

**Indian Farmer**

Volume 12, Issue 09, 2025, Pp. 536-557

Available online at: www.indianfarmer.net

ISSN: 2394-1227 (Online)

Original article**Organic Production of Ginger (*Zingiber officinale* Rosc.) in Meghalaya, India****Heiplanmi Rymbai, Hammylliende Talang, M. Bilashini Devi, Veerendra Kumar Verma and Bunshah Lyngdoh***ICAR Research Complex for NEH Region, Umiam, Meghalaya***Corresponding author: rymbaihort@gmail.com**Received: 10/09/2025**Published: 14/09/2025***ABSTRACT**

Ginger (*Zingiber officinale* Rosc.) is a commercially valuable crop cultivated for its aromatic properties. Oleoresin and oil extracted from ginger are high-value, low-volume products with significant demand. Varieties characterised by lower fibre content, higher dry matter recovery, and high levels of oil and oleoresin demonstrate substantial potential for export in international markets. The pungency of ginger is attributable to gingerol; hence, greater emphasis should be placed on selecting such varieties for organic cultivation. The production of ginger under organic production systems enhances the quality of the product, as well as its high market preference. The selection of a site free from any history of soil-borne pathogen incidence, and seed selection from disease-free and organically produced certified seeds, along with other cultural management practices such as the correct weeding, earthing up, nutrition, water management at critical stages, and intercropping as per the norms of organic systems, are crucial steps in successful ginger cultivation.

Keywords: Ginger, *Zingiber officinale*, organic cultivation, organic production, organic ginger

1. INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is a commercially valuable crop cultivated for its aromatic rhizomes, which serve as both a spice and a medicinal ingredient (Rymbai et al., 2021). It is a herbaceous perennial crop belonging to the Zingiberaceae family, believed to originate in southeastern Asia. The eastern Himalayan states of India possess immense potential for cultivating a wide variety of spice crops, including ginger, turmeric, chilli, bay leaf (tejpata), large cardamom, coriander, and garlic, owing to their highly suitable agro-climatic conditions. Furthermore, black pepper, cumin, saffron, and vanilla are also promising new crops. Ginger is the most significant cash crop among spices, supporting livelihoods and enhancing the socio-economic conditions of

many ginger farmers in the region (Rymbai et al., 2018). Ginger is produced in nearly all states in the region, with Meghalaya, Mizoram, Arunachal Pradesh, and Sikkim being the main producers.

The demand for organic ginger is increasing worldwide due to rising awareness, health consciousness, and a preference for chemical-free products among consumers. The cultivation practices in the region are organic by default. To grow ginger organically, maintain a 25-meter-wide isolation zone around the entire conventional farm. The produce from this isolation belt shall not be regarded as organic. As an annual crop, the necessary conversion period will be two years. The details of organic ginger production are presented in Figure 1.

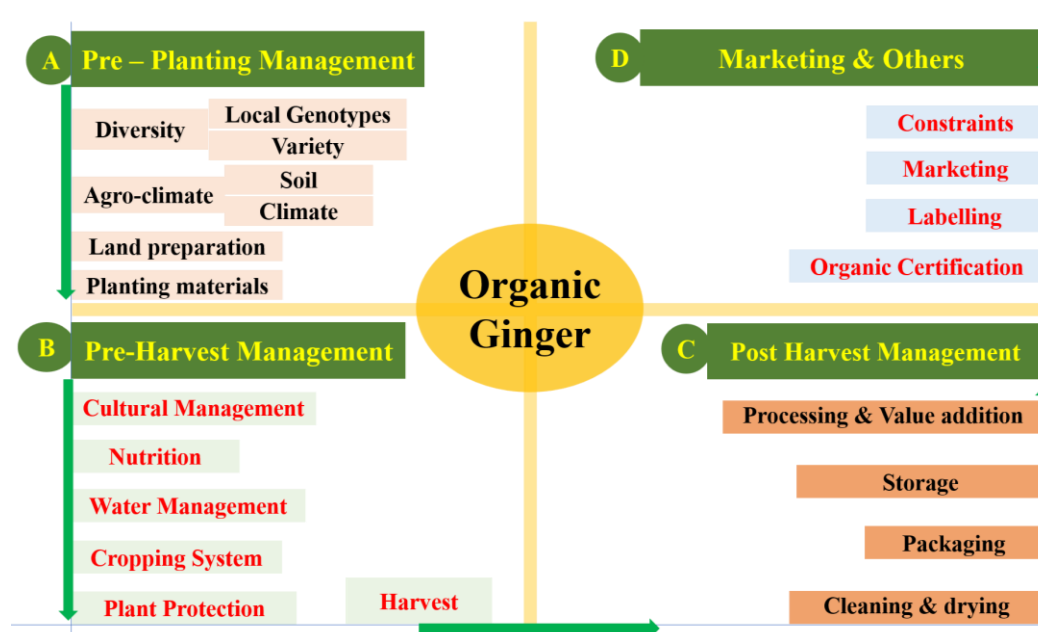


Figure 1. Graphical abstract of organic ginger production

Uses and commercial qualities of ginger

Freshly harvested ginger is mainly consumed as green ginger and also exported outside the region via middlemen, with considerable price variation. During glut periods, farmers are unable to sell their crops due to marketing constraints, such as limited local markets of sufficient size to absorb and handle large amounts of fresh ginger, as well as exploitation by middlemen. Consequently, to make the crop economically viable, part of the produce must be processed into low-volume, high-value products. Given the wide availability of ginger in the region, a range of products, including ginger oil, ginger oleoresin, ginger candy, and ginger powder, can be manufactured for export, as these items are in high demand internationally. Green ginger is used as a flavouring agent in tea preparation, curry, and pickles, among other applications. Dried ginger, known as Saunth, can also be prepared and may be sold as a whole rhizome or in the form of off-white to very light brown powder. Dried ginger or ginger powder is commonly used in the production of ginger brandy, wine, and beer in many Western countries. Furthermore, ginger oil is predominantly utilised as a flavouring agent in confectionery and soft beverages. Ginger is also utilised for various medicinal purposes, serving as a carminative and stimulant for gastric issues, dyspepsia, and flatulence, as well as a remedy for bee stings and bites. Ginger has been used in

the traditional health care system for indigestion, sore throat, stomachache, food poisoning, and nausea. Ginger can be pharmaceutically extracted and developed into products for antiemetic, antiulcer, anti-inflammatory, antioxidant, antiplatelet and anticancer activities (Vijayan, 2020). Oleoresin and oil are high-value and low-volume products with high demand in Western countries.

Varieties suitable for the international market

Varieties with lower fibre content, higher dry matter recovery, and high oil and oleoresin levels have significant potential for export in global markets (Rymbai et al., 2018). The pungency in ginger is due to gingerol, which has been found to be highest in Meghalaya and is suitable for export purposes. (Ngachan & Deka 2008). Therefore, greater emphasis should be placed on developing those varieties that possess the above qualities. The variety 'Nadia' is popular in Meghalaya and other states of the NE region mainly due to its low fibre content (4.2%) (Borthakur, 1992). The ICAR—Indian Institute of Spices Research, Calicut, has developed 'Varada,' a ginger variety with a fibre content of 3.2%. This variety is being multiplied at Ginger Development Station (GDS), Umsning, Meghalaya, and the performance of the variety is quite promising. Additionally, the GDS also maintains varieties such as 'Nadia,' 'Wynad,' and local cultivars. Similarly, about 112 genotypes of ginger, including improved cultivars, were evaluated at ICAR Research Complex for NEH Region, Umiam, to identify superior genotypes for yield and quality traits (Verma et al., 2023). In the international market, various grades of ginger are available, and the product has been classified into different grades accordingly (Table 1). The ginger produced in the region that meets this grade is suitable for export to obtain higher prices due to varying prices with grades.

Table 1. Quality characteristics in different grades of ginger

S.No.	Quality characters	Limits		
		Grade I	Grade II	Grade III
1	Extraneous matter, % by mass (maximum)	2.0	3.0	5.0
2	Insect-damaged matter, % by mass (maximum)	1.0	3.0	5.0
3	Pieces less than 25 mm, % by mass (max.)	0.5	1.0	2.0
4	Decayed pieces, % by mass (maximum)	Nil	0.5	1.0
5	Dry matter, % by mass (minimum)	22.0	20.0	18.0
6	Volatile oil, ml/100 gm (minimum)	0.7	0.5	0.3
7	Crude fibre content of dry matter, % by mass (maximum)	8.0	10.0	12.0
8	Non-volatile ether extract content of dry matter, % by mass (minimum)	5.0	3.0	2.0

Source: Spice India February (2004)

Scenario

The major ginger-producing countries in the world include India, China, Nepal, Indonesia, Thailand, Bangladesh, Japan, Nigeria, Cameroon, and the Philippines, among others. India leads the world in ginger production, accounting for 30.48% of total output, followed by China (20.97%), Nepal (12.85%), and Indonesia (12.38%). Asian countries are the main suppliers of ginger globally. China exports the majority, while India primarily exports whole and dried ginger. In the global market, Indian dry ginger is known as 'Cochin Ginger' or 'Calicut Ginger' and is regarded as among the finest in the world. Australia leads globally in value-added products, with India accounting for 50% of the trade in oil and oleoresin. The United Kingdom, the United States, Japan, and Saudi Arabia import significant amounts of ginger (FAO, 2014). The area and production of ginger at the national level are 0.176 million ha and 1.89 million metric tonnes, respectively. The cultivated area of ginger in the Northeastern region of India extends to 67.82 thousand Ha, with a production of 532.4 thousand MT and a productivity of 7.85 MT/Ha, which exceeds the national average productivity (2.56 MT/ Ha, Spice, 2025). The region accounts for 22.53% of the country's total ginger production. Approximately 67.6 thousand MT of ginger was produced in Meghalaya from an area of 10.2 thousand Ha (Spice, 2025).

2. Soil and agro-climatic conditions

2.1 Soil

The ideal soil for ginger cultivation is rich in humus, light, loose, and friable, with a minimum depth of at least 30 cm, ensuring good drainage and aeration. Ginger thrives well in sandy or clayey loam, red loam and lateritic loam soils with a *pH* of 6.0 to 7.5. However, rhizome growth is better on slightly acidic soil. Effective drainage is crucial to prevent a high incidence of disease. Ginger is an exhaustive crop; hence, it is not advised to grow the crop repeatedly in the same site year after year.

2.2 Climatic conditions

Ginger is a tropical crop and requires a warm and humid climate for its cultivation.

Altitude: Ginger is cultivated from sea level to altitudes of about 1500 m ASL. However, the optimum elevation for its successful cultivation is in the range of 300–900 m ASL. In the northeastern region, ginger is generally grown in Jhum (shifting cultivation) land or on fresh land situated in moderate to high altitudes.

Temperature: Ginger performs well in a temperature range of 19°C to 28°C and a humidity level of 70-90%. It does not grow well in areas where the temperature exceeds 32°C and the relative humidity is low. A cool, dry climate is ideal for rhizome development. Dry weather with average temperatures ranging from 28 to 30°C for about a month before harvesting is ideal. While high humidity throughout the crop period is necessary.

Rainfall: It is primarily grown as a rainfed crop, although it can also be cultivated under both rainfed and irrigated conditions. Areas with annual rainfall of 125-250 cm are favourable for ginger cultivation. The well-distributed rainfall during the growing season, from April to October, is ideal

for its cultivation. The optimum requirement of rainfall distribution for the successful cultivation of ginger is given in Table 2.

Table 2. Optimum rainfall requirement for successful ginger cultivation

S.No.	Time (Approx.)	Rainfall	Growth stage
1	April - May	Moderate rainfall	Sowing time rhizomes to sprout
2	June–September /October	Fairly heavy and well-distributed showers	Growing vegetative stages
3	October – November	Dry weather	One month before harvesting

Shade: Ginger is a shade-loving plant. Thus, it thrives well under partial shade, though it is also grown on a large scale in open areas.

3 Varieties

3.1 Diversity of ginger in the region

The northeastern region can be considered a rich reservoir of germplasm, and several cultivated types of ginger are known to exist in the region. Typically, cultivated genotypes are designated according to the localities where they are identified. The region is renowned for its diverse genetic resources, including commercially cultivated and related species of ginger, such as black and aromatic ginger, as well as mango ginger, which possess significant economic value (Verma *et al.*, 2023).

Varieties, like 'Nadia' and 'Rio-De-Janeiro,' are high-yielders of rhizomes with less fibre content as compared to standard or local cultivars. In addition to improved varieties such as Nadia, China, and Varada, the northeast region has several local cultivars, as listed below (Yadav *et al.*, 2004).

Assam: 'Maran' (287 g per plant) and 'Jorhat Local' (244 g per plant) have been reported to be good in rhizome yield. Dry ginger recovery of these varieties has been found to be even better than the exotic type 'Rio-de-Janeiro'.

Arunachal Pradesh: 'Basar Local' is very popular due to its high yield (209 q/ha) and adaptability to the local area.

Mizoram: 'Thingpui', 'Thingria' and 'Thinglaidum' are grown on a large scale. Thingpui produces about 193 q/ha and Thinglaidum (154 q/ha). Among these cultivars, farmers mostly prefer Thinglaidum, a medium-sized rhizome, as it contains less fibre and has a blackish ring.

Tripura: A local selection, Tripura Local performs better in comparison to the other types in the area.

Manipur: 'Thingpui' is commonly preferred in the hills and yields about 193.41q/ ha.

Nagaland: Commonly, two local cultivars are grown, viz., 'Viishii'/'Sungrosung', which is a small-sized rhizome having very high pungency and medicinal properties, and 'Osung', which is a

bigger-sized rhizome. In both cultivars, a pinkish tinge in the rhizome skin was observed during the immature stage.

Sikkim: Local types 'Bhainse' and 'Gorubathan' are grown commercially due to their high yield potential and large rhizomes.

Meghalaya: Local types, viz., 'Khasi Local' (150 q/ha) and 'Tura Local' (178 q/ha) are the most common varieties of ginger under cultivation. However, a considerable area under the selected type 'Nadia' has also been observed. In Meghalaya, other species are also cultivated as commercial crops, such as 'Kynshiang' / 'Syngkhmoh kynthai' (*Curcuma montana* Roxb.), 'Syng Makhir' (*Zingiber rubens* Roxb.), 'Syng Blei' / 'Syngkhmoh Shynrang' (*Z. montanum* Link ex. Dietr.)

3.2 Exotic varieties

In addition to the local types, 'Rio-de Janeiro', 'Nadia', 'Suprabha', 'Poona', 'Varada', and 'China' are also among the popular varieties of ginger in the region. Today, the variety 'Nadia' is very popular among all the states of the northeastern region (Table 3). The selection of ginger varieties for different uses is given in Table 4.

Table 3. Promising varieties of ginger in Meghalaya

Adapted varieties	Crude fibre content (%)	Dry matter content (%)	Oleoresin (%)	Oil (%)	Yield (t/ha)
Nadia	4.1	22.6	5.4	1.4	30.00
Poona	6.4	20.4	-	1.17	25.10
Varda	3.2	-	-	-	22.00

(-) data not available

Table 4. Suitable varieties for various purposes.

Sl. No.	Purposes	Varieties
1	High-yielding types	Maran, Karakkal, Rio de Janeiro, Mahim
2	Less fibre content	Jamaica, Bangkok, China, Thingpui
3	High oleoresin	Ernad Chered, China, Karuppamadi, Rio de Janeiro
4	High dry ginger recovery	Karakkal, Nadia, Maran, Tura
5	High-volatility oil	Sleeve local, Narasapattam, Emad Chemad

4 Land preparations

Generally, in the region, ginger is cultivated under the jhum system. However, it is advised to adopt a bed system of planting, which is known as bun in Meghalaya, zabo in Nagaland, tila in Tripura and Assam. The minimum-tillage operations can be applied during land preparation. Beds

of 15 cm in height, 1 m in width, and of a convenient length may be prepared, with 40-50 cm spacing between beds. On hill slopes, the beds are formed along the contours.

In areas prone to rhizome rot disease and nematode infestations, it is recommended to follow solarisation of beds. Solarisation of beds is beneficial for checking the multiplication of pests and disease-causing organisms. Solarisation is a technique in which transparent polythene sheets are spread over moist field beds, covering all sides and thus exposing them to the sun for a period of 40 days. After completing soil solarisation, the polythene sheets used should be stored safely.

5 Planting materials

5.1 Selection of rhizomes: Rhizomes for seed materials must be collected from healthy and disease-free mother plants. It must be obtained from organically produced farms or certified government agencies. The collected materials may be immediately planted or must be carefully preserved for use in the next season. The seed materials must be healthy, free from pests and diseases, high-yielding, and have good eyes for sprouting and germination potential. Seed material from high-yielding local varieties with a history of not using any inorganic practices can be used in the absence of organically produced material.

5.2 Seed size: The sprouted rhizomes are cut into sections with an approximate weight of 20–25 g, length (4–5 cm), and each section contains 2–3 good bud sprouts.

5.3 Seed rate: The seed quantity requirement varies by region, propagation techniques, and cultivation method. However, the average seed rate under a conventional cultivation system is 1,500–2,500 kg/ha. The seed rate can be significantly reduced using single-bud seed rhizomes in the pro-tray.

5.4 Seed treatment: Seed rhizomes of organic origin should not be treated with chemicals. Hot water treatment, on the other hand, is capable of decreasing adhered rhizome-borne pathogens. Seed rhizomes are dipped in hot water (about 50°C) for 10 minutes. The treated seeds are spread in shade for about 3–4 hours before planting. Rhizome sets may also be treated with cow dung and urine preparations, such as amrut pani, jeevamrut, panchagavya, and cow pat pit. Mother rhizomes may also be treated with Bio-organic for ginger (GF1), developed by the ICAR Research Complex for the NEH Region, Umiam. Mix the formulation at a rate of 20 ml per litre of water. The treatment of mother rhizomes is about 10–12 hrs in solution before sowing. The same solution can be used for the 2nd and 3rd lots of ginger rhizomes. Discard the left-out solution after 30–36 hrs. Generally, one litre of solution can treat up to one kilogram of planting material. Traditionally, farmers keep the seed rhizomes in the sun for about a day.

6 Planting

6.1 Spacing: Spacing of 30 cm between rows and 30 cm between plants.

6.2 Methods of planting: At the time of planting, neem cake powder (25 g) may be mixed well with the soil in each pit. Mix the small rhizomes (bits) containing bud sprouts with well-rotted FYM or Trichoderma-inoculated compost (10 g) per pit. The seed rhizomes are placed at a depth of 4–5 cm in shallow pits prepared with a hand hoe and covered with well-decomposed farmyard manure

and a thin layer of soil, then levelled. The seed rhizomes are planted to ensure that at least one viable and healthy bud faces upward. For rainfed crops, the beds are covered with leaf mulch for protection against the sun and heavy rains, as well as for moisture conservation and subsequent enrichment of organic matter in the soil.

6.3 Planting time: The planting time of ginger coincides with the onset of the monsoon season in April-May. However, under irrigated conditions, it can be planted as early as February or early March. Early planting in February and March coincides with light showers or irrigation supplements, resulting in a higher yield and lower disease incidence.

7 Cultural practices

7.1 Mulching: Mulching the ginger beds with green leaves is essential for promoting rhizome sprouting, germination, and preventing soil splashing and erosion caused by heavy rains. It also helps add organic matter to the soil, checks weed emergence, and conserves moisture during the latter part of the cropping season. The first mulching is performed with green leaves at the time of planting (10–12 t/ha), followed by an additional 5 t/ha at 45 and 90 days (Table 5). Leaf mulch is mostly used for mulching ginger plantations. Since most deciduous plants shed their leaves in the winter, it is best to collect leaves for ginger mulching at the time of planting. Mulching materials such as *Schima wallichii* and *Artemisia vulgaris* are widely used in Sikkim, which also reduces disease and pest problems. The use of *Lantana camara* and *Vitex negundo* as mulch may reduce the incidence of shoot borer infection. Cow dung slurry or liquid manure may be poured on the bed after each mulching to enhance microbial activity and nutrient availability.

Table 5. Scheduling of mulching

S.No	Time (approx.)	Quantity
1	Time of planting	Green leaves @ 10-12 tonnes/ha
2	45 days after planting, immediately after 1 st weeding, fertilisers are applied, and the soil is earthened up.	Green leaves, paddy straw, etc @ 5 t/ha
3	90 days after planting, immediately after 2 nd weeding, fertilisers are applied, and the soil is earthened up.	Green leaves, paddy straw, etc @ 5 t/ha

7.2 Cover crops: Cover crops are generally leguminous crops in ginger fields; however, it may be comprised of other green plants such as cucurbits. This helps manage weeds, improve soil fertility, regulate moisture, and prevent soil erosion, while also controlling diseases and pests. Incorporation of green manure crops, such as leguminous crops like pigeon pea, black gram, cowpea, cluster bean and French bean, is the most common practice. Additionally, cover crops are income-generating crops with strong market demand (Rymbai et al., 2021). In some cases, wood ash was used in the field to increase the potash content of the soil.

7.3 Earthing up: Ginger cultivation requires at least two earthing-ups for better growth and development of rhizomes. The soil around the plants is worked with the help of a spade in the first

week of September. It helps to break the fibrous roots, thereby supporting new growth. The soil surrounding the rhizomes becomes loose and friable, creating an ideal environment for rhizome development. It also prevents exposure of rhizomes. It is done at 45 and 90 days after planting, that is, immediately after weeding and manure application (Rymbai et al., 2018).

7.4 Weeding

Two weedings are generally done just before manure application and mulching to control weeds. The first weeding is done 4-6 weeks after planting, i.e., just before manuring and second mulching. Repeat the second weeding depending on the intensity of weed growth. The weed material may be used for mulching. Weeding may be repeated for the third time, if needed. During hoeing, every care should be taken to ensure that the rhizomes are not disturbed, injured, or exposed.

8 Nutrition

Ginger is a nutrient-exhausting crop, but not a limitation for organic production. The practice of intercropping ginger with leguminous crops, crop rotation and the use of cattle manure will supplement the nutrients exhausted by the previous crop. Generally, in the northeastern region, ginger cultivation is mostly on freshly prepared land, where adequate nutrients are already available. At planting time, apply FYM or compost (25–30 t/ha), neem cake (2 t/ha or 25 g per pit), and biofertilizer (Azospirillum + PSB) at 5–6 kg/ha to the planting pits to reduce the incidence of rhizome rot and nematodes, thereby increasing yield. After two months of planting, vermicompost (5 t/ha) should be applied to promote growth and production. Since the edible part of ginger is the underground rhizome, adding layers of leaves before planting the seed rhizome increases ginger production by loosening the soil texture around the seed rhizome in the later stages.

9 Water management

Generally, in the northeastern region, the crop is cultivated as rainfed in high-rainfall areas (uniform distribution for 5 to 7 months). Irrigation can be provided only in areas with less rainfall where the distribution is not uniform. The critical stages of ginger for irrigation are given in Table 6. The first irrigation should be carried out immediately after planting, with subsequent irrigations occurring at intervals of 7–10 days, depending on the weather and soil type. Sprinklers and drip systems can be used in irrigated crops to improve water use efficiency and yield. Ginger requires 1,300–1,500 mm of water during its crop cycle. Irrigated crops require about 16–18 irrigations until maturity. Drainage is also equally necessary for preventing disease incidence, such as wilt and soft rot. Sufficient soil moisture should be present in the soil during sprouting, rhizome initiation and rhizome development.

Table 6. Irrigation schedule at various stages of growth and development

S.No.	Period (approx.)	Time (approx.)	Critical stage	Irrigation
1	April-May	10-15 DAP	Germination	In the absence of showers, need 2-4 initial and an interval of 7 days
2	June- July	90 DAP	Rhizome initiation	The crop receives monsoon rain till September-October Irrigation may be given from October to mid-November
3	August-September	135 DAP	Rhizome development stages	
4	November-December	210-245 DAP	-	Avoid irrigation 30 days before harvesting
	Rhizome maturity & ready for harvest			

DAP – days after planting

Water sources in the NEH Region are mainly seasonal precipitation, rivers, and natural perennial streams. Water quality assessments can be conducted in accordance with the norms and guidelines of the approved organic package of practices. Proper drainage channels should be provided in the inter rows to drain off stagnant water, ensuring optimal drainage for a better plant stand.

10. Cropping system and pattern

Crop diversification, as displayed by intercropping, has long been a prominent feature of smallholder crop production in the region. Intercropping becomes increasingly important for increasing crop yield and cropping intensity as we strive to meet the food demands of a growing population. The growing concern about agricultural sustainability supports the use of intercropping systems because of their positive impact on soil conservation and fertility, as well as their significant potential for reducing pests and diseases.

Ginger can be grown organically as a sole crop, intercrop, or mixed crop, provided all the other crops are grown following organic methods. In the region, various cropping systems are followed for ginger cultivation. Most of the farmers prefer to grow ginger as a sole crop. However, mixed cropping with corn, chillies, brinjal, pumpkin, cucumber, papaya, tree tomato, yam, tapioca, colocasia and leguminous crops has also been practised in jhum and backyard gardens. Ginger is also intercropped with maize, pineapple, coconut, and coffee plantations in the Garo Hills and Ri-Bhoi, as well as with Khasi Mandarin in the Jaintia Hills. Growing ginger under tree shades allows the ginger to benefit from the decaying leaves that fall from the trees, which serve as a source of nutrients in addition to the shade provided by the trees. This is similar to the use of locust beans, which also help improve ginger yields.

The adoption of intercropping in ginger cultivation with suitable intercrops improves farmers' income. Ginger-based intercropping systems, such as ginger + maize + French bean + pumpkin, or ginger + maize + French bean, enhanced the productivity and economic conditions of hill farmers in the eastern Himalayas (Rymbai et al., 2021). In addition, diverse cropping supports a wide range of beneficial insects and soil microorganisms; helps in soil and water conservation; improves soil fertility; enhances farm productivity per unit land; and ensures security against potential risks of monoculture, alongside creating a platform for stabilising the diversified needs of farming households whose production is greatly influenced by the vagaries of nature. In northeastern regions, the following crops are the most common intercrops with ginger (Table 7).

Table 7. The most common intercrop in Ginger-based cropping

Sl.No.	Crops	Sl.No.	Crops
1	Chili (<i>Capsicum annuum</i>)	9	Tapioca (<i>Manihot esculenta</i>)
2	Brinjal (<i>Solanum melongena</i>)	10	Kidney bean (<i>Phaseolus aconitifolius</i>)
3	Winter squash (<i>Cucurbita maxima</i>)	11	Cluster bean (<i>Cyamopsis psoraloides</i>)
4	Pumpkin (<i>Citrullus lanatus</i>)	12	French bean (<i>Phaseolus vulgaris</i>)
5	Cucumber (<i>Cucumis sativus</i>)	13	Pineapple (<i>Ananas cosmosus</i>)
6	Maize (<i>Zea mays</i>)	14	Banana (<i>Musa spp</i>)
7	Castor (<i>Ricinus communis</i>)	15	Papaya (<i>Carica papaya</i>)
8	Pigeon pea (<i>Cajanus cajan</i>)	16	Colocasia (<i>Calocasia esculenta</i>)

In our experiment, we found that intercropping with French beans and cowpeas is more profitable in ginger-based cropping (Table 8).

Table 8. Yield performance of ginger in different cropping systems

Cropping system	Ginger yield (q/ha)	Ginger equivalent yield (q/ha)	Net income (Rs/ha)
Ginger sole	170.8	170.8	57,520
Ginger+ cowpea	148.4	202.5	1,00,500,
Ginger+ French bean	160.4	198.6	1,02,600
Ginger+ chilli	149.6	209.7	1,04,700
Ginger+ okra	132.4	187.9	77,120
Ginger+ brinjal	135.0	181.4	75,900

Crop rotation is a common practice in ginger. Crop rotation should be strictly followed to avoid insect pests and disease problems of ginger. Under rainfed conditions, it can be grown once every three to four years in rotation with sweet potato, yam, tapioca, and other leguminous

crops. Under irrigated conditions, ginger is rotated with plantain, turmeric, onion, garlic, chillies, other vegetables, sugarcane, maize, ragi, and groundnut. Under irrigated conditions, ginger is rotated with plantains, maize, garlic, onions, turmeric, chillies, other vegetables, ragi, sugarcane, and groundnut. Being an exhaustive crop, it is desirable to include a leguminous crop in rotation with ginger. Ginger-banana-legume or ginger-vegetable-legume cropping patterns are suitable. It is rotated with French beans or soybeans in the region, which not only enhances soil quality but also provides additional income (Rymbai et al., 2021).

However, there are crops that are not suitable as intercrops in ginger-based cropping systems. Root and tuber crops, such as colocasia and tapioca, are extensive crops. They compete with ginger for nutrients and moisture. Crop rotation using tomato, potato, chillies, brinjal, and peanut should be avoided, as these plants are hosts for the wilt-causing organism, *Ralstonia solanacearum*. Furthermore, seeds of cluster bean, pigeon pea, or castor are sown in irrigation channels on the corners of raised beds to provide shade.

11. Harvesting

Ginger begins to flower during June–July, coinciding with showers or the rainy season. The stage of harvesting the rhizomes depends on the purpose of use (Table 9). The indices for fully mature rhizomes are the leaves turning yellow and the pseudostems beginning to wither.

Rhizomes are lifted either with a digging fork or with a spade. The rhizomes are cleaned of dry leaves, roots, and soil adhering, and then manually separated. Fibre, volatile oil, and the pungency level are the most important criteria in assessing the suitability of ginger rhizomes for a particular processing method. The stages of maturity at harvest significantly govern the relative abundance of these three components in the fresh rhizome.

Table 9. Various harvesting stages of ginger for different purposes

Purposes	Stage of harvest (months after planting)
For green ginger, vegetable purpose and preparation of ginger preserve, candy, soft drinks, pickles and alcoholic beverages	5-6 (150-180 days after planting; September to October)
For curing purposes, dried ginger and preparation of ginger oil, oleoresin, dehydrated and bleached ginger	7-9 (210-250 days after planting; April to November-January)

12 Yield

The yield of green ginger is about 10-15 t/ha (green rhizomes) and 20-25 t/ha of mature rhizomes. The yield of cured ginger is 15-20% of the fresh produce.

In the hill districts of Assam, particularly in the North Cachar Hill district, farmers keep ginger unharvested for 2–3 years, and the weight of ginger also increases (one bunch of ginger may weigh 300–400 gm after three years). During the dry season, the weight of ginger is slightly less, but when harvested during the off-season (April–May) with a small shower of rain, the weight

increases. The average yield of fresh ginger ranges from 20 to 30 tons per hectare, depending on the variety.

In cases where the harvest period coincides with a market glut, irrigation is extended at 8–10-day intervals rather than harvesting. At the end of April, sprouting is seen. Manures and fertilisers are applied according to recommendations, and harvesting is done in August. In this case, the average yield obtained is about 30 to 40 t/ha.

13 Diseases

13.1 Soft rot

The main fungal pathogen responsible for soft rot of ginger is *Pythium myriotylum*. This disease is very common in this region and occurs in severe form during the rainy season (July–August).

Symptoms and damage

1. Leaves start yellowing from the bottom, and it extends to the top of the plant after a few days.
2. On the leaves, yellowing starts from the margins.
3. The most dependable symptom is softening of the junction (between pseudostem and rhizome), and after some time, it becomes watery.
4. The shoot can be easily pulled out.
5. The symptoms also mimic nitrogen deficiency.
6. Buds on the rhizome also become black.
7. Disease is most common during the months of July and August.
8. At an advanced stage of infection, the rhizome rots completely, and the pseudostem falls to the ground.
9. The pseudostem withers and dies.

Survival and spread

The primary source of survival for the pathogen is the infected rhizomes, which are kept for seed purposes, and also through oospores in infected plant debris. The disease mainly spreads through the planting of infected rhizomes.

Management

1. The best strategy is to plant disease-free rhizomes.
2. Seed rhizomes should be collected or purchased from disease-free areas.
3. Hot water treatment of rhizome at 50°C for 30 min.
4. Proper drainage to prevent waterlogged conditions.
5. Affected clumps should be removed immediately once detected.

6. Seed rhizomes should be treated with a Trichoderma-based formulation @ 4 g/l (Method: Dip the seed rhizomes for 45 min in the suspension, and then shade drying should be done before planting; 10 L of suspension is required for 10 kg of rhizomes)
7. Application of FYM and other organic manure to increase beneficial microorganisms.

13.2 Bacterial wilt

This disease is caused by bacteria, *Ralstonia solanacearum*. This is also a very deadly disease affecting ginger cultivation in this area.

Symptoms and damage

1. The most prominent symptom of the disease is quick wilt, i.e., wilting without yellowing in the initial phases of the disease. The infected leaves curl and roll.
2. In advanced stages, yellowing and necrosis are also observed.
3. Ooze test should be conducted for confirmation since symptoms in the field might be confusing sometimes. In the ooze test, a cut pseudostem or tiller is placed in a transparent tube containing water. In the case of bacterial wilt-infected plants, milky ooze can be observed emerging from the cut ends of tillers over time.
4. Vascular tissues turn brown in advanced stages.

Survival and spread

The bacteria survive in soil and infected plant debris. The bacteria are released from infected tissues and spread to nearby plants, causing infection. It can enter through natural or artificial wounds in the roots and spread through soil, water, and infected rhizomes. High temperature and soil moisture favour the disease development.

Management

1. Rhizome should be collected from disease-free areas for planting purposes.
2. Seed rhizomes should be treated with *Pseudomonas fluorescens*-based formulations or combined formulations of *Trichoderma* and *Pseudomonas* following the same methodology as provided in soft rot. Drenching should also be done using these formulations.
3. Crop rotation with maize, toria, paddy, and green manure can also be practised.
4. Growing a mustard crop and incorporating the plant into the field at the flowering stage can also suppress the pathogen.
5. Farm tools should be disinfected with the bleaching solution/ powder before using.
6. Weeds should be removed from the field and also from the irrigation channels.
7. Application of FYM and other organic manure to increase beneficial microorganisms.

Other minor diseases include- Phyllosticta leaf spot (*Phyllosticta zingiberi*), Cercoseptoria leaf spot, leaf blight (*Rhizoctonia* sp.) and Fusarium yellows (*Fusarium oxysporum* f.sp. *zingiberi*).

14 Insect pests

The major pests of ginger are shoot borer, leaf roller and rhizome scales. Regular field surveillance and the adoption of phytosanitary measures are necessary for effective pest management.

14.1 Shoot borer (*Conogethes punctiferalis*)

This is the most serious insect pest of ginger.

Life cycle description: The moths lay eggs on leaves and other soft parts of the plant. The eggs hatch in about a week. The larvae undergo 4-5 instars before becoming fully developed in 2-3 weeks. Pupation occurs within the seed, or occasionally in the grass that forms after feeding. The pupal stage lasts about one week. The life cycle is completed in 4-5 weeks, and three generations are completed in a year. The pest is most active from July to October.

Marks of identification: The adult caterpillar is 25-30 mm in length, reddish brown with black blotches all over the body and a pale stripe on the lateral side. The moths are orange and yellow, with black markings on both wings.

Nature of damage: The damage is caused by the caterpillar, which bores into the main stem of the young plants, causing their death. The larvae bore into pseudostems and feed on internal tissues. The infested pseudostems result in yellowing and drying of leaves. The characteristic symptoms and damage are the presence of a bore-hole on the pseudostem through which frass is extruded, and the withered and yellow central shoot.

Economic threshold level: Adoption of management methods at (i) a stage of 1 egg mass per square meter and (ii) when the first symptom of pest attack is seen on the top-most leaf in the form of feeding marks on the margins of the pseudostem.

Management

1. The shoots infested by the borer are cut open.
2. Caterpillars should be handpicked and destroyed.
3. Grow neem trees along with ginger crops to repel the pest.
4. An integrated strategy involving pruning and destroying freshly infested pseudostems during July-August (at fortnightly intervals) and spraying Neem oil-based formulation @ 5 ml/ L during September-October (at monthly intervals).

14.2 Rhizome scale (*Aspidiella hartii*)

Nature of damage: The scale infests rhizomes at later stages in the field and in storage.

Marks of identification: Adult (female) scales are circular (1 mm diameter) and light brown to grey and appear as encrustations on the rhizomes.

Nature of damage: They feed on sap, and when the rhizomes are severely infested, they become shrivelled and desiccated, affecting their germination.

Management

1. The rhizome scale can be managed by timely harvest.
2. Discard severely infested rhizomes
3. Treat the seed rhizomes before storage and before sowing in case the infestation persists.
4. The seed rhizome may be stored in sawdust + *Strychnos nux-vomica* leaves (dried) after seed treatment.

Minor insect pests are white grub (*Holotrichia seticollis*), rhizome fly (*Mimegralla coeruleifrons*), skipper (*Udaspes folus*) and scale (*Aspidiotus hartii*). White grub can also cause major damage to the crop by feeding upon feeder roots and rhizomes. The intensity of this infection was so severe that it affected 80-90% of the ginger crop (Vijayan, 2020).

14.3 General management practices

- Tilling of the soil during land preparation and solarisation leads to a reduction of the insect pest population, particularly white grubs, which get exposed at the time of tilling and are foraged by the birds.
- Light traps are used to control the adult population of insects.
- Mechanical collection of infected leaves and white grub adults. Destroying the adults of white grubs during their peak period of emergence is one of the cheapest, simplest, and most effective methods to minimise the white grub population.
- Biological controls: Application of *Trichoderma sp.*, *Beauveria bassiana*, or *Metarhizium anisopliae* mixing with vermicompost or drenching the soil with these entomopathogenic fungi @ 5 g/l gives an effective result.
- Mulching with *Lantana camara* at the time of planting reduces infestation by shoot borer.
- Fallowing of land for two consecutive years helps in reducing the pest.
- Growing of resistant crops such as sunflowers also checks the build-up of grub populations.
- Sowing of trap crops such as sorghum, maize, onion, etc., to reduce white grub infestation.
- Two sprays of Nimbicidine or Neemazal @ 3ml/l at 15-day intervals are found to be effective against the shoot borer, leaf roller and grasshopper of ginger.
- Conservation of hedgerows around the ginger plantation: to maintain a population of ladybirds, spiders, etc., which are good natural bio-agents for control of many of the insect pests.

14.4 Storage pests

Generally, no pest management practices are adopted during the storage of ginger, as the storage period is generally short. Care must be taken to avoid the damp conditions of the storage

area. The pre-storage treatment of rhizome by dipping in a 10% solution of a mixture of *Pseudomonas* and *Bacillus* for 30 minutes, followed by drying in the shade, helps reduce the incidence of the disease (Vijayan, 2020).

15 Post-Harvest Management

15.1 Cleaning

The harvested ginger rhizomes are usually cleaned manually. Adhering soil particles are removed, and the mother rhizomes are separated. The harvested ginger is left in the sun to dry for a few hours to a day. The duration of drying varies from area to area, depending on the availability of sunlight.

15.2 Drying

In the northeastern region, the rhizomes are generally kept in the sun for 2–3 hours (in the hill districts of Assam) or for a day (in the hills of Meghalaya). The harvested ginger is kept on raised wooden / bamboo platforms inside the shed, either for seed or for sale.

15.3 Packaging

The cleaned or dried ginger is kept in gunny bags for transportation.

15.4 Storage

The rhizomes to be used as seed material should be preserved carefully. To achieve good germination, the seed rhizomes are correctly stored in pits under shade. Generally, the harvested ginger, which are healthy and disease-free clumps, are kept in pits of convenient size made inside the shed/thatched huts to protect from the sun and rain. The walls of the pits may be coated with a paste made from cow dung. Seed rhizomes are stored in alternate layers along with well-dried sand/sawdust (20 cm thickness) every 30 cm of rhizome layer. A sufficient gap is to be left at the top of the pits for adequate aeration. The pits require inspection every twenty days to remove shrivelled and disease-affected rhizomes (Shadap et al., 2014). In some areas, the rhizomes are loosely heaped over a layer of sand or paddy husk placed in a thatched shed and covered with dry leaves. The indigenous practice involves spreading layers of *Glycosmis pentaphylla* leaves over the seed material.

15.5 Processing

The ginger is marketed as fresh and value-added products, including dried ginger, ginger powder, and ginger candy.

15.5.1 Fresh ginger

Most fresh ginger is produced and consumed locally in Asian countries. However, there has been a recent increase in demand for fresh ginger in European and American countries.

15.5.2 Dried ginger

The harvested rhizomes at the fully mature stage are cleaned and soaked in water for 3-4 hrs. The outer skin is peeled and placed on a clean surface to dry in the sun. It takes about 14

days for the rhizome to completely dry to a moisture level of 10%. The rhizomes are usually dried on a cemented floor or a floor made of cow dung paste. Dry ginger is used to make various products, including ginger powder, ginger oil, and ginger oleoresin, which serve as a base for numerous end products. The dry recovery rate of ginger is approximately 1/5 of the fresh rhizomes.

15.5.3 Storage of dried ginger

Dry ginger, packed in gunny bags for storage, is susceptible to infestation by insects such as *Lasioderma serricorne* (Cigarette beetle). To prevent the attack of such pests, thoroughly dried rhizomes can be stored in airtight containers such as high-density polyethene or similar packaging materials. If possible, keep the rhizomes along with dry leaves of *Azadirachta indica* (neem leaves). Long-term storage of more than two years will lead to loss and deterioration of the aromas, flavour, and pungency of ginger, especially at high temperatures.

16 Major production constraints

Ginger is an important and the oldest spice crop in the Northeast region, with potential for further boosting production and increasing ginger exports. Since it is a vegetatively propagated crop, a lack of consciousness in the selection of high-yielding varieties and several characters must have occurred in the past. There had also been an interchange of materials, but despite this, there has not been a tangible increase in production. The major bottlenecks are as follows:

16.1 Shifting cultivation: In this system, an agricultural crop is grown at one place for 3-5 years, and after that, the farmer starts growing at another place. Earlier, this cycle lasted for about 15 years; therefore, in the meantime, the soil gets sufficient time for the regeneration of biomass/forests. Now, due to the reduction in the jhum cycle to 3-5 years, the soil fertility has decreased. This system has led to large-scale deforestation, soil degradation, and depletion of the resource base.

16.2 Land tenure system: For boosting the production of ginger, settled cultivation is necessary, like other crops. The productivity is also low due to the land tenure system prevailing in the region, as farmers generally cultivate on leased land, leading to a sense of alienation from the land. Consequently, inadequate management practices are frequently adopted. Settled cultivation and the right of ownership of land to the farmers are necessary for the judicious management of land.

- Small land holdings: Due to the terrain, the size of land holdings in the region is small, and farmers cultivate multiple crops as needed from the same piece of land. Therefore, the commercialisation of crops or varieties on a large scale is very difficult in the region.
- Non-availability of quality planting materials and other inputs: Farmers lack access to good-quality, high-yielding, and disease-resistant rhizomes. The modern inputs, including organic management practices, have not been adopted systematically and are often referred to as organic by default. Although many high-yielding varieties have been identified and recommended by researchers in the region, large-scale quality seed

production is lacking due to the absence of agencies responsible for ensuring the quality of seed production.

- High rainfall: The region receives high rainfall, which causes heavy infestation with weeds, pests, and diseases, as well as leaching of nutrients.
- Lack of funds: Although ginger is a significant cash crop in the state, farmers are mostly resource-poor for purchasing quality seeds and other inputs.

16.3 Problems of processing and marketing:

For the NEH region, the success of ginger growing is closely linked with the success of processing units, marketing and transport facilities. To date, few processing units exist but are not functioning at the desired capacity. Marketing of ginger in the state faces a problem due to the non-availability of value-added products, such as oleoresin and volatile oils. Others include losses due to faulty storage methods and diseases such as rhizome rot, a lack of trained personnel with sound knowledge in post-harvest technologies, inadequate and poorly-implemented organic production technologies and management practices, and the remoteness of the state from the national stream. Additionally, the market for ginger has experienced significant fluctuations. With recent developments in telecommunication, networks, and online marketing, the state can be linked with other parts of the country through internet connections and websites, allowing for the supply of information related to the exact demand and price of produce in different markets across the country.

17. Future thrust

- The following are the areas where more intensive research is needed to enhance the overall scenario of organic ginger production by increasing production and productivity in the northeastern region.
- **Survey, diagnosis, and design:** There is a need for a survey and diagnosis of lands suitable for ginger cultivation, as well as the development of an area-specific farming system model in a cluster approach.
- **Introduction, evaluation and improvement:** Introduction of indigenous and exotic high-yielding strains of ginger suitable for the state. Breeding should be conducted for high-yielding and better-quality varieties with resistance to both biotic and abiotic stresses.
- **System management research:** There is a need to develop micropropagation and other propagation methods for rapid mass multiplication of plants. Use of IPM and an integrated nutrient management system is required.
- **Post-harvest management:** Processing and preservation of value-added products are required. There is a need to develop quality control measures, adequate packing and storage techniques. The processing industry can help address the problem of the proper disposal of perishable commodities. Value-added products can be extracted if processing

units are established in the region. The use of appropriate pre- and post-harvest practices is vital for the success of the crop and to provide a good return to the growers.

- **Economics and technology transfer:** A cost-benefit analysis is required, and there is an immense need to strengthen the extension system for transferring technologies generated and to provide training to farmers.
- **Emphasis on organic farming:** The ginger production in the northeastern region is organic by default, as farmers in the region do not apply chemical fertilisers or pesticides to their ginger crops. They are only applying the locally available farmyard manures (cow dung, pig manure, poultry manure, rabbit manure, etc.). In this way, the farmers' ignorance of technological advances is turning out to be a key to prosperity. Considering the increasing demand for organic produce worldwide, farmers can undoubtedly expect to receive better returns for their products. However, first and foremost, they need to have a marketable surplus. This surplus then needs to be collected, stored, packaged, and transported to the distant market after it has undergone proper certification and testing. Therefore, there is considerable scope to popularise organic ginger production for export to foreign countries from the region and establish an organic product-based ginger industry in the region.
- **Conservation techniques:** The following are the conservation techniques for soil, moisture, pollution, and microbes, *among others*.
 - Mulching conserves soil moisture by checking evaporation loss.
 - Bunds are constructed to prevent soil erosion and to retain the topsoil.
 - Proper drainage channels are provided to drain off stagnant water.
 - Seasonal legumes are also grown alongside ginger to suppress weed growth, minimise soil erosion, and enhance soil fertility.

Time Schedule of horticultural operations in Ginger Production

Sl.No.	Activity	Time
1	Collection of dry leaves for mulching and cushioning	December-January
2	Field preparation and FYM application	January-February
3	Planting and making of bun immediately after planting	March-April
4	Making of a drainage channel to drain off the excess water during rain	March-April
5	Weed removal and application of additional FYM and manure, followed by mulching	May-June
6	Application of Bordeaux mixture (1:1:10) at 15 day intervals or the initial symptom of bacterial wilt or soft rot	July-September

7	Irrigation should be stopped one month before harvest	November–December
8	Harvesting	December- March

CONCLUSION

The organically grown ginger enhanced the quality of the product, as well as its high market preference. The selection of a site free from any history of soil-borne pathogen incidence, and seed selection from disease-free and organically produced certified seeds, along with other cultural management practices such as the correct weeding, earthing up, nutrition, water management at critical stages, and intercropping as per the norms of organic systems, are crucial steps in successful ginger cultivation.

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