

Commercial edible bamboo species of the North-Eastern Himalayan Region, India. Part I: young shoot sales

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Abstract—This paper reports the results on some commercially available edible bamboo species of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura states of the North-Eastern Himalayan (NEH) region. On average, out of 349 market places, 141 markets covering 2081 primary and secondary vendors were surveyed and interviewed to understand the major edible bamboo species, their sales on markets and cost–benefit analysis of tender bamboo shoots. *Bambusa balcooa* Roxb., *B. polymorpha* Munro in Trans., *B. tulda* Roxb., *Dendrocalamus giganteus* Munro in Trans., *D. hamiltonii* Nees et. Arn, *D. hookerii* Munro in Trans., *D. longispauthus* Kurz, *D. membranaceus* Munro in Trans., *D. sikkimensis* Gamble, *Gigantochloa rostrata* Wong in Malay., *Melocanna baccifera* (Roxb.) Kurz, *Phyllostachys bambusoides* Sieb., *Schizostachyum dullooa* Gamble, *Teinostachyum wightii* Beddome and two unidentified spp., *Chingwa* and *Khupri*, have been found as commercial edible bamboo species in these tribal states. These edible species are also cultivated in home gardens in addition to their harvest from forests. Edible shoots are harvested from the first week of June to the third week of September every year for sales. However, market days varied from state to state and even from place to place within the state, with an average of 84, 84, 53, 81, 76 and 42 days/year, respectively, in Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. On average, 1979, 2188, 442, 433, 442 and 201 tons of bamboo shoots are harvested for consumption annually, accordingly in the same states. The primary species harvested for young shoots was *D. hamiltonii* (ca. 1859 ton/year), followed by *D. giganteus* (ca. 1094 ton/year), *D. sikkimensis* (ca. 1079 ton/year), *M. baccifera* (ca. 647 ton/year), *D. hookerii* (ca. 326 ton/year) and *B. balcooa* (ca. 272 ton/year), irrespective of states surveyed. Significant ($P = 0.05$) variations have been recorded for sales of edible species in different states. Genus *Dendrocalamus* accounted for 77% of the total sales of bamboo shoots in the region. In regards to diversity of edible species, a maximum of eight species have been observed in Manipur, followed by Tripura (6 spp.), and Arunachal Pradesh and Nagaland (5 spp. in both states). Among species, *D. hamiltonii* and *M. baccifera* were the most common species sold, and were found in almost all the states. Significant ($P = 0.05$) variations have been recorded for shoot length, basal diameter of young shoots and shoot weight among species. Shoot length and basal diameter was greatest for *D. giganteus* and lowest for *T. wightii*. Shoot weight was greatest for *D. giganteus* (1.8 kg/shoot) and lowest for *S. dullooa* (0.05 kg/shoot). Cost–benefit analysis for young bamboo shoots has also been estimated. The gross income was calculated to

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be (in million Rs. per year) *ca.* 11.95 (US\$ 261 290), 8.56 (US\$ 187 110), 2.56 (US\$ 56 470), 1.97 (US\$ 42 990), 1.61 (US\$ 35 100) and 1.31 (US\$ 28 700), respectively, in Arunachal Pradesh, Manipur, Nagaland, Meghalaya, Tripura and Mizoram. Thus, accordingly rural communities could earn net revenues of (million Rs.) 8.86 (US\$ 193 740), 5.69 (US\$ 124 410), 1.78 (US\$ 38 950), 1.14 (US\$ 24 900), 0.58 (US\$ 12 730) and 0.75 (US\$ 16 940) in these states by selling young edible bamboo shoots. On average, *D. hamiltonii*, *D. hookerii*, *D. sikkimensis*, *D. giganteus*, *M. baccifera*, *P. bambusoides* and *B. balcooa*, contributed 33, 18, 16, 14, 8, 5 and 3% to total earned revenue, irrespective of the states. Genus *Dendrocalamus* alone supplemented 81% to total revenue and the remainder was contributed by other genera. In addition to their food value, these species also play very important role in the life of tribal folk, particularly in the provision of materials for various day-to-day needs, as well as for paper-pulp industries.

Key words: Young bamboo shoots; North-Eastern Himalayan region; India; cost–benefit.

INTRODUCTION

There are more than 1300 bamboo species distributed in tropical, subtropical, and temperate regions of the world [1]. Uses of bamboo and its value to people in Asia are well recognized and it is considered a fast growing cash crop with diversified uses and easy marketability.

In India, more than 100 000 km² is occupied by bamboo spp., which contribute 12.8% of the total forest cover of the country. The North Eastern Himalayan (NEH) region of India possesses the highest diversity of bamboo. Out of the 126 species found in India, this region possesses 58 species, belonging to 18 genera. Various ethnic groups use bamboo for shelter, food, furniture, handicrafts, medicine and for various ethno-religious purposes. Young succulent shoots of bamboo are held in high esteem as an edible delicacy, especially in rural areas. The major portion of young edible shoots are consumed fresh, the remainder are used for making pickles and other fermented products. In the rainy seasons, young bamboo shoots are regularly harvested from forests and home gardens and are sold or used for domestic consumption [2].

Recently, considerable efforts have been made to document important bamboo species in the region, their traditional uses, management and conservation [3, 4]. Edible characteristics of bamboo species have not been given due importance in these studies, likely due to the fact that edible bamboo species were observed in the NEH region. Only a few scattered reports are available on production potential, marketability and cost–benefit analysis of major edible bamboo species [5]. This paper describes the major edible bamboo species found in the NEH, sales of important edible bamboo species and cost–benefit analysis. This information could be utilized to better understand the harvest rate of young shoots for domestic sales from forests and home gardens along with a cost–benefit analysis and market potential of commercial bamboo species. The other objective of the study was to explore the possibilities of potential edible species to generate revenue, to create employment opportunities, and to frame a comprehensive policy for sustainable

reforestation of commercially available edible bamboo species. For Meghalaya and Mizoram detailed information has already been published [6]; however, the data have been presented in the tables to compare the market potential of each NEH state.

STUDY SITE

The NEH region of India (total area 18.4 million ha) lies between 21.5°N to 29.5°N latitude and 85.5°E to 97.5°E longitude. The region is in a high rainfall zone and the climate ranges from subtropical to alpine. The elevational range of the region extends from 100 m to 4500 m above sea level (asl). Bamboo is an important resource in the region, and without bamboo life of the tribal people in the region is unthinkable.

This study was conducted in Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura states (Fig. 1). Arunachal Pradesh has an area of 83 743 km² and a population of 1.09 million, of which 79.6% is rural. The



Figure 1. Location of the study sites in India.

population density is 13 persons/km² and tribal population is 63.7% of the states' population. The state has 53 932 km² dense forest and 14 113 km² open forest, representing 81.3% of the total area of the state.

Manipur has an area of 22 327 km² and a population of 2.39 million, of which 76.1% is rural. The average population density is 107 persons/km². Dense and open forest in the state is reported to be 5710 and 11 216 km², respectively, which accounts for 75.8% of the total area of the state. The area of Nagaland is 16 579 km² and the population is 2 million. About 82.3% population is rural and the average population density is 120 persons/km². Dense and open forest cover is 5393 and 7952 km², respectively, which is 80.5% of total area of the state.

Tripura has a total area of 10 486 km² and a population of 3.2 million, of which 83.0% is rural. The average population density is 304 persons/km². Dense and open forest cover is 3463 and 3602 km².

Shifting cultivation is the primary form of subsistence agriculture in the region, excluding Sikkim where settled agriculture is dominant. Until three decades ago, shifting cultivation had a cycle of 20–30 years, but now it has been reduced to 3–5 years, partly due to increased population pressure and partly due to loss of fertile soil as a result of over exploitation of forest resources. According to one estimate, a total of 443 300 families were practicing shifting cultivation in NEH with the highest number in Nagaland (116 000) and the lowest number in Tripura (43 000) [7]. The total area under shifting cultivation during the period 1989–1997 has been estimated at 1.73 million ha for NEH, and Nagaland has the maximum area (0.39 million ha), followed by Mizoram (0.38 million ha) and Manipur (0.36 million ha). Tripura is the state with the minimum area under shifting cultivation (0.06 million ha). Large-scale deforestation in the NEH region caused 36.64% of the total area to become degraded lands, which is 1.82-times higher than the national average of 20.17% [8].

METHODOLOGY

During the young bamboo shoot season, all the NEH states were surveyed during the year 2002 and 2003. In all, 51 districts of six states were surveyed, covering 141 market places and 2081 vendors. Frequent field trips were made from May through September each year to record the major edible bamboo species and their market potentials. The methods employed in this study were designed with the purpose of producing baseline information regarding the use of bamboo shoots in local systems. In the first year, a preliminary survey of randomly selected markets was conducted to identify the primary commercially available edible bamboo species throughout each district of the NEH. The survey was conducted during the shooting period of all bamboo species in the region, which begins at the onset of the rainy season, i.e. May–June. Primary and secondary vendors in each market were identified and interviewed through pre-prepared questionnaires. Questionnaires included day-to-day sales patterns for each bamboo species; availability of young shoots in the market places (days/year); distance travelled by primary vendors

from bamboo growing areas to market places; means of transport; cost/man power involved in bamboo shoot harvesting, collecting, cleaning, carrying and selling; quantity used as fresh or fermented or both; traditional recipes prepared with young and fermented shoots; and edible shoot length, basal diameter of the young shoots and edible shoot weight. Information was also collected on merchandizing edible bamboo shoots, including monetary input/output and ecological status (distribution, frequency and availability in the forest/home garden, etc.). In each market, the survey was conducted throughout the day and a minimum of 10 vendors (either primary or secondary or both) were surveyed. Each vendor was treated as a replicate for each market place.

To better understand the physical efforts required for bamboo shoot collection, authors have travelled with the local people to the forest areas. The time and labour spent in bamboo shoot collection was measured in h and then converted to MJ. Energy expenditure/h was taken to be 0.418, 0.488 and 0.679 MJ, respectively, for sedentary, moderate and heavy labour for an adult male and 0.331, 0.383 and 0.523 MJ for an adult female. For heavy work by a child in the age category of 9–12 years, the energy value was 0.412 MJ. These values were used to calculate the total energy input required for young bamboo shoot collection, cleaning, transportation through head load, selling, etc., using the methodology of Gopalan *et al.* [9].

In the second year, the same markets were surveyed and the data was recorded. On the basis of the information gathered and primary data recorded, new secondary data sheets were prepared. Through these surveys, rich pockets of edible bamboo species were identified. The quadrat method was used to locate and characterize production areas [10].

To estimate the cost–benefit analysis from sales of young shoots, gross output (million Rs. per year) was calculated as sales prices of bamboo shoots on market places multiplied by total sales of young shoots. Thereafter, gross input was estimated as gross output minus net input. Net input include transportation charges for carrying the bamboo shoots from remote localities to nearby market places, cost involved in purchasing of young shoots (as secondary vendors purchase young bamboo shoots from primary vendors for sales) and other miscellaneous expenditures. Finally, net income from sales of bamboo shoots was estimated as gross income minus wages for mandays or physical efforts involved in harvesting/collection of young shoots, to make them clean for sales, carrying and selling, etc. On average, physical labour of 8–9 h of a person was considered as 1 manday. Prevailing markets rates (Rs. 50–80 per person for male workers, Rs. 50–60 per person for female workers and Rs. 50 per person for children) were considered to estimate the wages per manday, assuming that if the person would not have been involved in bamboo shoot sales, he would have earned the same wages by working as labourer for some other works in the village or village township [6].

To record the significant differences in bamboo shoot sales and monetary income, Student's *t*-test has been used at 5% level of significance. Least significant

difference (L.S.D.) was computed at 5% level of probability to record the variations in edible shoot length, basal diameter and young shoot weight of different species.

RESULTS

Sales of young bamboo shoots, irrespective of species

Out of 127 markets in Arunachal Pradesh, 48 markets were surveyed randomly throughout the district and 179 vendors were included in the survey (Fig. 2). On average, the total per day sales of young bamboo shoots was *ca.* 6.9 ton: the quantity sold was highest (1.6 ton) in Papumpare and lowest (0.03 ton) in Palin. In Arunachal Pradesh, availability of young shoots varied from district to district and even from place to place within a district; however, in general young shoots were sold for a period of 84 days/year. Irrespective of the species, the total consumption of young shoots was *ca.* 1979 ton/year, with most consumption (*ca.* 404 ton) in East Kameng and least (5.4 ton) in Lower Dibang Valley.

Physical efforts required for bamboo shoot collection, cleaning, transportation, selling, etc. have also been calculated. Villagers walked long distances to collect fresh shoots from native forests. On average, the maximum distances were travelled in East Siang and West Siang (≥ 2.00 km) as compared to other districts. Vendors

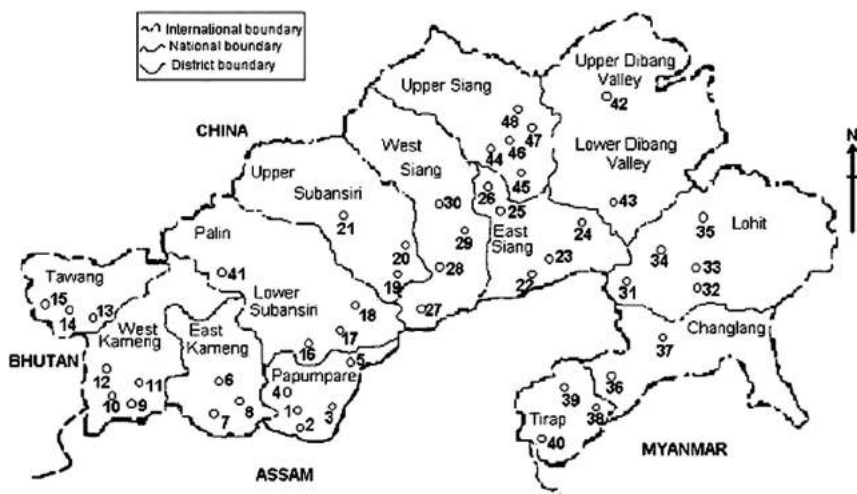


Figure 2. Market places explored for young edible bamboo shoots from Arunachal Pradesh, 1 — Ganga Market; 2 — Naharlagun; 3 — Nirjuli; 4 — Doimukh; 5 — Kimin; 6 — Seppa; 7 — Seijusa; 8 — Pakke Kesang; 9 — Bhalukpong; 10 — Tenga; 11 — Bomdila; 12 — Dirang; 13 — Jang; 14 — Tawang; 15 — Lumla; 16 — Ziro; 17 — Old Ziro; 18 — Raga; 19 — Daporijo; 20 — Dumporijo; 21 — Taliha; 22 — Ruksin; 23 — Pasighat; 24 — Mebo; 25 — Paying; 26 — Boleng; 27 — Likabali; 28 — Basar; 29 — Along; 30 — Yomcha; 31 — Namsai; 32 — Wakro; 33 — Chowkham; 34 — Tezu; 35 — Hayuliang; 36 — Changlang; 37 — Mihao; 38 — Laju; 39 — Khonsa; 40 — Longding; 41 — Palin; 42 — Anini; 43 — Roing; 44 — Jenging; 45 — Geku; 46 — Yingkiong; 47 — Mariang; 48 — Singa.

sold on average 2.7 to 39.4 kg of bamboo shoots in nearby markets. Females contributed the maximum labour for harvesting, carrying, cleaning and selling bamboo shoots in just over half of the districts, whereas men were the major labourers in Tawang, Upper Siang, Changland, Tirap, Upper Dibang Valley and Lower Dibang Valley districts.

In Manipur, 904 vendors distributed over 18 markets were randomly surveyed in the nine districts of the state (Fig. 3). On average, the total per day consumption of young shoots was *ca.* 12.7 ton with highest (5.2 ton) in Imphal West and lowest (0.05 ton) in Ukhrul District. Young shoots were available on the market for 84 days in a year with highest (92 days/year) in the Senapati, Churachandpur and Imphal East Districts, and lowest (73 days/year) in Chandel and Tamenglang. *D. giganteus* and *D. longispatus* produced the heaviest shoots compared to other species. The total annual consumption of young shoots was *ca.* 2188 ton, with highest (*ca.* 695 ton) in Imphal West and lowest (*ca.* 11.5 ton) in Ukhrul.

On average, villagers walked 1.6 to 4.0 km to collect bamboo shoots, with farthest distance in Imphal East and lowest in Chandel. Primary vendors each sold 13.6 to 44.1 kg of young shoots on average per day, with highest sales in Bishnupur and lowest in Chandel. In all the districts of Manipur, females were the primary labours involved in bamboo shoot collection, cleaning and selling.

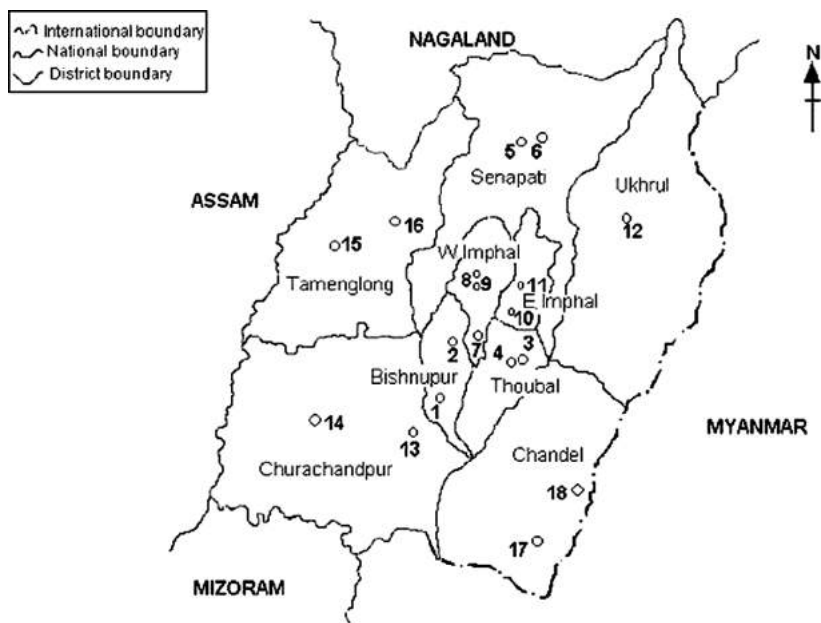


Figure 3. Market places explored for young edible bamboo shoots from Manipur, 1 — Bishnupur; 2 — Wangoi; 3 — Thoubal Bazar; 4 — Kakching; 5 — Motbung Bazar; 6 — Senapati Bazar; 7 — Moirang; 8 — Awang, Sekmai Bazar; 9 — Khwai Central Bazar; 10 — Lamlong; 11 — Kongba Bazar; 12 — Ukhrul; 13 — Churachandpur Bazar; 14 — Henglep; 15 — Phellon; 16 — Tamma; 17 — Mombi; 18 — Moreh.

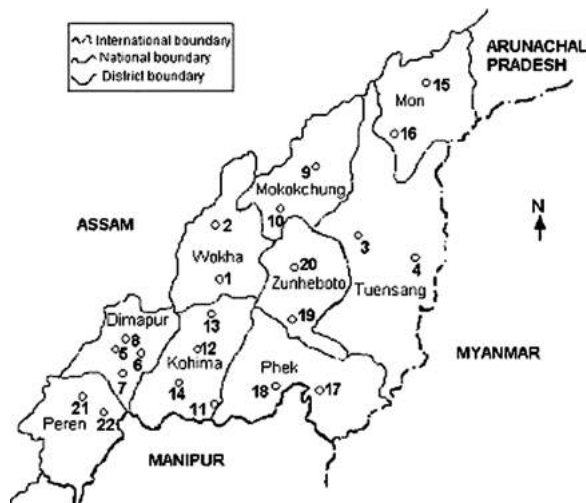


Figure 4. Market places explored for young edible bamboo shoots from Nagaland, 1 — Wokha; 2 — Sanis; 3 — Tuensang; 4 — Noklak; 5 — New Market Dimapur; 6 — New Chumukedima; 7 — Piphima; 8 — Chimakudi; 9 — Chonghyimsen; 10 — Mokokchung; 11 — Kekrinna; 12 — Narhema; 13 — Tsemingu; 14 — Super market Kohima; 15 — Wangla; 16 — Wakching; 17 — Meluri; 18 — Chizami; 19 — Satakha; 20 — Atoizu; 21 — Juluke; 22 — Pedi.

In Nagaland, 565 vendors in 22 markets were surveyed throughout the 9 districts of the state, with the highest number (330) in Dimapur and the lowest (15) in Peren (Fig. 4). The total annual consumption of fresh bamboo shoots for the state was recorded to be *ca.* 441 ton: the highest amount (*ca.* 126 ton) was recorded in Dimapur and lowest (20 ton) in Zunheboto. Young shoot consumption per day varied markedly among the districts, and was highest (1.08 ton) in Dimapur and lowest (0.1 ton) in Zunheboto. Irrespective of districts, the total consumption was recorded to be *ca.* 2.5 ton. On average, young shoots were sold 76 days/year in Nagaland. However, the number of days when bamboo shoots were sold in the market differed among districts. While fresh shoots were sold for a period of 90 days each year in Kohima District, in Phek District, fresh shoots were sold only for 67 days each year.

Villagers walked 1.5 to 4.0 km to collect bamboo shoots from the forests, with the longest distance in Mokokchung and the shortest in Dimapur District. The distance to markets also varied from district to district but was on average of 1.2–3.6 km. On average, each vendor sold 6.1 to 13.5 kg of bamboo shoots per day in the markets, with an average value of 10.0 kg/seller, irrespective of districts. Primary vendors spent 4.0–6.5 h per day for bamboo shoot collection, carrying, cleaning, selling etc. Similar to other states, females were the primary labours involved in bamboo shoot collection and selling.

In Tripura, 234 vendors in 15 markets were randomly surveyed (Fig. 5). The consumption of young shoots varied from 0.07 to 0.12 ton/day, and was highest in West District and lowest in Dhalai. On average, bamboo shoots were sold for a

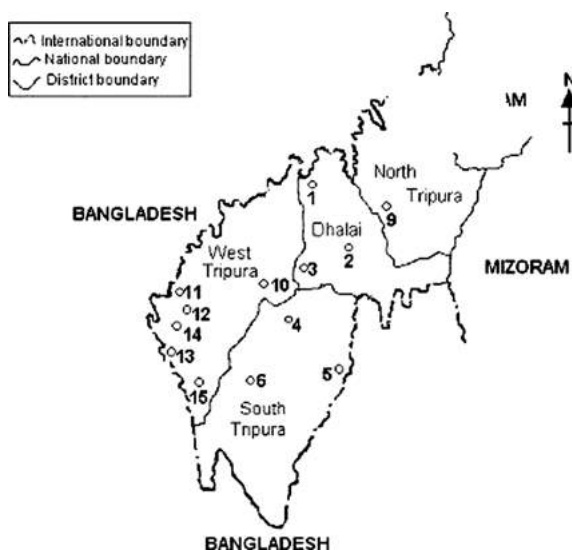


Figure 5. Market places explored for young edible bamboo shoots from Tripura. 1 — Khowal; 2 — Dhalai; 3 — Ambasa; 4 — Ampi Bazar; 5 — Matabari; 6 — Udaipur; 7 — Dharmnagar; 8 — Kumarghat; 9 — Kanchanpur; 10 — Taliāmora; 11 — Rani Bazar, Agartala; 12 — Bisalgah; 13 — Sonamura; 14 — Melaghar; 15 — Barjala.

period of 42 days in a year in the state. Compared to other districts, the number of market days in West District of Tripura was significantly higher (84 days in a year compared to 26–29 days in other districts). The total annual consumption of bamboo shoots was recorded to be *ca.* 201.3 ton and was highest (*ca.* 134.4 ton) in West District and lowest (*ca.* 19.6 ton) in South District. West District accounted for 67% of total consumption of bamboo shoots in the state.

On average, villagers walked 3.7–6.3 km to collect bamboo shoots in the forests. Distance to markets varied from 4.3 to 6.8 km in different districts, and 5.3–6.1 kg of bamboo shoots per day were sold by each seller in the market over a period of 5.1–5.5 h on average. In contrast to other states, in Tripura males were the primary labours responsible for bamboo shoot collection, cleaning, transportation and selling.

In the whole NEH region, the total sales of fresh shoots was recorded to be *ca.* 5685 ton, and Manipur, Arunachal Pradesh, Meghalaya, Nagaland, Mizoram and Tripura states accounted for 38, 35, 8, 8, 8 and 4% of total sales, respectively, irrespective of bamboo species. Significant variations ($P = 0.05$) have been recorded in sales of bamboo shoots in different states (Table 1).

Sales of young bamboo shoots at species level

Species-wise consumption of fresh edible bamboo species is shown in Table 2. *D. giganteus*, *D. hamiltonii*, *D. hookerii*, *M. baccifera* and *P. bambusoides* (Fig. 6) were found to be the major edible species in Arunachal Pradesh. However, distribu-

Table 1.
Sales of bamboo young shoots (\pm SD), irrespective of species at markets in six states in NEH

State	No. of markets	No. of markets surveyed	No. of vendors surveyed	Sales of young shoots per market (ton/day)	Sales of young shoot in all the markets (ton/day)*	Availability in the market (days/year)	Total sales (ton/year)**
Arunachal Pradesh	127	48	179	2.03 \pm 0.26	6.89 \pm 0.73 ^a	84 \pm 11	1979 \pm 281
Manipur	42	18	904	5.49 \pm 0.94	12.66 \pm 2.36	84 \pm 7	2188 \pm 298
Meghalaya***	50	23	113	0.19 \pm 0.03	9.56 \pm 0.46	53 \pm 12	442 \pm 30 ^a
Mizoram***	30	15	86	0.19 \pm 0.06	6.62 \pm 0.45 ^a	81 \pm 3	433 \pm 35 ^a
Nagaland	56	22	565	0.91 \pm 0.07	2.55 \pm 1.28 ^b	76 \pm 4	442 \pm 41 ^a
Tripura	44	15	234	0.36 \pm 0.04	1.43 \pm 0.19 ^b	42 \pm 30	201 \pm 21
Total	349	141	2081	9.18	39.70	—	5685

Between columns, means followed by the same letter are not significantly ($P = 0.05$) different.
* Estimated as young shoots sold per market (ton/day) \times No. of markets.
** Estimated as young shoots sold in all the markets (ton/day) \times availability of young shoots in the markets (days/year).
*** From Ref. [15].



Figure 6. Cultivation of *Phyllostachys bambusoides* in home garden, Lower Subansiri, Arunachal Pradesh.

Table 2.Species-wise availability and sales (\pm SD) of edible bamboo shoots

State	Species	Total availability of bamboo shoots (ton/day)	Total consumption of bamboo shoots (ton/year)*
Arunachal	<i>Dendrocalamus hamiltonii</i>	1.26 \pm 0.12	1260 \pm 121
Pradesh	<i>D. hookerii</i>	0.34 \pm 0.07	326 \pm 73.5
	<i>Melocanna baccifera</i>	0.26 \pm 0.05	224 \pm 43.5
	<i>Dendrocalamus giganteus</i>	0.12 \pm 0.01	143 \pm 14.5 ^b
	<i>Phyllostachys bambusoides</i>	0.06 \pm 0.01	26 \pm 2.8
Manipur	<i>Dendrocalamus sikkimensis</i>	2.69 \pm 0.28	1079 \pm 108
	<i>D. giganteus</i>	1.98 \pm 0.25	789 \pm 98
	<i>Bambusa balcooa</i>	0.43 \pm 0.03	170 \pm 12
	Chingwa (unidentified sp.)	0.18 \pm 0.06	73 \pm 22
	<i>Melocanna baccifera</i>	0.11 \pm 0.02	44 \pm 7.4 ^a
	<i>Teinostachyum wightii</i>	0.07 \pm 0.02	20.5 \pm 6.2
	<i>Dendrocalamus hamiltonii</i>	0.03 \pm 0.01	6.7 \pm 3.5
	<i>D. longispathus</i>	0.01 \pm 0.01	5 \pm 3.1
Meghalaya	<i>Dendrocalamus hamiltonii</i>	6.42 \pm 0.48	338 \pm 32.5
	<i>Bambusa balcooa</i>	1.00 \pm 0.02	52.6 \pm 0.94 ^c
	<i>Melocanna baccifera</i>	0.97 \pm 0.08	51.3 \pm 3.05 ^a
Mizoram	<i>Melocanna baccifera</i>	5.36 \pm 0.45	433 \pm 35.4
Nagaland	<i>Dendrocalamus hamiltonii</i>	0.50 \pm 0.04	237 \pm 8.5
	<i>D. giganteus</i>	0.32 \pm 0.03	163 \pm 8.7 ^b
	<i>Gigantochloa rostrata</i>	0.06 \pm 0.01	25.7 \pm 9.2
	Khupri (unidentified sp.)	0.02 \pm 0.00	9.76 \pm 1.18
	<i>Dendrocalamus</i>	0.02 \pm 0.00	6.06 \pm 1.49
	<i>membranaceus</i>		
Tripura	<i>Melocanna baccifera</i>	0.14 \pm 0.03	92.9 \pm 15.6
	<i>Bambusa balcooa</i>	0.10 \pm 0.02	49.7 \pm 7.8 ^c
	<i>Bambusa tulda</i>	0.07 \pm 0.02	42.5 \pm 8.2
	<i>Dendrocalamus hamiltonii</i>	0.04 \pm 0.01	12.4 \pm 5.9
	<i>Bambusa polymorpha</i>	0.01 \pm 0.00	2.1 \pm 1.0
	<i>Schizostachyum dullooa</i>	0.01 \pm 0.00	1.7 \pm 0.83

Between species, means followed by the same letter are not significantly different ($P = 0.05$). The different letters mark each species.

* Estimated as young shoots sold in all the markets of each species (ton/day) \times availability of young shoots in the markets (days/year).

tion of edible species varied from district to district within the state according to the topography of the area. *D. hamiltonii* was the only species that was sold in almost all 13 districts of the state, except Lower Subansiri (Fig. 7), East Siang and Palin Districts. Among the districts, its consumption was highest (*ca.* 404 ton) in East Kameng and lowest (*ca.* 3 ton) in Upper Dibang Valley. Other species were each found in two or three districts. On average, *D. hamiltonii*, *D. hookerii*, *D. giganteus*,



Figure 7. Sales of young shoots of *Dendrocalamus hamiltonii*, Ziro Market, Lower Subansiri, Arunachal Pradesh.

M. baccifera and *P. bambusoides* accounted for, respectively, 64, 16, 7, 11 and 1% to total consumption of young shoots in Arunachal Pradesh.

B. balcooa, *D. giganteus*, *D. longispatus*, *D. sikkimensis*, *T. wightii*, *M. baccifera*, *D. hamiltonii* and Chingwa (an unidentified sp.) were found to be the major edible species in Manipur. However, distribution of edible species varied from district to district, viz., *D. sikkimensis* was more extensively consumed in Bishnupur (Fig. 8), Thoubal, Senapati, Churachandpur and Imphal West District than other species. *B. balcooa*, *D. giganteus* and *D. sikkimensis* were sold in almost all the districts except those of Churachandpur and Ukhrul. Sales of *D. giganteus* were greatest in Imphal West and Imphal East Districts. Sales of other species were restricted to certain districts of Manipur. On average, *D. sikkimensis*, *D. giganteus*, *B. balcooa*, Chingwa, *M. baccifera*, *T. wightii* (Fig. 9), *D. hamiltonii* and *D. longispatus* accounted for 49, 36, 8, 3, 2, 1, 0.3 and 0.2%, respectively, of total sales of young shoots in Manipur.

D. hamiltonii, *D. giganteus*, *D. membranaceus*, *G. rostrata* and Khupri (an unidentified species) were found to be the major edible species in Nagaland. *D. hamiltonii* and *D. giganteus* were distributed in almost all the districts of the state and accounted for, respectively, 53 and 36% of the total young shoot sales in the state. Comparing the annual sales of species, *D. hamiltonii* was found to have maximum sales (ca. 126 ton/year) in Dimapur District and lowest (7.1 ton/year) in Phek District. *D. giganteus* had highest sales (40 ton/year) in Kohima and lowest



Figure 8. Young shoot sales of *Dendrocalamus sikkimensis* by secondary vendor, Bishnupur market, Manipur.



Figure 9. Sales of young shoots of *Teinostachyum wightii* by secondary vendor, Bishnupur market, Manipur.



Figure 10. A clump of *Dendrocalamus giganteus* in home garden, Twnsang, Nagaland.

(12.6 ton/year) in Zunheboto District (Fig. 10). *D. membranaceus* and *G. rostrata* were sold mainly in Mon and Tuensang Districts, respectively, whereas, *Khupri* was sold in Tuensang and Phek Districts with highest sales in Tuensang.

B. tulda, *B. balcooa*, *B. polymorpha*, *M. baccifera*, *D. hamiltonii* and *S. dullooa* were found to be major edible species sold on the market in Tripura state. Among these species, *B. tulda*, *B. balcooa* and *M. baccifera* were sold in all the districts of the state. Whereas *B. polymorpha* and *S. dullooa* were sold mainly in South and North Districts. *D. hamiltonii* also had a limited range of distribution and its shoots were sold mainly in Dhalai and North Districts. Among the species sold in the Tripura state, *M. baccifera* had the highest sales (46%) (Fig. 11), followed by *B. balcooa* (25%) and *B. tulda* (21%). Other species represented only 8% of total sales of bamboo shoots. Significant ($P = 0.05$) variations have been recorded for sales of young shoots of each species, except that of *D. giganteus* in Arunachal Pradesh and Nagaland; *M. baccifera* in Manipur and Meghalaya, and *B. balcooa* in Meghalaya and Tripura (Table 2).

Young bamboo shoot length, basal diameter, shape and young shoot weight

The length of bamboo shoots sold on the market varied significantly ($P = 0.05$) among species and *D. giganteus* was found to be the longest (34.6 cm) and *T. wightii* the shortest (13.0 cm). Basal diameter also varied significantly ($P = 0.05$) and was highest (11.3 cm) and lowest (0.8 cm) for the same two species. Shape

Table 3.

Length (cm), basal diameter (cm), shape and weight (kg/shoot) of shoots of edible bamboo species found in markets in NEH

Bamboo spp.	Young shoot length	Basal diameter	Shape	Weight
<i>Bambusa balcooa</i>	27.58 \pm 2.79	11.07 \pm 1.44	Conical, short and stout	1.62 \pm 0.97
<i>B. polymorpha</i>	21.00 \pm 1.00	2.60 \pm 0.60	Cylindrical thick	0.07 \pm 0.02
<i>B. tulda</i>	23.88 \pm 5.23	4.94 \pm 1.28	Cylindrical thick	0.17 \pm 0.52
<i>Dendrocalamus giganteus</i>	34.63 \pm 1.47	11.28 \pm 1.10	Short bullet shaped to long conical	1.83 \pm 0.91
<i>D. hamiltonii</i>	26.72 \pm 0.97	6.98 \pm 0.67	Conical	0.50 \pm 0.11
<i>D. hookerii</i>	30.55 \pm 4.36	6.85 \pm 1.11	Conical to cylindrical	0.41 \pm 0.04
<i>D. longispathus</i>	34.33 \pm 2.05	4.03 \pm 0.40	Cylindrical	0.33 \pm 0.07
<i>D. membranaceus</i>	28.15 \pm 3.44	3.44 \pm 1.12	Conical to cylindrical	0.32 \pm 0.08
<i>D. sikkimensis</i>	26.21 \pm 4.32	8.07 \pm 1.57	Bullet shaped, short thick	1.44 \pm 1.00
<i>Gigantochloa rostrata</i>	35.00 \pm 3.00	10.35 \pm 0.80	Conical	1.15 \pm 0.15
<i>Melocanna baccifera</i>	24.65 \pm 0.87	3.58 \pm 0.34	Cylindrical	0.17 \pm 0.10
<i>Phyllostachys bambusoides</i>	28.15 \pm 2.12	4.15 \pm 1.20	Cylindrical	0.13 \pm 0.03
<i>Schizostachyum dullooa</i>	17.67 \pm 2.05	1.03 \pm 0.33	Cylindrical	0.05 \pm 0.00
<i>Teinostachyum wightii</i>	13.00 \pm 4.36	0.84 \pm 0.20	Cylindrical	0.13 \pm 0.02
Ching-wa (unidentified sp.)	27.33 \pm 1.25	7.85 \pm 0.40	Cylindrical narrow	0.63 \pm 0.33
Khupri (unidentified sp.)	27.50 \pm 2.50	8.12 \pm 0.80	Conical narrow	0.45 \pm 0.21
L.S.D. (5%)	7.71	4.39		0.77

L.S.D. denotes least significant differences at 5% level of significance.

of the young shoots varied from conical to cylindrical to bullet shaped. Shoot weight also varied significantly ($P = 0.05$) and was highest for *D. giganteus* (1.8 kg/shoot), followed by *B. balcooa* (1.6 kg/shoot), *D. sikkimensis* (1.4 kg/shoot), and *G. rostrata* (1.2 kg/shoot). Lowest shoot weight (0.05 kg/shoot) was observed for *S. dullooa*. Edible bamboo species showed significant variations ($P = 0.05$) in shoot length, basal diameter and shoot weight (Table 3).

Energy expenditure for collection of young bamboo shoots

Energy expenditure involved for bamboo shoot collection is shown in Table 4. On average, total energy expenditure was highest in Manipur (202 190 MJ), followed by Arunachal Pradesh (182 840). Female family members contributed the maximum labour and therefore the highest energy in Arunachal Pradesh, Manipur, Meghalaya, Mizoram and Nagaland. Tripura was the only exception where males contributed the maximum labour and energy in bamboo shoot collection, carrying, leaning and selling.

Revenue and cost of sales of edible bamboo shoots

Revenue for young bamboo shoots of NEH states has been calculated. On average, the gross sales for Arunachal Pradesh was found to be highest of all the states (*ca.*

Table 4.
Energy expenditure (MJ) for bamboo shoot collection, irrespective of edible bamboo species

State	Family member	Activity				Total
		Harvesting	Carrying/transportation	Cleaning	Selling	
Arunachal Pradesh	Male	30 567	13 678	11 324	14 148	182 843
	Female	16 506	12 435	26 780	44 568	
	Child	6513	1525	3567	1231	
Manipur	Male	20 567	5234	2114	169	202 194
	Female	23 447	31 263	39 079	62 526	
	Child	7410	6457	1787	2124	
Meghalaya *	Male	5434	2958	3942	480	40 484
	Female	1771	929	5092	15 651	
	Child	342	1677	322	1867	
Mizoram *	Male	3965	2969	5291	3322	47 810
	Female	4695	3103	4245	15 782	
	Child	945	1004	1837	651	
Nagaland	Male	3413	3880	—	52	40 803
	Female	6653	4541	5689	12 451	
	Child	644	1456	1235	790	
Tripura	Male	4678	3478	1581	2409	19 434
	Female	2135	964	1251	752	
	Child	676	750	424	337	

* From Ref. [15].

12.15 million Rs. per year, US\$ 265 700) (Table 5). In Arunachal Pradesh, sales were highest (*ca.* 3.42 million Rs. per year, US\$ 74 830) in Lower Subansiri District and lowest (0.026 million, US\$ 563) in Lower Dibang Valley District. Both districts also showed a similar trend in regard to net income. The net income due to bamboo shoot sales in the state, after deduction of monetary input and physical efforts was found to be *ca.* 8.86 million Rs. per annum (US\$ 193 740), and was highest (*ca.* 2.59 million Rs. per annum, US\$ 56 540) in Lower Subansiri and lowest (0.013 million Rs. per year, US\$ 285) in Upper Dibang Valley District. Among the various districts, Papumpare, East Kameng, Lower Subansiri and East Siang had maximum net income from sales of bamboo shoots as compared to other districts in the state.

Irrespective of species, revenue from sales of edible bamboo shoots in Manipur was *ca.* 17.14 million per year (US\$ 374 880), and was highest (*ca.* 4.15 million per year, US\$ 90 660) in Imphal West district and lowest (*ca.* 0.14 million per year, US\$ 3110) in Ukhrul district. Monetary inputs were also highest in Imphal West and lowest in Ukhrul, respectively. The net income after deduction of cost and physical efforts was found to be *ca.* 5.69 million Rs. per year (US\$ 124 410) and was highest (*ca.* 1.5 million Rs. per year, US\$ 32 840) in Thoubal, followed by Imphal West (*ca.* 1.17 million Rs. per year, US\$ 25 480), Bishnupur (*ca.* 1.1 million Rs. per year, US\$ 23 950) and Imphal East (*ca.* 0.81 million Rs. per year, US\$ 17 620). These

Table 5.
Revenue and cost (Rs. million per year \pm SD) of sales of edible bamboo shoots, irrespective of species.

State	Gross sales per market per day	Gross sales from all the markets per day	Gross sales per year	Costs excluding physical efforts made for collection and selling per year	Gross income per year	Wages for man days required per year	Net income per year
Arunachal Pradesh	0.013 \pm 0.00	0.131 \pm 0.001	12.15 \pm 0.007	0.203 \pm 0.007	11.95 \pm 0.002	3.15 \pm 0.009	8.86 \pm 0.009 (US\$ 193 740)
Manipur	0.043 \pm 0.002	0.199 \pm 0.007	17.14 \pm 0.082 ^a	8.59 \pm 0.02	8.56 \pm 0.012	2.87 \pm 0.013	5.69 \pm 0.009 (US\$ 124 410)
Meghalaya*	0.001 \pm 0.00	0.039 \pm 0.02	2.26 \pm 0.115 ^{ab}	0.298 \pm 0.013	1.97 \pm 0.103 ^a	0.827 \pm 0.034	1.14 \pm 0.078 ^a (US\$ 24 900)
Mizoram*	0.0003 \pm 0.0003	0.12 \pm 0.002	1.86 \pm 0.15 ^a	0.549 \pm 0.102	1.31 \pm 0.059	0.538 \pm 0.044	0.775 \pm 0.031 ^{ab} (US\$ 16 940)
Nagaland	0.0053 \pm 0.001	0.033 \pm 0.001	2.58 \pm 0.073 ^b	Nil	2.58 \pm 0.073	0.747 \pm 0.051	1.78 \pm 0.07 (US\$ 38 950)
Tripura	0.003 \pm 0.0003	0.035 \pm 0.002	1.77 \pm 0.061 ^a	0.161 \pm 0.007	1.605 \pm 0.036 ^a	1.02 \pm 0.067	0.582 \pm 0.053 ^b (US\$ 12 730)

* After Bhatt *et al.*, 2003 [15].
1 US\$ = Rs. 45.73 in Indian currency.
Means followed by the same letter in each column are not significantly different ($P = 0.05$).

four districts accounted for 80% of the total income derived from edible bamboo shoots in the state. The lowest net income (*ca.* 0.07 million per year, US\$ 1540) from sales of bamboo shoots was found in Ukhrul District.

In Nagaland, the total annual gross sales from bamboo shoots were estimated to be *ca.* Rs. 2.58 million (US\$ 56 470). Dimapur district had the highest annual sales (*ca.* Rs. 0.66 million, US\$ 14 400), followed by Tuensang (*ca.* Rs. 0.42 million, US\$ 9110), Mokokchung (*ca.* Rs. 0.33 million, US\$ 7290) and Wokha Districts (*ca.* Rs. 0.24 million, US\$ 5170). Among the districts in Nagaland, lowest annual sales were found in Peren District (*ca.* Rs. 0.13 million, US\$ 2820). After deduction of wages for mandays, the net income for the state was estimated to be *ca.* Rs. 1.78 million (US\$ 38 950) and was highest (*ca.* Rs. 0.57 million, US\$ 12 500) for Dimapur, followed by Tuensang (*ca.* Rs. 0.33 million, US\$ 7110).

In Tripura, gross annual sales from edible shoots was *ca.* Rs. 1.77 million (US\$ 38 620) and was highest (*ca.* Rs. 1.2 million, US\$ 26 330) in West District and lowest (*ca.* Rs. 0.16 million, US\$ 3510) in South District. The gross income was calculated to be *ca.* Rs. 1.61 million Rs. per year (US\$ 35 100) for the state, and West District alone contributed 65% of the total gross income. Net income was estimated to be *ca.* Rs. 0.58 million per year (US\$ 12 730) for the state and was highest (*ca.* Rs. 0.38 million, US\$ 8280) in West District and lowest (*ca.* 0.05 million, US\$ 1120) in South District.

Significant differences ($P = 0.05$) have been recorded in gross output, gross income and net income of sales of young bamboo shoots, irrespective of species. Net income was significantly higher in Arunachal Pradesh and Manipur as compared to other states. Meghalaya and Mizoram, and Mizoram and Tripura, however, did not exhibit any significant differences in net income through sales of edible shoots (Table 5).

Gross income and net income through sales of young bamboo shoots at species level

Table 6 shows prevailing market prices of edible shoots of different bamboo species. Among the species, the market price was highest (Rs. 17.25/kg, US\$ 0.38) for young shoots of *T. wightii* and lowest (Rs. 4.8/kg, US\$ 0.11) for *B. balcooa* in Meghalaya. However, for each species the price varied from state to state and even from market to market within a state. In Arunachal Pradesh, *D. giganteus*, *D. hamiltonii*, *D. hookerii*, *P. bambusoides* and *M. baccifera* are all commercially available, while *D. hamiltonii* and *D. hookerii* accounted for 86% of the total net income from sales of edible bamboo shoots in the state. In the state, Papumpare and East Kameng Districts showed the highest net income (*ca.* Rs. 1.67 and 1.49 million, US\$ 36 490 and 32 510, respectively) from sales of edible bamboo shoots of *D. hamiltonii* as compared to other Districts. *P. bambusoides* accounted for highest net income in Lower Subansiri District. Similarly, *D. hookerii* accounted for the greatest portion of net income from sales of bamboo shoots in Lower Subansiri and East Kameng (*ca.* Rs. 1.62 and 1.66 million per year, US\$ 35 400 and 36 260). In Changlang District, *M. baccifera* accounted for the greatest portion of net income,

Table 6.

Species of edible bamboo shoots found in markets in six states in NEH, market prices (Rs/kg) and gross and net income from sales

State	Species	Prevailing market rates (Rs/kg)	Gross income including wages for mandays required (Rs. million per year)	Net income excluding wages for mandays required (Rs. million per year)
Arunachal Pradesh	<i>Dendrocalamus hamiltonii</i>	6.56 ± 1.41	5.742 ± 0.009	4.294 ± 0.003
	<i>D. hookerii</i>	9.17 ± 1.13	4.178 ± 0.003	3.295 ± 0.002
	<i>Phyllostachys bambusoides</i>	7.75 ± 1.93	1.432 ± 0.001	1.024 ± 0.001
	<i>Dendrocalamus giganteus</i>	6.50 ± 1.23	0.469 ± 0.01	0.177 ± 0.001
	<i>Melocanna baccifera</i>	6.05 ± 1.10	0.143 ± 0.008	0.069 ± 0.001
Manipur	<i>Dendrocalamus sikkimensis</i>	10.80 ± 1.33	3.939 ± 0.008	3.036 ± 0.003
	<i>D. giganteus</i>	11.31 ± 1.89	2.994 ± 0.012	1.903 ± 0.002
	<i>Bambusa balcooa</i>	13.22 ± 1.43	0.901 ± 0.008	0.336 ± 0.001 ^c
	<i>Teinostachyum wightii</i>	17.25 ± 2.75	0.185 ± 0.001	0.148 ± 0.009
	<i>Melocanna baccifera</i>	11.00 ± 1.75	0.210 ± 0.00	0.134 ± 0.00 ^b
	Ching-wa (unidentified sp.)	13.00 ± 2.25	0.248 ± 0.002	0.078 ± 0.009
	<i>Dendrocalamus hamiltonii</i>	12.00 ± 0.50	0.055 ± 0.00	0.041 ± 0.00
	<i>D. longispathus</i>	12.00 ± 1.00	0.025 ± 0.001	0.013 ± 0.001
Meghalaya	<i>Dendrocalamus hamiltonii</i>	5.16 ± 2.53	1.507 ± 0.122	0.816 ± 0.087 ^a
	<i>Bambusa balcooa</i>	4.82 ± 0.51	0.248 ± 0.021	0.178 ± 0.016 ^c
	<i>Melocanna baccifera</i>	4.95 ± 0.41	0.212 ± 0.022	0.145 ± 0.017 ^b
Mizoram	<i>Melocanna baccifera</i>	5.27 ± 1.57	1.312 ± 0.059	0.775 ± 0.031
Nagaland	<i>Dendrocalamus hamiltonii</i>	8.26 ± 0.77	1.34 ± 0.003	0.968 ± 0.001 ^a
	<i>D. giganteus</i>	7.02 ± 1.19	0.881 ± 0.007	0.591 ± 0.001
	<i>Gigantochloa rostrata</i>	8.70 ± 0.96	0.197 ± 0.006	0.169 ± 0.001
	Khupri (Unidentified sp.)	7.93 ± 0.64	0.069 ± 0.001	0.033 ± 0.001
	<i>Dendrocalamus membranaceus</i>	8.55 ± 1.04	0.042 ± 0.008	0.021 ± 0.00
Tripura	<i>Melocanna baccifera</i>	10.00 ± 1.06	0.760 ± 0.006	0.311 ± 0.004 ^b
	<i>Bambusa tulda</i>	8.25 ± 0.43	0.325 ± 0.002	0.104 ± 0.001
	<i>B. balcooa</i>	8.37 ± 0.41	0.369 ± 0.008	0.097 ± 0.001 ^c
	<i>B. polymorpha</i>	9.00 ± 0.00	0.101 ± 0.007	0.05 ± 0.001
	<i>Dendrocalamus hamiltonii</i>	15.00 ± 1.50	0.026 ± 0.001	0.012 ± 0.00
	<i>Schizostachyum dullooa</i>	10.00 ± 1.00	0.024 ± 0.001	0.007 ± 0.00

Between species, means followed by the same letter are not significantly different ($P = 0.05$). The different letters mark each species.

i.e. Rs. ca. 0.06 million (US\$ 1320), whereas in Lohit District, *D. giganteus* accounted for the greatest portion (ca. Rs. 0.13 million, US\$ 2770).

In Manipur, the gross income from sales of bamboo shoots was ca. 0.9 million per year (US\$ 19 700) for *B. balcooa*, and net income was ca. 0.34 million per year (US\$ 7350). Imphal West and Imphal East Districts had considerably higher net income through sales of *B. balcooa* as compared to other districts. Gross income



Figure 11. A secondary vendor selling young shoots of *Melocanna baccifera*, Taliamera, Tripura.

from *D. giganteus* was estimated to be *ca.* Rs. 2.99 million per year (US\$ 65 480) and net income was Rs. 1.9 million per year (US\$ 41 610). Net income through sales of *D. hamiltonii* shoots in Ukhrul was found to be *ca.* Rs. 0.04 million per year (US\$ 907). Similarly, *D. longispathus* was sold mainly in Bishnupur district and net income from the species was found to be *ca.* Rs. 0.013 million (US\$ 290). Highest net income in the state came from sales of *D. sikkimensis* (*ca.* Rs. 3.94 million Rs. per year, US\$ 86 120) and net income from this species was *ca.* Rs. 3.04 million per year (US\$ 66 380). In Thoubal, Imphal West and Bishnupur Districts, the majority of net income came from this species. *T. wightii* has restricted distribution in the markets and was only found in markets in Bishnupur and Ukhrul Districts. Similarly, *M. baccifera* was sold mainly in Tamenglong and Chandel Districts and net income from sales of this species were estimated as Rs. 0.21 million (US\$ 4590) and Rs. 0.134 million (US\$ 2930), respectively. Ching-wa was found on the market only in Churachandpur and Imphal East Districts.

In Nagaland, *D. hamiltonii* alone accounted for half (54.4%) the net income from sales of bamboo shoots. Within districts, sales of shoots of *D. hamiltonii* in Dimapur accounted for 59% of total income from shoots. Net income through sales of young shoots of *D. giganteus* was found to be *ca.* 0.59 million Rs./year (US\$ 12 920) and was highest (*ca.* 0.16 million Rs./year, US\$ 3590) in Mokokchung and lowest (*ca.* 30 000 Rs./year, US\$ 700) in Mon districts. On average, sales of *D. giganteus* in Kohima and Mokokchung accounted for 47% from sales of young shoots. Net

income from sales of *D. membranaceus* was Rs. 20 000 per year (US\$ 450) in Mon District. In Tuensang District, net income from sales of young shoots of *G. rostrata* was estimated to be *ca.* Rs. 0.17 million per year (US\$ 3680). Khupri was found for sale mainly in Tuensang and Phek Districts.

In Tripura, the annual gross income from sales of *B. balcooa* was Rs. 0.37 million (US\$ 8070) and net income was *ca.* Rs. 0.097 million (US\$ 2120). In the state, the gross income was highest (Rs. 40 000, US\$ 915) in West District and the lowest (Rs. 10 000, US\$ 235) in Dhalai District. Net income from sales of *B. tulda* was found to be *ca.* Rs. 0.1 million (US\$ 2270) of which 93% was from West District alone. Interestingly, sales of *B. tulda* as an edible shoot were only found in Tripura state. In other states of NEH, this species has not been popular as an edible shoot. Net income from sales of *B. polymorpha* was less than Rs. 10 000 (US\$ 150), whereas net income from sales of *D. hamiltonii* for the state was estimated to be Rs. 50 000 (US\$ 1090). Among species, *M. baccifera* accounted for the greatest portion of net income (Rs. 0.31 million per year, US\$ 6790) in West district as compared to other districts. Net income from sales of *S. dulloo* was found to be Rs. 10 000 (US\$ 260) in North District. In this state, *B. balcooa*, *B. polymorpha*, *B. tulda*, *D. hamiltonii*, *M. baccifera* and *S. dulloo* accounted for, respectively, 17, 1, 18, 9, 54 and 2% of the total net income from sales of bamboo shoots. Bamboo species showed significant ($P = 0.05$) differences in net income. However, no significant variations have been recorded for net income of sales of edible shoots of *D. hamiltonii* in Meghalaya (Figs 12 and 13), and Nagaland. *M. baccifera* sold in Manipur, Meghalaya and Tripura also did not exhibit significant differences. Similarly, net income from sales of edible shoots of *B. balcooa* was comparable in Manipur, Meghalaya and Tripura (Table 6).

Sales of bamboo species for fresh shoots, and gross and net income in NEH

Throughout the NEH, the greatest total sales (ton/year) of bamboo shoots were from *D. hamiltonii*, followed by *D. giganteus* and *D. sikkimensis* (Table 7). On average, the genus *Dendrocalamus* accounted for 77% of the total sales of young edible shoots. *M. baccifera* was found to be the another important species in regard to sales (Fig. 14), and accounted for 11%, whereas the genus *Bambusa* genus and the species *P. bambusoides* only accounted for, respectively, 6 and 4% of total sales. Total gross income and net income were found to be greatest for *Dendrocalamus* genus (Fig. 15), and among these species *D. hamiltonii* accounted for 33% of the total net income. Significant ($P = 0.05$) differences have been recorded for net income and per cent contribution to net income among species.

Per cent contribution of each species to sales of fresh shoots

Per cent contribution by each species to total sales of edible bamboo shoots in each state is shown in Table 8. Among the species, *D. hamiltonii* and *M. baccifera* has the most frequent distribution throughout the region. *B. balcooa* and *D. giganteus* were



Figure 12. *Dendrocalamus hamiltonii* with other tree species and pineapple in homestead system, Nongpoh, Meghalaya.



Figure 13. Young shoots of *Dendrocalamus hamiltonii*, sold by Khasi tribe, Nongpoh, Meghalaya.

Table 7.

Sales (ton/year) of bamboo species for fresh shoots, gross and net income (million Rs. per year), and per cent contribution of each

Species	Total consumption (ton/year)	Contribution of each species (%)	Gross income (million Rs/year)	Net income (million Rs/year)	% contribution to net income
<i>Dendrocalamus hamiltonii</i>	1859	32.7	8.74	6.17	32.78
<i>D. hookerii</i>	326	5.73	4.18	3.295 ^a	17.51 ^a
<i>D. sikkimensis</i>	1079	18.98	3.94	3.036 ^a	16.13 ^a
<i>D. giganteus</i>	1094	19.2	4.34	2.671 ^a	14.19 ^a
<i>Melocanna baccifera</i>	647	11.4	2.64	1.433 ^b	7.61 ^b
<i>Phyllostachys bambusoides</i>	224	3.95	1.43	1.024 ^{bc}	5.44 ^b
<i>Bambusa balcooa</i>	272	4.80	1.52	0.611 ^c	3.25 ^{bc}
<i>Gigantochloa rostrata</i>	25.7	0.45	0.197	0.168 ^d	0.89 ^{cd}
<i>Teinostachyum weightii</i>	20.5	0.36	0.185	0.148 ^d	0.78 ^d
<i>Bambusa tulda</i>	42.5	0.75	0.325	0.104 ^d	0.55 ^d
Chingwa (an unidentified sp.)	73.2	1.29	0.248	0.078 ^e	0.42 ^d
Khurpi (an unidentified sp.)	6.08	0.10	0.069	0.033 ^{ef}	0.17 ^{de}
<i>D. membranaceus</i>	6.06	0.11	0.042	0.021 ^f	0.11 ^e
<i>D. longispathus</i>	5.02	0.09	0.025	0.013 ^f	0.07 ^e
<i>Schizostachyum dullooa</i>	1.74	0.03	0.026	0.012 ^{fg}	0.06 ^e
<i>B. polymorpha</i>	2.10	0.04	0.024	0.007 ^g	0.04 ^e
Total	5685	100	27.9	18.8	100.00

Means followed by the same letter in each column are not significantly different ($P = 0.05$).



Figure 14. A primary vendor selling young shoots of *Melocanna baccifera* along with other vegetables, Bara Bazar, Aizawl, Mizoram.



Figure 15. Young shoot sales of *Dendrocalamus hookerii* by the secondary seller along with *Eunayl ferox*, Singjamei market, Imphal west, Manipur.

found in half the states in the region, whereas remaining species had a restricted distribution although they all contributed significantly to the amount of edible shoots available on the market.

DISCUSSION

Sales of young bamboo shoots

From the foregoing results it is well understood that edible bamboo species play a pivotal role in nutritional security of tribal communities in the region. Present study also revealed that out of 25 edible species in the region, 16 species have commercial importance. Among various species, *D. hamiltonii* has shown the maximum productivity as it contributed 33% of total sales of fresh bamboo shoots in NEH region. *D. giganteus* and *D. sikkimensis*, respectively, ranked second and third in order of fresh shoot sales. Besides *Dendrocalamus* spp., *M. baccifera* seems major edible species in the region as this species alone contributed 11% of the total annual sales of fresh bamboo shoots, followed by *Bambusa* genus (6%).

Table 8.

Percent contribution of each species to sales as fresh shoots in the states of NEH

Species	Arunachal Pradesh	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
<i>Bambusa balcooa</i>	—	62.5 ^a	19.3 ^a	—	—	18.2 ^a
<i>B. polymorpha</i>	—	—	—	—	—	100.0 ^b
<i>B. tulda</i>	—	—	—	—	—	100.0 ^b
<i>Dendrocalamus giganteus</i>	13.1 ^a	72.1 ^a	—	—	14.9 ^a	—
<i>D. hamiltonii</i>	67.6	0.4	18.8 ^a	—	13.2 ^a	0.7
<i>D. hookerii</i>	100.0 ^b	—	—	—	—	—
<i>D. longispathus</i>	—	100.0 ^b	—	—	—	—
<i>D. membranaceus</i>	—	—	—	—	100.0 ^b	—
<i>D. sikkimensis</i>	—	100.0 ^b	—	—	—	—
<i>Gigantochloa rostrata</i>	—	—	—	—	100.0 ^b	—
<i>Melocanna baccifera</i>	6.0 ^a	10.3	11.9 ^a	50.2	—	21.6 ^a
<i>Phyllostachys bambusoides</i>	100.0 ^b	—	—	—	—	—
<i>Schizostachyum dullooa</i>	—	—	—	—	—	100.0 ^b
<i>Teinostachyum weightii</i>	—	100.0 ^b	—	—	—	—
Chingwa	—	100.0 ^b	—	—	—	—
Khurpi	—	—	—	—	100.00	—

Means followed by the same letter in each column are not significantly different ($P = 0.05$).

Irrespective of species, the sales of fresh bamboo shoots were recorded highest in Manipur state (39%), followed by Arunachal Pradesh (35%). In Meghalaya, Mizoram and Nagaland, the sales percentage was 8 for each state. Among various states, Tripura contributed lowest (4%) to total annual bamboo shoot sales. In an earlier study, Singh *et al.* [4] reported that among the seven states of NEH, Manipur could fetch the maximum revenue through sales of edible bamboo shoots. This study supports to the present findings.

Although the sales of fresh as well as fermented bamboo shoots were highest in Manipur, the net monetary income was recorded highest for Arunachal Pradesh, followed by Manipur and Nagaland. Thus, Arunachal Pradesh, Manipur and Nagaland accounted for 47, 30 and 9%, respectively, to total income through sales of edible bamboo species. Lowest (3%) contribution was, however, made by Tripura state to total net income.

Traditionally wild edible species have been meeting the protein, carbohydrate, fat, vitamin and mineral requirement of tribal communities to a great extent [11, 12]. Among various edibles, bamboos play a great role in nutrition of tribal folk. Tribal communities are so mingled with bamboo resource that without bamboo, their existence is unthinkable. Nevertheless, quantitative as well as qualitative analysis of edible bamboo shoots of NEH region has not been made till date. Very few reports are available on edible bamboo species of the region, viz., Sarkar and Sundriyal [5] have reported edible bamboo species of part of Arunachal Pradesh; Jha and Laha [13], Jha and Lalnunmawia [14] for Mizoram; Singh *et al.* [4] for

Manipur, and Bhatt *et al.* [6, 15] for Meghalaya, Mizoram and Sikkim states of the region.

Besides the commercial species mentioned here, *M. baccifera*, *D. longispathus*, *D. hamiltonii* and *B. tulda* have been reported as miscellaneous edible bamboo species for Mizoram. Similarly, for Meghalaya, *B. bambos*, *B. khasiana*, *D. hookerii*, *Gigantochloa macrostachya*, *Phyllostachys manii* and *S. dullooa* have been reported as miscellaneous edible species. For Arunachal Pradesh, *B. tulda*, *B. pallida*, *B. nutans*, *Cephalostachyum pergracile* and various other unidentified species have been reported as edible species [5]. In Manipur, *Arundinaria callosa*, *A. hookerii*, *Bambusa kingiana*, *B. nana*, *B. nutans*, *B. tulda* and *Dendrocalamus strictus* are also edible as reported by Singh *et al.* [4].

Studies have also been conducted on chemical composition and nutritive value of wild edibles from Himalayan zone of India [16, 17] but no such reports are available for edible bamboo species probably because consumption of tender bamboo shoots is witnessed only in NEH region [18]. In NEH, almost for five months in a year, bamboo shoots are eaten as vegetables, pickles, salad, etc. The edible species are not only collected from forests but also raised frequently in home garden almost by all the tribal communities of the region.

Export potential of edible bamboo shoots

Taking into consideration the export possibilities, *D. hamiltonii*, *D. giganteus*, *D. sikkimensis*, *M. baccifera*, *P. bambusoides* could have great export potential outside the North-East, as well as abroad, since bamboo shoots have intercontinental delicacy and are being extensively used in Thailand, China, Denmark, Philippines, Taiwan, Tanzania, Puerto Rico, Malaysia, Singapore and Japan as vegetables, pickles, salad and various other purposes. For example Japan has a cultural preference for *Phyllostachys pubescens* (moso) somewhat larger than *C. hookeriana* and *P. bambusoides* of India. If given the due importance, these two Indian species could be exported to Japan. Shape, size and flavour of young shoots are other important characters for export potential as *Dendrocalamus latiflorus* shoots grown in China and Taiwan are mostly used for canning, drying and pickling but still considered to be of inferior quality to fresh shoots in the countries like Japan and Singapore. Among Indian species, *Dendrocalamus longispathus*, *D. sikkimensis*, *D. membranaceus*, *Gigantochloa rostrata* could be ideal for canning, drying and pickling purposes.

Consumption of fresh shoots in NEH is similar as elsewhere worldwide. For example in Bangkok area, Thais consume more than 10 000 ton of fresh shoots every year within their shoot season. Consumption of fresh shoots in Japan is estimated to be between 30 000 and 50 000 ton/year. To meet the requirement of fresh shoots, Japan has 70 000 hectares of moso plantation. Similarly, Australia is estimated to eat about 8000 ton/year of imported canned shoots. The actual productivity of bamboo shoots for NEH is difficult to work out partly due to inaccessibility of most of the areas and partly to shifting cultivation. However, it is well understood that

NEH region alone has more consumption of fresh and fermented shoots compared to Japan, Taiwan and Bangkok.

Morphological characters and shoot weight of edible bamboo species

Based on shape, size and weight, different bamboo shoots are preferred in international markets, viz., Japan prefers bullet-shaped smaller sweet shoots (weight 0.20–1.00 kg), whereas Thais prefer larger shoots (2–4 kg). Their major consumption is *D. asper*, with small amounts of bitter *Trysostachys siamensis*. Based on these observations, Indian species like *D. giganteus*, *D. hamiltonii*, *D. sikkimensis*, *D. longispathus*, *Gigantochloa rostrata*, *Bambusa balcooa* might find a market in Thailand. Similarly, *M. baccifera*, *P. bambusoides*, *T. wightii*, *S. dullooa*, *C. hooke-riana*, etc., may still find acceptability in Thailand and Japan as a smaller shoot.

The Government of India is carrying out a large number of programmes for community development on a nutritional status to overcome the problem of malnutrition. Despite food self-sufficiency at the national level, the country has not attained food security at a household level particularly in these tribal states. Hence, a considerable proportion of rural population is still undernourished and they meet their nutritional requirement through non-conventional means, i.e. by consuming various wild plants and animal resources and bamboo shoots include the diets of tribal communities to a great extent. Thus, the high diversity of bamboo resource plays a significant role in the food and nutritional security of the tribal population of NEH region.

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