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Vegetable Farming: Status, Prospects and Future thrust in the Northeastern Region of India

Veerendra Kumar Verma, M. Bilashini Devi and Vinay Kumar Mishra

ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya

Summary

India's Northeastern (NEH) region is characterized by diverse climate regimes ranging from subtropical to alpine, high rainfall zone, diverse terrain, slopes, altitude, land tenure systems. The vegetables are cultivated under homestay and mixed commercial systems with various production systems depending on high-, mid-, and foot-hills. The region is the wealthiest reservoir of genetic variability of vegetables such as chillies, Indian bean, winged bean, velvet bean, Dioscorea, colocasia, etc. These crops are an integral part of the dietary system of local communities and are grown abundantly in their *Jhum* land or kitchen garden as mixed cropping. Legume vegetables such as Indian bean, lima bean, velvet bean, winged bean, and leguminous tuber crop Sohphlang (*Flemingia vestita*) are highly suitable for climate-resilient agriculture. Prospects and thrusts in vegetable research for development are highlighted.

Introduction

India's Northeastern (NE) region comprises eight states, viz., Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura that cover 255 million hectares, about 8% of total India's landmass. More than 64% of the total area is surrounded by thick and deciduous forest (164.101 million hectares). The region is characterized by diverse climate regimes ranging from subtropical to alpine, high rainfall zone dependent mainly on the southwest monsoon (June – September), and drains through two main river basins (the Brahmaputra and Barak). The region is also known for its diverse terrain, slopes, altitude, land tenure systems, and cultivation practices. The region has high rainfall from 1500-12000 mm with an average annual rainfall of 2000 mm and maximum (90%) rainfall received during the southwest monsoon. Despite high rainfall, moisture stress is a major limiting factor in crop production during the winter season. Due to heavy rains and leaching of Ca and Mg, most soils are acidic with a pH range of 4.0 to 5.5, resulting in the deficiency of essential nutrients like Mo and B, fixation of P, and the toxicity of Fe and Al.

Based on the land use system, suitable vegetable crops identified for different altitudes are:

1. High Hills: Potato, cabbage, cauliflower, radish, beans, etc.
2. Mid Hills: Chilli, brinjal, tomato, beans, sweet potato, and tapioca, etc.
3. Foot Hills: Bordering areas of hills can be used for colocasia and cucurbits etc.

Table 1. Status of vegetable production in northeastern states of India

States	Area (000 ha)	Production (000 MT)	Productivity (t/ha)
Arunachal Pradesh	2.6	16.6	6.4
Assam	300.2	3292.9	11.0
Manipur	45.3	342.1	7.6
Meghalaya	49.1	519.7	10.6
Mizoram	36.2	171.0	4.7
Nagaland	46.2	561.6	12.2
Sikkim	38.4	229.1	6.0
Tripura	45.9	795.7	17.3
Total (NE)	563.9	5928.7	10.5

Source: *Horticultural Statistics at a Glance-2018*

There are many farming system models; under the agri-horti-silvi pastoral system, the lands are allocated as upper 1/3rd for tree species, middle 2/3rd area for horticultural crops, and lower 1/3rd for growing cereals and fodder crops. Terrace risers are used for growing fodder grasses. Under mixed horticulture land-use model, 2/3rd area for fruit crops, 1/3rd for growing vegetable crops.

Status of vegetable production

The NE region contributes about 5.5% (0.57 MH) and 3.22% (5.93 MT) of the national area and production of vegetables, respectively. The average productivity of the vegetable crops is low (10.51 t/ha) as compared to national productivity (17.97 t/ha) and varied from 4.72 t/ha (Mizoram) to 17.34 t/ha (Tripura). The maximum area and production of the vegetables are in Assam, followed by Tripura, Nagaland, and Meghalaya (Table 1). Besides, numerous minor vegetable crops, at subsistence level > 18 major vegetable crops grown in the region (Fig. 1). However, over 64% of the total production share is contributed by only five crops that are potato (20.4%), cabbage (18.17%), tomato (9.56%), cauliflower (9.28%), and brinjal (6.88%). The maximum area under these crops is mainly due to comparatively higher yield, storability, and markets.

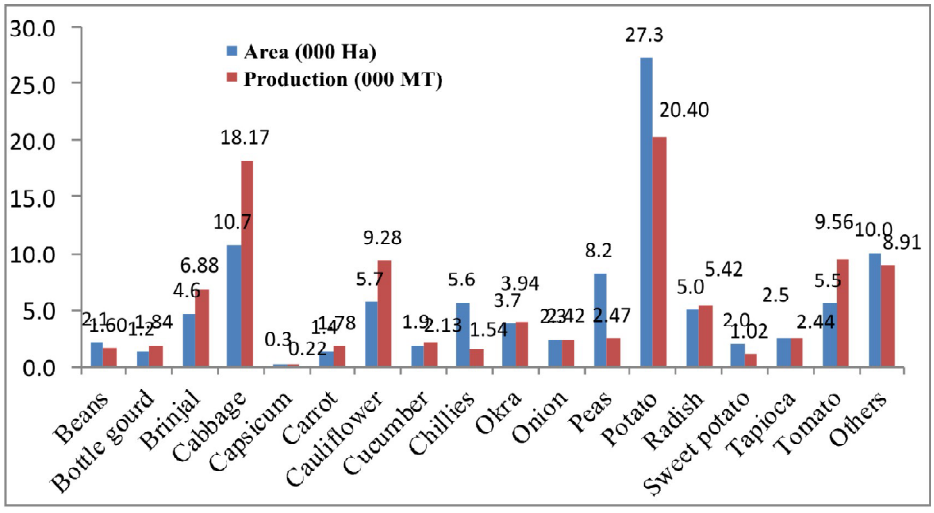

Fig. SEQ Figure * ARABIC 1. Area and production of vegetable crops in northeastern India

Patterns and Prospects of Vegetables

Vegetables in cropping/farming systems: Different farming practices depend on agro-climate, terrain, and topography of locations. In valleys, the farmers mainly follow rice-vegetables (French bean/ tomato/ capsicum/ pea/ potato, etc.) cropping system. However, under mid-hills, they grow commercial crops like ginger and turmeric and vegetables as pure crops. However, under *Jhum* land, the crops are grown in mixed cropping with rice, maize, tuber crops (sweet potato, colocasia, yam, tapioca), and seasonal vegetables (chilli, brinjal, okra, cowpea, rice bean, etc.).

Under the hilly ecosystem, among the warm season vegetable crops, the tomato was found highly profitable, followed by brinjal and bottle gourd. Similarly, the highest yield per hectare in cool-season crops has been recorded from cabbage (Verma et al. 2016). However, the highest input-output ratio (profitable) was recorded from Dolichos bean, followed by cabbage and broccoli. Tomato–cabbage cropping system was found to be most economical, followed by brinjal–cabbage (solanaceous–crucifer vegetable-based cropping system). Under legume–cucurbits systems, Dolichos bean–bottle gourd and Dolichos bean–cucumber cropping systems were highly profitable. Further, vegetable crops are the most economical enterprise under integrated farming systems with a BC ratio of 2.25 over cereals and livestock components (Anonymous 2018). Under assured irrigation, capsicum-french bean-pea, tomato-okra-broccoli, tomato-okra-cabbage, tomato-okra-toria, and tomato-okra-pea have been found economical with 300% cropping intensity with an income potential of Rs. 63.87/sqm.

Diversified farming and *Jhum* improvement: The NEHregion is the wealthiest reservoir of genetic

variability of different vegetables such as chillies, Indian bean, winged bean, velvet bean, Dioscorea, colocasia, etc. These crops are an integral part of the dietary system of local communities and are grown abundantly in their *Jhum* land or kitchen garden as mixed cropping. Due to the broader adaptability of these crops, especially tapioca and sweet potato can be grown in the marginal soil on the hill slopes and tapioca as an intercrop or fencing crop on the mainland boundary. Many leafy vegetables like amaranth, laffa, kulfa, chinese onion, etc., are short-duration and found suitable for different cropping systems.

Vegetables under protected cultivation: Different kinds of protected structures are used for vegetable cultivation. Due to mild weather in the mid-hills, naturally ventilated polyhouse has been found most suitable and cost-effective for year-round/off-season production of high-value crops like tomato, capsicum, king-chilli, cucumber, etc. Under naturally ventilated polyhouse, the highest yield of tomato from cultivar Megha Tomato 3 (3.05 kg/plant), capsicum hybrid Pusa Deepti (0.88 kg/plant), chilli hybrid Fungale (0.99 kg/plant), King chilli genotype Red Long (0.98 kg/plant) and cucumber genotype, RCC 2 (4.28 kg/plant) have been demonstrated (Verma et al. 2018). The highest per annum net income was recorded from the cropping sequence tomato (Megha Tomato 3)–capsicum (Pusa Deepti) followed by a sole crop of King chilli and cropping sequence tomato (variety Megha Tomato 3) – chilli (hybrid Fungale). However, the highest BC ratio (4.2) was observed from the King chilli sole cropping followed by tomato – capsicum cropping sequence (3.5).

The region is also having prolonged periods of rain (April - September). The use of low-cost rain shelters (bamboo frame and UV films) has also been found suitable for different vegetable crops' year-round/off-season production. Under mid-hills, cabbage, broccoli, palak, coriander, methi, etc., has been found highly remunerative (BC ratio of > 4.0) crops.

The use of mulch and drip irrigation significantly improves the yield, especially in Rabi (winter) season (November – February), when soil moisture is scarce. Verma et al. (2018) recorded the highest marketable head yield (22.75 t ha-1) from broccoli hybrid Pushpa using dry weed biomass mulch of *Eupatorium* and *Ambrosia* spp. @1 kg m-2 as well as black polythene over the traditional practices.

Improving households' nutrition: Vegetables are a rich source of micronutrients (vitamins, minerals, and secondary metabolites) hence known for their role in healthy foods. According to the Recommended Dietary Allowances (RDA) of the Indian Council of Medical Research (ICMR), per capita consumption of vegetables must be 300 g. Whereas the availability of vegetables per capita per day is hardly 241 g with inequality of availability and affordability across the society. According to the World Health Organization, protein-energy malnutrition (PEM) is India's major public health problem. It affects mainly the preschool children (< 6 years) during the most crucial period of development which can lead to permanent impairment in later life (Park 2007). In North-East India, 40.1% of the population suffers from anemia, whereas in Arunachal Pradesh, approximately 29.3% (stunting, wasting, undernutrition) under age three are suffering from PEM (Pandey et al. 2014). Similarly, 47.2% of women suffering from anaemia and 64.4% of children suffering from malnutrition have been reported in Meghalaya.

To ensure nutritional security and overcome the menace of PEM, legume vegetables and tuber crops can play an essential role in diet diversification. There are wide ranges of legume vegetables like pea, French bean, Indian bean, cowpea, broad bean, winged bean, lima bean, tree bean, etc. are rich in protein (H" 8%). Many tuber crops grown in the region are rich sources of starch like potato (61 - 80 %), sweet potato (65 -70%), colocasia (70 – 80%), Dioscorea (70-86%), and tapioca (74 - 87%) and also vitamins and minerals. Potato contains reasonable amounts of essential amino acids like leucine, tryptophane, and isolucine and yield about 97 Kilocalories per 100 gm fresh weight that is much higher than cereals. Several nutritional disorders due to vitamin A, C, and Calcium deficiency could be easily alleviated by consumption of root and tuber crops like cassava, sweet potato, yam, and aroids. Sweet potato variety ST-14 has been found rich in â- carotene (13.23 mg/100g) can be promoted for commercial production to ensure the nutritional requirements of vitamin A.

Leafy vegetables grown in the region are rich sources of vitamins like vitamin- A and folic acid. Mustard green (*Brassica juncea* var. *rugosa*) is very popularly known as *Laipatta* and grown almost round the year is rich in crude fiber (11.0 -12.5%), protein (28%), and vitamin A (10000-12000IU) content. Malabar spinach/ Poi (*Basella alba*) grown widely in the valleys are rich sources of dietary fiber (32 and 10 g/100 g DW), protein, folic acid, and beta-carotene content. *Amarantus viridis* is rich in crude protein (2.11%), crude fiber (1.93%), â- carotene (62.5 mg/100g FW), folic acid and minerals. More than 12 species of genus *Allium* have been reported in the region viz., *Allium chinense, A. kookeri, A. tuberosum, A. fistulosum, A. ascalonicum, A. macranthum, A. prattii, A. rubellum, A. wallichii, A. sativum, A. cepa*. Chollng (*A. chinense*) contains about 2.6% protein, 0.6% fat, 2.4% carbohydrate, 0.95% ash with small amounts of vitamins A, B1, and C. Many traditional vegetables popular in the NEH region are known for their ethnobotanical and medicinal uses (Table 2).

Potential vegetable genetic resources: Global diversity in vegetable crops is estimated at 400 species, with about 80 species originating in India (Chadha 2009). Due to the diverse climate, the NEH region is a hotspot of biodiversity. A wide range of wild and cultivated species are grown and can be used to improve tolerance to biotic and abiotic stresses and quality traits. The wild ancestor of cucumber, *Cucumis sativus* var. *hardwickii*, is found in natural habitats in the foothills, particularly in Meghalaya. This species is a potential source for resistance to downy mildew and root-knot nematodes. Three accessions (IC410617, IC527419, and IC538130) from Tripura are free from downy mildew symptoms. IC410617 was resistant to viral disease. *Cucumis hystrix* has also been found as a source of resistance to downy mildew. Two accessions (IC 420405 and IC 420422) from Mizoram having orange flesh showed high carotenoid content (Ranjan *et al*., 2013). *Cucurbita ficifolia* is found in the region, is a potential source for grafting of cucumber against moisture stress and low temperature. *Abelmoschus crinitus* and *A. pungens* are distributed. *A. crinitus* found resistance to *Yellow vein mosaic viruses* (YVMV), *Okra enation leaf curl virus* (OELCV), cercospora blight. Local landraces of *Capsicum* spp. King-Chilli, Birds' Eye Chilli, and Dalle Chillies rich in capsaicin and oleoresin content can be used as a donor parent for crop improvement.

Soil moisture conservation and climate-resilient agriculture: Legume vegetables and tuber crops have been found suitable for soil and water conservation. Sohphlang (*Flemingia vestita*), a leguminous tuber crop, can fix 250 kg nitrogen per hectare per year (Gangwar and Ramakrishnan 1989). Besides, other legume vegetables such as Indian bean, lima bean, velvet bean, winged bean grown during the rainy season have deep root systems with good soil binding properties with nitrogen fixation. Tuber crops like sweet potato, colocasia, tapioca, and sohphlang have good surface cover protecting the soil from water erosion. These crops are highly suitable for climate-resilient agriculture.

Thrust areas: For sustainable livelihood and nutritional security, there is a need to focus on the following interventions:

1. The region's ecology is highly diverse and fragile; hence focus should be on conserving potential vegetable genetic resources for future use.
2. Non-availability of quality seeds is one of the factors for low productivity of the crops, especially in winter season vegetables like pea, potato, cabbage, broccoli, knol-khol, lettuce, etc. Therefore, improved varieties/ hybrid seeds tested in the region should be promoted for commercial production.
3. There is enormous scope for the processing and value addition from different crops like sauce and ketchup from tomato, sauce, and pickles of the local chillies (dalle chilli, birds eye chilli), chow-chow totty fruity, dried powder of curry leaves, zanthxyllum, dehydrated mushrooms, and bitter gourd shreds, canned baby corn and mushrooms, sago from tapioca, potato chips, bamboo shoot pickles, etc.
4. Commercial vegetable cultivation faces problems of biotic (moisture stress, frost) and abiotic stresses (like, bacterial wilt and early and late blight in tomato, potato, bacterial wilt in brinjal), hence varieties should be developed and promoted which is well suitable for the region.

Table 2. Ethnobotanical and medicinal properties of popular traditional vegetable and aromatic crops of NEH

Name		Quantitatively verified, traditionally known properties and uses
Chow-chow (*Sechium edule*)	:	Rich in flavonoids especially in leaves (35.0 mg/10g dried leaves), roots (30.5 mg/10g) and stems (19.3 mg/10g). Fruits contain sechumin, an anticancer ribosome-inactivating protein, fruit extract believed to have antihypertensive, antibacterial, antifungal, antioxidant, antihyperglycemic, anticonvulsant and central nervous system depressant activities.
Teasel gourd (*Cucumis dipsaceus*)	:	Fruits are rich in β-carotene (162 mg/100 g), phenol (36 mg/100 g GAE) and considered to have cooling, analgesic, sedative, and diuretic properties. Fruits balances all the three Doshas (a term used in Ayurveda).
Spine gourd (*Momordica dioica*)	:	Fruits has hypoglycemic properties and believed to protects and regenerates pancreatic β-cells; enhances both insulin secretion and insulin sensitivity, helping to manage diabetes at all levels.
Morai napakpi (*Allium hookeri*)	:	Therapeutic values of higher concentration of total phenols (2 g/100 g dry wt.) and phytosterols (0.5 g/100 g) are known to lower the intestinal absorption of cholesterol.
Malabar spinach (*Basella alba*)	:	Leaves are rich sources of pigments lutein (107 ug/100g), β- carotene (1620 ug/100g), and betalains (80 mg) with antioxidant properties and hypoglycemic due to mucilage; also known for gastro-protective, ulcer healing, anti-inflammatory and wound healing properties.
Velvet bean (*Mucuna pruriens* (L.)	:	The seeds contain L-DOPA (2.9–5.6%) - potential medicine against Parkinson's. UKDMP-11 accession has been identified as rich in L-DOPA (5.62%).
Tree bean (*Parkia roxburghii*)	:	Kernels are traditionally used as a supplementary food and to treat leprosy and hypertension. Pods are used in bleeding piles. Bark extract is given in diarrhea and dysentery.
Sohphlang (*Flemingia vestita*)	:	Tubers are known for traditional medicine as vermifuge, tuber peel extract reported to be effective against helminthic parasite.
Wild yams (*D. floribunda* &*D. deltoidea*)	:	Good sources of corticosteroids e.g. sapogenins areused as oral contraceptives. *D. deltoidea* derived steroidal hormone, cortisone used in rheumatic illness and ophthalmic problems.
Spanish coriander/ Naga dhania (*Eryngium foetidum*)	:	Perennial herb plant cultivated for the aromatic leaves rich in essential oils contain E-2-dodecenal (eryngial; possess anthelmintic activity due to eryngial, anti-inflammatory action due to the phytosterol fractions, anti-convulsant and selective antibacterial activity.
Sweet basil (*Ocimum basilicum*), clove basil (*O. gratissimum*) & mint (*Mentha* spp.)	:	Aromatic leaves used in garnishing, flavouring. The aroma is due to essential oil having 1, 8-cineole, geaniol, estrageole and eugenol, a potential antioxidant; used to sharpen memory, as a nerve tonic, and remove phlegm from bronchial tubes. Leaves are also rich in polyphenol (126 mg/g) and also possess antimicrobial, antiviral, and anticancer properties.
Curry Leaf Tree *(Murraya koenigii* & *Zanthoxylum spp.*)	:	Aromatic leaves of perennial plant species such as *Murraya koenigii* and *Zanthoxylum* spp. are very popular. The leaves are rich in essential oils and possess anti-oxidant activities. Curry leaves oil has crystalline glucoside Ksenigin.

5. For most marginal farmers in the region, incentive and amenable policies for protected cultivation, including nursery production, could be helpful to increase income and year-round production for livelihood security.
6. Most of the farmers lack improved technical know-how of the crops and seed production; therefore, awareness programmes should be organized for the farmers.
7. There is also a need to focus on research to develop the package of practices and value addition of the underutilized vegetable crops and targeted value chain development.
8. Soils being acidic, applying liming @ 2.5q/ha should be promoted for better yield and quality of the vegetable crops. Likewise, promotion for conversion and uses of biomass (biochar, compost, etc.) in the production system could better impact the environment.
9. Water scarcity is one of the limiting factors of production during the winter season. Therefore, water harvesting in Jalkund/ponds and efficient utilization through drip/micro irrigation with mulching should be promoted for year-round production of vegetable crops, increasing the area of crops and cropping intensity.

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