolata* Roxb., *C. rubescens* Roxb., *Zingiber mioga* Rosc., *Z. cassumunar* Roxb Roxb. *Z. zerumbet* (L) Smith., *Z. clarkii* King ex.Benth *Z. aromaticum* Val, *Z. rubens*	Ornamental
Z. neessanum (Graham) Raman, *Z. zerumbet* (L.) Smith	Medicinal
Zingiber mioga Rosc.	Vegetable (flower & shoots), medicine and spice (rhizome)
Kaempferia galanga L.	Medicinal
K. pulchra, K. rotunda L.	Ornamental, religious
Alpinia galanga(L.) S.W., *A. calcarata* Rosc.	Medicinal
Costus speciosus(Koenig)Smith	Medicinal

Common names of some of these plants are given in Table 2.

Table 2. Common names of emerging species of economic importance of family Zingiberaceae

Species	Common name (English/ *Malayalam*)
Curcuma aromatica	Kasturi turmeric/*Kasturi manjal*
C. amada	Mango ginger/*Manga inchi*
C. caesia	Black turmeric/*Kari manjal*
C. zedoaria	Yellow zedoary/*Manja koova*
C. aeruginosa	*Neela koova*
C. anguistifolia	East Indian arrow root, *Koova*
C. decipiens	*Kuzhi koova*
C. zanthorrhiza	Javanese turmeric
C. alismatifolia	Tulip ginger
Zingiber mioga	Myoga ginger, Japanese ginger
Z. neesanum	Wild ginger/*Kattinchi*
Z. zerumbet	Shampoo ginger, Pine cone ginger/ *Malainchi*
Alpinia calcarata	*Chittartha*
A.galanga	Greater galangal,Siamese ginger/*Aratha*
Kaempferia galanga	Indian crocus/*Kacholam*
K.pulchra	Peacock ginger
K.rotunda	*Chengazhaneer*
Costus speciosus	*Unnithandu*

Propagation

All the species are propagated using rhizome bits of 20-25 g size and are grown either as annual or perennial. No major pests are reported for these plants.
Brief details of cultivation, parts used and medicinal application of some of these species are presented below.

C. aromatica

Rhizome bits of 20-25 g size are planted during May-June in raised beds, like turmeric. A basal application of FYM@10-15 t/ha plus a fertilizer dose of 100:50:50 NPK Kg/ha in two or three splits are recommended. The crop matures in 7 months. Mother rhizomes are small and only one or two per clump. Freshly harvested rhizomes are sliced and sun dried or even fresh rhizomes can be used in toiletry products or perfumes.

True *C. aromatica* produces cream coloured rhizomes with persistent camphoraceous aroma. In fact, yellow zedoary (*C. zedoaria*), with big mother rhizomes and pale yellow colour is widely traded as *C. aromatica* by design or default in India.

C. zedoaria

Yellow zedoary is characterized by big mother rhizomes and very few fingers. Cultivation practice is like that of the turmeric. Crop matures by October-November. Rhozomes are sliced and sun dried. Rhizomes are credited with anticancerous and hepatoprotective properties besides its use in healing bruises and sprains. Zedoary is also used in the manufacture of liquors, various essences, cosmetics and perfumes. Toxicity of yellow zedoary starch ('shoti') is also reported.

C. amada

Mango ginger prefers well drained loamy soil and the cultivation is like turmeric cultivation using rhizome bits of 20-25 g size in raised beds or in ridges and furrows. FYM@30-40 t/ha (basal application) plus NPK @ 30:30:60 Kg/ha in split doses are recommended. Harvesting is done in November-December. 'Amba' is an improved variety having high yield from HARS, OUA & T, Pottangi, Orissa. Fresh rhizomes are used for making pickles, chutney, preserves, candy, sauces and other culinary preparations.

Kaempferia galanga

Raised beds of 1 m width, 25 cm height and of convenient length with spacing of 40 cm between beds prepared by March-April to plant *Kaempferia*. Whole or split rhizome with at least one healthy sprout is the planting material. Planting is done during the month of May with the receipt of the pre-monsoon showers in small pits in the beds in rows with a spacing of 20 x 15 cm and at a depth of 4-5 cm. Seed rate is 700-800 kg/ha.

A basal dose of FYM or compost @20 t/ha plus N, P_2O_5 and K_2O @ 50, 50 and 50 kg/ha at the time of the first and second weeding are recommended. After planting, the beds are mulched with dry or green leaves at the rate of 15 t/ha.

Rajani and Kasthuri are newly released high yielding varieties from Kerala Agricultural University, Thrissur with an yield potential of more than 2 tons dry rhizomes per ha.

Leaf rot disease occurs in certain localities during heavy rains. For controlling this disease, the beds are drenched with 1% Bordeaux mixture. Thiram 0.2% can also be sprayed.

The crop can be harvested seven months after planting. The crop is harvested carefully without cutting the rhizomes, dried leaves and roots removed, the rhizomes washed in water and dried. With sharp knife, the rhizomes are chopped into circular pieces of uniform size except the end portion, which has to be cut separately. The cut rhizomes are spread uniformly on clean floor and dried for four days. On fourth day, the rhizomes are heaped and kept overnight. On the next day it is again spread and dried. The dried produce is cleaned, heaped, bagged and stored in cool dry place or is marketed.

Fresh/dried rhizomes are used in various Ayurvedic drugs. (Source: Package of Practices. Kerala Agricultural University, Vellanikkara, Thrissur).

Alpinia galanga

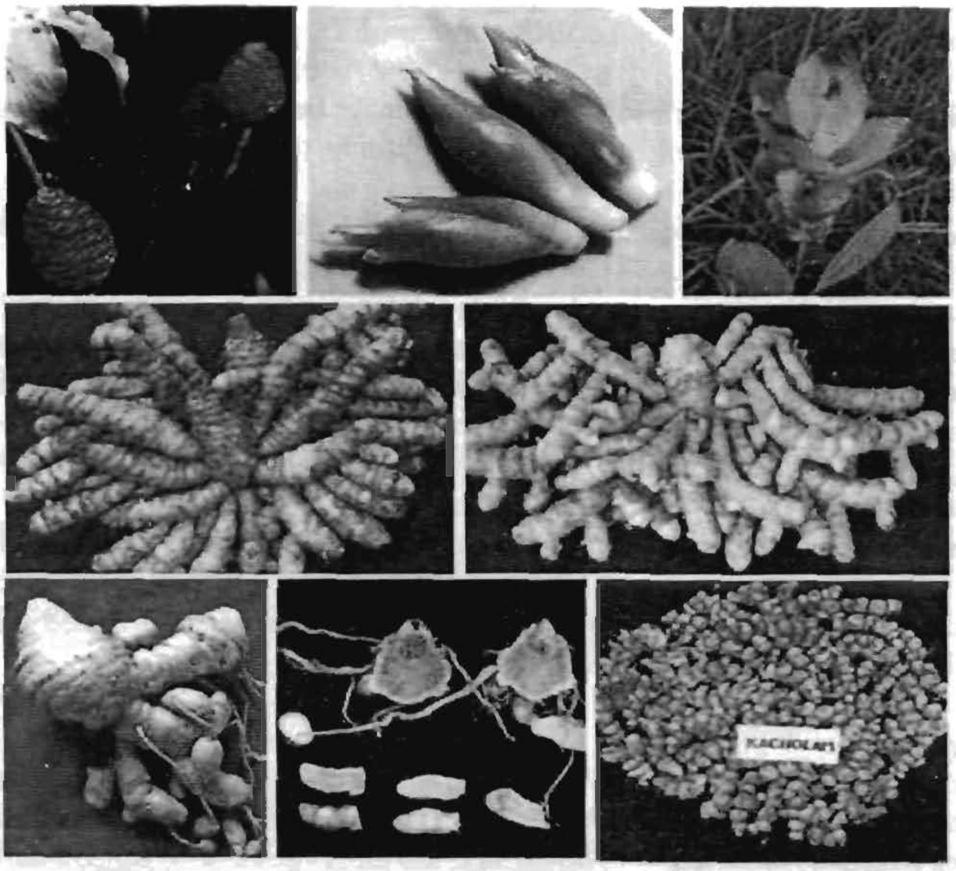
Greater galangal thrives well in tropical climate. Well drained soils are ideal for the crop. Rhizome bits of 5 cm length are planted in raised beds during May-June. Seed rate is 1000-1500 kg/ha. FYM @10-15 t/ha at the time of bed preparation followed by NPK@100:50:50 kg/ha in 2-3 splits per year are recommended. For better quality rhizomes and high yield, it is better to harvest the crop 34-42 months after planting. Average yield is 23 t/ha. The harvested rhizomes are cleaned, roots separated, sliced in to 5 cm long pieces and sun dried for 4-5 days to attain 10% moisture. Rhizome is used in medications of bronchial asthma, as a carminative besides its application in rheumatoid arthritis, inflammations, cough, diabetes, dyspepsia, obesity, hiccough etc.

Zingiber mioga

This species is endemic to Japan though now it is cultivated in countries like China, Vietnam, Taiwan, Thailand, Australia, New Zealand etc. It is grown for its edible flowers and young shoots.

Rhizome bits of 25 cm length are used for planting. Myoga ginger is a perennial plant preferring well drained fertile soils. Shoots emerge in the spring and produce dense foliage and robust stalk. The flowers emerge from the underground rhizomes during summer and autumn. Flower buds are harvested from the second year.

Apart from the flower and shoots, the rhizomes are used as a substitute for ginger in Japan.



Zingiber zerumbet, Zingiber mioga, Curcuma alismatifolia,, Curcuma aromatica Curcuma amada, Curcuma zedoaria, Curcuma caesia and Kaempferia rotunda

Bioactive principles and nutraceuticals in zingiberaceous spices

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Introduction

Spices, the predominant flavoring, coloring and aromatic agents in foods and beverages have been used in traditional systems of medicine for a long time. Historical records show the use of botanicals for flavor and medication as early as 6000 B.C. in China. The number of higher plant species (angiosperms and gymnosperms) on this planet is estimated at 250,000 with a lower level at 215,000 and an upper level as high as 500,000 (Cronquist, 1988). Of these, only about 6% have been screened for biological 'activity, and a reported 15% have been evaluated phytochemically. A total of 122 compounds were identified; 80% of these compounds were used for the same (or related) ethnomedical purposes. Research interest has focused on various herbs that possess hypolipidemic, anti-platelet, anti-tumor, or immune-stimulating properties that may be useful adjuncts in helping to reduce the risk of cardiovascular disease, arthritis and cancer, which are the key health issues of today. Spices or their active principles could be used as possible ameliorative or preventive agents for these health disorders.

The term "nutraceutical" was only coined in the 1980's, as a marketing label to distinguish certain foods and food ingredients, usually from natural sources, which confer specific health benefits. The term (an amalgamation of "nutrition" and "pharmaceutical") has been used interchangeably with "functional food" or, less commonly, "pharmafood. Nutraceuticals and play significant role in the prevention of a number of age-related diseases and are essential for healthy aging. Scientists have indicated that antioxidant nutraceuticals supplied from daily diets quench the reactive oxygen species or are required as cofactors for antioxidant enzymes. Epidemiological studies also reported the relevance of antioxidative nutraceuticals to health issues. India, the land of spices, could exploit the fast growing nutraceutical sector with her high intrinsic quality spices. There is scope of spices like turmeric, ginger, cardamom, fenugreek, garlic and red pepper in the nutraceutical industry with their possible role in the control/prevention of important health disorders.

Experiments using animal models indicate that spices could be consumed at higher dietary levels without any adverse effects on growth, organ weights, food efficiency ratio and blood constituents. The hypocholesterolemic and antioxidant properties of a few specific spices have far-reaching nutraceutical value. These beneficial physiological effects also have the potential of possible therapeutic application in a variety of disease conditions. With the advancement in the technology of spices and on knowledge of the chemistry and pharmacology of their active principles, their health benefit effects are being investigated more thoroughly in recent decades.

A food is defined as functional if it has a beneficial effect on target functions in the body, beyond adequate nutritional effects, in a way that is relevant to health and well-being and/or reduction in disease. Spices are the common dietary adjuncts that contribute to the taste and flavour of foods. Besides, spices are also known to exert several beneficial physiological effects.

Potential bioactive compounds identified in the zingiberaceous family

Major Spices of zingiberaceae include ginger (*Zingiber officinale*), galangal or Thai ginger (*Alpinia galanga* and others), melegueta pepper (*Aframomum melegueta*), myoga (*Zingiber mioga*), turmeric (*Curcuma sps.*), cardamom (*Amomum sps.*, *Elettaria sps.*) etc.

The rhizomes of the zingiberaceae family are widely used in many Asian countries, and their medicinal functions have been broadly discussed and accepted in many traditional recipes. 18 species of five genus of Zingiberaceae plants from Taiwan area on analysis, exhibited antimicrobial activity against all tested food microorganisms.

Several commonly used herbs have been identified by the National Cancer Institute as possessing cancer-preventive properties. These herbs include members of the zingiberaceae family (Caragay, 1992). Researchers have identified a host of cancer chemoprotective phytochemicals in turmeric and ginger, like curcumin, gingerols, and diarylheptanoids. In addition, a variety of phytosterols, triterpenes, flavonoids, saponins, and carotenoids, found in these spices have been shown to be cancer chemoprotective. (Steinmetz and Potter, 1991).

Ethanolic and water extracts, together with volatile oils from the rhizomes of six selected zingiberaceous plants, including *Curcuma manga, Kaempferia galanga, Kaempferia parviflora, zingiber cassumunar, Zingiber officinale and Zingiber zerumbet* were investigated for their anti allergic activities using a RBL/ 2H3 cell line. The ethanolic (EtOH) extract of *Kaempferia parviflora* exhibited the most potent anti allergic effect against antigen- induced beta-hexosaminidase release as a marker of degranulation in RBL/ 2H3 cells. (Tewtrakul and Subhadhirasakul, 2007)

Anti cancerous compounds

A wide variety of phenolic substances derived from spice possess potent antimutagenic and anticarcinogenic activities. Examples are curcumin, a yellow colouring agent, contained in turmeric (*Curcuma longa L.*), [6]- gingerol, a pungent ingredient present in ginger (*Zingiber officinale* Roscoe,) and capsaicin, the major pungent principle in hot chili pepper (*Capsicum annuum* L, *Solanaceae*). The chemopreventive effects exerted by these phytochemicals are often associated with their antioxidative and anti/ inflammatory activities. Cyclo oxygenase- 2 (COX- 2) has been recognized as a molecular target of many chemopreventive as well as anti- inflammatory agents.

Chemoprevention can be defined as the use of natural or synthetic chemicals to reverse, suppress, or to prevent the process of carcinogenesis. Numerous studies have been published on the positive effects of turmeric, both in the prevention of cancer and in the recovery from chemotherapy and radiation treatment. In addition to its capacity to intervene in the initiation and growth of cancer cells and tumors and to prevent their subsequent spread throughout the body by metastasis, curcumin increases cancer cells' sensitivity to certain drugs commonly used to combat cancer, rendering chemotherapy more effective. It is known to induce apoptosis in malignant cell lines by suppressing a number of key elements in cellular signaling pathways pertinent to growth, differentiation and malignant formation. It is one of the extensively investigated phytochemical, with regard to chemopreventive potential. Curcuminoids can also act as photochemoprotective agents that provide protection against UV B radiation induced oxidative stress. This inhibition of UV B radiation induced damage can reduce the incidence of skin cancer (Afaq *et al.*, 2002).

The anti-cancer action of curcumin has been studied in a standard model of radiation-induced tumour in rat mammary gland In animal studies, curcuminoids inhibited capsaicin- induced mutagenic changes in mouse bone marrow. Additionally, mice maintained on turmeric or curcuminoid-enriched diets, when challenged with carcinogens, excreted low levels of mutagenic metabolites as well as carcinogens. Curcumin is reported to prevent DNA damage even in individuals who may be genetically susceptible to toxic effects of xenobiotic exposures and is also able to exert antimutagenic/anticarcinogenic properties at levels as low as 0.1–0.5% in the diet (Polasa *et al.*, 2004).

Ginger, a natural dietary component, has been known to have anti oxidant and anti carcinogenic properties The antioxidant activity was determined by inhibition of phospholipid peroxidation induced by the $FeCl_3$ – ascorbate system. Gingerol also exerts an inhibitory effect on xanthine oxidase, responsible for the generation of superoxide anion.

Gingerols are a group of structurally related polyphenolic compounds isolated from ginger and known to be the active constituents. The chemopreventive efficacy of ginger, in colon cancer is well established. The anti cancer properties have been attributed to the presence of pungent vallinoids viz. [6]-gingerol and [6]-paradol, shogaols, zingerone etc. An anti - ulcer constituent, 6-gingersulfonic acid, and three monoacyldigalactosylglycerols, gingerglycolipids A, B, and C, were isolated from ginger showed weaker pungency and more potent anti- ulcer activity than 6- gingerol and 6-shogaol.

The anticancer properties of zerumbone (2,6,9 humulatriene-8-one) a sesquiterpenoid from *Zingiber aromaticum* has been established and compared with that of curcumin. The concentration of zerumbone in the *Z. aromaticum* extract diet was assayed at 300 ppm and of curcumin in the *C. longa* extract diet was also 300 ppm. Zerumbone is effective as an anticancer agent, possibly by its apoptosis-inducing and antiproliferative influences which is currently being investigated.

Angiogenesis, the formation of new blood vessels from pre-existing endothelium is fundamental in a variety of physiological and pathological processes including wound healing, embryonic development, chronic inflammation, tumor progression and metastasis. [6]-Gingerol in ginger could block capillary-tube like formation by endo thelial cells in response to Vascular Endothelial Growth Factor (VEGF) and strongly inhibited sprouting of endothelial cells in rat aorta and formation of new blood vessel in the mouse cornea in response to VEGF (Kim *et al.*, 2004).

Curcumin also is a potent angioinhibitory compound, as demonstrated by inhibition of angiogenesis in two angiogenesis assay systems *in vivo*, *viz*. peritoneal angiogenesis and chorioallantoic membrane assay. The angioinhibitory effect of curcumin *in vivo* is corroborated by the results on down-regulation of the expression of proangiogenic genes by curcumin.

Antioxidants

Antioxidants are suggested to enhance the body's defenses against harmful reactive oxygen species, generated endogenously or exogenously. Polyphenols from plants compose the majority of this class. Recently, it has been shown that bioavailability of these molecules are very low, therefore it becomes logical to use them in different combinations of various medicinal plants. Benefits of antioxidative nutraceuticals in the prevention of diseases and promotion of healthy aging have been extensively reported in recent years. Reactive oxygen species cause lipid oxidation, protein oxidation, DNA strand break and base modification, and modulation of gene expression.

Curcuminoids are natural phenolic compounds with potent anti-oxidant properties, which were reported as early as 1975 .Both turmeric and curcumin inhibit generation of super oxide and hydroxyl free radicals. Th.e antioxidant properties of curcumin in the prevention of lipid peroxidation are also well-recognized. The three forms of the pigment have dual prolonged antioxidant activity *viz*; preventing the formation of free radicals as well as intervening in their propagation. In fact, the anti-oxidant activity has been attributed to its unique conjugated structure which includes two methoxy phenols and an enol form of β-diketone, with the typical radical trapping ability as a chain breaking anti-oxidant.

Curcumin also has the potential to prevent oxidative damage to the arterial wall. Thus administration of 500 mg of curcuminoids daily to healthy human beings for 7 days reduced lipid peroxides by 33% and blood cholesterol by 29%, indicating a possible role of curcumin in reducing cardiovascular diseases .An *in vitro* study on the comparison of antioxidant activity of curcuminoids and tetra hydrocurcumin using rabbit erythrocyte membrane showed highest activity with tetrahydrocurcumin.

Kikuzaki and Nakatani (1993) evaluated the antioxidant effects of some ginger constituents. The non-volatile fraction of the dichloromethane extract of ginger rhizomes exhibited a strong antioxidative activity. The fraction was purified by chromatographic techniques to provide 5 gingerol-related compounds and 8 diaryl heptanoids. Among them, 12 compounds exhibited higher activity than α-tocopherol. The activity was probably dependent upon side chain structures and substitution patterns on the benzene ring. The bioactive components of ginger rhizomes were characterized by spectroscopic analysis as zingerone and dehydrozingerone, which exhibited potent antioxidant and tyrosinase inhibition activities. It was observed that both number and position of hydroxyl groups on aromatic ring and a double bond between C 3 and C4 played a critical role in exerting the antioxidant and antityrosinase activity (Kuo *et al.*, 2005).

Anti-inflammatory compounds

Curcuminoids and other constituents of turmeric are well-known for their anti-inflammatory activity. Turmeric extract, volatile oils from turmeric and curcuminoids were reported to possess this property in different experimental models of inflammation in mice, rats, rabbits and pigeons. Administration of curcuminoids to patients who underwent surgery or suffered from trauma, could reduce inflammation to a comparable level with phenylbutazone. Oral administration of curcumin at a dose of 3 mg/kg was also found to be effective in reducing inflammation associated with various forms of arthritis. The anti rheumatic properties of curcuminoids were also tested successfully in patients with diagnosed rheumatoid arthritis.

Curcumin also enhances wound healing in diabetic rats and mice and in H_2O_2 induced damage in human keratinocytes and fibroplasts. The wound healing effect is expressed by inhibiting the activation of NF-kappa B transcription factor.

Accumulation of β-amyloid proteins in the brain is one of the hallmarks of Alzheimer's disease. Dietary curcumin at low dose (160 ppm) and high dose (5000 ppm) significantly lower oxidized proteins and interleukin 1–β, a pro-inflammatory cytokine elevated in the brains of mice. With low dose, the astrocytic marker, GFAP was reduced and insoluble β-amyloid (Abeta), soluble Abeta and plaque burden were significantly reduced by 43-50% (Lim *et al.*, 2001).

Ginger extract derived from ginger and *Alpina galanga* inhibits the induction of several genes involved in the inflammatory response. These include genes encoding cytokines, chemokines, and the inducible enzyme cyclooxygenase-2. This discovery provided the first evidence that ginger modulates biochemical pathways activated in chronic inflammation. Identification of the molecular targets of individual ginger constituents provides an opportunity to optimize and standardize ginger products with respect to their effects on specific biomarkers of inflammation. Such preparations will be useful for studies in experimental animals and humans.

The rhizome of ginger also contains pungent vanillyl ketones, including [6]- gingerol and [6]- paradol, and has been reported to possess a strong anti/ inflammatory activity. These pungent substances have a vanilloid structure found in other chemopreventive phytochemicals, including curcumin (Surh *et al.*, 1999).

The efficacy and safety of a standardized and highly concentrated extract of 2 ginger species, *Zingiber officinale* and *Alpinia galanga* on reducing symptoms of osteoarthritis of the knee has also been reported recently.

Anti platelet agents

Gingerols represent a potential new class of platelet activation inhibitors. The ability of 20 pungent constituents of ginger and related substances to inhibit arachidonic acid (AA) induced platelet activation in human whole blood showed that [8]- Gingerol, [8]- shogaol, [8]-paradol and gingerol analogues (1 and 5) exhibited antiplatelet activities with IC(50) values ranging from 3 to 7 microM, whilst under similar conditions the IC(50) value for aspirin was 20+// 11 microM (Nurtjahja *et al.*, 2003).

Antiviral compounds

In order to identify novel lead compounds with antiviral effect, methanol and aqueous extracts of eight medicinal plants in the Zingiberaceae family were screened for inhibition of proteases from human immunodeficiency virus type 1 (HIV- 1), hepatitis C virus (HCV) and human cytomegalovirus (HCMV). In general, the methanol extracts inhibited the enzymes more effectively than the aqueous extracts. HIV-1 protease was strongly inhibited by the methanol extract of *Alpinia galanga*. This extract also inhibited HCV and HCMV proteases, but to a lower degree.

HCV protease was most efficiently inhibited by the extracts from *Zingiber officinale*, with little difference between the aqueous and the methanol extracts. Many of the methanol extracts inhibited HCMV protease, but the aqueous extracts showed weak inhibition. In a first endeavor to identify the active constituents, eight flavones were isolated from the black rhizomes of *Kaempferia parviflora*. The most effective inhibitors-5- hydroxy-7-methoxyflavone and 5,7-dimethoxyflavone- inhibited HIV- 1 protease with IC50 values of 19 microM. Moreover, 5- hydroxy-3,7- dimethoxyflavone inhibited HCV protease and HCMV protease with IC50 values of 190 and 250 microM, respectively (Sookkongwaree *et al.*, 2006)

Antifungal compounds

Curcumin at concentrations of 2.5 - 50 mg/100ml inhibited *in vitro* growth of *Staphylococcus aureus*. Interestingly, the antibacterial and antiviral activities of curcumin were significantly enhanced by illumination with visible light . Curcumin also inhibits *in vitro* production of aflatoxins - toxins produced by the mold *Aspergillus parasiticus*, which may grow and contaminate the poorly preserved foods and is a potent biological agent causing injury to the liver, often resulting in liver cancer. Curcumin possesses leishmanicidal effects *in vitro* and is more potent than the standard leishmaniasis drug pentamidine. LD_{50} for leishmanicidal activity *in vitro* is found to be 37.6± 3.5 microM.

A bioassay/ guided isolation of antifungal compounds from an African land race of ginger, led to the identification of [6], [8] and [10]- gingerols and [6]- gingerdiol as the main antifungal principles. The compounds were active against 13 human pathogens at concentrations of <1 mg/ml.

Extract of cardamom seed displayed a variable degree of antimicrobial activity on different microorganisms .Assays indicated that cardamom seed had inhibitory activity on *M. smegmatis, K. pneumoniae, S. aureus, E. coli, E. faecalis, M. luteus* and *C. albicans*.

Anti diabetic components

Scientific research has gradually verified the antidiabetic effects of ginger, especially gingerols, which are known to improve diabetes including the effect of enhancement against insulin sensitivity.

The efficacy of turmeric and curcumin on blood sugar and polyol pathway in diabetic albino rats showed significant reduction in blood sugar and glycosylated hemoglobin levels. This could be due to decreased influx of glucose into the polyol pathway, leading to an increased NADPH/NADP ratio and elevated activity of the antioxidant enzyme glutathione peroxidase. The activity of sorbitol dehydrogenase, an enzyme that catalyzes the conversion of sorbitol to fructose, is also lowered significantly on treatment with turmeric or curcumin.

Conclusion

The demand for functional foods and food supplements is certain to grow, and it has been predicted that 'virtually all foods will have a functional form', in the same way that most foods today have a "diet" or "low fat" form. Nutrigenomics is the study of the effects of bioactive compounds from food on gene expression. In the last several years, an increasing body of scientific evidence has demonstrated that individual compounds, as well as complex mixtures of chemicals, derived from food alter the expression of genes in the human body. By turning on or off genes, bioactives in food alter the concentration of specific proteins directly or indirectly associated with human diseases. Several human diseases result in multiple inflammatory responses which are associated with many diseases including arthritis, cancer, cardiovascular disease, dermatitis, asthma, obesity, and others. Detailed mechanisms of action as to how food derived components play an active role in prevention of inflammation have been elucidated. The bioactive components mentioned above will have a definite role to play in the prevention of various aforesaid diseases. Phytochemistry and Pharmacokinetics have to be amalgamated to achieve these goals.

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Quality planting material production of ginger and turmeric

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Introduction

Ginger and turmeric are two important spice crops of India. Apart from the role they play as a foreign exchange earners, the domestic market for these crops is so strong, that the ups and downs in this sector affect a large section of the people. Both these crops are an inseparable part of the Indian cuisines used mostly as spice and also extensively used in the Indian Systems of Medicines for the medicinal value attributed to them.

Distribution

Ginger (*Zingiber officinale* Rosc.) originated as a native of tropical South-Asia, was introduced into the West Indies, African countries and other tropical countries of the world. The major ginger producing countries are India, China, Nigeria, Indonesia, Bangladesh, Thailand, Philippines, Jamaica etc. Nigeria ranks first with respect to area under ginger covering about 52 % of total world area followed by India 24 %, China 7 %, Indonesia 5 %, Thailand 4 %, Nepal 3 % and Bangladesh 2 %. India ranks first with respect to ginger production contributing about 29 % of world's production followed by China 26 %, Indonesia 14 % Nigeria 10 %, Nepal 8 % and Bangladesh 4 %. UK, USA and Saudi Arabia import large quantities of ginger.

Ginger production in India during 2005-06 was at 4.14 lakh tons from an estimated area of 1.14 lakh ha. Ginger is grown in almost all the states. However Kerala, Meghalaya, Arunachal Pradesh, Karanataka, Nagaland, West Bengal, Orissa and Himachal Pradesh are major ginger growing states.

Turmeric (*Curcuma longa* L.) is an important common flavouring spice with growing demand with a variety of applications such as condiment, dye and drug. India is the largest producer, consumer and exporter of turmeric. There are more than 30 turmeric varieties grown in India. Among them, Madras and Alleppey are of great commercial significance. India keeps most of its Madras turmeric for domestic use and exports most of its Alleppey turmeric variety. India is the world's largest producer of turmeric with an annual production of 8.46 lakh tons from an area of 1.70 lakh ha. Andhra Pradesh is the foremost state in turmeric production with an area of 70,000 ha and production of 5,19,000 tons followed by Tamil Nadu, Orissa, Karnataka and West Bengal. During 2005-06, 61% of the country's turmeric out put was from Andhra Pradesh, which has an area of 41 % of the total area under turmeric in the country. State-wise area and production of ginger and turmeric in India during 2005-06 are given in Table 1.

Table 1. Area and production of ginger and turmeric in India (2005-06)

(Area: '000 ha, Production:'000 tons, Yield: kg/ha)

State	Ginger			Turmeric		
	Area	Prod.	Yield	Area	Prod.	Yield
Andhra Pradesh	1.9	10.9	5823	70	519	7414
Arunachal Pradesh	4.8	32.9	6854	0.4	1.6	4000
Assam				11.6	8.5	733
Bihar	0.8	1.2	1500	3.5	3.4	971
Chhattisgarh	1.3	1.2	923	0.7	0.6	857
Gujarat	1.9	4.0	2105	1.0	14.1	14100
Haryana				0.7	9.6	13714
Himachal Pradesh	2.2	16.2	7364	0.1	0.1	1000
Karnataka	21.7	28.3	1304	4.1	19.4	4751
Kerala	12.2	56.3	4604	3.4	8.2	2434
Madhya Pradesh	5.1	6.3	1235	0.5	0.5	1000
Maharashtra	1.0	1.0	1000	7.0	8.0	1143
Manipur	2.2	3.7	1682	0.0	0.1	
Meghalaya	9.6	53.6	5570	1.8	10.5	5783
Mizoram	4.5	29.6	6578	0.3	2.3	7667
Nagaland	10.2	63.5	6225	0.6	3.1	5167
Orissa	15.8	30.8	1949	24.0	57.1	2379
Rajasthan	0.1	0.2	2000	0.1	0.2	2000
Sikkim	6.5	34.7	5338	0.5	1.7	3400
Tamil Nadu	0.7	12.6	18000	26.0	143.4	5515
Tripura	1.4	2.8	2000	1.5	4.3	2867
Uttar Pradesh	0.8	1.9	2375	1.0	4.4	4400
Uttaranchal	0.8	6.1	7625			
West Bengal	7.7	14.0	1818	11.8	25.0	2119
A & N Islands	0.5	1.8	3600	0.1	0.7	7000
All India	*113.7*	*413.6*	*3637*	*170.7*	*845.8*	*4956*

Importance of quality planting material

The important factors considered to improve the productivity of these crops are to bring more area under high yielding varieties with improved management practices. The poor coverage of area under high yielding varieties is attributed to the non-availability of quality planting materials of improved varieties at the farmers' level. In fact, the Ministry of Agriculture, Government of India has identified inadequate availability of quality planting materials being the single most important factor that contributes to low productivity of most of the horticultural crops including ginger and turmeric.

Requirement of planting material

Ginger is grown in an area of 1.13 lakh ha (Table 1) for which the planting material requirement (@ 1.4 tons/ha) would be around 1.58 lakh tons. Similarly turmeric is grown in an area of 1.70 lakh ha for which the planting material requirement would come to around 3.40 lakh tons of seed rhizomes. The requirement further increases at the rate of 2% annually. Since the Government Institutions alone cannot meet the requirement stated above, the role of private nurseries takes prominence.

Constraints in quality planting material production

Operational

- Lack of awareness, inadequate facilities and lack of proper maintenance of the stock plants and nursery activities.
- Procurement of planting materials by Government Departments through public quotation leading to cheap but poor quality materials.
- No restrictions in movement of seed material from one state to other exist.
- Proper mechanism for storage of surplus seeds is not available.

Technical

- Inadequate and slow supply of seed rhizomes of improved varieties from different Research Institutions causing delay in spread of these varieties at the desired rate.
- Non-maintenance of healthy stock or blocks of elite varieties at different centres.
- Careless multiplication of breeders seed by State Agencies
- Techniques like soil solarization and fumigation are not followed leading to avoidable casualties.
- Non-adoption of effective disease and pest management in commercial seed production.
- Non-availability of improved tools for different field operations.
- Quarantine norms not in operation in movement of plant materials within the country causing spread of new disease strains like in ginger.
- No mechanism to regulate the quality of planting material being supplied to farmers through private/Government nurseries.

Planting material production

The two most important issues in planting material production are:

1. Making available improved varieties released by Research Stations in sufficient extent so that it is further multiplied at the Government and certified seed production centres.

2. Making available quality disease-free planting materials at the farmer's level.

Important high yielding varieties / cultivars

Number of varieties have been released by various Research Stations with very high yield potential. The important varieties / cultivars in ginger and turmeric are as follows.

Ginger: IISR-Varada, Suprabha, Suruchi, Suravi, Himagiri, China, Assam, Maran, Himachal, Nadia, Rio-de-janerio, Burdwan, Ernad Chernad, Gorubathan, Karakkal, Kuruppampadi, Manamthodi, Narasapattam, Poona, Taffingiva, Thinladium, Thingpuri, Tura, Uttar Pradesh, Valluvanad, Wynad local, Wynad, and Kunnamangalam.

Turmeric: Suvarna, Suguna, Sudharshana, IISR-Prabha, IISR-Prathibha, IISR-Alleppey Supreme, IISR-Kedaram, Kanthi, Sobha, Sona, Varna, Co-1, BSR-1, BSR-2, Megha, Pant Peetabh, Suranjana, Krishna, Sugandham, Roma, Suroma, Ranga, Rasmi and Rajendra Sonia.

Sustainable technology for production of disease-free planting materials

Production of healthy (disease-free) planting material of ginger and turmeric becomes a crucial issue in ensuring longevity, productivity and sustainability of the crop over years. This is mainly because there are several soil borne pathogens that become a major production constraints in these crops. Being soil borne, these are more elusive for an effective disease management. Ginger and turmeric are vegetatively propagated and vertical transmission of the disease becomes important and hence ensuring seed health / plant health is of paramount importance.

The major soil borne diseases of ginger and turmeric:

Ginger	:	*Pythium aphanidermatum* / P.*myriotylum* - soft rot
		Ralstonia solanacearum - bacterial wilt
		Fusarium oxysporum sp. *zingiberi* - yellows
		Pratylenchus coffeae } Nematodes
		Meloidogyne incognita } Nematodes
Turmeric	:	*Pythium graminicolum* / *P. aphanidermatum*
		Fusarium solani
		Pratylenchus coffeae

Many of the above soil borne plant pathogens are known to be seed borne / plant borne which go unnoticed as they look apparently normal at nursery stage/early stage of crop growth. It is here that the sanitization of planting material becomes important to ensure disease free planting material. Supply of disease free nursery stock becomes an essential prerequisite for the developmental agencies to further multiply the nucleus planting material provided by the R & D institutions (SAUs / ICAR). Besides, the appraisal of the farming community about the status of disease problems and the quality of planting material are important to make the healthy planting material production programme a success.

Strategies for healthy planting material in ginger and turmeric

In the absence of high degree of host resistance for many of the soil borne plant pathogens, it becomes imperative to give a major thrust on an effective disease management, which starts right from seed production stage. Over years, the microbial technology suppressive to soil borne plant pathogens in these crops have been developed which becomes handy to implement. These microbial technologies need to be exploited to ensure protection from root infection. The technologies are, *Soil disinfection through solarization:* Soil disinfection through fumigants or through complete soil sterilization becomes difficult because of high-energy costs involved. However, soil solarization technique developed by Israelis is important and practicable. The solarization of soil becomes an effective medium to reduce the chances of soil borne pathogens and consequent infections.

Incorporation of bio-control agents into the nursery mixture: Soil solarisation combined with microbial innoculum, which were found to be effective disease suppressers, is a proposition to reduce root infections in seed production programmes. Of the microbes available, Vesicular Arbuscular Mycorrhiza (VAM), antogonist like *Trichoderma* spp., *Psuedomonas* spp., *Bacillus* spp. have been extensively used for the nursery programmes as well as field management of the diseases. *Glomus flasiculatum* is one VAM fungus, which has been extensively investigated and was found effective in protecting the root system against *Phythophthora capsici, Radopholus similis* and *Meloidogyne incognita*. Incorporation of VAM inoculum into the soil (either solarized or non solarised) prior to planting would ensure greater protection of the root system, leading to production of disease free planting material.

Fungal antagonists like *Trichoderma hazarianum*, *Trichoderma viridae* etc. have been amply demonstrated to be highly effective in checking the soil borne infections. This has been well established for control of soil borne pathogens in the case of ginger, turmeric, black pepper, cardamom, cumin, coriander and fenugreek. As such, it is recommended to incorporate these bio inoculants in the soil for seed production.

Similarly, *Psuedomonas flouresens*, *Bacillus subtilis* and Plant Growth Promoting Rhizobacteria (PGPR) are the other important bacterial antagonists, which are found effective against soil borne problems. These also can be effectively utilized for disease management. These PGPRs not only ensure protection from the soil borne pathogens but also ensure plant growth and induced systemic resistance that would ensure health of the planting material.

Seed disinfection: In the case of ginger and turmeric, the soil borne plant pathogens viz., *Ralstonia solanacearum, Pythium aphanidermatium, Pratylenchus coffeae* that remain associated with the planting material when the seed rhizomes are collected from diseased gardens, which are apparently normal. Collecting normal rhizomes from the field is age-old practice of farmers without giving due importance to source (healthy and diseased plots). These apparently normal rhizomes when used for fresh planting become source of initial infection in the field and subsequent spread. It is important to eliminate these seed borne pathogens from the rhizomes followed by seed treatment with some of the above-mentioned microbial bio inoculants (biocontrol agents). In Sikkim, seed treatment of ginger seed rhizomes at 51^0 C for 10 minutes was found to be highly effective in seed disinfection, which resulted in a better crop free from dry rot (*Pratylenchus-Fusarium* complex). When hot water treated rhizomes are coated with biocontrol agents, the protection was more evident and is now being practiced in the ginger programmes in Sikkim as a part of participatory technology development (PTD) programmes. The same type of procedure can be followed for turmeric also. *F. oxysporum* being the causal agent of vascular wilt of vanilla, similar studies are warranted to eliminate inoculum in symptomless stems.

Micropropagation (Tissue Culture) as a strategy for production of healthy planting material: Biotechnological method of plant propagation called as micropropagation through tissue culture technique is in vogue for several horticulture crops. Protocols for micropropagation of spices and aromatics have been standardized. The biggest advantage of tissue cultured planting material is total elimination of all the major pathogens, if one selects explants from high yielding clones totally free from diseases, which otherwise is impossible in conventional multiplication through vegetative propagation mentioned earlier. High cost of production is the limitation of this method. However, this approach becomes imperative if production of healthy planting material becomes impractical through conventional methods.

Planting material production under National Horticulture Mission

With the launch of National Horticulture Mission (NHM) during 2005-06, the availability and supply of good quality planting materials received focused attention. Since it is not possible to meet the demand of planting material through public domain alone, it was found necessary to encourage private participation in the sector. To ensure that only quality planting material reach the farmers it was found necessary that a uniform regulatory mechanism should be established in the country.

The Directorate of Arecanut and Spices Development, Calicut is implementing two important schemes, which supplement the effort of NHM in augmenting the availability of planting materials in the country.

1. Production and distribution of nucleus planting materials

Under NHM various State Governments have been assigned with programmes for area expansion, high yielding varieties coverage, rejuvenation etc., requiring sizeable quantity of quality planting materials of the respective spices crops. In order to meet the requirement of various planting materials for the above programmes, nucleus planting material production programme of released high yielding varieties is being taken up directly by the Directorate of Arecanut and Spices Development, through State

Agricultural Universities (SAUs) and ICAR Institutes etc. The Directorate assesses the requirement of nucleus planting materials well in advance, for the large scale multiplication for various State Horticulture Mission (SHM) programmes and ensure their timely supply. Here 100% assistance is given to SAUs and ICAR Institutes for the production of nucleus planting material of high yielding varieties.

2. Development of infrastructure for Seed Production

To facilitate proper handling, storage and packaging of seeds, assistance is provided for creating infrastructure like drying platforms, storage bins, packaging units and related equipments. The scheme is project based and 100% assistance is provided to the public sector. The assistance to the private sector is credit linked back ended subsidy limited to 25% of cost.

Conclusion

National Horticulture Mission aims at doubling the production of these crops by the XI Plan period, primarily through improvement in productivity. To achieve this task, availability of healthy planting materials of improved varieties takes the centre stage of all developmental activities. The Directorate of Arecanut and Spices Development has been supplementing these efforts by implementing programmes on nucleus planting materials, field demonstration plots, seed infrastructure, and transfer of technology programmes through various SAUs and National Research Institutes. Thus there is a concerted effort from the Government of India to improve upon the availability of the quality planting materials of high yielding varieties of these crops, which will pave the way for the development of Spice Industry in the country in a sustainable way.

Tamil Nadu precision farming project: A successful model of market linked small farmers corporate

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Introduction

Tamil Nadu Precision Farming Project is a Tamil Nadu State sponsored turn-key project being implemented at Dharmapuri and Krishnagiri districts in 400 ha with a total budget of 7.20 million for a period of three years. It is a state mega demo to train the farmers to empower them as agri-entrepreneurs. It is an effort to strengthen the production systems for export in general and raw produces in particular. The project has adequately prepared the farmers for market driven production at a time when MNCs like Wall Mart, Carry Four, Tesco, WoolsWorth, Reliance and Barti Telecom are all set for invasion into retail vegetable market in India.

Objectives

1. To sensitize the farmers on the market forces and to reorient the whole production system to respond to the market.

2. To provide participatory farming through registered growers associations with precision farming technologies in production and make farmers understand the food safety issues

3. To help farmers to generate produces acceptable to international consumers.

Paradigm shift in the horticultural sector

During 1906-1994, the State Agricultural Universities, Developmental Departments and Policy makers made best of their efforts to maximize the productivity vis- a- vis production. The whole exercise was to produce maximum possible in the given land with available water resource and the existing environmental conditions. It was predominantly a production led horticultural activity. WTO has necessitated a shift in the focus, taking into account the market forces in globalized trade system and demanded a new market driven production systems as follows:

a. Production system for local market characterized by small area (1-2 ha), too many varieties and intensive nature of cultivation.

b. Production system for interstate market (internal export) characterized by larger horticultural estates, one or two specific varieties and extensive nature of cultivation.

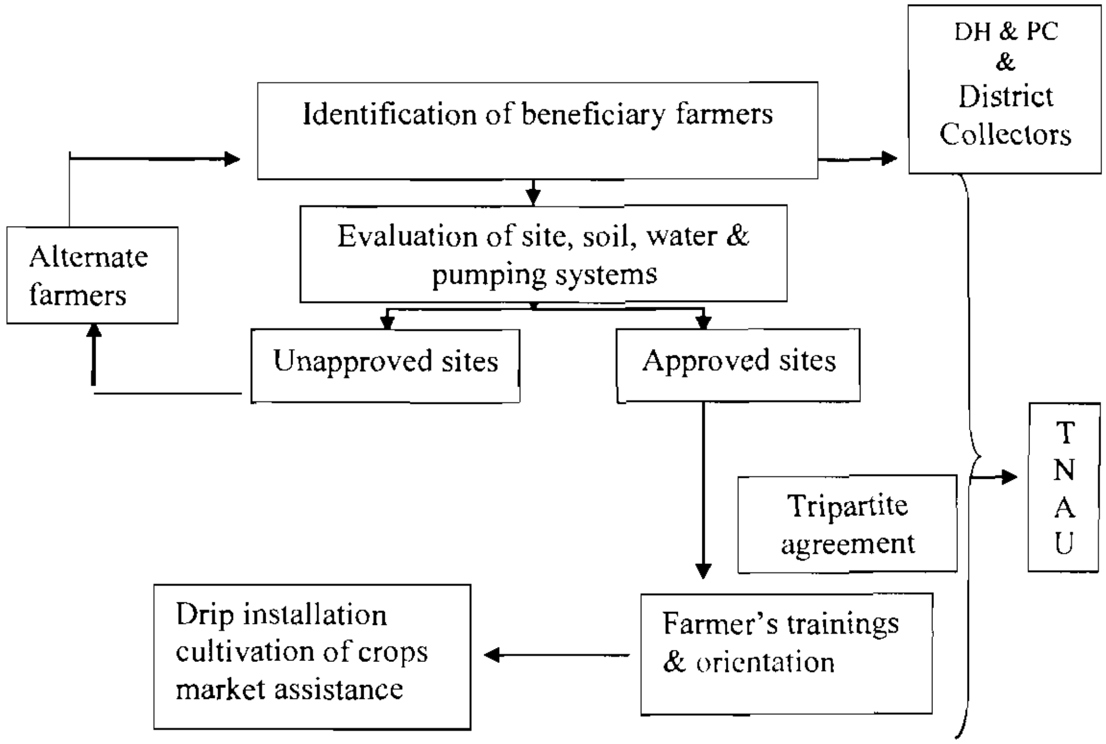
c. Production system for export of raw produces involving Good Agricultural Practices, organically certified production, precision farming etc. with total concern for consumer's preference of the importing countries.

d. Production system for export of value added products to developed countries, duly following the prescribed sanitary and phytosanitary standards, HACCP and traceability ensuring 100 per cent food safety.

Physical size of the project

The physical size of the project was 400 ha which had to be implemented in three years. Though implemented in Dharmapuri and Krishnagiri districts, the project is a demonstration for the state with the hope that the system would be taken to all the districts in Tamil Nadu to get the markets linked to the production and to ensure better livelihood system for the farmers.

Work plan and activity chart



Achievements

400 ha was planted with 23 kinds of vegetables for over two years with 60% increase in yield and 90% marketable quality with buyback tie-up for 70% of the crops. The buyers and sellers meet has become an every day affair. The associations and federations of the farmers assumed bargaining powers both for purchase of inputs as well as for sale of the produce. The site has become the training ground for the farmers of rest of the state.

Cluster approach

The cluster approach was adopted for operational conveniences and ensured better logistics. The consolidation of holdings was not done in the farm holding where the extent is too small and where there is lesser compatibility among the farmers. The cluster approach rendered support to collective marketing through mutual consultations and discussions. There were proactive farmers, active farmers and indifferent farmers in each cluster at the beginning of the project but their awareness level at the end of first crop harvest was satisfactory to accept the change in perception and mindset. There are eleven registered Precision Farmer's Associations. They used to meet regularly during the first week of every month to discuss about the markets and interact with buyers and input suppliers. The association is slowly getting empowered in as much as it acts as redressal mechanism for the problems of the farming.

Key teehnologies

Remote sensing technology

Making use of the GIS, the physiographic map, soil map and the land use map for Dharmapuri and Krishnagiri districts were developed. The remote sensing programme enabled the scientists to exactly locate the actual field to scale map its boundary. Two sites were selected for the observation viz., field at Periyammittahalli and a field at Thorapalli. The data on N, P, K, Ca, Mg, Mn, Fe and Cu availability was collected and variability for the field was assessed. This enabled the scientists to precisely recommend the required nutrient in accurate quantities to the root zone during critical phases of crop growth.

Chisel plough

The chisel plough technology ensured better aeration to root zone and effective drainage during rainy days. Further it helped the plants to develop root system with characteristic uniformity in pattern, architecture and biomass. The Chisel plough needs to be operated once in two years.

Hi-Tech community nursery

The seedlings were raised in portrays under net houses with insect proof netting making use of EC and pH adjusted coco peat media treated with pseudomonas. The seedlings producced were uniform with similar physical and physiological maturity there by ensuring 100 per cent field stand and productive plants. The root mass was on the outer surface of root ball and hence there was no causality. The cabbage and cauliflower seedlings were extremely sensitive to media, pH and EC while chilli hybrid seedlings were hardy.

Drip and fertigation system

Drip and fertigation system implemented through this project ensured water economy, precise application of water-soluble fertilizers to root zone and an ideal moisture regime of 60%. In conventional system, immediately after irrigation, the air gradient of soil becomes zero and moisture gradient becomes 100 per cent. Before irrigation the gradients are reversed thus exerting stress over the root zone. In fertigated fields, the moisture regime was 60% with air gradient 40% and the growth became unchecked till harvest.

Growing crops and growing with the crops

The field scientists stayed at villages and extended the technical support to the farmers through out the crop period. The growing with the crop has made all the difference.

Market support

The marketing scientists have taken the beneficiary farmers to market places like Cochin, Chennai, Bangalore, Safal and Coimbatore and sensitized them on the importance of minimal grading and sorting and timely delivery at the market. Further, the buyers from the market were taken to the project site and impressed them on the healthy, hi-tech production system, highlighted the best of the quality parameters and there by strengthened the supply chain.

The farmers were provided with plastic crates and trained sufficiently on grading and sorting to different markets. The marketing scientists also studied the market situations and flow of vegetables and guided the farmers to select crop and variety for cultivation during particular season, thus making the production market-led production in real sense.

Special features

Empowerment of Farmers and Farmers' Forum

The beneficiary farmers' were organized under various commodity forums *viz.*, Adhiyaman Precision Farmers' Forum, Dharmapuri, Rajaji Precision Farmers' Forum, Krishnagiri etc. There are eleven such associations at present. The organizations were registered under Societies Act and they were imparted skills to develop awareness on the latest state of art technologies. The forum has helped them to buy the inputs directly from the manufacturers cutting the cost down to minimum and strengthened their bargaining power while selling their produce.

Insurance cover

The tomato growers feared most the hails storm during summer and theft of coils in the motors of the drip system. The Farmers' forum and the United India Assurance officials meeting were organized and eventually, the insurance cover was extended to the crop with a low premium of 4 per cent.

Market tie-ups

Market tie ups for the crops raised are being negotiated between the Farmer's forum and the buyers like M/s. Planct Pickles, M/s. Green Global Company, M/s Rasi Seeds, M/s Magritta Exports etc. The buyers are now frequenting the production site for tie-up for purchase of vegetables, since the quality of the produce is always highest. The produce from precision farm excelled in quality and commanded a premium price in all the markets. Further M/s. International Food Staff Company and Agri Biotech (P) Ltd of Sri Lanka have discussed with Precision Farmers Association executives and the MoU for forward contract for vegetables for export is in progress. Safal market has rated the banana from the precision farming site as super quality, a new grade status. Dole, Barti Telecom, and Reliance Fresh are now negotiating with the associations for buyback tie-up.

Reduction in pesticide usage

The farmers are now aware of the intricacies of pesticide quality, the dosage, the time of spray and method of preparation. The practice of going for 16 rounds of combination sprays have been avoided and judicious combination has been put into practice. The drip and fertigation technology always maintain a dry soil for a depth of 3 cm and this helps to reduce the weed growth and spore multiplication.

Promotion of brand value

The Precision Farmers' Association has developed a 'logo' and brand of their own and in each crate the logo was pasted. The logo is now gaining popularity with the buyers offering higher rate for crates with such logo.

Farmers' Corporate

The corporates have four virtues with which they are successful. They are,

Quantity : The corporates have the capability to honor any order of high volume

Quality : They are able to cultivate professionally thereby the physical and nutritive qualities are ensured.

Uniformity : The first lot and the last lots are strikingly uniform.

Timely delivery : They are able to deliver in time

These virtues are inculcated in the minds of the farmers and the Farmer's Forum is now gaining the corporate qualities and thus becoming a Farmers' Corporate, a new model to emulate in countries like India where holdings are too fragmented and empowerment of Farmers' Forum is the only way.

Farm documentation and record maintenance

Each farmer has been maintaining a weekly DMS to record all the activities of the week, including inputs used and the harvests made. This record also helps to work out the economics of production and arrive at cost-benefit ratio. The newer laws in EU demand traceability, which is essentially through maintenance of records at farm level. The records were signed both by scientists and the farmers and are a foolproof document to ensure food safety in long run.

Impact analysis

Economic impact: The study was made between the TNPFP farmer and a non-project farmer. The gross income of crops for project farmers ranged from Rs. 1,20,000 to Rs. 5,00,000/ha. Among the 13 crops cultivated under TNPFP in Krishnagiri district, the highest gross income obtained was in Chrysanthemum (Rs. 5,00,000 lakh/ha) followed by marigold. Among the vegetables, paprika (bajji chilli) has given the highest gross income of Rs. 2,92,500/ha. In all the crops, the percent increase in net returns was positive and it ranged from 43 to 221% among the crops grown. Among the different crops, though the % increase in net returns was the highest (221%) in cucumber, the net income realized was lower than other crops. In general, the profit margin was higher in all the crops under TNPFP. This was achieved by increased yield and reduced labour cost particularly for irrigation and weed management. Besides higher yields, improvement in quality of the produce was also visualized. For example in cabbage, the produce fetched premium price in the market than the conventionally grown cabbages because of medium sized heads with more compactness. Similarly in Goldenrod, the stalk length was extraordinary with increased brightness in colour, which led to more market preference. This has brought the buyers to make beeline to the project site for buyback tie- up.

Expansion of drip system: The precision farmers and neighbors, and farmers from rest of the state who have visited the fields have invested on their own to expand the area with their own investment to the extent of 30%. Further the TNAU will take up this programme to 1120 ha during 2007-08 with funding support from NHM and micro irrigation project.

Resolving indebtness: Indebtness is a traditional illness of farming community. Irrespective of the category of farmer either marginal, small medium or big, every one suffered by this illness. They could not resolve their long-pending debts. But a hand-full of farmers were able to resolve their indebt ness through the income realized from crop cultivation under precision farming system. Now they are relieved, breath freely and economically equipped them at least to proceed for subsequent cropping.

Improvement in life-Style: Lot many changes have been visualized in their life-style. In this juncture, a small share of the money obtained by this project was utilized for personnel development. Purchase of motorcycles, TV, VCD, and other consumer durables has been witnessed. The farmers are economically prepared enough to change themselves according to the changing modem life. Besides they also started to have better, nutritious food items, dressing mannerism etc. In nut-shell, TNPFP helped a lot to lead a decent life of modern era.

Post-harvest management: TNPFP has also sensitized the farmers on post-harvest operation like sorting, grading, packing and marketing. They realized better market prices for their quality produce from TNPF system because of their quality consciousness. Hence now they have switched over from ordinary packing to quality packing, use of gunny bags to use of plastic crates. The plastic crates used are red in color with their own logo "green triangle and tomato inside". The traders offered higher prices for the products with this logo and the farmers were able to understand and appreciate the brand image.

Dharmapuri Precision Farmers Agro services Ltd.

Precision farmers association at Dharmapuri has established its own agro service dealership for seeds fertilizer, pesticides etc., In future, it can procure and distribute better inputs in required quantities at required time at reasonable prices with a good margin to the concerned association member farmers. The firm was incorporated under company's Act and started functioning from 01.02.07. It is a total empowerment of the farmers to become entrepreneurs.

Scale up

The farmers had 60% enhanced yield in almost all the crops, market tie-up for the produce, insurance coverage, banking support, and above all, the produces are gaining the status in all the markets with exceptional quality. The State Government has scaled up the programme in seven more districts in 700 ha. The State government has agreed in principle to scale up the programme in 1110ha for field crops, 150ha of banana and 30,000ha in sugarcane. The World Bank has sanctioned a project in the name of "Irrigated Agricultural Modernization and Water Resources Management" with inbuilt precision system based on the success of the TNPF project with a budget of Rs. 2500 million for TN State and TNAU will operate the precision farming system in all river basins covering 60,000 ha.

Production and marketing of zingiberaceous spices

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Introduction

India has been a traditional producer, consumer and exporter of spices. Almost all states in the country produce one or other spices. With variety of spices in its production list, almost one third of the world demand is being met by Indian exports. About 9% of total spices production in the country was exported to earn foreign exchange worth Rs.357575 lakhs in 2006-07 (Table 1). Ginger, turmeric and cardamom are the major zingiberaceous spices constituting around 30% of the total spices production in the country. Ginger and turmeric together constitute more than 15% of the total spice exports from India in terms of quantity, while the country has lost its supremacy in cardamom export to Guatemala.

The SWOT (Strength-Weakness-Opportunities-Threat) analysis of Indian spice industry in general and zingiberaceous spices in particular indicates an exciting but a challenging future for India to remain as a major player of the spices trade at global level. Rich genetic resources, the research attainments through agro-technology development and diverse agro climatic zones conducive to these spices are our strengths. Lack of high degree of host resistance to biotic and abiotic stress, lack of infrastructure facilities for production of quality planting materials and inadequate extension network, are the weaknesses. Excellent scope for the value added product production and product diversification; development of entrepreneurs with developed technologies, which are commercially viable, and infrastructure and human resources development are the opportunities. High cost of production, crop loss due to severe disease and pest incidence, weather aberrations, non-availability of quality planting materials and price instability are some of the threats.

Decadal development in production

The effort taken by the government through research and development agencies has resulted in increased production of zingiberaceous spices in the country. Production has increased from 1170200 tons to 3817900 tons recording nearly 268% increase between the periods of 1980-81 to 2004-05 (Table 2). This historical change in production was achieved due to change in area expansion (36%) and yield (97%). However, in the case of ginger and turmeric, per cent change in area expansion is more pronounced than the productivity increase, while productivity increase played major role in the case of cardamom.

Table 1. Production and export of zingiberaceous spices in India

Crop/ Product	Production (2004-05)				Export (2006-07)		Share in Total Export		Export as per cent of
	Area	Prodn.	Yield	% in	Qty.	Value	Qty.	Value	produc
	('000 Ha)	('000 MT)	(Kg/ Ha)	Total	(M.T)	(Rs. Lakhs)	(%)	(%)	-tion
Cardamom	95.48	16.6	174	0.4	650	2236	0.2	0.6	3.9
Ginger	100.27	397.99	3969	10.4	7500	3975	2.0	1.1	1.9
Turmeric	161.23	716.84	4446	18.8	51500	16480	13.8	4.6	7.2
Others	2214.8	2686.5	-	70.4	314100	334884	84.0	93.7	6.3
TOTAL	2571.77	3817.9	1485	100	373750	357575	100.0	100.0	9.1

(Source: DASD & Spices Board, Govt. of India)

Table 2. Historical changes in area, production and productivity (1980-81 to 2004-05)

Spice	Area ('000ha)			Production ('000 t)			Productivity (kg/ha)		
	1980-81	2004-05	% change	1980-81	2004-05	% change	1980-81	2004-05	% change
Cardamom(S)	94.0	65.8	-30.0	4.4	10.2	131.6	62	158	154.8
Cardamom(L)	25.7	29.7	15.7	4.0	6.4	60.0	195	152	-22.1
Ginger	40.5	100.3	147.9	82.4	398.0	382.8	2038	3969	94.7
Turmeric	101.5	161.2	58.8	216.9	716.8	230.5	2137	4446	108.0
Spices (all)	1513	2572	70.0	1170	3818	226.3	773.4	1485	92.0

Note: Estimated using the data from Spices Board & DASD, Calicut.

Pattern of growth

Based on the period-wise estimated annual compound growth rate (CAGR) in area expansion, production and productivity indicated that, the major zingiberaceous spices, ginger, turmeric and cardamom (small & large) in the country had a mixed trend of both area and productivity led growth in production since 1980-81 period indicating the impact of improved technology on production in this crop. However, cardamom (large) recorded a negative growth in productivity during the same period.

Economics

As far as the cost of cultivation is concerned (Table 3), the benefit cost ratio is nearly two in the case of cardamom (small), while it is around 1.5 for both ginger and turmeric. However, year-to-year fluctuation (high instability) in ginger and turmeric prices makes the crop more uneconomical and affects area allocation to the crop in subsequent years. The problem can be better understood from the fact that, farmers buy seed rhizomes (ginger and turmeric) for prices as high as Rs.25/kg at times but their harvested crop could fetch them only less than one fifth of this price. This fluctuating prospect had greater impact on production economics of the farming community.

Keeping the above points in mind, here in this article an effort is made to analyse the present status of the major zingiberaceous spices viz. ginger, turmeric, and cardamom in terms of their production and marketing in the country.

Table 3. Economics of cultivation

Spice	Yield	Net Income (Rs/ha)	Employment labour days	B : C ratio
Cardamom (s) (dry - kgs)	207	52694	206	1.91
Ginger (fresh - tons)	20	12388	333	1.46
Turmeric (dry - quintals)	28	50147	409	1.48

(Source: Indian Institute of Spices Research)

1. Cardamom

Cardamom, which was grown under the regulated shades of tropical evergreen rain forest, has become an important component crop in the cropping pattern in plantations (coffee - pepper) of the Western Ghats. Kerala, Karnataka and Tamil Nadu are the major cardamom (small) producing states in the country. North eastern states and West Bengal are the major large cardamom producing states in the country. Table 4 provides state-wise area and production of cardamom in the country.

Table 4. State-wise area, production and productivity of cardamom (small)

Year	Variable	Kerala		Karnataka		Tamil Nadu		India
		Actual	(%)	Actual	(%)	Actual	(%)	
1980-81	Area (ha)	56380	60.0	28220	30.0	9350	1.0	93950
	Production (t)	3100	70.5	1000	22.7	300		
	Productivity	54.98		28.22		32.09		
1990-91	Area (ha)	43826	53.7	31605	38.8	6123	7.5	81554
	Production (t)	3450	72.6	800	16.8	500	10.5	4750
	Productivity	78.72		25.31		81.66		58.24
2001-02	Area (ha)	41336	56.9	26258	36.1	5069	7.0	72663
	Production (t)	8380	73.7	2115	18.6	870	7.7	11365
	Productivity	272		102		238		210
2004-05	Area (ha)	41380	62.9	19500	29.6	4900	7.5	65780
	Production (t)	8620	84.6	1100	10.8	480	4.7	10190
	Productivity	215		56		92		158

(Source: Spices Board, Cochin)

Production

Trend : A perusal of the period-wise performance (1970-71 to 2000-01) indicates significant decline in production in years 1972-73, 1976-77, 1982-83, 1983-84, 1987-88 and 1996-97. Cardamom being a rain fed crop, climate exerted greater influence on production, and productivity. Severe drought that prevailed in certain years not only affected the yield during those years but also in the subsequent years. However, the crop registered positive growth rate both in production and productivity, even though there is a negative growth rate in area expansion. Kerala has increased its share up to 85% with 63% area under the crop, while the share of other producing states of Karnataka and Tamil Nadu both in area and production has gone down marginally.

Area : The time series data on area under cardamom from the year 1970-71 onwards can be grouped into three categories based on the observed trend:

1. 1970-71 to 1977-78 – Period of no change in the area under cardamom
2. 1978-79 to 1988-89 – Period of increasing trend and
3. 1989-90 to 2000-01 – Period of decline.

Area under the crop remained unchanged during the first period for about eight years, though there were year-to-year fluctuations in production depending on the climatic changes. A sudden dip in area under cardamom during 1989-90 was merely a correction (change) in existing statistical figures on record. In the third 'period of decline', though there was a marginal improvement during 1992-95, the area under the crop continues to be below average of 84818.39ha.

Production

Cardamom production in India is characterized by certain cyclical fluctuations in yield *i.e.*, after a continuous increase of production and productivity for two to three years, a trend of decline sets in and continues before climbing up again. The climatic variations occurring in a cyclical nature was responsible for this phenomenon. There were cyclical fluctuations during 1973-76, 1978-81 and 1985-87. The peaks were achieved after gradual increase for two to three years, and then there was a sudden dip. During 1990s, India's production had been showing a consistently increasing trend from 4250 tons in 1992-93 to 7900 tons in 1995-96, but declined to 7150 tons in 1997-98. The increasing trend in production set in from the crop year 1998-99 and the country has crossed the 10,000 tons mark in the year 2000-01. An all time record production of 11920 tons was achieved during the crop year 2002-03 and the production level is maintained despite changes in climatic factors.

Productivity

The yield level of around 34.65kgs/ha during 1970-71 has not shown much improvement till the end of 1980 except for occasional fluctuations towards higher side (up to 48 kgs/ha during 1979-80). However, productivity level has improved in 1990s to reach 218 kg/ha during 2002-03. Productivity registered during 2000-2001 is more than four times the productivity of 1980-81. The recorded productivity increase during 2000-01 is 416 % over the base year yield.

Constraints

Over the years, though productivity per unit area has gone up in all the states, Kerala the major producer registered comparatively better performance than the other two states. The level of productivity achieved is not high enough to score competitive advantage over Guatemala, where the productivity is more than 1000 kgs/ha. The attributed major constraints of production of cardamom India are

1. Recurring climatic vagaries, especially drought in the absence of irrigation practice.
2. Absence of regular replanting activities – Under the mixed cropping system farmer is happy with the additional income from the aged cardamom plants, where as replanting with improved high yielding varieties would have given better yield.
3. Deforestation and resultant changes in the ecological conditions prevailing in the growing area – leading to conversion of cardamom land to other competing remunerative crops.
4. Lack of eagerness among planters to adopt high production technologies – though better varieties and practically proved high production technologies (HPT) is available to enhance yield level up to 600 kg/ha.
5. Problems of pests and diseases
6. Remote location of plantations without proper link roads to reach input.
7. System of land tenure – does not allow long term planning for improvement by the actual producer who works on the land.

Marketing

An important aspect of the regulated domestic trade for cardamom (Fig. 1) is the existence of an efficient auction system, which ensures fair prices to the sellers, who take their produce to the auction centre. In the figure the thickness of the arrow indicates the major channel of distribution for the crop. There are at present 11 auction centers in India. Though the auction system is efficient, the quantity flowing through the auction centers is only about 70% of the total production. The reasons being: (1) Non availability of auction centers in growing regions, (2) Because of the fixed quantity (600 g/lot) of the sample size etc. makes auction sales is not profitable for lots less than 16 kgs.

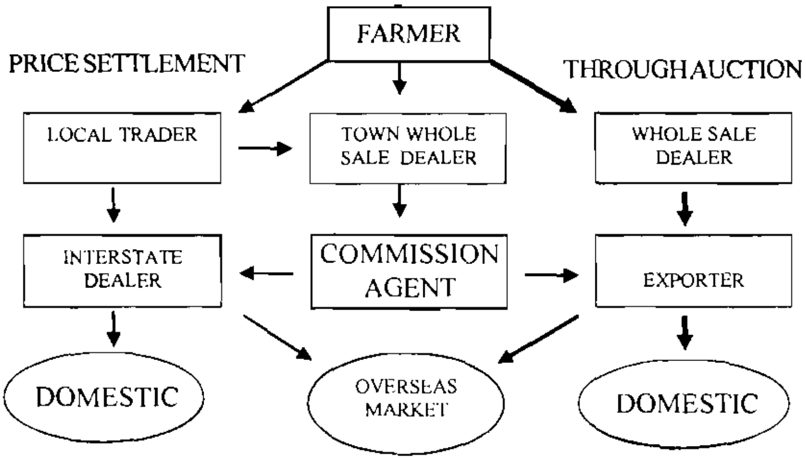

Fig. 1. Marketing system for cardamom in India

Price analysis

Prices often act as a guiding force in production decisions. Positive trend stimulates the farmer to invest more on the crop to get better yield. In the absence of long-term storage, producers and traders tend to clear their stock within the crop year, thereby ruling out speculations. Analysis of relationship between price, lot size and quality reveals that, during the peak season, quality (68%) explains the price variation across different lots and the changes in lot size explain the price variation during the slack season.

Further, there is a cyclical fluctuation of prices, which seems to occur in the following manner: prices remain stable or tend to increase during a certain period followed by a sharp fall. They remain low for the next few years, then start moving up and continue to increase or remain stable for another period; the process of decline and subsequent increase repeats itself. Period of this cycle is worked out to be around 11 years.

Price transmission

Earlier studies have indicated that, the export price leads the domestic price with a lag of about one-month. However, there exists an asymmetry, that a rise in the export price is not always paralleled by a corresponding increase in the domestic price, whereas a fall in the export price is transferred entirely to the domestic price. At times the domestic (wholesale) price used to be more than the export prices, indicate the strong domestic market. An analysis of trends in auction, wholesale and f.o.b. prices of cardamom and price transmission from one level to other during the period from 1971-72 to 1997-98 indicated that, a rupee change in export price is estimated to have given rise to 0.88-rupee change in farm prices, a rupee change in export price is estimated to have give rise to 1.00 rupee change in wholesale price and finally a rupee change in wholesale price has given rise to 0.83 rupee change in farm price.

2. Ginger

India has the enviable position of World's largest producer and consumer of ginger. Ginger production during the crop year 2004-05 was around 397990 tons from 100270 hectares. Though ginger is produced in almost all the states, the major producers of ginger are Kerala, Orissa, Meghalaya, West Bengal etc. State-wise area production and productivity of ginger in the country reveals that, Kerala has the maximum share in both area (18.8%) and production (19%) in the country. Meghalaya with only 8.4% of the total area under the crop produces 18.6% of the total production mainly because of the high productivity (7490 kg/ha). However, the maximum yield per unit area of 8803 kg/ha achieved by Mizoram, which is more than two times that of national average (3391 kg/ha).

Production

Growth in area, production and productivity

Period-wise estimated compound growth rates for area, production, and yield of ginger in major producing states of the country is given in Table 5. In the first period, there was a moderate productivity led production growth in most states except in Andhra Pradesh, Kerala, Sikkim, Madhya Pradesh and Karnataka. Positive growth rate of 4.7% in production was recorded by the country as a whole. During the second period, states like Himachal Pradesh, Sikkim and Orissa entered into productivity led high growth, while Mizoram and Arunachal Pradesh maintained high growth in production through area expansion. Karnataka also joined the group of high growth states by bringing more area under the crop. Implementation of Technology Mission for Horticulture (TMH) and incentive for ginger cultivation under the scheme may be one of the reasons for better performance of some of the north-eastern states. The overall growth rate (5.4%) in the country also crossed high growth rate mark mainly due to area expansion. Sikkim and Himachal Pradesh are the two states to achieve productivity led higher growth rate in production. Another matter of concern observed is, except the eastern and north-eastern states, all other states have recorded either negative or low growth rate in productivity during the second period. Earlier analysis also indicated that, 1980 to 1995 productivity played major role in enhancing ginger production in the country, while in the later period from 1995 onwards area expansion was the deciding factor in increased production.

Table 5. State-wise CAGR (%) in area, production, and yield of ginger

State	Period-I (1985/86 -1994/95)			Period-II (1995/96 - 2004/05)		
	Area	Production	Yield	Area	Production	Yield
Kerala	-2.5	-0.4	2.2	-5.3	-3.8	1.6
Meghalaya	2.6	7.0	4.3	2.6	1.0	-1.6
Orissa	6.7	4.2	-2.4	4.0	7.9	3.8
Sikkim	6.4	-9.2	-14.6	6.6	37.0	30.6
West Bengal	4.2	6.2	1.8	0.8	0.8	0.0
Mizoram	5.8	0.3	6.5	7.6	7.9	0.3
Andhra Pradesh	-4.4	-1.2	3.4	-1.5	-3.5	-1.8
Arunachal Pradesh	18.4	21.3	2.4	4.7	5.1	0.3
Tamil Nadu	-7.1	47.1	58.1	-4.0	-8.9	-5.1
Madhya Pradesh	-1.5	-0.9	-0.6	5.5	3.0	-2.4
Karnataka	-2.3	-2.3	0.0	14.2	15.7	-0.1
Tripura	5.0	14.9	9.4	4.6	3.6	-1.0
Himachal Pradesh	-5.2	5.0	10.8	5.7	49.4	39.9
Others	8.7	16.8	7.5	9.2	9.7	0.5
India (total)	*1.9*	*4.7*	*2.8*	*3.7*	*5.1*	*1.4*

One of the important dimensions of ginger industry in India is the considerable variance in production, a measure of instability. Increased instability in yield and/or area, which has the bearing on production instability, could be caused by host of factors including agricultural policies, occurrence of natural calamities like flood, drought, and introduction of improved varieties etc. In the foregoing analysis it was observed that, except the few traditional ginger producing states, others behaved differently in two periods. The second period starts from the year of liberalized world trade under WTO. Ginger, being an export oriented crop, international price had an impact on the domestic price and consequent production variance in states like Kerala. Price, the major deciding factor for area allocation in subsequent years had an overall growth rate of around 10% for both wet and dry ginger. However, the estimated coefficient of variation (cv) of 68% for dry ginger and 63% for wet ginger indicates the extent of year to year fluctuation in prices. Promotional programmes under the central government sponsored 'Technology Mission for Horticultural' in north eastern states might have served as catalyst for growth in ginger production in the region.

Marketing

Ginger is marketed both as fresh and dry. The commonly followed marketing channels for ginger in the country to feed the domestic and export market are:

1. Producer → Village merchant →Commission agent → Consumer
2. Producer → Village merchant → Commission agent → Wholesaler (assembly market) → Wholesaler/Commission agent (consumption centre) → Consumer

Regarding farm gate prices and producer share in consumer price, various studies revealed that, around 45-64% of the consumer price received by the producer depending on the channel followed and product marketed.

3. Turmeric

Turmeric of commerce is the cured and dried rhizome or underground stem. For commercial exploitation, it is grown as an annual crop both under rain fed and irrigated condition in many parts of the country. It is one of the most important spices used extensively by all classes of people in India. Besides, it is one of the most ancient and traditional spices of export for this county.

India has monopoly in production and export of this major zingiberaceous spice in the world, but the production of this crop has been highly unstable. In 1950-51 India produced 152,000 tons of turmeric from an area of 56,000 ha. The average productivity for that year was 2764 kg/ha and that was the record average productivity for turmeric in the country so far. The main turmeric growing areas in India are distributed in the states of Andhra Pradesh, Orissa, Tamil Nadu, Maharashtra, Assam, Bihar, and

Kerala. Andhra Pradesh, the largest turmeric producing state in the country producing more than 50% of the production in the recent past (Table 6). The average productivity per hectare was highest in Tamil Nadu 5834 kg/ha during 1998-99. The State could maintain its position from the beginning. Andhra Pradesh could improve its productivity in the recent past with 5183 kg/ha during the same period to achieve the second position pushing back Karnataka. The national productivity also showed an improvement.

Table 6. State-wise area, production and yield of turmeric in India

(Area (ha), Production (mt), Yield (kg/ha)

State	1980-81 to 1984-85		1990-91 to 1994-95		2000-01 to 2002-03		
	Area	Prodn	Area	Prodn	Area	Prdn.	Yield
Andhra Pradesh	23767	74333	51240	241880	67700	375100	5541
Arunachal Pradesh	133	333	320	960	550	2000	3636
Assam	8367	5133	8580	5540	11700	8100	692
Bihar	4233	6533	3040	3740	3000	3000	1000
Karnataka	2300	9333	4280	50136	8000	38300	4788
Kerala	3100	5600	3080	5780	4100	9000	2195
Madhya Pradesh	400	367	680	1820	350	350	1000
Maharashtra	8200	12867	6840	8660	7000	9000	1286
Meghalaya	1167	1700	1340	1800	1500	8600	5733
Orissa	25867	32867	24580	51000	26350	56600	2148
Rajasthan	133	400	160	500	150	500	3333
Tamil Nadu	8867	56267	15260	85840	28300	138450	4892
Tripura	1033	1567	1500	3580	1450	6400	4414
Uttar Pradesh	633	733	920	1520	1100	1900	1727
West Bengal	2850	7350	10680	20020	13350	22200	1663
India	*94167*	*214933*	*133460*	*490540*	*175190*	*635950*	*3630*

The crop statistics reveal that between 1960-61 and 1980-81 the area and production of turmeric went up by 151 per cent and 100 per cent respectively, while its productivity came down by 20 per cent. The year 1979-80 was the peak year for Indian turmeric both in respect of area (105,000 ha) and production (235,000 tons), but not in productivity in the past. However, in recent years the country has achieved the record production of 7168 tons during the crop year 2004-05. However, the record productivity of 4734 kg/ha achieved during 1999-2000 against the present level of 4446kg/ha.

Production

Production of turmeric in India has been showing a steady increasing trend during the past two decades to reach 527.460 thousand tons during 2002-03 from 191.3 thousand tons in 1981-82. An increase of nearly 250% in production is due to improvement in both area (49.30%) and productivity (97.25%)

State-wise average area, production and productivity for the periods 1980-81 to 1984-85, 1985-86 to 1989-90, 1990-91 to 1994-95 and 1995-96 to 1999-2000 are given in Table 7. As it can be seen from the table, against the national average yield of around 2.28t/ha achieved during 1980-81 to 1984-85, states like Andhra Pradesh, Karnataka and Tamil Nadu have been consistently recording a higher level of yield. Tamil Nadu achieved maximum productivity level of 6.35t/ha during the period and has maintained the productivity along with increase in area during the subsequent periods.

Productivity

Productivity of turmeric in the country has increased over the years from 1.871 t/ha during 1970-71 to 3.534t/ha during 2002-03. Productivity registered during 2002-03 is nearly two times the productivity level in 1970-71. There was a steady improvement in productivity till the middle of 1980's except for occasional fluctuations towards the lower side during 1976-77 and 1977-78. It seems that the yield increase (79.53%) during this period does contributed much to the increase in production (143.76%).

Growth estimates

The estimated annual compound growth rate indicates that the area under turmeric registered an average annual growth rate of 2.91% for the period from 1980-81 to 2002-03. Growth in production was at the rate of 5.36% during the same period indicating a slight improvement in productivity, which was around 2.38% for the period. However, there was a negative growth rate in area and production during 2000-01 to 2002-03 reflecting the better performance of major producing states.

In Andhra Pradesh, the situation is almost similar to the national scenario. In the case of Tamil Nadu the other major producing state, increase in production during the IIIrd period was largely due to area expansion. The role of productivity is negative. Change in production, area and yield was negative during the second period alone in Kerala and first and second in the case of Maharashtra.

Table 7. Change in Turmeric production, area and the relative contribution of changes in area and yield for selected periods

State	1980-81/1984-85 to1985-86/1989-90	1985-86/1989-90 to1990-91/1994-95	1990-91/1994-95 to1995-96/1999-00
All India: *Change in:*			
Production	71.41	43.20	10.06
Area	22.72	17.66	11.59
Productivity	38.66	20.58	0.45
Change in production due to change in:			
Area	39.49	45.30	114.44
Productivity	65.12	86.91	2430.71
Andhra Pradesh: *Change in:*			
Production	83.73	113.38	11.90
Area	60.41	42.03	13.62
Productivity	17.25	44.86	0.57
Change in production due to change in:			
Area	77.69	46.30	113.58
Productivity	296.93	94.69	2262.69
Tamil Nadu: *Change in:*			
Production	57.33	10.36	22.49
Area	37.03	6.47	29.33
Productivity	17.05	0.66	-1.22
Change in production due to change in:			
Area	69.52	63.54	126.79
Productivity	200.07	949.01	-2090.54
Kerala: *Change in:*			
Production	19.71	-7.23	47.62
Arca	10.34	-2.34	20.00
Productivity	8.55	-4.03	21.63
Change in production due to change in:			
Area	54.71	31.61	46.81
Productivity	120.03	57.61	93.11

Note: Based on time-series data from Spices Board, India, Cochin, Kerala

Marketing

Products of commerce

Primary products of turmeric traded in the world market are dried rhizome, turmeric powder, oils & oleoresin. Further, turmeric powder is an essential and integral part of the various types of curry powder mix traded. Dried rhizomes are the major form in which turmeric is internationally traded. Dried turmeric is used directly as a spice and also for the preparation of its extractives, turmeric oleoresin and turmeric oil.

Market structure

The prevailing marketing channel for turmeric in India looks like the one given in fig 2, with slight variation between the regions. To begin with, farmers, sell off their produce to commission agents/ village traders who collect the produce either at farm gate or nearby market place. Thus collected produce in the assembly market in the taluk/block level is transported to the regional/district level main marketing centres. Farmers having a large production base often take their produce to local and/or regional markets directly. From the regional markets it is moved to terminal/distribution markets like Cochin, Chennai, Mumbai, Bangalore, Calcutta and New Delhi. Table 8 provides the list of major markets (assembling/distribution) for turmeric in each producing states.

Turmeric cultivators of Mysore area in Karnataka take production advance from the commission agent/ wholesalers from Erode regulated market with an agreement to sell them on harvest. Maximum of 80% of the produce marketed through the identified channel of 'Producer → Commission Agent → Erode APMC market', where the producer gets 81.38% of the wholesale price at Erode market and 52% of the price of consumer's price for the processed end product (turmeric powder). Turmeric from Mysore area starts arriving from middle of January and continues up to April followed by arrival of local harvest. Thus, Erode regulated market for turmeric functions through out the year. The market also receives nearly 35% of the total estimated market arrivals in the country.

Markets in Andhra Pradesh collect and distribute more than 50% of market arrivals in the country. At Duggirala regulated market the estimated price spread indicates that, the grower gets 56.36% of the consumer's price. Sangli market in Maharashtra is the only futures market in India exclusively for turmeric. Bombay, Cochin, Chennai, and Tuticorin are the major ports in order of quantity exported through them.

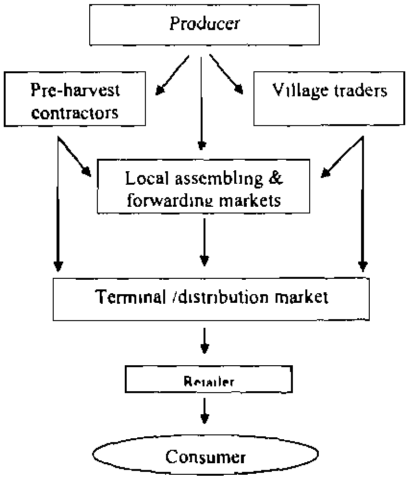

Fig. 2. Commodity distribution system for turmeric in India

Price analysis

There has been an overall rising trend in the unit value realization from turmeric, even though the year-to-year variation is found to be very wide. During the period 1976-77 to 1980-81, the unit value averaged at Rs.7.00/kg when compared to the current price (Rs.14.00/kg), which is almost equal to the lowest recorded price of Rs.15.92/kg in 1994-95 in the recent past. This drastic fall in price has affected the crop prospects. Analysis of time series data on whole-sale prices in various markets indicated the existence of both long and short term cycles in turmeric prices. While business cycle for turmeric price in Erode wholesale market was estimated five years, analysis of price data for Alleppey turmeric in Cochin market revealed the existence of six years cycle. In Andhra Pradesh, a peak in price was estimated once in every eight years.

Table 8. Important assembling and distributing/terminal markets for turmeric

State	Assembling market	Terminal/ Distribution market
Andhra Pradesh	Duggirala, Cuddapah, Nizamabad, Rajamundry, Vijayawada, Kodur, Tenali	Hyderabad
Maharashtra	Bombay, Sangli, Karad, Poona, Tekkari, Kolhapur, Tasgaon, Nagpur	Bombay, Sangli
Tamil Nadu	Mettupalayam, Erode, Salem, Coimbatore, Karur, Tiruchirapally, Madras, Madurai	Chennai, Erode, Madurai
Orissa	Berhampur, Parlekimedi, Tikkabali	
Kerala	Cochin, Calicut, Alleppey, Telicherry, Muvattupuzha, Kalpetta, Baliapattam, Thodupuzha, Wayanad, Koduvally, Kodencherry, Badagara, Taliparamba	Cochin, Calicut, Alleppey, Tellicherry
	Other distribution/terminal market	Bangalore, Amritsar, Calcutta, Kanpur

Seasonal index

Analysis of monthly prices in major turmeric markets for seasonality is presented in Table 9. The monthly average index value indicates by how many percentage points each month's value lies above or below the average (100%) for the period as a whole. Seasonal index below 100 was observed during the months of June to September in Cochin market and February to June in Erode market indicating the low price prevailed during the period. An interesting observation is that, the price in Cochin market alone was ruling high during the harvesting season. This is because of the storage /holding behaviour of the farmer. Since turmeric is a storable commodity, farmers can sell their produce when the prices are ruling high. Thus, as it can be seen from the chi-square value given in the table, there exists a strong seasonality in all the markets.

Market integration

In order to measure the relative influence of past market price on present local market price, Timmer's Index of Market Connection (IMC) was estimated. The analysis indicates that, most markets in Andhra Pradesh are integrated with Chennai rather than with Mumbai. Further, prices at Cochin and Mumbai had effect on Chennai market. This may be because of the fact that part of the produce move to these major port cities for export.

Table 9. Estimated seasonal index for turmeric wholesale price in major markets

Month	Market					
	Cochin	Erode	Mumbai	Sangli	Duggirala	Cuddapah
January	104.75	104.19	96.9	61.54	98.41	98.74
February	100.98	99.32	96.19	76.92	97.88	93.74
March	100.56	94.97	99	92.31	92.7	97.95
April	100.79	96.75	99.88	107.69	98.57	96.06
May	99.42	93.69	96.69	123.08	95.79	94.59
June	96.62	93.76	101.81	138.46	102.47	98.85
July	95.47	99.98	101.21	153.85	100.87	105.83
August	96.53	105.54	102.3	169.23	99.54	104.76
September	98.49	105.59	102.71	184.62	103.29	101.83
October	100.08	104.12	98.56	15.38	102.09	103.22
November	102.79	104.31	101.62	30.77	104.36	103.1
December	103.52	104.87	98.91	46.15	101.21	101.16
Chi-square	*91.24*	*248.19*	*58.08*	*33848.31*	*124.26*	*172.43*

Conclusion

The gap between the yield level obtained at experimental and demonstration farms and the achieved average yield in the country indicates the vast potential to be tapped by the country to increase the production level in ginger and turmeric. The domestic market is one of the biggest in the world market providing cushion to fluctuating prices, which depends on international price to a large extent. WTO accord has brought producers in different countries for the same commodity to compete with each other. The country has to increase the yield levels especially in the case of ginger making use of the available High Production Technologies (HPT), lest they will be out of the world market. Selection of suitable varieties also play a major role, as the consumer in the changing market oriented economy is selective in making his purchase decision. In the export front, there is an increasing demand for value added spices. So, the country can make use of the opportunity to export valuc added products instead of exporting bulk raw spices. The demand for natural colour and seasoning/flavouring agents are also likely to have a surge in export of spices especially in the light of demand for Indian culinary specialties in Europe, USA and the Far East. In all, the following points of strategy are recommended:

- Diversification of product range and development of new range of products
- Shift from commodity marketing to value added products
- Achieving cost competitiveness both in production and pricing
- Reinforcing existing markets and exploring new markets
- Shortening the distribution channels for both processed and raw spices
- new consumer oriented products and packaging in tune with market needs
- Enhancing quality capabilities and promotion of brands at retail level

Finally to conclude, 'quality and value addition' should bc the bottom line in the spices production and marketing to sustain production and profitability.

Research extension farmer linkages in technology transfer

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Introduction

The direct linkages of research institutions with line extension functionaries and farmers are essential to facilitate transfer of technology pertaining to research findings to the farming community. The two main research institutions engaged in research on Zingiberaceous crops in Kerala have clear mandate to fulfill the functions of technology dissemination to the farming community. Functions are performed as clear-cut technical progarmmes by these institutions to foster functional linkages with state extension machineries, NGOs and farming community per se. In this article, an attempt is made to iterate the technology dissemination functions of two research institutes; Indian Institute of Spices Research, Calicut and Indian Cardamom Research Institute, Myladumpara.

Indian Institute of Spices Research

The mandate of the institute lay down the following pertaining to extension functions

- To act as a centre for training in research methodology and technology up gradation of spices and to coordinate national research projects.
- To monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of farming community.
- To serve as a national centre for storage, retrieval and dissemination of technological information on spices.

The concept

The technology dissemination functions of the institute are performed through the schemes of Agricultural Technology Information Centre (ATIC) and Krishi Vigyan Kendra (KVK).

The motto of ATIC is to facilitate services that provide timely access for all stakeholders to information, inputs and products with the ultimate objective of field application to achieve enhanced productivity and quality of cultivated spice crops. The specific objectives of the centre are:

- To provide a single window delivery system for services, information, inputs and products to farmers and spice industry.

- To facilitate direct access to the farmers to the institutional facilities and resources available in terms of high production technology, nursery management for production of quality planting material, crop diagnosis and management of pests and diseases and post harvest technology on spices.

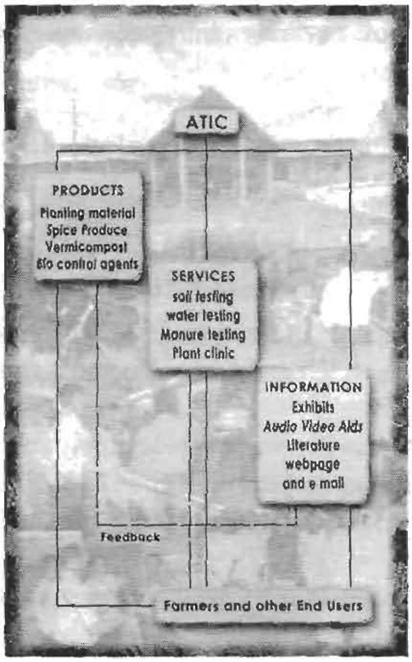
- Monitoring and evaluation of information disseminated from the feed back obtained from farmers as a means of technology assessment and to serve as a link between the research institute and the farmers.

The functions of the centre as per the above outlined objectives are

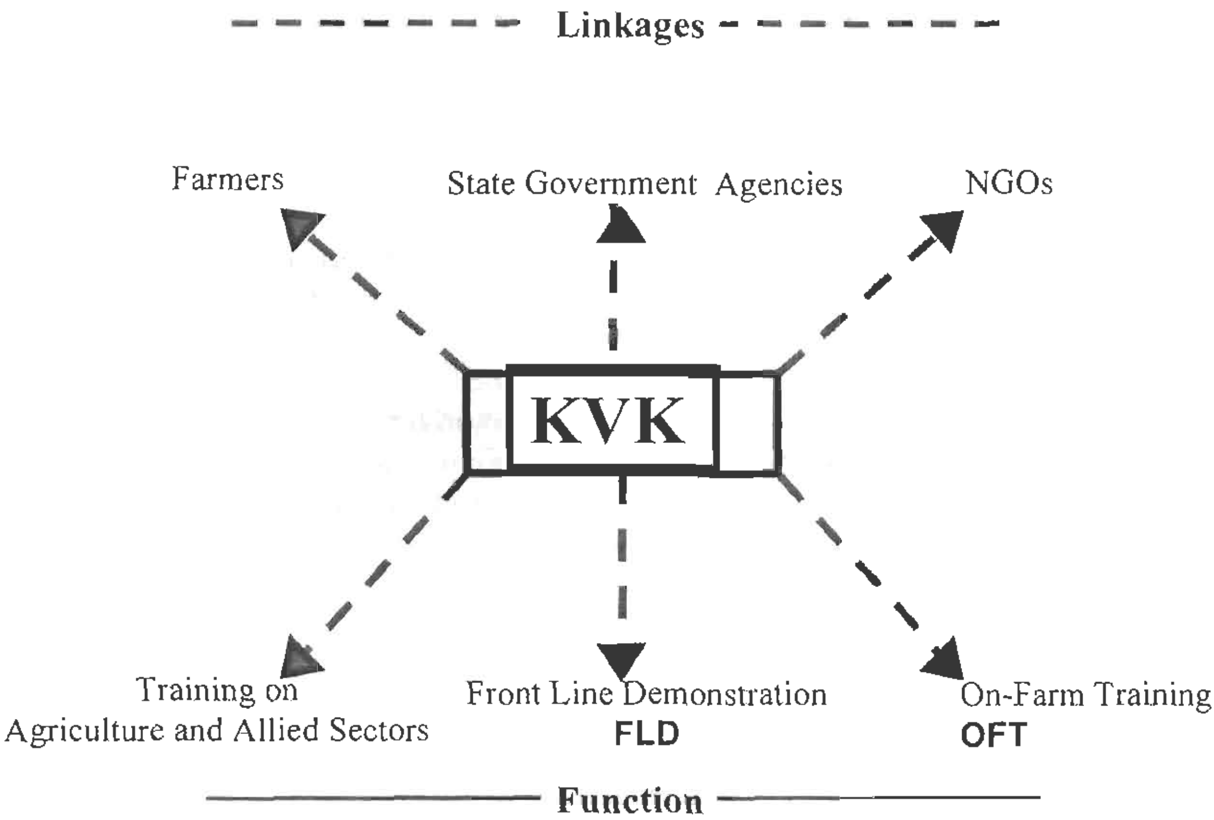
- Monitoring production and distribution of quality planting material
- Monitoring production and distribution of printed literature
- Providing and facilitating farm advisory services including crop diagnostic services
- Organising information dissemination through multimedia, video and interactive databases
- Monitoring audio visual aid support to the institute activities
- Organising technology dissemination services like exhibitions, seminars to farmers and other users.

The Krishi Vigyan Kendra is a scheme of ICAR that essentially provides training on agriculture and allied subjects to practicing farmers, extension agents and farm women.

ATIC Operational Model



KVK Operational Model



Technical programme

The ATIC and Krishi Vigyan Kendra work in Tandem with research divisions and out side extension agencies to organize various farmer oriented extension services and training programmes to take the technologies to farmers.

Farmers' training programmes

Training programmes are regularly organized by the KVK for farmers on various aspects of cultivation of spices.

Front line demonstrations and on farm trials

Front line demonstrations on proven technologies and on-farm trials on frontier technologies which need validation in farmer's fields are carried out on a regular planned basis.

Farm advisory services

The ATIC at the main campus cum laboratory, experimental farm and KVK receive visiting farmers and provide advisory services to them free of cost. The institute also provides free of cost field visits to solve farmers field problems.

Large scale demonstration projects

Under the Large-scale demonstration programme the institute's high production technology on ginger, turmeric and cardamom are demonstrated in the farmer's field. Demonstrations are currently on in Guntur and Vijayawada in AP on "Prathibha" variety of turmeric in collaboration with the AP state department of horticulture. Also, varieties of ginger and turmeric have been popularized in Wai taluk of Satara district in Maharashtra with the help of supply of planting material, training of farmers and field visits. The demonstration on high production technology programmes on a campaign mode is in progress in cardamom growing tracts of south India under the Cardamom Research Centre at Appangala, Madikeri, Karnataka.

Impact and constraint analysis

Impact analysis was carried out to know the successful implementation of the institute's technology for control of *Phytophthora* foot rot disease in black pepper in Kerala.

Trainer's training programmes and training for extension functionaries

The institute is organizing regular and sponsored training programmes on various aspects of spices production technology to line extension functionaries of various states and NGOs.

Consultancies

The institute also offers consultancy services on a project mode to the needy clientele.

Mass extension contacts

The institute regularly participates in exhibitions, farmers seminars and krishi melas at local, district, state and national level.

Education through satellite linked video conferencing

The institute is identified as one of the expert centers under the RSVY-VSAT project of the Kerala State Planning Board where educational progarmmes through video conferencing are carried out on scheduled basis with identified village class rooms in Wynad district of Kerala.

Indian Cardamom Research Institute

The primary mandate of Indian Cardamom Research Institute is to develop sustainable production, protection and post harvest technologies for small and large cardamom, vanilla, herbal spices etc. The activities of the institute have now been expanded to cover adaptive research programmes on other spices such as black pepper, ginger, turmeric, tree spices, chilli, paprika, seed spices and other minor spices.

Technology transfer programmes

These activities aim at bridging the gap between the scientists and farmers by transferring the achievements of the institute for application in the planters' field. This is mainly achieved through training programmes, conducting seminars, group discussions, exhibitions, organising spice clinics etc.

Training programmes on production protection and post harvest technology management of cardamom, vanilla and other important spices have been organized. Scientists of the institute serve as the resources personnel in seminars and planters meetings.

Spice clinic is an open house interaction between farmers and scientists to clarify the doubts of farmers. Exhibitions have been organized at various places to enlighten the farmers with the latest technologies developed by the research institute.

Protection of Plant Varieties and Farmers' Rights

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Introduction

With the signing of TRIPS agreement of the World Trade Organization (WTO), India has agreed to provide protection of plant varieties. Protection of plant varieties is legally introduced in our country by a legislation called Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FR Act). The Government of India, which enacted this legislation, states four reasons for introducing the PPV&FR Act.

1. To protect the intellectual property associated with the development of plant varieties in fulfillment of an agreement signed by India under the WTO.

2. To recognize the rights of farmers arising from their contribution in conserving, improving and making available plant genetic resources to develop new plant varieties.

3. To stimulate public and private investment in plant breeding to accelerate agricultural development.

4. To ensure high quality seed and planting material to farmers by promoting the seed industry.

The PPV&FR Act

The Act has a mandate all over India. The administrative apex body is the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FR Authority). The Authority came into force in November 2005. PPV&FR Authority comprise of a Chairperson and 14 ex-officio and nominated members. Members include representative of farmers, tribal people, women's organization and private seed industry. The PPV&FR Authority is responsible for implementation of this Act, including the grant of registration to plant varieties. The Act defines the farmer as a person cultivating crops or conserving and preserving traditional crop varieties or wild species of crops and selecting them for their useful properties. In other words, the Act recognizes the farmer as a cultivator, conserver and breeder.

Plant selection requires an intimate understanding of the behaviour of varieties and deep knowledge about its characters and properties. Such knowledge can only be gathered over the years. In the selection of every variety, there is an intellectual contribution from farmers. This intellectual process has been responsible for the evolution of every traditional or farmers' variety. Farmers' varieties are also eligible for protection under the PPV&FR Act.

The PPV&FR Act allows the registration of three types of plant varieties. These are farmers' varieties, extant varieties and new varieties. New varieties are those varieties newly developed by either scientist breeders or others including farmers.

Extant varieties are those Indian varieties bred by the public and private research system and officially released for cultivation by the State or Central Government and have not completed 15 years from the date of release. Extant varieties also include farmers' varieties and other varieties of common knowledge and in public domain. Farmers' varieties are those traditional varieties developed and conserved by farmers. This includes the landraces, folk varieties and wild species of crop plants, about which farmers possess useful knowledge. Most of these varieties are usually developed and conserved collectively by community of farmers rather than by individual farmers. Hence, the Act recognizes that varieties conserved by communities of farmers are also eligible for registration.

Other important features of the Act are the provisions with regard to (1) researchers' rights, (2) benefit sharing between breeders and farming or tribal communities who have contributed to the genetic diversity used by the breeder, and (3) the establishment of a national gene fund to promote conservation.

Plant Breeders' Right (PBR)

Legally valid ownership rights assigned to the creator of intellectual works are called Intellectual Property Rights (IPR). Intellectual creations are of different kinds: writing poetry or a novel, composing music, creating a work of art, inventing a new technology, discovering a new medicine, producing a new chemical, creating a market brand, etc. One or more individuals who create a new idea, process or product become eligible to establish IPR on their creations. It is an exclusive right given to the owners to commercialize their creation for economic gains. This right is transferable by sale, licensing or succession. This ownership, however, is not permanent, like the ownership on real estate, but is assigned only for a prescribed period. On completion of this period, the IPR becomes a public property with exclusive right to none.

IPR on plant variety means that the person who establishes the ownership right on the plant variety alone has the legal right to produce, store, process and market the seed of that variety for as many years as the ownership is valid. Ownership right is established on the basis of evidence that the person has contributed to the development and conservation of a variety. This right is called the Plant Breeder's Right (PBR). The PBR can be licensed, sold or inherited. Under the PPV&FR Act, PBR on a plant variety is established by registration of the variety. By registering a variety, a person becomes its PBR holder.

Breeders always develop new varieties by using available genetic diversity. The origin of this genetic diversity is from on-farm conservation and selection of many traditional or farmers' varieties.

Farmers' Rights (FR)

Farmer's rights are the traditional rights farmers have on the seeds or the propagating material of plant varieties. This right arises from the important role farmers have been playing to conserve and enrich varieties and the knowledge they hold on the total genetic variability of the country. Hence, the farmers' rights on seed is concerned with both the traditional varieties conserved by them and modern varieties bred by using traditional varieties. The importance of these rights from the conservation point of view becomes more compelling with the grant of PBR to breeders. Therefore, the PPV&FR Act safeguards farmers' rights on plant varieties, while simultaneously allowing PBR. This Act gives the traditional rights on the seed and other collateral rights arising from seed. The Act also allows their traditional rights on the seeds of all varieties, including the protected varieties, while PBR is allowed to breeders. Legal protection to this traditional right to save, re-sow, exchange, share or sell seeds is important to majority of Indian farmers and to Indian agriculture.

The farmers' right on seeds is a traditional right enjoyed by farmers all along the history of agriculture. This right includes the right to save the seed from one's crop and use the saved seed for sowing, exchanging, sharing or selling to other farmers. It is fundamental to the conservation role performed by farmers. The PPV&FR Act allows the registration of traditional varieties or farmers' varieties. Registration of the variety grants PBR on the variety, which allows exclusive legal right to the PBR-holding farmers to produce and market its seed. Farmers are awarded PBR by the Act on their recognition as breeders. Traditional varictics developed or conserved by a community of farmers and new varieties developed by one or more farmers are eligible for registration. In the case of registration of a traditional variety, it is important to involve all communities associated with its conservation. The Act also provides for equitable sharing of the benefit earned from the new variety with farming or tribal communities that had contributed varieties used as parents.

The primary purpose of registration of a plant variety under this Act is to establish exclusive commercial right on the varicty. Commercial demand arises from the capability of the variety for better agronomic performance. The PPV&FR Act has a provision to check such unfair marketing practices by breeders and their seed sellers. The Act requires that the seed be sold with a declaration on its agronomic performance and the cultivation conditions ensuring this performance.

Registration of plant varieties

The registration of a plant varicty under the PPV&FR Act is a legal process. This process establishes the PBR on the plant variety in favour of the applicant(s). PBR is thc legal ownership right granted on a plant variety similar to the legal ownership right on a property. PBR is inhcritable according to succession laws, transferable and also salable. The ownership right of PBR is not permanent, but only for a specified period. On completion of this period the ownership automatically lapses. Persons who have bred or conserved a variety or their assignees are eligible to register their variety. In the case of farmers, either the individual farmer or a group or community of farmers are eligible to register varieties. It is important that the applicant farmers should have reasonable ground to claim ownership on the variety either by its breeding or longer conservation.

The period of ownership or duration of PBR of a registered plant variety under the PPV&FR Act is short. This period is 18 years for varieties of perennial vines like grapes, black pepper, betel vine and trees like mango, orange, palm, apple, etc. For other annual crop plants like rice, wheat, sugarcane, potato, banana, ragi, brinjal, etc. the period is 15 years. However, the initial grant of registration is only for a period of 9 years in the case of trees and vines and 6 years for rest of the plants allowed under this Act.

The PPV&FR Act does not define the names of crops whose varieties are eligible for registration. According to the Act, the Government of India is empowered to decide and notify in the Government Gazette as to which crops are to be brought under the purview of this Act.
Only those varieties which satisfy the following requirements will be eligible for registration:

1. The variety should belong to the crops notified by the Government of India.

2. The variety must be distinct from all other existing varieties of that crop. This means that any person who is familiar with the crop should be able to distinguish it easily from all other known varieties of the crop. This may be possible only when the variety has at least one character, which distinguishes it from the rest.

3. The variety should be uniform. This means that plants grown from different seed lots of that variety should have very high similarity with respect to its characters.

4. The variety should be stable. This means that the characteristics of the variety should not change generation after generation.

There are two important steps for registration. In the first step, the applicant farmers have to fill up the variety registration application form. The applicant(s) can be one farmer, a group of farmers or a community of farmers, depending on their contribution to the candidate variety. When the applicant is a community of farmers, the community has to authorize in writing a few of its members as its representatives to file the application on its behalf. In the second step, the applicant farmer(s) should produce adequate quantity of good quality seed of the variety which the Authority may require for conducting the DUS (Distinctiveness, Uniformity and Stability) test. A variety registration application is required to provide all the characteristics of the variety, highlighting the characters that make the variety distinct from others. Information on the origin of the variety and its geographical location is also important.

Registration of farmers' varieties is free and costs nothing to register farmers' varieties. Moreover, renewal of registration of farmers' variety is also free. The primary purpose of registration of plant varieties is to establish the IPR of the breeder on the plant variety bred by him/her. This IPR is the basis of the PBR on the variety. The PPV&FR Act recognizes farmers as breeders for their profound and extensive contribution in developing and conserving so many varieties. Thus farmers are eligible for the PBR on their varieties. The PBR granted on farmers' varieties offers exclusive right to produce and market the seed of registered varieties. There are many farmers' varieties in several crops, which are popular and offer commercial opportunities for large-scale sale of seed and propagating material. Farmers themselves can exploit this market with the help of exclusive marketing right on the seed or license the PBR of the variety for a competitive licensing fee. Many farmers' varieties are notable for one or more special traits, which may have greater value in contemporary and future crop improvement. The PPV&FR Act provides for equitable share of benefit from new plant varieties, which were bred by using one or more farmers' varieties.

Although farmers have contributed to the development of hundreds of traditional varieties, they have not held these varieties as their property. What they own is the crop they raise within their farm and not the variety. These varieties were left in the public domain for free use by other farmers within and outside the country. With this freedom on varieties, farmers are more familiar with sharing seed on free or exchange basis or with occasional sale. Therefore, the paradigm of ownership on plant variety is totally new to them. As this ownership under PPV&FR Act is established by registration of plant variety, it is natural that the farmers should know why they should register varieties.

For claiming eligible benefit share, the farming communities should have timely information on the varieties being registered under the Act, timely understanding on the notification on such varieties, inviting claims for benefit sharing, and capability to understand the disclosed characteristics of the new variety vis--a-vis those of parental varieties. The capability of farmers in accessing this right can be strengthened by vigilant farmers' associations and panchayats by regularly following the notifications of the PPV&FR Authority. Assistance from governmental or non-governmental organizations may also help farmers in this regard.

Institutional credit support for zingiberaceous spices

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Introduction

India is the largest producer, consumer, and exporter of spices in the world. Indian spices are world famous and it brings the much needed foreign exchange. The share of spices in India's agricultural commodities export earning is substantial. Till the seventies, India had a virtual dominance in the international trade. During 2006-07, the export earnings was Rs. 3576 crores through the export of 3.74 lakh tons of various raw and value added spices. The value of spices produced in India is approximately Rs 36,800 cr. However in the post WTO era, our commodities face stiff competition in the international markets. There is an urgent need for creation/modernization of infrastructure facilities for processing, value addition, etc., in both private and public sectors to meet the stringent quality parameters. Institutional credit from banks is the critical link for such initiatives.

Among the zingiberaceous spices, small and large cardamom, ginger and turmeric are commercially cultivated with institutional credit support. Arrowroot is also being cultivated by some of the innovative farmers.

Small cardamom

The estimated area under cardamom was about 40 thousand hectares in the 1930's, increased to slightly over one lakh hectares by the beginning of 1980's and then started declining before crossing the one lakh hectare mark again in the early 1990's. Kerala (84.5%), Karnataka (10.7%) and Tamil Nadu (4.7%) are the major cardamom (small) producing states in the country. As per the information available with Spices Board, GoI, the new high yielding varieties have not only achieved an average yield of about 240 kg/acre but also shortened the pre-bearing period from three years to two years.

Large cardamom

Large cardamom is a principal commercial crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal. The area under this crop is about 26,000 hectares with an annual production of 4500 to 5000 metric tons. Sikkim occupies lion share in area and production in large cardamom.

Ginger

Ginger is a perennial herb, but cultivated as an annual for its underground rhizome which is used as a spice. Ginger is a more versatile spice commodity with its multi use property as vegetable, spice and also for medicinal purpose and is traded world over. India has the enviable position of World's largest producer and consumer of ginger. Though ginger is produced in almost all the states, the major producers of ginger are Kerala, Orissa, Meghalaya, west Bengal etc. Promotional programmes under the central government sponsored 'Technology Mission for Horticulture' in north-eastern states might have served as catalyst for growth in ginger production. Ginger comes to yield in a period of 6 to 9 months and the average yield of ginger is about 4500 kg/ha (dry).

Turmeric

Turmeric is one of the most important spices used extensively by all classes of people in India. Besides, it is one of the most ancient and traditional spices of export for this country. India is by far the largest producer of turmeric in the world, but the production of this crop has been highly unstable. The main turmeric growing areas in India are distributed in the States of Andhra Pradesh, Orissa, Tamil Nadu, Maharashtra, Assam, Bihar, and Kerala. Andhra Pradesh has emerged as the largest turmeric producing state in the country accounting for more than 50% of the total production in the country.

Ginger and turmeric are extensively grown in Andhra Pradesh, north eastern states including Sikkim, Orissa and Kerala. Agricultural and Processed Food Products Export Development Agency (APEDA) has already identified some districts in Assam, Sikkim and Orissa as Agri Export Zone (AEZ) for turmeric and ginger. The details are given in annexure-I. Though there is enormous export potential, the progress in terms of export is not encouraging. Further, investments are also not on the expected lines.

Financing of zingiberaceous spices

Type of credits available

Short Term (ST) Credit: Banks provide credit support at relatively low rate of interest for the production purposes. Each withdrawal against the sanctioned credit limit is repayable within 12 months. NABARD provides Refinance for State Coop Banks (SCBs) and Regional Rural Banks (RRBs). In Kerala, NABARD is providing Short Term credit limit to Kerala State Co-operative Agriculture and Rural Development Bank (KSCARDB) also, as a pilot programme. The eligible activities for NABARD refinance under short term are such as i) Seasonal Agricultural Operations (SAO): for timely credit to farmers, for the purposes of crop production ii) Marketing of Crops: for checking incidence of distress sale iii) Agricultural Inputs: for timely supply of agricultural inputs, etc. When crop loss on account of natural calamities is substantial, as declared by State Govt. refinance by way of medium term loan is granted to Coop. Banks and RRBs to enable them to convert the short term loans of farmers into medium term loans, repayable in 3 years which could be extended to a max of 7 years.

Long Term (LT) Credit: Investment credit leads to capital formation through asset creation. It induces technological upgradation resulting in increased production, productivity and incremental income to farmers and entrepreneurs. Credit is normally provided for a period of 3 to 15 years (Medium Term: 3 to 5 years and Long Term: 5 to 15 years). NABARD provides LT credit to Commercial Banks (CBs), RRBs, State Co-operative Agriculture and Rural Development Banks (SCARDBs), SCBs, Scheduled Primary Urban Cooperative Banks (PUCBs), North East Development Finance Corporation Ltd. (NEDFi) and also Non-Banking Financial Companies (NBFCs). Eligible activities are such as land development, farm mechanization, minor irrigation, plantation and horticulture, storage and market yards, postharvest management, food and agro processing, etc., besides, other allied activities such as fisheries, animal husbandry, forestry, micro finance, non-farm sector activities, etc.

Rural credit: Organizational set-up

The agricultural and rural credit delivery system in our country is through Commercial Bank (CBs) of public sector, private sector and foreign banks, Rural Regional Banks (RRBs), sponsored by CBs to enhance the banking network in rural areas, State Co-operative banks (SCBs) and State Co-operative Agricultural and Rural Development Banks (SCARDBs); having two tier and three tier systems (Primary Co-operative Societies - PACs; District and State level Apex Bank).

As regards to credit for zingiberaceous spices, banks are financing plantation development activities, which include i) area clearance, land development activities & layout, planting material and planting cost, cost for intercultural operations, harvesting and curing, storage, labour quarters, etc. The activity is being supported under priority sector lending (agriculture). NABARD extends refinance assistance for both schematic (investment credit) and short term loans (for production and maintenance purposes). The plantation development activities of small cardamom, processing facilities of almost all spices, creation of irrigation facilities, etc. are covered under schematic landing and cultivation cost of zinger and turmeric (which are short term crops, take 6-9 months to yield), maintenance cost of small cardamom from third year onwards are covered under short term (production) credit.

NABARD encourages investment credit by initiating various promotional efforts. As part of this endeavour, it has prepared a model bankable project for plantation development of small cardamom, organized seminars/workshops, extends grant assistance for research and development, etc.

Technical aspects

The various technical aspects banks would look into while arriving at the investment costs are such as suitable climatic conditions, soil, selection of varieties, availability and cost of planting material, availability and cost of input materials, availability of labour and cost of intercultural operations such as manuring, irrigation, weeding, pest and disease control, harvesting, etc. Such information are being standardized and made available by Spices Board, ICAR sponsored All India Co-ordinated Research Projects for Spices (under IISR), State Agricultural Universities and Krishi Vigyan Kendras (KVKs).

Model unit cost

Based on the information available at present, the estimated unit cost for plantation development of small cardamom is indicated below:

Cardamom

(Rs. per ha)

Particulars	I year	II Year	Total Cost
Labour Cost @ Rs.120/MD	51120	47520	98640
Input Cost	29589	19440	49029
Total (rounded off)	80700	67000	147700
Matured Maintenance Cost (from III Year onwards)			67000

The unit costs are indicative and may vary from project to project. Banks are free to arrive at their project specific unit cost taking in to account the item of investments proposed. Similarly, unit costs may also vary from state to state, taking in to account the prevailing labour cost, other input costs. Besides, NABARD also supports short term loan for maintenance of existing plantations.

Ginger and turmeric

NABARD extends short term credit for ginger and turmeric cultivation as the crops come to yield with in 6 to 9 months. The production credit (scale of finance) for such short term crops are being finalized by District Level Technical Committee (DLTC), convened by the District Level Co-operative Credit Banks. The scale of finance may vary from district to district, taking into account the ground level conditions.

Term loan facilities are available for investments for value addition/ processing of ginger and turmeric. Various products such as preserve, candy, syrup and beverages, pickles, paste, etc., can be made with a moderate investment of Rs.2 lakh to Rs.10 lakh for a processing capacity of 100 to 200 kg of raw ginger. However, for oleoresin extraction unit, the investment cost may be in the range of Rs.4 to Rs.10 crore. Various value addition/ processing technologies are readily available after standardization by institutes such as CFTRI, RRLs, State Agricultural Universities, etc.

Beneficiaries

Institutional credit is available to individual farmers/ entrepreneurs/partnership firms/companies/co-operatives through financial institutions such as CBs, RRBs, SCARDBs and SCBs. NABARD extends refinance support to replenish the resources of its client banks. The existing rate of interest on NABARD's refinance support, quantum of refinance and repayment period prescribed, etc., to various client banks is given in annexure II. NABARD has also opened a new window called "co-finance". Under this window, NABARD jointly with other banks, finances projects of relatively high investment cost (more than Rs. 1 crore). NABARD's share under such arrangement is to the maximum of 50% and the present interest rate on NABARD's share is 12.5% p.a (interest rates are subject to change from time to time).

Promotional role

Besides credit support, NABARD undertakes initiatives such as exposure visits for farmers, organizes seminar and workshops, extends Research and Development Grant assistance for conducting research activities, supports rural innovations through Rural Innovation Fund (RIF), etc.

Subsidy

NABARD administers subsidy for many Government of India Capital Investment Subsidy Schemes. The subsidy schemes which have relevance for zingiberaceous spices are scheme for rural godowns, marketing infrastructure and cold storages. The details of the subsidy schemes, in brief is given in annexure - III. Spices Board, Ministry of Commerce, Government of India operates many subsidy schemes for a variety of activities. For details, it is suggested to visit www.indianspices.com.

Annexure- I

Statement of actual investment and exports from agri export zones

(As on MAY, 2007; Amt Rs. Crore)

S No	State	AEZ Project	State and Districts	Actual Exports	Actual Investments
1	Sikkim	Ginger	Sikkim (North, East, South & West Sikkim)	0.00	0.00
2	Orissa	Ginger and Turmeric	Orissa (Kandhamal District)	1.76	0.00
3	Assam	Fresh & Processed Ginger	Assam (Kamrup, Nalbari, Barpeta, Darrang, Nagaon, Morigaon, Karbi Anglong and North Cachar	2.17	3.15
	Share of Zingeberaceae Spices			3.93	3.15
Total				5451.63	866.40

(Source: APEDA website)

Annexure – II

NABARD's refinance: rate of interest, quantum of refinance and repayment period

Purpose	Agency	Rate of Interest (% p.a.)	Quantum of support (% of bank loan)	Repayment period
Seasonal Agricultural Operation/Short Term	SCB RRB	3.0% 4.5%	35-40% *15%	1 year 1 year
Schematic/ Investment credit/Term loan	CBs SCBs RRBs SCARDBs	9.0% 8.5% 8.5% 8.5%	90 to 100% 90 to 100% 90 to 100% 90 to 100%	Max. 5 years Max. 15 years Max. 15 years Max. 15 years

Note: * as per eligibility, which is based on banks' performance
All parameters are subject to change from time to time.

Annexure – III

Govt. of India sponsored programmes implemented through NABARD

1. CISS for construction/ renovation of rural godown

Eligible Borrowers	Cooperatives, Corporations, Federations, Marketing Boards, Companies, Partnership and Proprietary firms, Groups of farmers, NGOs, SHGs and Individuals
Salient Features	Back-ended subsidy on capital investments like godown building, boundary wall, internal roads etc. Godowns located outside municipal limits only are eligible.
Assistance available	Subsidy @ 15 to 33.33% of project outlay on godowns with capacity of 100 MT to 10,000 MT.
Release mechanism	50% of subsidy released in advance on sanction of bank loan and release of first instalment. Balance 50% after joint inspection

2. CISS for development/ strengthening of agricultural marketing infrastructure, grading and standardization

Eligible Borrowers	Cooperatives, Corporations, Federations, Marketing Boards, Companies, Partnership and Proprietary firms, Groups of farmers/ growers/ consumers, NGOs, SHGs and Individuals
Salient Features	For setting up agricultural markets in private and co-op sector and creation of agricultural marketing infrastructure
Eligible investments	Infrastructure for collection/ assembling, drying, cleaning, grading, standardization, quality certification, packing, labeling, etc. Market user facilities- shops/offices, platforms for loading/ unloading/assembling etc, parking, internal roads, garbage disposal system. E-trading, market intelligence, extension services
Assistance available	Subsidy@ 25% of project cost upto 50 lakh (33.33% upto Rs.60 lakh for tribal areas). Bank loan at minimum of 50% of project outlay
Release mechanism	50% advance subsidy on sanction of term loan and release of 1st instalment and balance 50% after joint inspection by NABARD, DMI and bank.

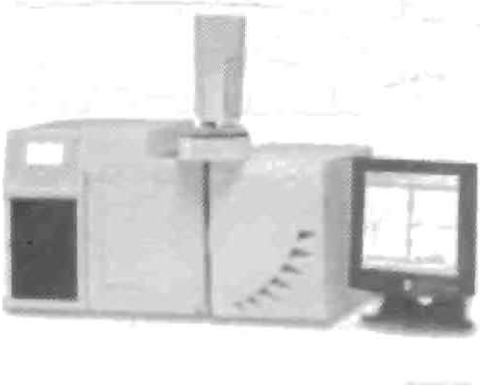
3. CISS for construction, modernization & expansion of cold storages

Eligible Borrowers	Cooperatives, Corporations, Boards, Companies, Partnership and Proprietary firms, Agro industries Corporation., Growers association, and Individuals
Salient features	For storage of horticultural produce
Project Cost	New cold storages/ expansion- @ Rs.4000 per MT or actual Modernization/ rehabilitation- Rs.1000/ MT or actual
Margin	25% of project cost in general
Assistance	25% of project cost upto maximum of Rs.50 lakh

4. CISS for commercial production units of organic inputs

Eligible Borrowers	Coops, Corporations, Federations, Marketing Boards, Companies, Partnership Proprietary firms, Groups of farmers, NGOs, SHGs and Individuals
Projects covered	Bio-fertilizer unit, vermi-culture hatcheries, fruit and vegetable waste compost units.
Assistance available	Back-ended subsidy@ 25% of project cost as given below:Bio-fertilizer units -Rs.20 lakh, Vermi hatcheries -Rs.1.50 lakh, Fruit & Vegetable waste compost unit -Rs.40 lakh
Margin money	@ 25% of project cost
Release mechanism	50% of subsidy on sanction of term loan and release of 1st instalment and balance 50% after joint inspection by NABARD, Bank, NCOF and Dept of Agri & Coop.

(Contact: www.nabard.org)



Indian Society for Spices

The Indian Society for Spices was founded in 1991 for the advancement of research and development of spices, aromatic, medicinal and related crops. The society aims at providing a forum for research workers on these crops for exchange of ideas, and as a catalytic link between research and development organizations and the industry. The society organizes symposia, conferences and seminars in collaboration with other organizations on aspects relevant to spices, aromatic and medicinal crops. The society fosters to the professional interest of research workers on spices, medicinal and aromatic crops through its journal, the Journal of Spices and Aromatic Crops, which is available free of cost to members. Members also receive publications of the society at reduced cost and can participate in scientific meetings and other functions of the society.

Membership rates

Patron	: Rs 50,000
Sustaining member	: Rs 25,000
Institutional member	: Rs 5,000
Life member	: Rs 2,000
Ordinary member (annual)	: Rs 400

For membership, contact
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Journal of Spices and Aromatic Crops

An international journal published by the Indian Society for Spices and devoted to the advancement of research on spices, medicinal, aromatic and related crops. The journal publishes critical reviews, research articles, research notes, book reviews, and bibliographic surveys in English, on all aspects of spices, medicinal, aromatic and related crops. The journal is published twice a year, during June and December. Manuscripts for publication in this journal are submitted to the Editorial Office, Journal of Spices and Aromatic Crops, Indian Institute of Spices Research, Marikunnu P.O., Calicut-673012. All authors should be members of the Indian Society for Spices. Authors are advised to refer to a recent issue of the journal prior to preparation and submission of manuscript.

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