

Prospects of Vegetable Crop Production in Northeast Region

Northeastern region is characterized by diverse climate regimes ranging from subtropical to alpine, high rainfall zones, diverse terrain, slopes, altitude, and land tenure systems. Vegetables are cultivated under homestay and mixed commercial systems with various production systems depending on high, mid, and foothills. The region is the wealthiest reservoir of genetic variability of vegetables such as leafy vegetables, tomato, brinjal, chilli, Indian bean, winged bean, velvet bean, tree tomato, tree bean, cucurbits, 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 cowpea, French bean, lima bean, Indian bean, velvet bean, winged bean, and leguminous tuber crop Sohphlang are highly suitable for climate-resilient agriculture. Prospects and thrusts in vegetable research for development are highlighted in the paper. The horticulture sector in Northeastern region is moving in the right direction and slowly but steadily moving towards ushering in a new era of golden revolution.

THE Northeastern (NE) region of Bharat is located between 21.5° N - 29.5° N latitude and 85.5°E - 97.3° E longitude with more than 98% international border sharing with Bhutan, China in the north, Myanmar in the east and Bangladesh in the south-west. The region has several unique features such as fertile land, abundant water resources, evergreen dense forests of about 67%, high rainfall, mega biodiversity and agriculture-friendly climate. Bharat being one of the mega diversity hotspots has four hotspot regions: the Himalayas, the Indo-Burma region, the Western Ghats and the Sunderbans. The Indo-Burma region is stretched over an area of 23,73,000 sq km, including Northeastern states. Northeastern region accounts for only 8% of the total geographical area of the country measuring 2,62,230 sqkm. The total area under horticulture in the country is 28.28 million ha contributing 350.87 million tonnes production. The area under horticultural sector in Northeast is about 1.4 million ha with production of 12.50 million tonnes contributing to 5.7% and 3.98% of total area and production of the country respectively. The region is blessed with different agro-climatic zones supporting the rich flora, which is home to diversity of underutilized fruits and vegetables. 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 vegetable 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.

Status of vegetable production in NE region

The Northeastern region contributes about 1.14 million ha and 20.4 million tonnes of the national area and production of vegetables, respectively. The average productivity of the vegetable crops is low (11.34 t/ha) as compared to national productivity (18.1 t/ha) and varied from 4.76 t/ha (Mizoram) to 17.38t/ha (Tripura). The maximum area and production of the vegetables are in Assam, followed by Tripura, Nagaland, and Meghalaya. Besides, numerous underexploited vegetable crops, at subsistence level more than 20 major vegetable crops are grown in the region. However, over 64 % of the total production share is contributed by only five crops that are potato (20.6 %), cabbage (18.20 %), tomato (9.7%), cauliflower (9.32%) and brinjal (6.93 %).

Potential vegetable genetic resources

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 of resistance to downy mildew and root knot

Table 1. Agro-climatic characteristics of Northeast Hilly region

Zones	Altitude (m)	Altitude range areas	Vegetable crops
Alpine zones	More than 3500	Arunachal Pradesh: Gorichen, Tawang, Bumla, Sela pass areas of West Kameng District Jidu and adjoining areas of Northern Siang Sikkim: Gnathong, Chhangu, Serrathong, Thangu, Yakthan, ZemaLachen, eegyathathang, Samsingeling, Cholemu, Lima, Nathula range.	Leafy vegetables under protected structures
Temperate and sub-temperate zone	1500-3500	Arunachal Pradesh: Tawang, west Kameng District, Dibang Valley, Upper Subansiri district Meghalaya: Upper Shillong, Mawphlang and Mariang of East Khasi hills district Manipur: Mao & Ukhrul and adjoining areas of east district Sikkim: Bordong, Resi, Kangdin, Melli, Param, Lachem, Laichung, Hilley, Yoksum Mizoram: Blue Mountain, Halikhan Nagaland: Tuensang and Zunhoeboto district, Vangkhong area of Wokha district, Higher areas of Mokokchung district Assam: Karbi Anglong, N.C. Hills Tripura: Chittagong Hill, Jampui, Bethliangchhip	Potato, cole crops, root crops, solanaceous vegetables, vegetable pea and beans.
Sub-Tropical Hill and Plain Zone	200-1500	Arunachal Pradesh: Changyak, naga and Khonsa area of Tirap district, Along in West Siang, Pasighat in East Siang, Seppa in East Kameng Meghalaya: Jowal sub-division of Jaintia Hills, part of Nongstoin sub-division, Nokret and Kailash area of west Garo Hills and Western part of east Garo Hills Sikkim: Namchi, Gayzing, Rongli, Mangan, Chanthang, Uttre, Gangtok Mizoram: Whole state except lower valley of Northern and Western parts and area adjoining Chachar district and lower parts of chhimtuipuii district Nagaland: Medziphema, Southern part of Dimapur subdivision, etc. Manipur: Imphal Valley Assam: Barak Valley Zone, Lower Brahmaputra Valley Zone, Upper Brahmaputra Valley Zone, Central Brahmaputra Valley Zone Tripura: Agartala and adjoining areas.	Cruciferous and solanaceous vegetables, water spinach, velvet bean, winged bean, <i>Perkia roxburghii</i> , broad bean and common vegetables, sweet potato, potato, underexploited Vegetables.

nematodes. Accessions IC410617, IC527419 and IC538130 from Tripura are reported to be free from downy mildew. Genotype IC410617 is reported to be resistant to viral disease. *Cucumis hystris* has also been reported as source of resistance to downy mildew. Two accessions (IC420405 and IC 420422) were reported from Mizoram which have orange flesh and high carotenoid content. *Cucurbita ficifolia* found in Nagaland is a potential source for grafting of cucumber against moisture stress and low temperature. *Abelmoschus crinitus* and *A. pungens* are widely distributed in the region. *A. crinitus* have been reported as resistance to YVMV, OELCV and cercospora blight. Local landraces of *Capsicum* spp., Bhoot jalokia/ naga viper, king chilli, birds' eye chilli and dalle khursani are rich in capsaicin and oleoresin content and are effective donor parents for crop improvement.

Strengthening of *kharif* chilli production

The farmers traditionally follow the cultivation of rainfed paddy cultivation during *Kharif* season which is not much economical. Crop diversification is the need of the hour for this region to uplift the socio-economic status of tribal farmers. The second author has explored the possibility of cultivation of *Kharif* chilli as a substitute crop by replacing paddy in the cropping system. It was noted that during March-September, the region faced adverse conditions due to heavy rainfall and poor communication which resulted in paucity of commodities leading to extreme hikes in price of vegetables in the local market

including chilli. Therefore, technology of pre-*Kharif* chilli production can be a boon for the region. The findings of the evaluation studies showed that if the transplanting of chilli is done during March-April and harvesting of green chilli from mid of July to September, the yield of *Kharif* chilli may go up to 150-200 q/ha with the production cost of ₹ 1,10,000.0/ha. The growers may get a net return of about ₹ 3,20,000.0/ha by selling the green chilli fruit @ ₹ 40-50 per kg. Thus, it shows that there is a good prospect of cultivation of *Kharif* chilli in the region. There is need to provide leadership and coordinated network research with regional KVKs to generate location and variety specific technologies and unveil new avenues for farmers. Development of *Kharif* chilli production technology in NEH region on the strategies suggested above is likely to improve the productivity and production of chilli.

Emerging scenario and future strategies of *Kharif* onion production

Besides other vegetables, onion, potato and tomato are the major vegetable crops in the region. There is a good prospect of cultivation of *Kharif* onion. The paper has explored the possibility of cultivation of *Kharif* onion as a substitute crop by replacing paddy with the *Kharif* onion in the cropping system at CHF, CAU, Pasighat, Arunachal Pradesh. Also, it has been observed that during March-September, the region faced adverse conditions due to heavy rainfall and poor communication



Kharif chilli – field view at CHF, CAU Pasighat



Kharif Onion – field view at CHF, CAU Pasighat

which resulted in extreme hikes in the price of onion in the local market. Keeping in view of facts, initiative was taken for proper production aspects, optimum time for sowing transplanting of *Kharif* onion, development of technology and specific research works were done. The research team tried to put in extensive efforts to popularize the production technologies for *Kharif* onion and its proper implementation among the farmers of the region and have explored the possibility of cultivation of *Kharif* onion. Findings of the cultivation of *Kharif* onion at CHF, CAU, Pasighat, Arunachal Pradesh showed that if the transplanting of onion is done during April and harvesting of bulb during July and the yield of *Kharif* onion may go up to 200-250 q/ha in complete rainfed condition with the production cost of ₹ 80,000/ha. The potential for growing *Kharif* onion in various pockets of the region is enormous.

Strategies to be adopted for climate-resilient vegetable crops

Legume vegetables and tuber crops have been found suitable for soil and water conservation. 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 have good surface cover protecting the soil from water erosion. These crops are highly suitable for climate-resilient agriculture.

Screening of vegetable crops suitable for different cropping systems

In valleys, the farmers mainly follow paddy-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 cultivation of tomato is highly profitable, followed by brinjal and bottle gourd. Similarly,

the highest yield per hectare in cool-season crops has been recorded from cabbage. However, the highest input-output ratio is found in Indian bean, followed by cabbage and broccoli. Tomato-cabbage cropping system is found to be most economical, followed by brinjal-cabbage (solanaceous-crucifer vegetable-based cropping system). Under legume-cucurbits systems, Indian bean-bottle gourd and Indian bean-cucumber cropping systems are highly profitable. Further, vegetable crops are the most economical in integrated farming system with BC ratio of 2.25 over other components. 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 ₹ 63.87/sqm.

Vegetable based diversified farming and *Jhum* improvement

The NE region is the wealthiest reservoir of genetic variability of vegetables such as water spinach, cowpea, French bean, chillies, Indian bean, winged bean, velvet bean, Dioscorea, Colocasia, etc. These crops are an integral part of the dietary system of local communities and grown abundantly in their *Jhum* land or kitchen garden as mixed crop. 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 fence crop on the mainland boundary. Many leafy vegetables like water spinach, laipatta, amaranth, kulfa, green onion, etc., are short-duration and found suitable for different cropping systems.

Vegetable cultivation in protected cultivation

Different kinds of protected structures are used for vegetable cultivation. Due to mild weather in the mid-hills, naturally ventilated polyhouse is 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,



Different vegetable promotional activities undertaken by ICAR-IIVR, Varanasi in NE region

genotype, RCC 2 (4.28 kg/plant) have been recorded. The maximum per annum net income was found from the cropping sequence tomato (Megha Tomato 3)–capsicum (Pusa Deepti) followed by a sole crop of King chilli and cropping sequence tomato (Megha Tomato 3) – chilli (hybrid Fungale). However, the highest BC ratio (4.2) was observed from the King chilli as the sole crop followed by tomato - capsicum cropping sequence (3.5). 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., have been found highly remunerative (BC ratio of > 4.0) crops. The use of mulch and drip irrigation would significantly improve the yield, especially in the winter season (November-February), when soil moisture is scarce.

ICAR-IIVR Varanasi Tech in NE region for strengthening and promotion of vegetable production

ICAR-IIVR, Varanasi has taken the lead to enhance vegetable supplies through low-cost production and consumption technology, demonstration of improved production and protection technology, real time supports for basic inputs, advance vegetable cooking and processing methods coupled with educational programs to improve productivity, secured income, minimize risks associated and make market perfect as most effective strategies to boost vegetables production in NE region throughout the year as part of 'Promotional Activities of Vegetables'

under ICAR-IIVR-NEH component. Under this backdrop presently ICAR-IIVR, Varanasi is undertaking different activities modules with the following objectives:

- To train small and marginal farmers of the region.
- To distribute quality seed materials of vegetables and other inputs in the form of minikit.
- To enhance awareness and assist in the promotion of production technologies, processing, and utilization of selected micronutrient-rich vegetables through front line demonstration.
- Introduction of different promotional activities.
- Crop cafeteria or home stead garden creation.
- Low-cost poly house for growing of high value vegetable crops (like. Capsicum, Cherry tomato and/or Broccoli).
- Introduction of new crops in the nontraditional areas (like *kharif* Onion)
- Nursery raising of vegetable by covering with 60 mesh nylon net and nursery raising of high value vegetable crops by plug tray techniques under low cost poly house.
- Off season vegetable cultivation.
- Use of Poly-mulch or Agri-mulch for better yield & productivity.
- To promote vegetable-based value added products.

Technological constraints in the region

- Lack of suitable high-yielding vegetable varieties for diverse upland situations, flood affected areas,

moisture stress conditions, and hill areas.

- Alternative crops for escaping pre-monsoon showers to avoid the problem of pre-harvest sprouting of crop in flood, free period.
- Develop improved crop management practices for shifting cultivation.
- Improvement and standardization of production techniques of vegetable crops.
- Use of improved post-harvest management including pest and disease management and processing techniques for the major vegetable crops.
- Land and water management technique specifically for acid soils.
- Economic packages for integrated farming systems combining vegetable cultivation with livestock, fishery, etc.
- The access to institutional credit facilities for the farmers must be improved substantially.
- Poor marketing infrastructure existing in the region.

Thrust areas

- The region's ecology is highly diverse and fragile; hence focus should be on conserving potential vegetable genetic resources for future use.
- 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.
- 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 (dale chilli, birds eye chilli), chow-chow totty fruity, dried powder of curry leaves, zanthoxylum, dehydrated mushrooms, and bitter gourd shreds, canned baby corn and mushrooms, sago from tapioca, potato chips, bamboo shoot pickles, etc.
- Commercial vegetable cultivation faces problems of abiotic (moisture stress, frost) and biotic stresses (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.
- Most of the farmers lack improved technical know-

how of the crops and seed production; therefore, awareness programmes should be organized for the farmers.

- 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.
- 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.
- Water scarcity is one of the limiting factors of vegetable 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.

To enhance vegetable productivity, using new innovative methods and technologies is the best alternate to sustain food security. The adoption of improved agronomic practices, such as staking and mulching in open field-tomatoes, resulted in yield increase by 15% and reduction of labour costs by 30%. The cultivation of cucumber, bitter gourd, brinjal, tomato, chili and capsicum under farmers' friendly low cost protected cultivation with improved production practices such as staking and mulching enabled farmers to obtain yield ranging from 150 to 200%. Therefore, as an off-season crop, technology-led vegetable production hold bright prospect. The cultivation of *Kharif* chilli, *Kharif* onion and *Kharif* tomato can provide immense potential in the Northeastern region and thereby contribute towards higher income per unit area, diversification of agriculture for better land use with least investment, food and nutritional security, scope for massive employment generation, unveiling new horizons for economic and social betterment of the rural community.

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Germplasm Indigenous Sources

During the year 2022-23, a total of 3,346 accessions of horticultural crops comprising 182 fruits [Mango (11), citrus (10), guava (10), bael (10), tamarind (4), rose apple (24), jamun (8), dragon fruit (23), jack fruit (4), papaya (6), banana (11), muskmelon (3), longan (52), grape (6)]; plantation crops (15); 1,595 vegetables [Potato (44), okra (5), brinjal (481), garden pea (450), french bean (86), onion (42), carrot (3), radish (7), ridge gourd (133), cucumber (202), bottle gourd (3), ash gourd (23), drumstick (92), curry leaf (10), pumpkin (8) and summer squash (6)]; 112 tuber crops [Cassava (48), sweet potato (13), taro (29), elephant foot yam (5), greater yam (3), wild yam (2), lesser yam (1), Colocasia (1), Chinese potato (1) and other minor crops (9)]; 108 spices [Black pepper (29), Zingiberaceous spices (41), nutmeg (5), cinnamon (5), clove (1) and Garcinia (27)]; 1075 flowers and medicinal plants [Gladiolus (12), *Gymnema sylvestris* (10), brahmi (10), betel vine (1), rose (35), chrysanthemum (09), orchids (83), anthurium (13), tuberose (05), gerbera (24), marigold (16), liliun (11), dahlia (05), specialty flowers (31), ornamental fillers and florist greens (51)]; medicinal and aromatic plants (759); and 215 mushrooms (175) collections were identified up to genus level and 30 specimens up to species level) were collected from different sources.

Source: ICAR-Annual Report 2022-23