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Major spices of North Eastern Hill Region of India: A review

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Abstract
Spices are high value and export-oriented commodity crops, which play an important role in agricultural economy of the country. India is the principal source for supply of spices in the global market. India is the largest exporter of spice and spice products. During the year 2020-21, the country exhibited an upward trend and exported spices worth US $4.18 which was a 34% increase from that of 2019-20. The North Eastern Hill Region (hereafter; NEHR) comprising of states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura has tremendous potential for production of spice crops. The climatic condition of the region is highly suitable for cultivation of a large number of spices such as ginger, turmeric, chilli, bay leaf, large cardamom, coriander, and garlic. Though recently introduced, the region has a potential for commercial cultivation of black pepper, cumin, vanilla and saffron. The NEHR are by default organic in nature and is home to some endemic spice crops like black turmeric, Lakadong turmeric, King Chilli, Bird's eye chilli, Assam lemon, etc., which has high market demand for their unique features. Large scale production and commercialization of spices from the region could improve the livelihood of the farmers and economic growth of the country. The paper aims to review the major spices of NEHR of India.

Keywords: Spices, NEHR, Lakadong turmeric, king chilli, bird's eye chilli

Introduction
The history of spices in India is believed to be as old as the human race. India is rightly called as "spice bowl of the world" for her production of variety and superior quality spices. India has highest number of spice varieties in the world. India produces about 75 of the 109 varieties listed by the International Organization for Standardization (ISO). The most produced and exported spices are pepper, cardamom, chilli, ginger, turmeric, coriander, cumin, celery, fennel, fenugreek, garlic, nutmeg & mace, curry powder, spice oils and oleoresins. Out of these spices, chilli, cumin, turmeric, ginger and coriander make up about 76% of the total production. (Spice Industry and Export in India 2022) [23]. Almost all the states and union territories in the country produce at least one of the spices because of the favourable climatic conditions prevailing in the states (Rajanbabu *et al.* 2022) [37]. Spices can be in various structures like new, prepared, dried or broken and can also be the barks, leaves, buds, roots, seeds, etc that cause the smell, flavour, taste, sharpness in the food items apart from just the seasoning aspect. The demand for the spices produced in India is higher as indicated by the Spices Board of India, a Government of India initiative for the development and worldwide promotion of Indian spices whereby the report stated that the export of spices has attained a record in terms of both the volume and value in the previous financial year with a 30% increase in volume and a 23% increase in value (Rupee terms).

Spices are integral to the Indian community, as not only did it influence the Indian history but also an important additive in all the Indian cuisines. Besides offering culinary value in exquisite aroma, texture and taste, spices also possess tremendous nutritive and therapeutic value (Dini, 2018; Bower *et al.* 2016; Srinivasan, 2014) [14, 10, 55]. Spices are low volume and high export-oriented commodity that has great economic significance in India (Sugasini *et al.* 2018) [57]. In terms of the value of world trade, pepper, cardamom, ginger, turmeric, capsicum/chili, cinnamon, nutmeg/ mace, cloves and vanilla are the most important spices crop from tropical regions and cumin, coriander, sesame seeds, mustard, sage, bay, oregano and mint are the spices crop from the non-tropical regions (FAO, 2005) [17]. India is the largest exporter of spice and spice products. During the year 2020-21, the country exhibited an upward trend and exported spices worth US $4.18 which was a 34% increase from that of 2019-20.

United States of America (USA) imports the highest quantity of spices in the world (Sharangi and Pandit, 2018) [44] with a value of 1,701 thousand USD which contributes 16.35 per cent of world import value whereas India ranks third with a value of 596 thousand USD with a total share of only 5.73 per cent in the import value of the world (Yes Bank and IDH, 2018) [59].

Spices contributed 1.24 per cent of India's total export earnings. Table No.1 shows the major spice producing states of India during the year 2016-17. The share of spices in the export earnings from agricultural and allied products is 8.5 per cent. Status of export and import of spices during 2018-19 showed that the export quantity was 11,00,250 MT with value of Rs. 19,50,581 lakhs, while we are also importing spices with value of Rs. 4,99,549 lakh. This shows the need of increasing both area and production under spice crops (Spices Board, 2020).

NEHR, a biodiversity hotspot, harbours many spices which is endemic to this region. The total geographic area NEHR is 262,180 square km which is nearly 8% of the total geographic area of the country. The availability of wide genetic resource base and varying production systems in these regions ensures sustainable production of different spice crops. Among spices, ginger cultivation has increased by 3,356 ha followed by 3,775 ha of large cardamom, 2,773 ha of black pepper and 843 ha of turmeric. Though introduced in recent times, the region has a potential for commercial cultivation of vanilla, cumin and saffron. An area of 1,40,241 ha is under spice production with annual production 1,37,514 tonnes. Among the different spices grown in the region, three commercial crops are ginger, turmeric and large cardamom. Among all spices, ginger is the main cash crop supporting the livelihood and improving the economic level of many ginger growers of north eastern region. Ginger is grown in almost all the states of the region but the leading states are Meghalaya, Mizoram, Arunachal Pradesh and Sikkim (Hnamte, *et al.* 2012) [22]. The NEHR are by default organic in nature. After Sikkim, the government is aiming to make Meghalaya an organic state, except for few pockets where intensive cultivation of vegetables using inorganic fertilizer and chemicals is preferred (Sanjay-Swami, 2020) [42].

This paper reviews the studies conducted on the spices of NEHR, India with emphasis on ginger, turmeric, chilli, large cardamom and the scopes, challenges and constraints faced in the cultivation, transport and export potential of spices from this region.

Table 1: Top ten spice producing states of India during 2016-17

State	Area ('000 ha)	%	Production ('000 MT)	%
Rajasthan	1004.39	27.35	1391.8	17.14
Madhya Pradesh	524.59	14.29	1077.89	13.27
Andhra Pradesh	246.44	6.71	1009.76	12.43
Gujarat	502.3	13.68	868.07	10.69
Telangana	184.18	5.02	786.95	9.69
Karnataka	225.41	6.14	399.44	4.92
Maharashtra	41.81	1.14	371.72	4.58
West Bengal	119.64	3.26	334.42	4.12
Assam	119.99	3.27	291.3	3.59
Uttarakhand	60.57	1.65	227.36	2.8
Total (India)	3672	8122		

***Source*:** GoI 2018 [18]

Suitability of spices in NEHR

The entire NEHR is located between 22°1'N and 29°31'N latitude and 89°47'E and 98°55'E (GoI, 2015) [18]. It comprises of the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The region is categorized by diverse agroclimatic and geophysical features which makes it distinctive in many ways. Of the total geographical area of the region 65% is under undulating tracks and hills while remaining 35 per cent is plain. Physio-graphically, the entire NEHR India is divided into four well differentiated units: i) the eastern Himalayan region, ii) the eastern mountain region, iii) the Meghalaya-Mikir table land and iv) the Brahmaputra valley. The climate of NEHR region varies from near tropical in the plains of Assam, Tripura and south Mizoram to near alpine in the northern Sikkim and Arunachal Pradesh. The soils of the region are usually rich in organic matter and acidic to strongly acidic (pH 4.5- 5.0) in reaction and thus suitable for growing different spice crops (Hnamte *et al.* 2012) [22]. The NEHR region faces unpredictable high rainfall and consequently nutrient depletion and the soil erosion occur. Agro-climatically the region is known for its wide diversity representing temperate, subtropical and tropical areas. The diversity of the region provides ample scope for growing a large variety of crops. (Devi *et al.* 2021) [13]. Table 2. shows the major spices found in the region.

Table 2: Major spices of NEHR

Type	Spice	Origin
Chilli	Bird eye chilli	Mizoram
	Bhut Jolokia/Naga King Chilli	Nagaland, Manipur, Assam, Arunachal Pradesh
	Local chilli	Assam, Meghalaya, Arunachal Pradesh
Rhizomes and root spices	Ginger	Assam, Meghalaya, Arunachal Pradesh, Anipur, Sikkim
	Lakadong turmeric	Meghalaya
	Local turmeric	Assam, Manipur, Meghalaya, Mizoram, Nagaland
Seed/Fruit spices	Large cardamom	Sikkim, Arunachal Pradesh
	Long pepper	Meghalaya, Manipur
	Black Pepper	Meghalaya, Assam
	Black sesame	Assam
	Coriander	Assam
	Mustard	Assam
Leaf spices	Bay leaf	Meghalaya, Sikkim

***Source*:** Gopalakrishnan 2015 [20].

Spices of NEHR

NEHR is home to some endemic spice crops like black turmeric, Lakadong turmeric, Bird's eye chilli. King chilli, Assam lemon, Nadia ginger etc., which has huge market

demand for their unique features and is grown organically (Momin *et al.* 2018; Sanjay-Swami *et al.* 2022) [31, 22]. Major spices are chilli, ginger, turmeric, large cardamom, black pepper etc and the region is coming forward in organic production of ginger and turmeric and is exporting about 60% to 70% production outside the region and neighbouring countries. Share in national market of ginger, turmeric, chilli, large cardamom and black pepper are 40, 12, 4, 90 and 5% respectively (NEC 2013). The major cash crops are turmeric and ginger mostly cultivated in jhum fields (Pandotra *et al.* 2013) [34]. Area and production of spices during 2016-17 has been shown in Table 3.

Table 3: Area and production of spices in NEHR during 2016-17

State	Area ('000 ha)	%	Production ('000 MT)	%
Arunachal Pradesh	11.44	4.79	68.72	9.02
Assam	119.99	50.22	291.3	38.22
Manipur	10.47	4.38	23.14	3.04
Meghalaya	18.61	7.79	92.16	12.09
Mizoram	24.81	10.38	97.2	12.75
Nagaland	15.69	6.56	105	13.78
Sikkim	32.25	13.5	66.58	8.73
Tripura	5.69	2.38	18.04	2.37
Total (NE)	238.95	100	762.14	100
Total (India)	3672	8122		
% Share to total of India	6.51	9.38		

***Source*:** GoI 2018 [18].

Status of Spice production in NER

The status of spice production in NEHR region (2019-20) is presented in Table 4. An area of 2,28,950 ha is under spice production with an annual production 7,37,550 tonnes (DASD, 2020) [12]. Among the different spices grown in the region, the three commercial crops are ginger, turmeric and large cardamom. Ginger is grown in almost all the states of the region. Large cardamom farming as an under-storey crop in hill slopes of Sikkim is a unique traditional production system. Black pepper is also showing promise and organic production is possible to a limited extent.

Table 4: Major spices production in NEHR, 2019-20 (in tonnes)

State	Pepper	Ginger	Red chillies	Turmeric	Garlic	Large cardamom	Coriander	Tejpat/cinnamon	Tamarind	Total
Assam	2899	183157	21867	22829	67418		32839			331009
Mizoram	3	61001	10918	29510	12		21		26	101491
Sikkim		65646		9085		5000				79731
Meghalaya	781	66286		3314		2038		5000		75381
Arunachal Pradesh		39112	2886	3375	5					47416
Nagaland	29	35773	1804	1857	2385		82	2		44240
Tripura	337	16245	6632	7722						30936
Manipur		17902	3927	5511			3			27343
Total	4049	485122	48034	83202	69820	9346	32945	5002	26	737546

***Source*:** DASD, 2020 [12].

Major spices

Ginger

Ginger (*Zingiber officinale* Rosc.) is widely grown in different countries of the world with its area and production distributed over countries namely India, Nigeria, China, Nepal, Indonesia, Thailand etc. India is the largest producer and consumer of ginger in the world (Anonymous, 2018) [2]. India is the largest producer of ginger in the world with 1,109,000 tonnes while Nigeria has the highest area under ginger contributing about 56.23 percent of the world ginger areas followed by India, China, Indonesia and Bangladesh.

Ginger is one of the regionally advantageous crops in the NEHR. It is grown in almost all the states of the region but the leading states are Assam, Sikkim, Meghalaya and Mizoram. (Hnamte *et al.* 2012) [22]; Singh *et al.* 2022; Jha and Deka, 2012; Yadav *et al.* 2004) [53, 25, 58]. It is the main cash crop supporting the livelihood and improving the economic level of many ginger growers NEHR. (Yadav *et al.* 2004) [58].

Diversity of ginger in NEHR

Apart from improved and commercial varieties like Nadia, China and Varada, a number of indigenous varieties are grown in the region. (Jha and Deka 2012; Singh *et al.* 2022) [25, 53] which are given different names depending on the locality they are grown. Though less prevalent, these local varieties are very popular among the local community. Maran, Bhola and Jorhat Local, indigenous varieties of Assam, reportedly have good rhizome yield and the dry ginger recovery of these varieties have been found to be higher than exotic type Rio-de-Janeiro. Tripura Local from Tripura was also found to be superior to other types. Basar Local of Arunachal Pradesh, is known for its high yield and adaptability to the area. Local types Thingpui, Thingaria and Thinglaidon of Mizoram are grown at large scale, whereas in Manipur, Thingpui is mainly concentrated in the hills. The Sikkim local types Bhainse and Gorubathan are grown commercially for their high yield and large rhizome size. (Yadav *et al.* 2004, Jha and Deka 2012) [58, 25]. A highly pungent, small size variety and another with pinkish rhizome is commonly grown by the tribals in Nagaland. Another variety called black ginger with bluish black rhizome is grown by certain communities like Bodo, Naga and Mizo for use as folk medicine and reportedly sold at very high price probably due to high medicinal value. (Rahman H *et al.* 2009;

Yadav *et al.* 2004) [36, 58].
Shing bhukir of Meghalaya has the smallest rhizome and is best known for its medicinal value (Rahman H *et al.* 2009) [36] in addition to local varieties, Khasi Local and Tura Local, considerable area has been brought under selected type Nadia. At present the variety Nadia is very much popular among all the states of NE region due to its low fibre content. (Yadav *et al.* 2004) [58].

Status of ginger in NE region

During 2019-20, the area under ginger in NER accounts for 57.18 thousand hectares with a production of 504.7 thousand tons which is much lower as compared to national level with an area of 175.26 thousand hectares and production of 1875.94 thousand tons. Among the states in NER, Assam has the highest area and production under ginger, producing about 183.16 thousand tons during the fiscal year 2020 contributing about 9.76 percent to the total ginger production in the country (Singh *et al.* 2022) [53]. Warm, humid climate with well-drained soil is preferable for the successful growth of ginger. In North East region ginger is grown as rainfed crop while in other parts of the country it is grown both as rainfed and irrigated crop (Gosh 1984) [21]. As ginger is an exhaustive crop, in the NE region it is rotated with French bean or soybean, which improves the physical condition of the soil and gives additional income to the farmers. One of the most significant features of the agriculture in the NE region is the prevalence of *jhum* cultivation. In the hills of the region, ginger is generally cultivated on raised bed (called bun) in the *jhum* fields (Gosh 1984; Yadav *et al.* 2004) [21, 58].
Reported the promising local genotypes of ginger in NER. Nadia and Tura local gave the least fibre content. Dry matter content was highest in Kachrai ginger and Maran. Gingerol content was highest in Nadia, while oil content was highest in Meghalaya local. Yield was highest in Nadia and Kachrai ginger. Yadav *et al.* (2004) [58] made a comparison of local varieties *viz* Nadia, Poona and Thingpui with high yielding variety Varada and found that the yield for Nadia was 30 t/ha while that of Varada was only 22 t/ha. It may be noted that average yield of ginger in most of the states of northeast region was much higher than the country average. High variability is especially noted in the states Nagaland, Mizoram and Tripura. Table 5 depicts the area and production of ginger in NEHR and Table 6 shows promising varieties of ginger in NEHR.

Table 5: Area and Production of Ginger in NEHR

State	Area (in ha)	Production(in MT)
Assam	15700	122300
Sikkim	10030	54990
Mizoram	7300	28400
Meghalaya	9600	63000
Manipur	2400	3800
Arunachal Pradesh	7000	57000
Tripura	1800	7600
Nagaland	5300	36000

***Source*:** Das, 2016 [12]

Table 6: Promising local genotypes of ginger of North East Region

Genotype	Crude fibre content %	Dry matter content %	Gingerol %	Oil %	Yield (t/ha)
Manipuri No.1	6.77	21.18.	1.14	1.45	17.13
Basar	7.02	22.54	1.12	1.30	20.94
Tura Local	5.50	21.9	1.32	1.55	17.82
Thimpui	5.74	22.47	1.25	1.80	19.34
Maran	6.25	24.02	1.10	1.75	19.81
Meghalaya Local	6.02	20.12	1.71	2.10	14.76
Thinglaidum	5.86	22.38	1.23	1.45	15.42
Kachai Ginger	5.72	24.87	1.20	1.70	20.09
Nagaland Local	6.93	19.8	1.18	1.87	19.18
Nadia	4.56	22.25	0.64	1.45	30.00

***Source*:** Sanwal *et al.* 2007 [43].

Turmeric

Turmeric (*Curcuma longa* L.) is a spice derived from the rhizomes of Curcuma longa, which is a member of the Zingiberaceae family. As a dried rhizome of an herbaceous plant, turmeric is closely related to ginger. This spice is also called "Indian saffron" because of its yellow colour. This golden spice contains the highest diversity comprising 40 species (Ashraf *et al.* 2017) [4] and some are important varieties exported outside. Turmeric is mostly traded as a whole rhizome, which is then processed into powder or oleoresin (ASTA, 2002) [5]. It is a highly commercial spice of India. The rhizome of turmeric spice contains yellow pigments called *curcumin* which is the main active compound as well as the main colouring agent which also has certain therapeutic properties. Turmeric is part of Indian's culture: it is an important ingredient in curry dishes; it is also used in many religious observances, as a cosmetic, a dye, and it enters in the composition of many traditional remedies. India is the largest producer, consumer and exporter of turmeric in the world because of its high curcumin content. Globally, the production of turmeric is around 11 lakh tonnes per annum and India with a total production of 938955 thousand tonnes has the lion share in the world production contributing 85.35 percent and 60 percent of the world export. The major turmeric exporting countries are India, Thailand, Taiwan and other Southeast Asian countries, Central and Latin American countries and the major importing countries includes Japan, Sri Lanka, Iran, UAE, US, UK and Ethiopia (Singh *et al.* 2022) [53]. Turmeric ranks third in spices export of India. The turmeric export goes on increasing over the years with an export of 1.36 lakh tones in 2019-20 (Spice board of India-2020). Turmeric is one of the most widely cultivated spice crops in NEHR because of agro-climatic suitability, rich genetic diversity and high curcumin content. Apart from improved varieties like Lakadong and Megha Turmeric- 1, a number of local cultivars exist in north eastern region. The best performing genotypes in the experiment belong to NEHR ('Megha Turmeric-1' ranked first) for both traits of

commercial importance (dry matter recovery and curcumin yield). Therefore, the NEHR genotypes should be given importance in the programmes of genetic enhancement and varietal improvement of turmeric (Singh and Ramakrishna, 2014).

Turmeric Production in NEHR Region

Turmeric is an important cash crop in the NEHR and the area under turmeric in the NER stood at 38.6 thousand hectares with a production of 93.16 thousand tons which was also quite lower as compared to national level. Among the states of NEHR, Assam has the highest area under turmeric with 17.63 thousand ha followed by Mizoram and Sikkim. In case of production, Mizoram stood at the top with 29.51 thousand tons followed by Assam and Sikkim (Singh *et al.* 2022) [53] The agro-climatic conditions of the region characterised by warm and humid summers with abundant rainfall and cool winters are favourable for turmeric cultivation (SFAC, 2012). Like other food crops grown in the NEHR, turmeric is cultivated using the traditional knowledge of the inhabitants which are generally eco-friendly, less expensive and organic inputs. Turmeric is an important cash crop in the NEHR and shares about 8.30 per cent of the total production in the country. Mizoram, with a total production of 27.82 thousand MT (million tonnes) is the leading state in the region followed by Meghalaya (16.63 thousand MT) and Manipur (15.40 thousand MT)**.** (Singh *et al.* 2020) [52].

Lakadong Turmeric

The Lakadong variety of *C. longa* is an indigenous turmeric of Lakadong area of Jaintia hills district of Meghalaya. In Lakadong turmeric is cultivated in humid and warm climate with very high rainfall of about 4000 – 10000 mm. The farmers had experienced that when this turmeric variety is cultivated outside the Jaintia hills the quality deteriorates thereby posing a limitation for cultivation outside the traditional Lakadong area. (Daimei *et al.* 2012) [11]. It is considered one of the world's finest varieties of turmeric with a high curcumin content of 6.8-7.5%. (Shreeranjan 2006; Daimei *et al.* 2012) [50, 11]. It is darker than the other variety grown in India. The higher curcumin content of Lakadong turmeric indicates its high significance towards its medicinal importance. Thus, the more frequent consumption of Lakadong turmeric by the local inhabitant might also function as a natural armour against different diseases. The Lakadong turmeric variety is grown as an intercrop with maize, ladies' finger, gourd, chillies, taro (*Colocasia* sp.), onion, brinjal, ragi, etc (Daimei *et al.* 2012) [11].

Black turmeric

Black turmeric is a perennial herb with bluish black rhizomes. It is native to NEHR of India. It has been listed as endangered species by Indian Agricultural Department. The plant has been cultivated for ornamental purpose whereas the roots have been used for medicinal and religious purposes. It is presumed to possess anti-fungal, anti-inflammatory properties. The rhizome has characteristics pungent smell which is attributed to the presence of the essential oil which is rich in eucalyptol (16.43%), camphor (11.56%), starch etc. (Borah *et al.* 2019) [8]. It is cultivated as an important cash crop by many farmers in Meghalaya. (Sanjay-Swami *et al.* 2021) [21].

Table 7: Turmeric growing states in NEHR, India (2016-17)

State	Area('000 ha)	Production('000 MT)
Meghalaya	2.61(16.35)	16.60(18.94)
Mizoram	7.20(45.11)	27.82(31.74)
Manipur	1.40(8.77)	16.40(18.71)
Nagaland	0.70(4.39)	10.72(12.23)
Arunachal Pradesh	0.80(5.01)	3.84(4.38)
Tripura	1.30(8.15)	6.59(7.52)
Sikkim	1.95(12.22)	5.68(6.48)
Total(NEH)	15.96(100)	87.65(100)
Total(India)	221.78	1056.1
Per cent Share of NEH	7.2	8.3

***Source*:** GoI 2018 [18]; Note: Figures in parentheses are percentages to the total of NEHR region

Table 8: Major turmeric cultivars grown in India

State	Cultivars/varieties
Kerala	Alleppey Finger
Maharashtra	Rajapore, Karhadi, Waigon
Andhra Pradesh	Nizamabad, Armoor, Vontimitta
Tamil Nadu	Erode local, BSR-1, PTS-10
West Bengal and Assam	Pattant
Meghalaya	Lakadong, Lashein, Ladaw, Lakashain and Megh-I
Mizoram	Lakadong and RT-1
Manipur	Lakadong and local variety
Sikkim	Lakadong and local variety

***Source*:** APEDA, 2018

Large Cardamom

Large cardamom (*Amomum subulatum Roxb*) widely known as bada elaichi in Hindi is one of the world's oldest spices belonging to the family Zingiberaceae. Large cardamom has an explicit aroma and pleasing odour; and regarded as Queen of spices present on earth. India in particular, is the largest producer of large cardamom, and contribute to 54% of total production. Sikkim in general contributes to 88% among the total production quantity (Momim KC 2018) [31]. It is a perennial herb and grows wild in forest ecosystem but also domesticated in the Sub-Himalayan region. This crop is believed to have been first domesticated by the indigenous Lepcha tribe and then by other communities such as the Bhutias and Nepalis of Sikkim, and was later passed on to the neighbouring district of Darjeeling in India and to southern Bhutan and eastern Nepal (BA Gudade *et al.*. 2019; Sharma *et al.*. 2000; Sharma *et al.* 2007; Adhikari, 2016) [45, 48, 1]. Nepal is the largest producer of large cardamom in the world with a share of 53% where more than 95% of the produce is marketed to India, the largest exporter of large cardamom India is the second largest producer and the largest exporter of large cardamom, contributing about 37% of the world's production, (Sharma *et al.* 2009; Singh and Pothula 2013; Subedi *et al.* 2014; Sharma *et al.* 2018) [47, 51, 56, 49] Large cardamom is cultivated on an area of about 23,082 ha with an estimated annual production of 4,075 tonnes (2015-16). Sikkim contributes up to 88% of India's production of large cardamom. The cash income earned from this crop in Sikkim increased from US$ 1.9 million in 1975 to US$ 13.8 million in 2005 and as high as US$ 50 million in 2010 (Sharma *et al.* 2009; Sharma and Acharya 2013; Partap *et al.* 2014; Momim *et al.* 2018) [47, 46, 35, 31]. Sikkim is also fast becoming known in India for its organic farming, and organic large cardamom has a potentially strong international market (FSADD and HCDD

2012). Cardamom forms a substantial part of people's livelihood and food security and for many families, it is the only source of cash income. Over the last few decades, cultivation of this crop has spread to North-Eastern Indian states including Nagaland (550 ha), Arunachal (400 ha), Mizoram (400 ha), Meghalaya (250 ha), and Manipur (250 ha) and to the central Indian Himalayan state of Uttarakhand with 41 ha of acreage (Anonymous 2017) [3].

Production of large cardamom in Sikkim

Rich genetic diversity, scientific production and processing practices as well as well-informed planters and better institutional support has made cardamom from the State of Sikkim as number one in quality. The productivity is highest in the north district, followed by the east district due to favourable shade, humid environment and soils rich in organic matter. Productivity among different plantations varies from a low of 100 kg/ha to a high of 450 kg/ha, the average being 150 kg/ha. Large cardamom is grown in all districts of Sikkim; however, North Sikkim and East Sikkim have more area under its cultivation as compared to other two districts of the state. Two species of cardamom are grown in Sikkim, namely Golsey or Bada Dana and Ramsey or Chota Dana. Golsey is grown in the north and east districts of Sikkim, and the west and south districts grow both Golsey and Ramsey. More than 50% of the production of cardamom is from the north district.

Cardamom was raised on 17,020 ha during the year 2014-15 with a production of 3,970 tonnes. Based on farm gate price the estimated value of production is Rs 2.26 million. Table 9 shows a comparison of area, production, productivity of large cardamom in Sikkim, West Bengal and India.

Table 9: Area, production, productivity of large cardamom in Sikkim, West Bengal and India

State	Area (000'ha)	Production (000'tonnes)	Productivity (tonnes ha-1)			
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Sikkim	18	21.8	5	5.23	0.28	0.24
West Bengal	2.97	3.31	0.82	1.07	0.28	0.32
India	31.59	36.6	9.64	10.48	0.31	0.29

***Source*:** DASD, 2020 [12]

Local and improved cultivars

The local farmers in Sikkim grow more than 8 different local cultivars of cardamom developed, tested and practiced in different agroclimatic situations and under different farm management conditions. Of them, 6 varieties are widely grown between 600 and 2300 m throughout Sikkim and some parts of the Darjeeling hills. Seremna, a variety developed by the Limboo tribes of Hee Bermiok, West Sikkim, is a location-specific cultivar that is tolerant to diseases and pests and gives a high yield (300– 450 kg ha1). Another disease-tolerant cultivar that is cultivated widely is Dzongu-golsai, developed by the Lepchas of Dzongu, North Sikkim. The local cultivar Bharlangey is best suited to the middle and higher altitudes (1500–2000 m) and has a high market value due to its high productivity, large capsule size, good aroma, and characteristic and marketable maroon color. The Indian Cardamom Research Institute of the Spices Board in Gangtok identified the potentially disease-tolerant varieties Sikkim I and Sikkim II in 2000 on farmers' cardamom farms, but they have not yet scientifically confirmed that these varieties are disease and pest resistant as well as high yielding, and farmers have not yet tested them.

Chilli

India is the largest producer, consumer and exporter of chillies in the world. In India, per capita consumption is highest for chillies, among the spices produced. It occupies around 30% of the area shared among major spice crops of the country Indian Horticulture Database (2011) [24] Though chillies are grown all over India, NE states contribute 51.72% of its annual production while having only 8% area under chilli cultivation (Spice Statistics, Spice Board, 2004). NE region of India is an excellent place to find the diverse range of chilli genotypes, because there are numerous heterogeneous landraces of chilli available in this region and these landraces serve as a reservoir of genetic variability for chilli breeders (Dutta SK 2017a) [16] Warm, hot and humid climate of Manipur, Mizoram, Meghalaya, Nagaland, Tripura and Arunachal Pradesh are suitable for cultivation of chilli (*Capsicum* spp.). Some of the chilli species that are available in the region are *C. annum* L. var. avicular, *C. annum* L. var. grossum, *C. annum* L. var longum, *C. chinense*, *C.eximium*, *C. frutescens*, *C. minimum*, and *C. pubescens*. The Naga King chilli (*Capsicum chinense* Jacq.) member of the Solanaceae family (tribe Solaneae, subtribe Capsicinae) is the world's spiciest chilli entering the Guinness book of world record (2006) with Scoville heat units (SHU's) level of 879,953 to 1,001,304 SHU. Of 1,001,304. (Guinness world record in September, 2006) originating in Northeast India mainly in Nagaland and is cultivated throughout the NE region. Variants of this chilli are seen in the NE region of with different local names such as Naga chilli in Nagaland, *Bhut Jolokia* in Assam, and *U-Morok* in Manipur (Kumar *et al.* 2011) [26], and possesses a pleasant and palatable aroma. It is an interspecies hybrid, mostly *Capsicum chinense* with some *Capsicum frutescens* genes (Bosland and Baral, 2007) [9]. Three distinct colours are found like light red, dark red and orange (Bhagowati and Changkija, 2009) [7]. The Naga chillies are either consumed fresh or as a condiment.

Table 10: Area and Production of Chilli in NEHR

State	Area (in ha)	Production (in MT)
Assam	18915	16500
Sikkim	791	2665
Mizoram	9000	8200
Meghalaya	2000	1600
Manipur	6500	3900
Nagaland	800	1000
Tripura	2400	3700

***Source*:** Das, 2016 [12]

In coming years the oleoresin powder extracted from Naga chilli is predicted to dominate the market (Ritesh *et al.* 2000) [38]. Countries like Canada, Europe, Japan, Korea and the USA, where it is used to increase spiciness of food (González-Estrada, 2006) [19]. They are also incorporated into certain traditional medicine for the treatment of ulcers, diabetes, rheumatism, headache, night blindness, rheumatism, arthritis, gastritis, ankylosing spondylitis, digestive diseases and to reduce chronic congestion (Bhagowati and Changkija, 2009) [7]. (Meghvansi *et al.* 2010) [29], contains biologically active components capsaicin and dihydrocapsaicin beneficial

for human health (Lhami *et al.* 2007) [27] (Rahman and Inden, 2012) [36] (Sanatombi and Sharma, 2008) [39], and has been reported to prevent various diseases associated with cardiovascular system, cancer and neurological diseases (Menichini *et al.* 2009; Mueller *et al.* 2010) [30, 32].

Mizo Chilli (*Capsicum frutescens* L.) known as Bird's Eye Chilli, is known by other names such as Tabasco pepper, African pepper, Zanibar pepper, red pepper and Cayenne pepper. Varieties under *Capsicum frutescens* are generally annual and sometimes short-lived perennials. The chillies are pungent, small, erect berries possessing light to dark green colour when immature and dark red when mature. NE states are popular for the bird's eye chilli (Baruah and Barua, 2004) [6] with Mizoram as the state of biodiversity hotspot with characteristic size, shape, pungency, colour, physiological characters, crop adaptability and disease pest interaction (Ozgur *et al.* 2011; Dutta *et al.* 2015) [33, 16], earning the geographical indication (GI) 'Mizo Chilli'. (Mandal and Loya 2021) [28].

NEHR though rich in genetic diversity of chilli crops, very few research has been conducted in chilli crops Therefore, more research should be encouraged as there is a high probability of discovering a number of genes/alleles contributing to resistance against abiotic and biotic stresses, some chemicals/compounds that can be used as medicine and other secondary metabolites that are of high value.

GI tag of spices from NEHR: Many of the spices in the NEHR have been GI tagged.

1. **Naga chilli:** In 2007, Guinness World Records certified that the ghost pepper was the world's hottest chilli pepper, 401.5 times hotter than Tabasco sauce; the ghost chilli is rated at more than 1 million SHU (Scoville Heat Units). Classic Tabasco sauce ranges from 2,500 to 5000 SHUs.
2. **Mizo chilli:** Mizoram bird's eye up to SHU 2,50,500. This chilli comes from eastern most part of India, bordering Burma. The flavour and heat is wonderful and very enjoyable too. It has distinct flavour and blood red colour with capsaicin content of 1.1 per cent. This chilli will make the perfect Vindaloo.
3. **Karbi Anglong ginger:** Ginger fields in Karbi Anglong. The district produces best organic ginger in the world. The average annual production of ginger in the district is 30,000 tonnes and it is grown by about 10,000 farmers. The ginger grown in Karbi Anglong has a low fibre content, Eg. Aizawl (4.1%). Varieties such as Nadia and Aizol, which yield high quantities of dry rhizome and oleoresin and oil, are in great demand among domestic buyers and exporters.
4. **Lakadong Turmeric:** A very high curcumin variety (7-8%) native to the village Lakadong in Jaintia Hills of Meghalaya
5. **Sikkim large cardamom:** Cultivated as an understorey crop with other shade trees. Post-harvest management is largely traditional which follows Bhatti system. Large cardamom produce from the region is purely organic

Scope of organic spices in NEHR

Most of the NEHR states are having virgin land without any commercial cultivation that is very much suitable for organic cultivation of spices and major spices like black pepper, ginger, turmeric and chillies have larger area in this tract. The region, by default use only less fertilizers and pesticides, far below the national average and this offers great potential for organic cultivation of spices. Area under organic spice cultivation can be instantly recognized and the process of certification expedited unlike other parts of the country.

Scope of value addition in Spices

In NEHR, a huge quantity of good quality spices *viz.*, ginger, turmeric, chillies and black pepper are produced, but most of the growers during peak season sell their produce at throwaway prices in the local market or to the commission agent. Different value-added products from spices like oil and oleoresins, powdered form, paste from ginger and turmeric; pepper and ginger in brine; curcumin from turmeric; capsanthin and capsaicin from chillies; candy, cookies, flakes, beer, wine and juice from ginger, white, dehydrated, freeze dried canned, bottled and dehydrated salted green pepper etc. can be prepared from this NE region.

C**onstraints in spice production in NEHR:** Cultivators of spices in NEHR faces various challenges such as small land holding because of the terrains in the region where farmers have to grow many crops in the same piece of land making commercialization of crop on large scale difficult. Shifting cultivation which is the major cultivation system leads to reduced soil fertility causing huge deforestation, soil degradation and depletion of resource base. High rainfall in the region makes crops prone to infestation with weeds, pests and diseases and leaching of nutrients. Farmers usually do not have access to good quality and high yielding varieties and though many high yielding varieties have been identified and recommended by the researchers for the region, quality seed production on a large scale is lacking due to non-functioning of agencies responsible for quality seed production. Spice processing units, marketing and transport facilities needs to be closely linked for successful spice production. Very few cold storage facilities are available with few processing units which do to function up to the desired capacity. (R.K. Yadav *et al.* 2004) [58].

Conclusion

From the above studies, it could be concluded that NEHR holds potential for production and commercialization of various spices of high value which could earn revenue for the region and for India at large. The need is to focus on reducing impacts of climate change by implementing adaptation and mitigation plans, taking into consideration local and indigenous knowledge. Work on developing disease-free, high-quality plant materials, improve disease and pest control, provide irrigation facilities, provide training to farmers, improve product quality through improved post-harvest technology, and increase market channel efficiency. Other indigenous spices from the region should also be explored for large scale production and marketability. Also, as NEHR is well known organic farming it should be encouraged further.

Vocal for local should also be popularised further by engaging the youths of the region through entrepreneurial ventures.

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