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Potential of Temperate Fruit Crops in Northeastern States of India

The Northeastern Himalayan (NEH) region of India is one of the potential horticultural ecosystems that has enormous temperate fruits and the entire range of fruit crops grown in the tropical, subtropical and temperate regions. The areas have tropical climate with high rain fall and moderate temperature regimes. However, the higher altitudes of Arunachal Pradesh, Nagaland, Meghalaya and Manipur have ideal soil and climatic conditions and have great scope for temperate fruits. These areas receive moderate to high chill units during winter season. Therefore, apple is grown nearly on the top of the hills and other fruits like stone fruits, walnut, kiwi, strawberry and persimmon are grown in the mid-hills successfully. The area under temperate fruit cultivation is very limited inspite of the ideal soil and climatic conditions and the availability of low chill temperate fruit and nut crops. Therefore, adoption of technological innovations in Northeastern states have potential for area expansion in the region.

NORTH EASTERN states consists of 8 states namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (officially the North Eastern Region, NER) is the easternmost region of India. The NE region shares international boorder with China in the north, Myanmar in the east, Bangladesh in the southwest, Nepal in the west, and Bhutan in the northwest. It comprises an area of 262,184 square km (101,230 sq mi), almost 8% of India. Due to the biodiversity and crop diversity of the region, researchers believe that early settlers of Northeast India had domesticated several important plants. In the region, 8 important temperate fruit crops are grown on a very small scale namely apple, pear, peach, plum, kiwi, grapes, walnut and strawberry in 6 states *viz.*, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Sikkim (Table 1.) The areas in NE region fall under the wet temperate region which receives mild to high chill units. The maximum area among the temperate fruits lies in Arunachal Pradesh followed by Mizoram and Sikkim. However, no area under temperate fruit cultivation has been reported in Assam and Tripura. Among the temperate fruits, the maximum area is under kiwi followed by apple, grapes, pear, walnut, plum, peach and strawberry. Similarly, the maximum production comes from the same states, where the area is available for cultivation (Table 2). Productivity of kiwi is significantly higher than the national average; however, in rest of the fruit crop, productivity level is many fold lower than the national level (Table 3). Therefore, there is an urgent need for technological interventions at a faster pace on priority crops like kiwi, persimmon, walnut, strawberry, pear and apple.

Table 1. The area of temperate fruit crops in NER during 2021-22, ('000 ha)

State	Apple	Grapes	Kiwi	Peach	Pear	Plum	Strawberry	Walnut
Arunachal Pradesh	4.44	-	3.56	0.05	0.29	0.04	-	0.74
Assam	-	-	-	-	-	-	-	-
Manipur	-	0.02	0.29	-	-	-	-	-
Meghalaya	-	-	-	-	-	-	0.13	-
Mizoram	-	2.35	0.30	-	-	-	0.17	-
Nagaland	0.24	0.12	0.30	0.26	0.20	0.44	-	-
Sikkim	-	-	0.41	0.14	1.66	-	-	-
Tripura	-	-	-	-	-	-	-	-

Source: (MoA & FW, 2023)

Table 2. Production of temperate fruit crops in NER during 2021-22, ('000 ha)

State	Apple	Grapes	Kiwi	Peach	Pear	Plum	Strawberry	Walnut
Arunachal Pradesh	6.83	0.01	7.11	0.07	0.56	0.14	-	0.42
Assam	-	-	-	-	-	-	-	-
Manipur	-	0.22	3.03	-	-	-	-	-
Meghalaya	-	-	-	-	-	-	1.20	-
Mizoram	-	17.30	1.03	-	-	-	1.08	-
Nagaland	1.78	0.23	1.69	1.77	2.06	2.77	0.01	-
Sikkim	-	-	2.17	0.33	4.14	-	-	-
Tripura	-	-	-	-	-	-	-	-

Source: (MoA & FW, 2023)

Table 3. Yield of temperate fruit crops in NEH during 2021-22, (t/ha)

State	Apple	Grapes	Kiwi	Peach	Pear	Plum	Strawberry	Walnut
Arunachal Pradesh	1.54	3.33	2.00	1.50	1.96	3.81	-	0.57
Assam	-	-	-	-	-	-	-	-
Manipur	-	12.94	10.58	-	-	-	-	-
Meghalaya	-	-	-	-	-	-	9.06	-
Mizoram	-	7.35	3.43	-	-	-	6.35	-
Nagaland	7.37	1.91	5.66	6.95	10.08	6.32	3.50	0.00
Sikkim	-	-	5.33	2.41	2.49	-	-	-
Tripura	-	-	-	-	-	-	-	-
Total	8.22	20.81	3.11	6.33	7.05	3.62	4.43	2.79

Climate

The Northeast region has a predominantly humid sub-tropical climate with hot, humid summers, severe monsoons, and mild winters. Geographically, apart from the Brahmaputra, Barak and Imphal valleys and some flatlands in between the hills of Meghalaya and Tripura, remaining two-thirds of the area is hilly terrain interspersed with valleys and plains; the altitude varies from almost sea-level to over 7,000 m (23,000 ft) above MSL. Arunachal Pradesh and Sikkim have a montane climate with cold, snowy winters and mild summers. In Northeast Region, part of Arunachal Pradesh and part of Nagaland fall under temperate zone; Assam, Meghalaya, part of Tripura, and part of Arunachal Pradesh fall under subtropical zone; while part of Tripura and Mizoram under coastal/tropical zone. Temperatures are moderate in the Brahmaputra and Barak valley river plains which decreases with altitude in the hilly areas. At the highest altitudes, there is permanent snow cover. In general, the region has 3 seasons: Winter, Summer, and rainy season in which the rainy season coincides with the summer months much like the rest of India. Winter is from early November until mid-March while summer is from mid-April to mid-October. According to the Köppen climate classification, the region is divided into i) Tropical climates, ii) Warm temperate mesothermal climates, and iii) Snow microthermal climates (Table 4). Temperatures vary by altitude with the warmest places being in the Brahmaputra and Barak River plains and the coldest at the highest altitudes. It is also influenced by proximity to the

Table 4. Climatic conditions in Northeastern states in India

Region	Climate	Remarks
Manipur, Tripura, Mizoram, and the Cachar plains south	Tropical wet and dry	-
Assam, Nagaland, northern parts of Meghalaya and Manipur and parts of Arunachal Pradesh	Warm temperature mesothermal climates	Mean temperatures in coldest months range from −3 to 18°C
Brahmaputra valley	Humid subtropical climate with hot summers	Warm
Eastern hills of Nagaland, Manipur and Arunachal Pradesh	warm summers	500 and 1,500 m (1,600 and 4,900 ft)
Meghalaya, parts of Nagaland, and northern Arunachal Pradesh	Short and cool summers	Above 1,500 m (4,900 ft)
Extreme northern parts of Arunachal Pradesh	Cool climate	Humid continental climates with mean winter temperatures below −3°C

sea with the valleys and western areas being close to the sea, which moderates temperatures. In the mountainous areas of Arunachal Pradesh, the Himalayan ranges in the northern border with India and China experience the lowest temperatures with heavy snow during winter and temperatures that drop below freezing. Areas with altitudes exceeding 2,000 m receive snowfall during winters and have cool summers. Below 2,000 m above sea level, winter temperatures reach up to 15 °C during the day with nights dropping to zero while summers are cool, with a mean maximum of 25 °C and a mean minimum of 15 °C. In the hilly areas of Meghalaya, Nagaland, Manipur and Mizoram, winters are cold while summers are cool. No part of Northeast India receives less than 1,000 mm of rainfall a year.

Table 5. Potential temperate fruit crops for commercial cultivation in Northeast region

State	Temperate fruits
Arunachal Pradesh	Apple, kiwi, persimmon, strawberry, pear, plum, grapes
Assam	Low chill pear, strawberry
Manipur	Kiwi, grapes
Meghalaya	Low chill pear and strawberry
Mizoram	Grapes, kiwi and strawberry
Nagaland	Apple, kiwi, grapes, peach, pear, plum
Sikkim	Kiwi, peach, pear

Suitable areas for temperate fruit cultivation

Areas suitable for temperate fruit growing in NE Region states are presented in Table 5. There are lot of scope to grow new Gala strains of apple, which are more self-fruitful, high colouring, moderate chilling requirement and higher productivity through the adoption of HDP and assured irrigation as well as nutrient /pest management in the higher reaches of Arunachal Pradesh and Nagaland. While peach, plum, and pear can be successfully cultivated in certain parts of the above states based on the availability of chilling units. In Arunachal Pradesh, temperate fruit cultivation has been intensified in mid (900-1800 m) high hills (above 1800 m). Apple cultivation started in 1956 and with active participation of State Department of Agriculture, large area has been brought under temperate fruits like apple and walnuts. At present, over 250 ha of land is under commercial production of apples especially in Kameng district, in the altitude range of 1600-3500 m above msl with a rainfall of about 900 mm. This is considered ideal for apple cultivation. Another belt of apple is developing in Ziro-Hapoli area of Subansiri district. Other nuts like almond, chestnut, etc are being tried, if these are successful, they will be a boon to the tribal farmers. In Meghalaya central plateau of Khasi and Jaintia hill districts (1000 to 2000 m above msl) grow high quality plum, pear, peach and apricot. Apple has been introduced to a limited scale. It has also the potential for growing persimmon and cherries. In the valley of Manipur - Sekmai, Maram, Tabudi and Mai areas, pear is grown. While in areas like Ukhrul, Mao-Maram, Tengnoupal and Manipur valley stone fruits like peach and plums are grown to some extent. In Ukhrul some apple plantations also exist.

Technological Interventions

Indian Council of Agricultural Research and the States Department of Agriculture are instrumental in the execution of Research and Developmental activities of this region. Department of Agriculture, Nagaland established Two stations for temperate fruits, one at Pfutsero in Phek district and other in Atoizo at Mokok Chung district. The Horticulture Research Station Pfutsero is situated at an elevation of 2000 m and large collections of improved varieties of apple, pear, peach, plum and apricot have been made at the station covering about 31 ha. The var. 'Maharaji' has been found better than 'Golden Delicious', 'Cox's Orange Pippin', 'Baldwin', 'Jonathan', 'Rome Beauty', 'Winter Banana', etc. Recently, new strains of Gala have been doing very nicely in Arunachal Pradesh and farmers are getting 3-4 higher yield and income. In Meghalaya, temperate fruits were introduced 70 years back. Some varietal recommendations have been made for Apple - 'James Grieve', 'King David', 'Cox's Orange Pippin', 'William's Favorite', 'Charles Ross'; Plum: 'Santa Rosa', 'Doris Satsuma', 'Pond's Seedling', 'Green Gage'; Pears: 'William Bon Chretien', 'Fertility'; Apricot: 'New

Kiwi high-density orchard in Dirang, Arunachal Pradesh

High density orchard of Persimmon in Dirang, Arunachal Pradesh

Castle'; Persimmon: 'Daidai Maroo'; Cherries: 'Black Heart'.

High-density orcharding of apple, kiwi, persimmon

Apple, kiwi and persimmon are one of the potential crops to grow under high density in NE region. These crops are very potential for the region, due ideal climatic conditions. In apple, Gala varieties grafted on clonal rootstocks have been proved very profitable in Arunachal Pradesh. Likewise, the kiwi and persimmon are another fruit crops are yielding significantly higher yield of quality fruits as compared to other regions of the country.

Low chilling cultivars suitable for subtropical Conditions

Selection of cultivars of the temperate fruits to be grown under subtropical climate is one of the key

High density orchard of Apple in Arunachal Pradesh

requirements for their successful cultivation in the subtropical regions. Only those cultivars which have low chilling requirement and ability to tolerate high summer temperature should be selected. Breeding programs have provided new cultivars selected for their short chilling requirements and tolerance to high temperature. One of the most successful cultivars is 'Anna' apple, developed by A. Stein in Israel. This is now extensively grown in areas with limited chilling. The introduction and the selection of superior types have remained major research activities at various institutes, as a result of which cultivars like Sharbati peach, Titron and Kala Amritsari plum, Pathernakh, LeConte and Baghugosha pears became commercially popular in some parts of the subtropical India.

Constraints and Strategies

Inspite of suitable agroclimatic conditions and large potential for growing temperate fruits in this region, it has not been exploited and still it remains in a neglected state and no organized industry exists due to the following constraints like lack of suitable planting material, lack of skilled labour, lack of trained personnel, lack of

Table 6. Temperate fruits and their cultivars suitable for cultivation under subtropical climate

Fruit crop	Cultivars (*Chilling hours required; value given in bracket indicates the chilling requirement of the respective variety)
Peach	Florda Grande (100), Flordabelle (110), Flordared (110), Flordawon (110), Florda Prince (150), Florda Glo (150), Tropic UF Beauty (200), Sunred (210), Florda Sun (310), UF Sharp (325), Florda King (350), Florda Crest (350), Gulf King (350), Desert Gold (350), Jewel (350), Gulf Crimson (400), Gulf Prince (400), Sun Ripe (400), Florda Home (400), La Festival (400), La Pecker (400), Rio Grande (400), Tejan (420), Rechan (450), Tex Star (450), Whiterobin (500), Bonita (500), Sunfire (500), Ventura (500), May Gold Su (500), Gulfcrest (525), Flordaqueen (540), Sungold (540), Springtime (650), June Gold (650), Maygold (660), Junegold (660), Springtime (660), Armgold (660), Suwannee (660), Tropic Snow, Double Flowering, Parbhat, Pratap, Khurmani, Sharbati, Safeda Early Cream, Saharanpur Prabhat, Shan-i-Punjab, Shaharanpur No. 6, Ranjit Bagh Early, Safeda (LR Brothers), Shaharanpur Hybrid 3, China Flat, Babcock,
Nectarine	Sunbest (225), Sunraycer (250), UF Royal (250), UF Queen (250), Sunmist (275), Sundollar, (350), Suncoat (375), Sunred
Apple	Dorsett Golden (250), Anna (300), Tropic Mac (300), Tropic Sweet (300), 88-20 (375), Ein Scheimer (400), 60-39 (400), Tamma, Neomi, Tropic Beauty, Gallia Beauty, Winter Banana, Tame, Vered
Pear	Patharnakh, Gola, Leconte, Keiffer, Smith, Baghugosha, China Pear, Pineapple, Baldwin, Tenn, Flordahome, Ayers Hood, Orient, Carnea, Tsu Li, Ya Li, *P. calleryana* (rootstock requires 400 chilling hours)
Strawberry	Chandler, Tioga, Torrey, Selva, Belrubi, Fern, Pajaro
Plum	Satluj Purple, Kala Amritsari, Jamuni Meeruti, Titron, Aloo Bokhara, Alucha Black, Titron Howe, Gulfruby, Gulfbeauty, Gulfblaze, Gulfrose
Persimmon	Hachiya, Fuiju, Jiro, Hyakuma
Blue berry)	Sharpblue (150), Emerald (200), Jewel (200), Windsor (225), Springhigh (225), Chaucer (400), Woodard (400), Brightwell (400), Climax (450), Tifblue (550), Powderblue (550)

Sunbest nectarine

Sunmist necatine

Suncoat nectarine

Florda Prince Peach

Earli Grande

Babcock Peach

Dorsett Golden Apple

Anna Apple

Tropic Sweet Apple

demonstration orchards, language barrier, non-existence of suitable transport facilities, non-adoption of suitable plant protection measures, non-existence of suitable marketing agency for the produce, non-adoption of suitable agro-techniques.

Future scope

There are several success stories written that these could be cultivated under subtropical climate as in Venezuela, Israel, Vietnam, Australia and Mexico. Therefore, these can also be repeated in Indian conditions. A collaborative effort among researchers, extension workers and development department could lead to make a breakthrough for their commercialization. This requires a systematic approach includes, identifications of zones according to chilling accumulation and high summer temperature, selection of appropriate fruit crop, selection of appropriate cultivar/ hybrid, awareness campaign by extension workers, and financial support by the financial institutions including public v/s private.

Recent attempts have led to the development of new cultivars of apple, peaches, and nectarines. These cultivars can be grown successfully under subtropical conditions. Locally adapted or developed cultivars/ varieties of peach and some plum cultivars produce crops of high quality can be applied in many parts of the Northeastern Region of Indian.

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