TECHNICAL ADVANCES FOR IMPROVING PRODUCTION OF GINGER

V. A. Parthasarathy, K.Kandiannan, M.Anandaraj and S.Devasahayam
Indian Institute of Spices Research (ICAR), Calicut, Kerala 673 012

Ginger (*Zingiber officinale*) is grown in tropical and subtropical regions of the world for its spice and medicinal values. It is a perennial, herbaceous, monocotyledon, usually grown as annual. Ginger is also known for centuries as a medicinal and spice crop. It is a plant of very ancient cultivation and the spice has long been used in Asia. It is one of the earliest oriental spices known to Europe and is still in large demand today (Purseglove *et al.* 1981). Its important part is underground rhizome, which as a most pungent and aromatic is used for culinary purposes in ginger- bread, biscuits, cakes, puddings, soups and pickles. Ginger is traded in 3 basic forms - green (fresh), pickled or preserved and dry. Only dry ginger (whole, peeled or sliced) is regarded as a spice; green or fresh ginger is considered basically as a vegetable, while pickled or preserved ginger is destined largely for the trade connected with Chinese and Japanese cuisine. In addition, ginger oil and oleoresins are also traded. Although a number of countries produce ginger, exports of dry ginger on a significant scale are limited to India and China, the two dominant suppliers, followed by Nigeria, Sierra Leone, Australia, Fiji, Bangaladesh, Jamaica, Nepal and Indonesia. The area and production from India over the years have increased (Table 1). The USA, UK, Saudi Arabia, Morocco, Japan, Germany, Republic of Yemen and Canada are important importers of ginger. In India, ginger is cultivated in 21 states, Kerala, Orissa, Andhra Pradesh, Himachal Pradesh, Meghalaya and West Bengal being important ginger-growing states. Kerala and Meghalaya accounts for nearly 40 % of the country's production. Northeast has inherent potential for ginger production. It is essential to build appropriate market or establish post harvest facilities to sustain the interests of the farmers to continue ginger cultivation in northeastern India.

Ginger requires a tropical or subtropical climate. It thrives well up to an altitude of 1500 m above mean-sea-level in the Himalayas, the optimum range being 300-900 m. The temperature of 28-35°C is ideal for its cultivation. Brilliant sunshine, heavy rainfall and high relative humidity are necessary for good yield. A rainfall of 1,500 – 3,000 mm, well distributed in 8-10 months is ideal. Ginger is cultivated under rainfed and irrigated conditions. In areas receiving less rainfall, its crop needs regular irrigation. The crop is sensitive to water-logging, frost and salinity, and tolerant to wind and drought. Deep slope in hilly areas is not recommended for its cultivation as it leads to soil erosion during heavy rainfall.

Table 1. Area, production and export of ginger from India over the years

Year	Area (ha)	Production (tonnes)	Export (tonnes)	Share (%)
1970-71	21,590	29,290	3,156	10.8
1980-81	40,450	82,440	6,811	8.3
1990-91	53,930	1,53,450	6,555	4.3
2000-01	83,940	3,06,960	6,580	2.1

Source: Spices Board, Cochin

Cultivation

Soil

Ginger has wider adaptability for different soil types. Tthe soil should be loose, friable and offer minimum resistance to rhizome development. Well-drained soils with at least 30 cm depth is essential, but by adopting bedding and surface mulching shallower soil can be utilized satisfactorily. Compact clay soils which are subject to water-logging or coarse sands without water holding capacity, gravelly soils or those with hard pan are not conducive for the cultivation of high yielding healthy varieties. In India, ginger is grown on a wide variety of soils such as sandy loams, clay loams, black rich clay soils and lateritic soils. Virgin forest soils particularly after deforestation is ideal for its cultivation. Ridely (1912) quoted a farmer who grew ginger for 40 years in the same patch and it is therefore quite unnecessary to destroy forests of great value. Sahu and Mitra (1992) reported that maximum yield is achieved in sandy loam soil having minimum bulk density (1.20 g/cc), moderately acidic reaction (pH 5.7) and high organic matter (organic carbon 1.1%) and available potassium (351 kg/ha). The yield decrease with increase in soil clay content and decrease in pH.

Cultivars

As ginger rarely sets seed, its general mode of propagation is asexual. Crop improvement is mainly through introduction and selection. Several commercial cultivars of ginger are cultivated throughout the world especially in India, many land races and improved cultivars which excel in yield and one or more quality traits are available. Yield, percentage recovery of dry ginger from fresh ginger and fibre content are main criteria used to differentiate these types (Aiyadurai 1966). Potential yield and quality of genotypes may vary with agroclimatic conditions, soil fertility and agronomic practices. Improved cultivars released for cultivation are given in Table 2.

Table 2. Improved varieties of ginger released for cultivation in India

Variety	Origin	Yield (tonness /ha)	Dry recovery (%)	Crude fibre (%)	Oleoresin (%)	Essential oil (%)
Suprabha	Orissa	16.6	20.5	4.4	8.9	1.9
Suruchi	Orissa	11.6	23.5	3.8	10.0	2.0
Suravi	Orissa	17.5	23.0	4.0	10.2	2.1
Varada	Kerala	22.6	20.7	3.29	6.7	1.75
Mahima	Kerala	23.2	23.0	3.26	4.48	1.72
Rejatha	Kerala	22.4	20.8	4.0	6.34	2.36
Himgiri	Himachal Pradesh	13 -14	-	-	4.29	1.63

The Indian Institute of Spices Research, Calicut, has 637 accessions of *Zingiber* and identified cultivars useful for different needs(Table 3). Chandra and Govind (1999) evaluated 21 ginger genotypes at Meghalaya and found that Tura (26.7 tonnes /ha), Poona (25.0 tonnes/ha.) and Basar (24.9 tonnes/ha.) recorded higher yields. The genotypes Karakai, Chekeralla, Rio-de-Janeiro, Thingpuri and Khonsa Local had high dry recovery (19.1-20.4 %).

Table 3. Ginger cultivars identified for economically important traits

Attribute	Cultivar / Accession
High yield	Varada, Rio de Janeiro, Suprabha, Himachal, Maran, Suruchi, Suravi, Mahima, Rejatha.
Bold Rhizome	Varada, Gurubathani, Bhaise, China, Mahima, Rejatha.
High dry Recovery	Varada, Maran, Zahirabad, Kuruppampadi, Jorhat Local, Mahima . Elakallan, Sabarimala.
High oil High oleoresin	Wynad, Kunnamangalam, Ambalavayal, Ernad, Chrnad
High gigerol and shogaol	Wynad, Kunnamangalam, Ambalavayal, Rio de Janeiro, Swathing Puri
Resistance to storage pest	Varada, Acc. No. 215, Acc. No.212

Planting

Ginger is generally planted during March-June in India and September in Australia (Whiley,1974), March-April in West Indies (Ridley,1912), mid-April in South Eastern Nigeria (Okwuowulu *et al*., 1990), May-June in Jamaica (Graham,1936), February-April in Taiwan (Lawrence, 1984), April-May in Sierra Leone and Hawaii (Lawrence,1984) and June in Ghana ((Lawrence,1984). The main considerations while planting ginger are time of year in relation to climate and depth of seed placement and spacing (Whiley,1974). In India, ginger is planted with commencement of South-West monsoon. In areas where the monsoon is late, planting is done in June or later. A higher yield of 100 – 200% is recorded by planting it during first week of April, with the receipt of summer showers, than general practice of planting in May-June (Aiyadurai,1966). Early planting is beneficial (Randhawa *et al*, 1972) and ensures that its crop grows sufficiently to withstand heavy rains and grows rapidly with the receipt of heavy rains. Early planting at Himachal Pradesh also shows beneficial result.

To high yield, soil should be loose and friable. Good shaped rhizomes are desirable for marketing and post-harvest processing. Land preparation may vary with soil types, slopes and irrigation. Two distinct methods of cultivation are adopted in India (CSIR,1976). In Malabar system, 3m x 1m beds are laid out at a distance of 30 - 45 cm from each other, small shallow pits for planting are then made on beds at required spacing. Beds are smaller in slopy areas. A handful of cattle manure is applied to each of these pits. In South Kanara system no beds are laid out. A mixture of manure and burnt earth is applied in the form of a 5 cm thick ridge in between rows 100-200 cm apart from each other. The seed rhizomes are placed at required distance in rows and earthed up to make the ridge 15-20 cm high. The field is given a light irrigation soon after sowing. Aiyadurai (1966) recommended that flat bed system for sandy loam soil and raised beds for clay loam soil are most suited for its successful cultivation.

Seed material

Ginger is propagated vegetatively from rhizomes. The length and weight of pieces of rhizomes used vary from place-to-place and variety to variety. A direct relationship has been established between size of planting material and final yield. Whiley (1974) observed that seed size influences rhizome size at harvesting

and increases with larger seed pieces. Transplanting of ginger is also successful at Himachal Pradesh (Kumar and Korla, 2000). Optimum seed size identified for different locations are given in Table 4.

Table 4. Seed size for different region

Region	Seeds Size (cm X cm)	Refernces
Punjab	60 – 150	Randhawa *et al*., (1972)
Himachal Pradesh	20 –25	Korla *et al*.(1989)
West Bengal	40	Sengupta *et al*. (1986)

In general, a seed rate of 1,200-1,400 kg/ha is being used. It varies with variety and soil fertility. The yield increase with seed rate (Mohanty *et al*., 1988); Jayachandran *et al*., (1980) reported that high seed rate, accounted for 40-46 % of the total cost of production. Seed rhizomes remain undecomposed at crop maturity and can be detached during crop growth without significantly affecting yield (Okwuowulu 1988). A mean of 58 % of seed ginger from smaller setts and 86 % from larger setts can be recovered in fully plantable condition. In some places, farmers plant whole rhizomes and unearth them when its crop reaches 30-35 cm height, thus, recovery being 94.6 % at 3 months after planting (Jayachandran *et al*. 1982). By this method farmers get back 60 -70 % of the seed cost. This is popular in low-income group. During May/June, mother or seed rhizomes are removed in north-east. This is known as 'mau' in Sikkim (Patiram *et al*. 1995)

Seed treatment is done to induce early germination and to prevent seed-borne pathogens and pests. Rhizome rot is a serious disease, which is seed-borne. Therefore seed rhizomes should be treated before planting. Seed rhizomes are treated in hot water at 48°C for 20 minutes before planting. The cut end of seed may provide entry for fungal pathogens. To prevent this cut seeds are dipped in benomyl 0.25 % for 10 minutes (Whiley 1974). Formulations such as Agallol 0.5 % for 3 minutes or wettable Ceresan 0.1 % for 30 minutes or coppersan 0.3 % for 60 min can also be employed (CSIR,1976). As a prophylactic measure against soft rot disease, wettable Ceresan 0.25 %, Dithane M-45 can be used for seed treatment. Treating rhizomes in ethrel increases growth and development of ginger .

Spacing

Spacing may vary with soil fertility, variety, climate and management practices. Closer spacings give higher yield. Planting depth may vary depending upon seed size, soil type and soil moisture content. In general, bolder seeds are planted deeper and smaller seeds at a shallow depth. Seed rhizome pieces are generally planted at 4-10 cm depth. As depth of planting influences the time of germination, it is necessary to plant at optimum depth. Under ideal conditions ginger appears above ground 10-15 days after planting, but may be prolonged up to 2 months.

Mulching

Mulching enhances germination, prevents washing of soil due to heavy rains and surface run-off, increases infiltration, conserves moisture, regulates temperature, decreases evaporation, suppresses weed growth, enhances microbial activity and improves soil fertility by adding organic matter. Mulching could change the physical and chemical conditions of soil resulting in increased availability of nutrients. The quantity of mulch applied varies with availability of material. In general, 10 - 30 tonnes/ha is applied twice or thrice, one at planting, second and third at 45 and 90 days after planting. Commonly used mulch materials are green and dry forest leaves, residues like sugarcane trash, paddy, wheat, finger millet, little millet and barely straws and also weeds and vegetation of the locality. Farmyard manure (FYM) and compost are also used. If quantity of above materials is in short supply, live mulches like sunhemp, greengram, horsegram, blackgram, niger, common sesbania, clusterbean, Frenchbean, soybean,

cowpea, *daincha* and redgram can be grown as intercrop and used for in-situ mulching between 45 and 60 days after planting. In addition,*in situ* green manuring reduces weed problem. Application of forest leaves (20 tonnes/ha) in 2 equal splits, one at planting and second 45 days after planting increases yield by 200 % (Kannan and Nair 1965).

Crop nutrition

Adequate amounts of nitrogen, potassium, calcium, mangnesium, phosphorus, sulphur, chlorine, iron, boron, manganese, zinc, copper and molybdenum are essential for healthy growth and higher yield of ginger.

Soil organic matter has positive correlation with yield. Staple manure, bat guano, marl, sheep manure, FYM, poultry manure, press mud, compost, oil cake, biofertilizer, night soil and urine and pig manure are used as sources of organic matters. The quantity of organics applied may vary with availability of materials and generally it varies between 5 and 30 tonnes / ha. These are mostly applied as basal doses and in certain places it is also applied after the emergence of crop as mulch.

Fertilizer recommendation varies with variety, soil type and climate. A fertilizer dose of 36-225 : 20-115 : 48-200 N, P_2O_5 ,K_2O kg / ha) has been adopted in different states in India. In Australia, it is 200: 229:199; 66: 82: 66 in West Indies and 105: 241: 126 in Nigeria. For nitrogen, urea, calcium ammonium nitrate, ammonium sulphate and ammonium nitrate are used as source. Superphosphate and diammonium phosphates are the sources for phosphorus and potassium sulphate and potassium chloride are the sources for potassium. Apart from these straight fertilizers, fertilizer mixtures containing NPK 8:8:16 are also used for ginger production. Pawar and Patil (1988) obtained a beneficial effect by using organic and inorganic nutrition together.

Fertilizer schedule for different states is given in Table 5 .

Table 5. Manures and fertilizers recommendation for ginger in different state of India

State	Fertilizer / manure
Kerala	FYM 30 tonnes/ha, NPK 70:50:50 kg/ha. Full dose of phosphorous and 50% K may be applied as basal dose. Half the quantity of N applied at 60 DAP. The remaining quantity of N and K applied at 60 DAP
Karnataka	FYM/compost 25 tonness/ha, NPK 100:50:50 kg/ha. Apply the entire dose of P and K at planting. Half quantity of N to be applied at 30-40 DAP and other half at 60-70 DAP.
Orissa	FYM 25 tonnes/ha. NPK 125:100:100 kg/ha. Full P and half applied as basal in furrows before planting and N and K in 2 splits at 45 and 90 DAP.
Himachal Pradesh	FYM 20-30 tonness/ha. NPK 100:50:6 kg /ha, apply P and K at the time of planting and N in 3 equal doses at planting, 30 & 60 DAP. Potash may be applied 2 splits i.e first at planting and at rhizome initiation
Bihar	NPK @ 60:60:120 kg/ha.
Andhra Pradesh	N, P_2O_5, K_2O @ 75:50:50 kg /ha.
Chattisgarh	NPK @ 150: 125: 125 kg/ha.
Sikkim	40-60 tonnes/ha. Manure, few farmers apply fertilizers to ginger (Patiram *et al*.1995)
Meghalaya	FYM 10 tonnes/ha. + 60:90:60 N:P_2O_5:K_2O (Govind *et al*. 1995)

Irrigation

Water requirement of ginger has been estimated by the Queensland Irrigation and Water Supply Commission to be between 1320 and 1520 mm during complete crop cycle. In areas receiving less rainfall, its crop needs regular irrigation. Irrigation is given at fortnightly intervals, usually during mid September to mid November in India, which increases the yield by 56 % with improved quality (Aiyadurai 1966). Increased water supply increases the yield of rhizomes and essential oil content also (Lawrence 1984). Ginger crop raised during first week of May in Orissa (India) needs 2 or 4 initial pot waterings at 7 days interval depending on soil type. After this it receives monsoon rainfall, and comes up well till September end. Subsequently, its crop has to be given pot watering commencing from mid- October to December end at 15 days intervals. (Panigrahi and Patro, 1985). They also identified that germination stage, rhizome initiation stage (90 days after planting) and rhizome development stage (135 days after planting) are critical. First irrigation is given to ginger immediately after planting and subsequent irrigations are given at 10 days intervals with total water of 90-100 cm in 16?18 irrigations. A fortnightly irrigation during the drier part of monsoon months contributed significantly to increased yield with improved quality of the produce (Gupta 1974). Scheduling of irrigation at 60 mm cumulative pan evaporation (CPE) and IW/CPE ratio of 1.0 producesd maximum rhizome yield.

Weed control and earthing-up

As ginger receives a high amount of external nutrition coupled with initial slow growth, conditions favour weed emergence which later compete with the crop for moisture, nutrition, space and sunlight. When mulching is practised, weed growth is suppressed to some extent, which increases crop emergence, growth and yield. Generally,2-3 weedings are done depending upon weed growth. The first weeding should be done just before second mulching (45 days after planting) and the second weeding 120-135 days after planting. The surface soil may harden up after rain or irrigation. Soil stirring and earthing-up are essential as they help in enlargement of daughter rhizomes and provide adequate aeration for roots and protect t rhizome from scale insects apart from controlling weeds. The first earthing-up is done 45 days and second at 120-135 days after planting. Earthing-up may be combined with hand-hoeing (weeding) and mulching.

Shade requirement

Ginger crop prefers light shade for good growth, but shade is not absolutely necessary (CSIR, 1976). Shading is helpful in reducing water loss and general cooling of the plant (Lawrence, 1984). In Queensland, overhead sprinkler irrigation protects the crop from sunburn (Whiley,1974) and evaporative cooling with sprinkler during summer increases yield in South Africa (Anderson *et al*., 1990).

Diseases and Pest Management

Ginger crop is affected by a few fungal and one bacterial and viral pathogens in field. Besides several types of rot diseases have been observed in storage. Among them, soft rot, bacterial wilt, leaf spot diseases and a few diseases caused by nematodes are important .

Soft rot or rhizome rot

Soft rot is most destructive disease of ginger, which results in total loss of affected clumps. The disease as soil-borne and is caused by Pythium aphanidermatum. The P. vexans and P. myriotylum are also reported to be associated with the disease. The fungus multiplies with build up of soil moisture with the onset of South-west monsoon. Younger sprouts are most susceptible to its pathogen.

The infection starts at the collar region of pseudostems and progresses upwards as well as downwards. The collar region of affected

pseudostems becomes water-soaked and the rotting spreads to rhizomes resulting in soft rot. At a later stage root infection is also noticed. Foliar symptoms appear as light yellowing of the tips of lower leaves, which gradually spreads, to leaf blades. In early stages of disease, middle portion of leaves remains green while the margins become yellow. The yellowing spreads to all leaves of plant from the lower region upwards and is followed by drooping, withering and drying of pseudostems.

Treatment of seed rhizomes with Mancozeb 0.3% for 30 minutes before storage and once again before planting reduces the incidence of the disease. Cultural practices such as selection of well drained soils for planting is important for managing the disease, since stagnation of water predisposes the plant to infection. Seed rhizomes are to be selected from disease free gardens, since the disease is also seed borne. Application of *Trichoderma harzianum* along with neem cake @ 1kg/bed helps in preventing the disease. Once the disease is located in the field, removal of affected clumps and drenching the affected and surrounding beds with Mancozeb 0.3% checks the spread of the disease

Bacterial wilt

Bacterial wilt caused by Ralstonia solanacearum, is also a soil- and seed-borne disease that occurs during southwest monsoon when its crop is young (Sarma *et al.*, 1978). Water-soaked spots appear at collar region of pseudostems and progresses upwards and downwards. The first conspicuous symptoms and mild drooping and curling of leaf margins of lower leaves which spread upwards. Yellowing starts from lowermost leaves and gradually progresses to upper leaves. In advanced stage, plants show severe yellowing and wilting symptoms. The vascular tissues of affected pseudostems show dark streaks. The affected pseudostems and rhizomes when pressed gently extrudes milky ooze from vascular strands.

The cultural practices adopted for managing soft rot should also be adopted to control bacterial wilt. The seed rhizomes may be treated with Streptocycline (200 ppm) for 30 minutes and shade-dried before planting. Once the disease is noticed in field all beds should be drenched with Bordeaux mixture (1%) or copper oxychloride (0.2%).

Leaf spot

Caused by Phyllosticta zingiberi, this is noticed on leaves from July to October. The disease starts as water-soaked spots which later turn as white spots surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas. The disease spreads through rain splashes during intermittent showers. The incidence of disease is severe in ginger growing under exposed conditions. Spraying of Bordeaux mixture (1%) or Mancozeb (0.2%) can controls this disease.

Dry rot

An important post- harvest disease is caused by *Macrophomina phaseolina*. It rarely affect plants in field (Sarma and Nambiar, 1974).

Manifested by shrinkage of rhizomes results in drying of whole rhizomes. Black growth of fungi and its fruiting bodies (sclerotial bodies) can be seen in rhizomes. Rhizome often fail to sprout which results in poor germination . There is no sprout formation.

Rhizomes should be treated with a mixture of mancozeb-carbendazim (50ppm) before storage. Rhizomes must be stored hygienically.

Eye rot caused by *Fusarium oxsporum*, it is one of the important post-harvest rot. It results in rotting of germinating sprouts that result in germination failure.

Emerging sprouts often rot.Sprouts turn into brown instead of typical creamy nature.The sprouts generally results in drying. Rhizomes should be treated with a mixture of mancozeb-carbendazim (50ppm) before storage. Rhizomes

can be treated with carbendazim alone at 50ppm concentration.Rhizome must be stored hygienically.

Chlorotic leaf streak

Very common viral disease in ginger often ignored due to its non-destructive nature. The incidence is increasing in the farmers' fields. Chlorotic streaks develop running along the veins. Select rhizomes from healthy plants.

Nematode Pest Management

Root knot *(Meloidogyne spp.)*, burrowing *(Radopholus similis)* and lesion *(Pratylenchus spp.)* nematodes are important pests of ginger (Ramana and Eapen, 1995).

Stunting, chlorosis, poor tillering and necrosis of leaves are common aerial symptoms. Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water-soaked areas in the outer tissues. Nematode infestation aggravates rhizome rot disease.

Treating infested rhizomes with hot water (50^{0}C) for 10 minutes, using nematode-free seed rhizomes and solarizing ginger beds for 40 days can control the nematodes.

Insect Pests Management

More than 45 species of insects have been recorded to infest and damage various parts of ginger such as rhizomes, shoots and leaves in India. However among them, shoot-borer (*Conogethes punctiferalis* Guen.) and rhizome scale (*Aspidiella hartii* Ckll.) can be considered as major insect pests. The root grub and leaf roller are minor insect pests causing sporadic damage in certain areas. Various insects also infest stored ginger among which *Lasioderma serricorne* (Fab.) is more common (Koya *et al.*, 1991; Devasahayam, 1999)

Shoot-borer

The shoot borer (*Conogethes puctiferalis* Guen.) is the most serious insect pest of ginger and is widely distributed in India. However, authentic information on its incidence in various regions of the country is not available.

The larvae of shoot-borer bore into pseudostems and feed on central growing shoot, resulting in yellowing and drying of infested shoots. The presence of a bore hole in the pseudostem through which frass is extruded and the withered central shoot is a characteristic symptom of pest infestation . Studies on yield loss caused by the pest indicated that when more than 50% of the pseudostems in a clump were infested, there was a reduction of 38 g of yield per clump (Koya *et al.*, 1986).

The adults are medium-sized moths with a wingspan of 18-21 mm; the wings are orange-yellow with minute black spots. The egg period lasted for 3-4 days. There are five larval instars and they last for 3-4, 5-7, 5, 3-8 and 7-14 days, respectively (on turmeric). Fully grown larvae are light brown with sparse hairs and measure 16-26 mm in length. The pre-pupal and pupal periods lasted for 3-4 and 9-10 days, respectively. However, at cooler regions of the country the duration of life cycle may be prolonged. Adult females laid 30-60 eggs during its life span. In field, 6-7 generations were completed during a crop season. The shoot borer is highly polyphagous and has been recorded on more than 30 plant species belonging to diverse families (Jacob 1981).

The shoot-borer is observed in field throughout the crop season (June-December in Kerala). However, its population is higher in field during October- November at Peruvannamuzhi (Kerala).

Various natural enemies have been recorded on shoot-borer. Among them Apanteles taragamae plays a significant role in reducing the population of pest in field (Devasahayam 1996).

Spraying of malathion (0.1%) or Dipel (a *Bacillus thuringiensis* product) at 21 intervals during July-October is effective for the

management of shoot-borer (Koya *et al*., 1988; Devasahayam, 2000a). An integrated strategy involving pruning and destruction of freshly infested shoots at fortnightly intervals during July-August and spraying of malathion (0.1%) at monthly intervals during September-October has also been found effective for its management. By adopting this strategy, two insecticide sprays can be avoided, thus conserving natural enemies and causing less harm to the ecosystem.

Rhizome scale

Rhizome scale (*Aspidiella hartii Ckll.)* infests rhizomes of ginger and turmeric both in the field (especially during the later stages of the crop) and in storage. However, authentic information on its incidence in various regions of the country is not available.

The pest infestation is generally seen in the form of encrustations during the later stages of the crop and severely infested plants wither and dry. In storage, pest infestation results in shrivelling of buds and rhizomes leading to loss in weight of rhizomes; when its infestation is severe, it adversely affects sprouting of rhizomes.

The adult females are minute, circular and light brown to grey and measure about 1 mm in diameter. Females are ovo-viviparious and also reproduce parthenogenetically. Little information is available on life-history of pest. Rhizome scales have also been recorded on tubers such as *Amorphophallus campamulathus* Roxb., *Dioscorea alata* L. and *Xanthosoma sagittifolium* (L.) Schott.

A few natural enemies have been recorded on rhizome scale among which Physcus comperei Hayat is more common (Devasahayam 1996).

Discarding of severely infested rhizomes, dipping the rhizomes in quinalphos (0.1%) for 15 minutes after harvesting and before planting is effective for controlling the pest infestation (Devasahayam 2000b).

Root grubs

Root grubs occasionally feed on tender rhizomes, roots and base of pseudostems causing yellowing and wilting of shoots. At Sikkim, *Holotrichia seticollis* Mosher, causes serious damage to ginger in many areas. The pest can be controlled by drenching the soil with quinalphos (0.05%) or chlorpyriphos (0.08%) (Varadarasan et al., 2000).

Leaf roller

The larvae of leaf roller (*Udaspes folus* Cram.) cut and fold leaves, remain within and feed on them. The adult is a medium-sized butterfly with brownish-black wings with large white spots; fully grown larvae are dark green and about 35 mm in length. The pest is generally abundant in field during monsoon season in Kerala. Spraying of carbaryl (0.1%), dimethoate or phosphamidon (0.05% each) has been recommended to control this pest (Devasahayam, 2000b).

Storage pests

Various insects have been recorded on ginger and turmeric in storage of them , *Lasioderma serricorne* (Fab.), *Stegobium paniceum* L., and *Araecerus fasciculatus* (Deg.) are more common. Fumigation with methyl bromide or with aluminium phosphide and spraying the bags with malathion have been recommended for reducing the damage caused by storage pests (Abraham, 1975).

Harvesting and Quality

The time of harvest depends on product for which the rhizomes are to be used, price trend in market and climatic conditions. If rhizomes are used for vegetable or for preparation of ginger preserve, candy, soft drinks, pickles and alcoholic beverages, harvesting should be done 4?5 months after planting. If it is used for dried ginger and preparation of value-added products like ginger oil, oleoresin, dehydrated and bleached ginger, harvesting should be done between 8 and 10 months. Early

harvesting (200-215 days after planting) gives higher yield than late harvesting (230-245 days after planting) in India (Aiyadurai 1966). Harvesting of ginger is done by using a spade, hoe or digging fork and also by mechanical diggers at Queensland. Care is required during harvesting to minimize damage to rhizomes. The soil, roots and tops are then removed and rhizomes are washed. Export of ginger from India is mainly in the form of dry ginger. Chemical composition of dry ginger may vary due to varietal, soil and climatic differences. Dry ginger consist of volatile oil (1.25-2.80 %), crude fibre (1.4-80%), cold alcohol extract (1.12-4.00%), total ash (6-9 %), acid insoluble ash (0.30-1.23 %), crude protein (8-11 %), starch (40-50 %), water extracts (10-20 %), acetone extract (3-8 %) and moisture (10-12 %) (Natarajan and Lewis 1982). Dry ginger is used for manufacture of value-added products such as ginger oil, oleoresin, ginger essence, ginger powder crystallized ginger and candied ginger.

Storage of Seed Rhizomes

Duration between first harvesting and next planting is 120-150 days at India. As ginger is vegetatively propagated, rhizomes should be stored safely during off?season; but it is a highly perishable commodity and is susceptible to soil?borne fungi and insects. The seed rhizomes should be stored appropriately so that rotting, shriveling, dehydration and sprouting can be avoided until the next season. Different methods are being adopted by farmers for storage of seed ginger (Kannan and Nair 1965). Storage losses can often be as high as 10-50 %. Recovery of seed rhizomes at planting was as high as 96 % by selecting fully matured rhizomes for storage, dipping in a solution of quinalphos (0.05%) and Dithane M-45 (0.3%) for 30 minutes and drying under shade and storing in pits (wherever bacterial wilt is a problem, the seeds should be treated with streptocycline 200 ppm).

Cropping System

Ginger can be grown as sole crop under open or shade apart from as a component in inter, mixed and undercropping systems. Ginger is intercropped with vegetables (cabbage, tomato, chillies, french bean and okra), pulses (pigeonpea, black gram and horse gram), cereals (maize,finger millet), oilseeds (castor,soybean,sunflower and niger) and other crops (sesnania,tobacco and pineapple). Ginger can also be grown as a mixed crop with castor, redgram, fingermillet and maize. As ginger requires partial shade it can be grown as an undercrop in coconut, arecanut, rubber, orange, stone fruit, litchi, guava, mango, papaya, loquat, peach, coffee and poplar plantations. Ginger is most favoured crop component under agroforestry. However, crop rotation is essential, as ginger depletes more nutrients in soil coupled with rhizome rot problem under monoculture contuniously. The crop is rotated with tapioca, chilli, seasame, little millet and dry paddy in rainfed conditions, and finger millet, groundnut, maize and vegetables are rotated with ginger under irrigated condition. Crop rotation using tomato, potato, chilli, eggplant and peanut should be avoided as these plants are hosts of wilt causing organism (*Pseudomonas solanacearum*).

Ratooning

Ratooning is not common in ginger and is not prefered for marketing as it contains more fibre. Extracts from ratoon ginger had a more fiery taste and less flavour than those from planted ginger (Purseglove *et al*., 1981). However, Ridley (1912) mentioned that a few farmers at Jamaica practiced ratooning.

Economics of Ginger Production

Economics of ginger production varies from place-to-place and depends on cost of inputs, price trend in the market etc. Data pertaining to ginger cultivation as an intercrop in coconut-based homestead farms of Kerala in 1989-90 shows that ginger give a net return of Rs 7,500/

ha (Regeena and Kandaswamy,1992), whereas, in Orissa as per 1991-92 data net profit was Rs 90,000/ha (Mohanty *et al*., 1994).

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