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Microenvironmental characteristics of the natural habitat of *Arundinaria maling* Gamble in Arunachal Pradesh, India

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Abstract: *Arundinaria maling* is a temperate bamboo having durable culms with multipurpose application. From ecological point of view, it has been described as a rare and endemic species which is distributed in the Himalayan centre of the world's biodiversity hotspots. The largest habitat of this bamboo species was identified in the Jang area of Tawang district of Arunachal Pradesh, India covering an area of about 3170ha along an altitudinal gradient of 2400-3600 m a.s.l. Both edaphic and climatic factors had significant role on the distribution and growth of *A. maling*. The microclimatic factors preferred by *A. maling* which was worked out from this study include 1894-1996 mm annual rainfall, 20500-88400 lux light intensity, 5-11°C air temperature, 1-5 km h^{-1} wind velocity, 2-8 °C soil temperature, 40-52 per cent soil moisture content, 54-65 per cent water holding capacity, 0.20-0.40 g cm^{-3} bulk density, 5.26-5.46 soil pH, 0.41-0.88 per cent soil nitrogen, 6-8.82 $\mu g\ g^{-1}$ available phosphorus, 0.052 per cent potassium and 6.36-9.93 per cent soil organic carbon.

Key words: *Arundinaria*, microenvironmental factors, Himalayas, rainfall, temperature, soil nutrients.

INTRODUCTION

Bamboo, the perennial woody grass belonging to sub-family Bambusoideae of Poaceae family, is one of the most important multipurpose plants of high economic and environmental value. Bamboo occurs mostly in Asia and South America and to a limited extent in Africa. They have a wide range of ecological amplitude and are distributed throughout the tropical, sub-tropical and cold temperate regions except in Europe, from sea level to 4000 m a.s.l. (Soderstrom and Calderon, 1979). Diversity and natural distribution of bamboo are governed mainly by physiographic features such as altitudinal variation, climatic, edaphic, and biotic factors. Among climatic factors, rainfall and temperature play a very important role. More than 50 per cent of the Indian bamboo resource is confined to the north-eastern region of the country. As many as 78 bamboo species (both indigenous and exotic) belonging to 19 genera

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have been reported from this region (Hore, 1998). Arunachal Pradesh with more than 12 genera and 30 species is rich in bamboo resource which forms a major forest produce of the state (Haridasan and Deori, 1987).

Arundinaria maling Gamble (locally called 'Rui') a temperate species has been an integral part of the life and culture of local Monpa tribe. They use it for house construction, handicrafts, fencing, and as stakes and support for climbing and twining agricultural and vegetable crops. Besides, it also has religio-spiritual and ethno-botanical importance. Young shoot known as 'Shongje', is used to prepare 'Rhoo', which is one of the most delicious traditional dishes of the area. *A. maling* is a rare and endemic species localized in a few very specific pockets of Arunachal Pradesh, Sikkim and hills of West Bengal in India and in Nepal and Bhutan.

In Arunachal Pradesh, only three habitats of this species have been identified, where 'Rui' forms pure bamboo brakes. In the Jang area, the 'Rui' forest is the major source of fuelwood for cooking as well as for keeping the dwellings warm during the winter. Besides, the 'Rui' bamboo stands provide natural habitat, food and breeding ground for several wild temperate animals such as red panda, snow bear, squirrel, birds, snakes, *etc*.

Worldwide, ecological studies on temperate and alpine bamboos are meager in comparison to tropical and subtropical ones. The habitat characterization and ecological requirements of different species of bamboos need to be studied intensively for proper understanding and management of the forest ecosystem. Therefore, this study was carried out to understand the climatic and edaphic characteristics of a natural habitat of *A. maling* in the Jang area of Tawang district of Arunachal Pradesh.

MATERIALS AND METHODS

The study was carried out in *A. maling* stands at three different elevation zones (2400-2800, 2800-3200 and 3200-3600 m a.s.l) in Jang area of Tawang district of Arunachal Pradesh (27° 30′-27° 35′ N latitude and 91° 55′-92° E longitude). The area is hilly terrain with steep slopes. The aforesaid three elevation zones have been designated in this study as the low elevation (2400-2800 m a.s.l), medium elevation (2800-3200 m a.s.l) and high elevation (3200-3600 m a.s.l.) sites. Beyond the high elevation site, there were barren lands with a few perennial deciduous shrubs and herbs growing on them.

The microclimatic data pertaining to the respective study sites were recorded for two consecutive years (April 2001 to March 2003). Rainfall, snowfall, relative humidity (RH), air temperature, soil temperature, light intensity and wind velocity were measured throughout the study period. Rainfall and snowfall were measured using standard rain gauge and snow gauge; RH and air temperature were measured by using hygrometer and max-min thermometer, respectively. Wind velocity and wind direction were recorded with a fan wheel anemometer with wind vanes. Light intensity was measured using a Lux meter (LUBRON LX-101) and soil temperature by using a soil thermometer (ELITE).

Soil samples were collected in April, July, October and January during 2001, 2002 and 2003. From each elevation site, nine replicate samples were collected using a steel corer (6.5 cm diameter and 30 cm height) from three soil depths (0-10, 10-20 and 20-30 cm). The replicate samples of a given depth were thoroughly mixed to obtain one composite sample. The samples were air-dried, sieved through a 2 mm mesh sieve to remove stone particles and gravel and then passed through 0.5 mm mesh screen for the determination of their physical and chemical properties. Soil samples were analysed once for texture, bulk density, water holding capacity, and soil porosity, whereas soil moisture, pH, organic carbon and soil nutrients (N, P and K) were analysed at different sampling dates *i.e.*, January, April, July and October. Soil texture and bulk density were determined by Bouyoucos hydrometer method and gravimetric method, respectively, and soil porosity was determined using the bulk density data following Allen *et al.*(1974). Water holding capacity (WHC) was determined by Keen's box method using copper cups of 5.6 cm internal diameter and 1.6 cm height (Piper, 1942). Soil moisture content was determined gravimetrically by taking 10 g of fresh unsieved soil and the result expressed on oven-dry weight basis; pH was determined electrometrically by a digital pH meter (SYSTRONICS-335) in 1:2.5 suspension of soil in deionized water (Anderson and Ingram, 1993). Soil organic carbon was determined by rapid titration method (Walkley and Black, 1934). Total Kjeldahl nitrogen (TKN) was determined by digesting air-dried soil samples with concentrated sulphuric acid using Kjeltab (TECATOR) as catalyst, on a block digester followed by distillation and titration in a KEL PLUS distillation system and Schott Titro Line easy (ELITE EX), respectively. Available phosphorus was determined by molybdenum blue method (Allen *et al.*, 1974) after extracting the soil phosphorus in 0.5 M sodium bicarbonate solution. Soil potassium was determined by using flame photometer after digesting the soil samples with tri-acid (Allen *et al.*, 1974). Each analysis was performed in triplicate and the final results are expressed on oven-dry weight basis. All the data on the climatic variables and edaphic parameters were statistically analysed using multiway ANOVA.

RESULTS

Climatic variables

The annual rainfall did not differ significantly among the three elevation sites, although it varied significantly among the sampling dates ($F = 161.74$, $P < 0.001$). Mean annual rainfall during the study period was highest at the medium elevation site (1996 mm), followed by the low elevation site (1986 mm) and lowest at the high elevation site (1894 mm). At all the three elevations, low rainfall was received between October and March, while good rainfall was received during April and September, and the highest rainfall was recorded in the month of July (Fig. 1). Snowfall increased with elevation, and the differences were significant among the three elevation sites (F = 5.397, $P< 0.01$) and sampling dates (F = 12.791, $P< 0.001$). The mean annual snowfall was much higher (1736 mm) at the high elevation site, while it was 581 mm and 516 mm at the medium and low elevation sites, respectively. At all the three elevation sites, maximum snowfall took place during January. At the high elevation site, snowfall occurred during October and March, whereas at the medium and low elevation sites it occurred during November to February and December to February, respectively (Fig. 2). Differences in mean monthly maximum and minimum temperatures of the three elevation sites during the study period were significant among the sites (F = 15.617 and 11.652 respectively, $P< 0.001$) and sampling dates (F = 7.32 and 40.259 respectively, $P< 0.001$).

Air temperature was higher at the low elevation site than at the medium and high elevation sites. At all the three sites, the maximum air temperature was observed during July and minimum during January. The mean annual maximum temperature observed at the low, medium and high elevation sites was 19.3 °C, 15.8 °C, and 12.8 °C, respectively, whereas the minimum temperature was 2.3 °C, 0 °C and -1.6 °C, respectively at the low, medium and high elevation sites. The relative humidity (RH) at all the three elevation sites was significantly different among the sites and sampling date (F = 113.62 and 27.00 respectively, $P< 0.001$). Mean annual RH at the low, medium and high elevation sites was 87%, 66% and 62%, respectively. Wind velocity differed significantly among the three elevation sites and sampling dates (F = 17.187 and 12.794 respectively, $P< 0.001$), with highest velocity at the high elevation site and minimum at the medium elevation site. Maximum and minimum wind velocity at the low elevation site was observed during May (4.57 km h^{-1}) and August (2.10 km h^{-1}). At the medium elevation site, it was recorded as 4.47 km h^{-1} during February and 1.94 km h^{-1} during October. At the high elevation site, mean wind velocity was recorded maximum during January (6.28 km h^{-1}) and minimum during August (3.23 km h^{-1}). There were significant differences in light intensity among the sites and sampling dates (F = 164.48 and 36.76 respectively, $P< 0.001$). Maximum light intensity was recorded during October, minimum during January at all the three elevation sites. Mean annual light intensity was highest at the medium elevation site (88395 lux) followed by the high and low elevation sites (67703 and 20517 lux, respectively) (Fig. 2).

Edaphic variables

At all the three elevation sites, maximum soil temperature was recorded during July and minimum during January. Statistical analysis revealed significant differences in soil temperature among the elevation sites, sampling dates and soil depths (F = 39.147, 7.389 and 44.301 respectively, $P< 0.005$). Soil temperature at the high elevation site was found to be lower (ranging from -3 to 6.9 °C) than the other two sites throughout

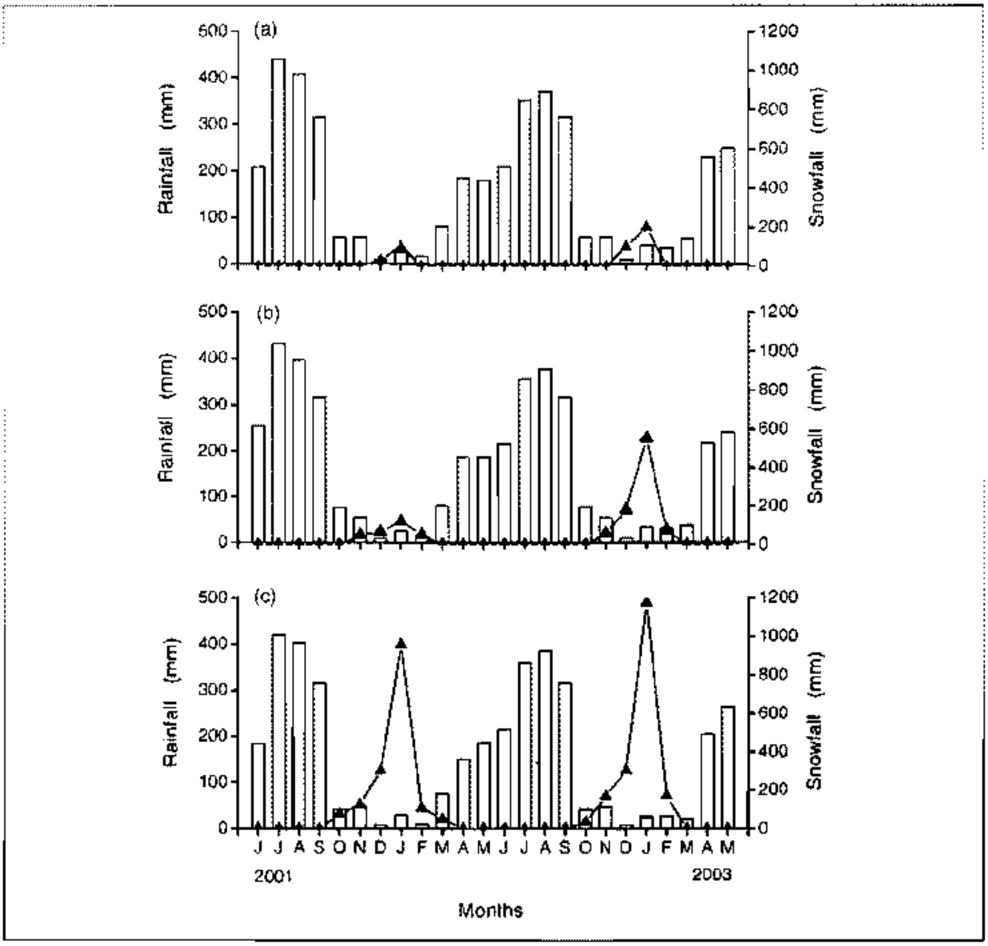

Figure 1. Monthly variation in rainfall ( ) and snowfall (-▲-) at the low (a), medium (b) and high (c) elevation sites of *A. maling* forest.

the year. Soil temperature at the medium elevation site was moderate ranging from -2 to 10 °C, while at the low elevation site it was relatively higher (0 to 11.7 °C). Soil temperature decreased with the increase in soil depth at all the three elevation sites, except during January. During January, soil temperature of the surface layer (0-10 cm depth) at the high and medium elevation sites was lower than the other two depths (10-20 and 20-30 cm) due to snow cover. Mean annual soil temperature at 0-30 cm depth at the low, medium and high elevation sites was 6.3 °C, 4.4 °C and 1.8 °C, respectively. Differences in soil moisture content at different soil depths, three elevation sites and sampling dates were significantly different (F = 62.61, 117.81 and 101.12 respectively, $P < 0.001$). It was significantly higher at the medium elevation site at all the three depths compared to the low and high elevation sites, which was attributed to the higher precipitation through rainfall and snowfall. Maximum soil moisture content was observed during July at the low elevation site, while two peaks of soil moisture (during July and January) were recorded at the medium and high elevation sites due

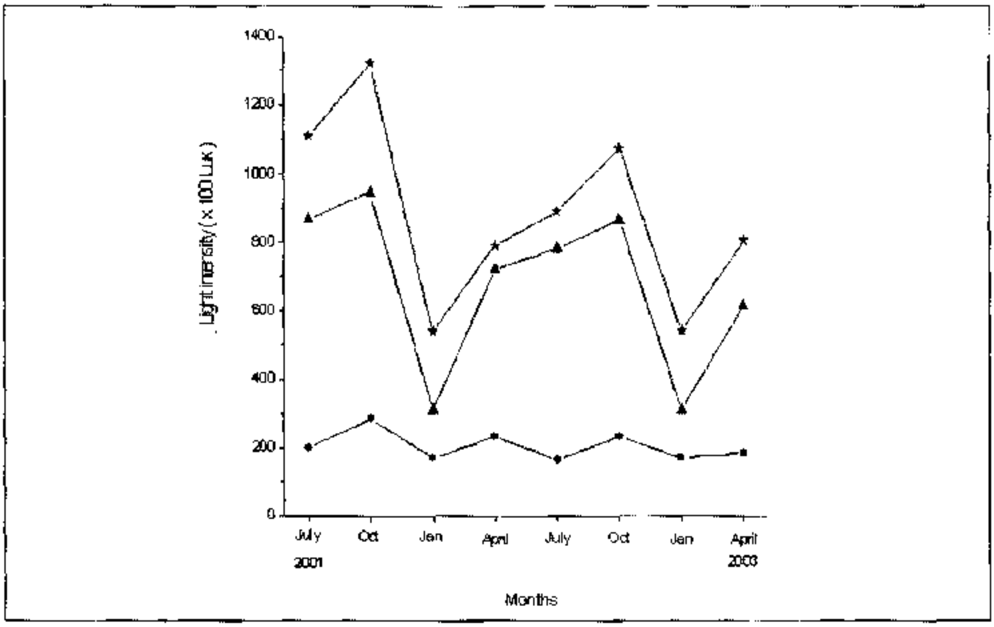

Figure 2. Temporal variation in light intensity at the low (-●-), medium (-★-) and high (-▲-) elevation sites in the *A. maling* forest.

to high snowfall during winter. Minimum soil moisture content was noticed during April at all the three elevation sites. There was a significant decrease in soil moisture content with the increase in soil depth at all elevation sites. Mean soil moisture content in the surface soil (0-10 cm depth) at the low, medium and high elevation sites was 46.5 per cent, 56.5 per cent and 42.8 per cent respectively. At 10-20 cm depth, it was 42.8 per cent, 52.4 per centan 38.8 per cent respectively; whereas at 20-30 cm depth, the soil moisture content was comparatively lower (36.7%, 47.7% and 37.9% respectively) at the low, medium and high elevation sites.

The pH of the soil of all the three elevation sites tended to be acidic. It was significantly different among the soil depths, elevation sites and sampling dates (F = 39.37, 92.46 and 209.80 respectively, $P < 0.001$). At all the elevation sites, soil pH was highest during October and lowest during April. There was a decline in soil pH from the surface layer to the subsurface layers during the study period at all the elevation sites, except during 2001-2002, when the surface soil (0-10 cm) at the low elevation site was more acidic than the two subsurface soil layers (10-20 and 20-30 cm depths). Soil pH at the medium elevation site was significantly higher compared to the other two elevation sites. Bulk density of soil at different depths at the three elevation sites varied significantly (F = 20.05 and 80.50 respectively, $P < 0.001$). The high elevation site having open bamboo forest showed higher values which gradually declined at the medium and low elevation sites that had better vegetation cover. Bulk density increased with the increase in soil depth at all the three elevation sites, which implies increase in soil compactness with depth. The soil at the low elevation site was more porous compared to the medium and high elevation sites (Table 1). Water holding capacity did not differ significantly among the three soil depths, however, it differed significantly among the three elevation sites (F = 22.087, *P< 0.001*). Soil of the middle depth (10-20 cm) showed maximum water holding capacity at the low and medium elevation sites, while at high elevation site, it was greater in the surface soil than the sub surface soil. The medium elevation site had the highest water holding capacity. The texture of the soil was sandy at the high and low elevation sites, whereas it was loamy sand at the medium elevation site. Silt and clay percent was significantly higher at the medium elevation site compared to the other two elevation sites.

Soil organic carbon (SOC) showed significant difference among the three soil depths, three elevation sites and sampling dates (F = 410.34, 478.02 and 556.97 respectively, *P< 0.001*). SOC decreased with the increase in soil depth and was greater during October, while it was minimum during April at all the three elevation sites. There was no significant difference in SOC between the two consecutive years during the study period, although an insignificant increase was observed in the surface soil. SOC at two sub-surface soil layers (10-20 and 20-30 cm) increased during April and July, and it declined during October and January (Table 2). Total nitrogen differed significantly among the three soil depths, elevation sites and sampling dates (F = 14.96, 87.64 and 19.90 respectively, *P< 0.001*). The soil of the surface layer had higher total nitrogen concentration which gradually declined in the sub-surface layers. Maximum total nitrogen was observed at the low elevation site and minimum at the high elevation site. It attained peak value during July at the low and medium elevation sites, whereas at the high elevation site, it peaked during October. Minimum total nitrogen concentration was recorded during April at all the elevation sites. An increase in total nitrogen concentration was observed at the low elevation site during the study period, while there was no significant change at the medium elevation site, but at the high elevation site there was a gradual decrease in N concentration (Table 3).

Concentration of available phosphorus (P) was significantly higher at the medium elevation site (F = 16.154, *P< 0.001*), and lowest at the high elevation site. It differed significantly among the three soil depths and sampling dates (F = 31.867 and 29.953 respectively, *P< 0.001*). Surface soil of the three elevation sites had higher P concentration, which gradually decreased with the increase in soil depth. Concentration of available P had two peaks *i.e.*, during July and January at all the three elevation sites. Highest P concentration at the low elevation site was observed during July, whereas at the medium and high elevation sites highest values were recorded during January. Lowest concentration of available P was noticed during October. A gradual increase in available phosphorus was observed during the study period at all the elevation sites (Table 4). Concentration of total potassium did not differ significantly among the soil depths, elevation sites, and sampling dates. It was higher (10-20 cm depth) at all the three elevation sites. At the low and medium elevation sites, maximum K concentration was observed during July, while at the high elevation site it was

Table 1. Physical properties of soil at three depths at the three elevation sites in the *A. maling* forest

Elevation sites	Soil depth (cm)	BD* (g cm^{-3})	Porosity (%)	WHC (%)	Percentage of soil particles			Textural class
					Sand	Silt	Clay	
Low								
(2400- 2800 m a.s.l.)	0-10	0.24 ± 0.03	90.82 ± 1.01	70.54 ± 9.54	94.19 ± 1.24	4.50 ± 0.03	1.31 ± 0.03	S
	10-20	0.29 ± 0.02	88.93 ± 0.88	65.96 ± 2.56	93.13 ± 1.71	5.10 ± 0.02	1.77 ± 0.02	S
	20-30	0.31 ± 0.02	88.24 ± 0.83	54.82 ± 6.88	92.96 ± 0.63	5.51 ± 0.03	1.53 ± 0.12	S
Medium								
(2800-3200 m a.s.l.)	0-10	0.23 ± 0.03	91.26 ± 0.96	64.66 ± 9.54	80.71 ± 0.57	17.00 ± 1.18	2.29 ± 0.03	LS
	10-20	0.26 ± 0.02	90.31 ± 0.81	67.44 ± 8.17	79.38 ± 2.04	18.11 ± 0.51	2.51 ± 0.04	LS
	20-30	0.29 ± 0.02	88.99 ± 0.82	63.46 ± 6.60	77.63 ± 1.15	19.44 ± 0.03	2.93 ± 0.03	LS
High								
(3200-3600 m a.s.l.)	0-10	0.40 ± 0.02	84.78 ± 0.75	59.44 ± 5.60	94.75 ± 2.60	4.00 ± 0.30	1.25 ± 0.05	S
	10-20	0.50 ± 0.02	81.19 ± 0.75	53.98 ± 3.20	93.72 ± 1.26	4.56 ± 0.21	1.72 ± 0.04	S
	20-30	0.56 ± 0.03	78.87 ± 1.07	47.07 ± 6.76	92.92 ± 1.55	4.61 ± 0.20	2.47 ± 0.05	S

*BD: Bulk density; WHC: Water holding capacity; S: Sandy; LS: Loamy Sand, ± indicates SE (n = 3).

Table 2. Temporal variation in soil organic carbon (%) at the three elevation sites in the *A. maling* forest

Elevation sites	Soil depths (cm)	2001 - 2002					2002 - 2003				
		April	July	October	January	Mean	April	July	October	January	Mean
Low	0-10	6.85	8.20	12.80	9.20	9.26	7.30	8.24	14.70	9.29	9.88
		± 0.02	± 0.06	± 0.03	± 0.03		± 0.03	± 0.04	± 0.03	± 0.03	
	10-20	4.90	7.80	11.70	8.00	8.10	5.80	7.71	11.00	7.10	7.90
		± 0.02	± 0.04	± 0.05	± 0.09		± 0.08	± 0.04	± 0.02	± 0.04	
	20-30	4.00	5.00	10.70	6.70	6.60	4.40	5.60	9.00	5.60	6.15
		± 0.07	± 0.04	± 0.02	± 0.03		± 0.05	± 0.07	± 0.06	± 0.02	
Medium	0-10	8.48	10.20	14.70	11.70	11.27	9.20	11.00	16.00	11.70	11.98
		± 0.02	± 0.03	± 0.07	± 0.02		± 0.06	± 0.05	± 0.07	± 0.05	
	10-20	6.50	9.80	13.50	10.70	10.13	7.30	10.50	11.30	8.50	9.40
		± 0.06	± 0.05	± 0.05	± 0.03		± 0.04	± 0.06	± 0.05	± 0.04	
	20-30	5.50	8.00	12.50	7.06	8.27	6.70	9.20	10.70	7.60	8.55
		± 0.05	± 0.06	± 0.03	± 0.03		± 0.04	± 0.06	± 0.05	± 0.05	
High	0-10	5.40	7.40	10.70	8.20	7.93	6.40	8.00	10.70	8.90	8.50
		± 0.03	± 0.04	± 0.05	± 0.05		± 0.05	± 0.04	± 0.06	± 0.03	
	10-20	3.30	6.00	9.20	7.40	6.48	4.40	6.70	7.00	5.30	5.85
		± 0.04	± 0.01	± 0.06	± 0.04		± 0.06	± 0.05	± 0.04	± 0.04	
	20-30	2.50	4.50	7.60	4.30	4.73	3.30	6.10	6.30	3.00	4.68
		± 0.02	± 0.02	± 0.03	± 0.04		± 0.02	± 0.05	± 0.06	± 0.07	

± Indicates SE (n = 3).

Table 3. Temporal variation in soil total nitrogen (%) at the three elevation sites in the *A. maling* forest

Elevation sites	Soil depths (cm)	2001 - 2002					2002 - 2003				
		April	July	October	January	Mean	April	July	October	January	Mean
Low	0-10	0.54 ± 0.046	0.96 ± 0.012	0.93 ± 0.012	0.62 ± 0.006	0.76	0.76 ± 0.005	1.37 ± 0.012	1.17 ± 0.029	0.66 ± 0.046	0.99
	10-20	0.51 ± 0.006	0.87 ± 0.006	0.69 ± 0.035	0.55 ± 0.023	0.66	0.66 ± 0.008	1.20 ± 0.023	0.73 ± 0.012	0.57 ± 0.012	0.79
	20-30	0.42 ± 0.012	0.82 ± 0.006	0.60 ± 0.012	0.52 ± 0.069	0.59	0.60 ± 0.012	1.07 ± 0.006	0.64 ± 0.046	0.56 ± 0.006	0.72
Medium	0-10	0.34 ± 0.006	0.95 ± 0.006	0.44 ± 0.012	0.49 ± 0.017	0.56	0.46 ± 0.046	0.70 ± 0.006	0.49 ± 0.023	0.51 ± 0.006	0.54
	10-20	0.30 ± 0.005	0.77 ± 0.012	0.36 ± 0.023	0.44 ± 0.012	0.47	0.39 ± 0.017	0.65 ± 0.012	0.39 ± 0.006	0.46 ± 0.023	0.47
	20-30	0.18 ± 0.029	0.53 ± 0.029	0.29 ± 0.006	0.42 ± 0.017	0.36	0.31 ± 0.003	0.53 ± 0.046	0.31 ± 0.046	0.43 ± 0.012	0.40
High	0-10	0.41 ± 0.046	0.22 ± 0.006	0.54 ± 0.012	0.48 ± 0.017	0.41	0.21 ± 0.012	0.36 ± 0.003	0.56 ± 0.017	0.47 ± 0.006	0.40
	10-20	0.38 ± 0.012	0.21 ± 0.006	0.47 ± 0.017	0.41 ± 0.006	0.37	0.10 ± 0.029	0.25 ± 0.023	0.51 ± 0.012	0.42 ± 0.012	0.32
	20-30	0.33 ± 0.012	0.17 ± 0.017	0.41 ± 0.012	0.34 ± 0.017	0.31	0.08 ± 0.005	0.21 ± 0.017	0.43 ± 0.006	0.36 ± 0.017	0.27

± Indicates SE (n = 3).

maximum during October. Minimum K concentration was observed during April at the low elevation site, whereas at the medium and high elevation sites, minimum concentration was recorded during January (Table 5).

DISCUSSION

This study has revealed that *A. maling* occupies a well-defined habitat in the hills of Arunachal Pradesh, in northeast India. Some studies on habitat preference of *Dendrocalamus strictus* under Indian conditions were reported (Deogun, 1937; Sen Gupta, 1952). Soil pH from 5.0 to 6.5 is the most suitable for bamboo growth, whereas some species grow even at pH 3.5. The acidic nature of the soils of *A. maling* forest irrespective of the elevation of sites may be due to the leaching or removal of cations due to heavy precipitation and due to accumulation of certain cations in bamboo biomass. Light intensity was higher at the medium elevation site due to open canopy and low fog. Although the high elevation site had greater canopy opening, it received poor sunlight due to the presence of very dense fog. The low elevation site has a very close canopy due to higher clump density and hence, the light intensity was low at this site too. There are also reports on the promotion of bamboo growth by soils rich in N, P, and K (Uchimura, 1980). Besides soil nitrogen and phosphorus which are the most important factors affecting bamboo growth, soil organic matter, texture, aeration and depth are also important (He and Ye, 1987). The climatic and edaphic factors of *A. maling* forest in Jang area greatly differ from the areas where other tropical and subtropical bamboo species grow (Uchimura, 1981; Chung and Ramm, 1990; Tewari *et al.*, 1994). The climatic conditions prevailing in Jang area (1894-1996 mm annual rainfall, 215-1736 mm snowfall, 62-87% RH, 5-11°C air temperature, 1-5 km h^{-1} wind velocity and 20500-88400 lux light intensity) seem to be quite favourable for the distribution and growth of *A. maling*. The good growth of bamboo in Jang area also indicates that the soil conditions of the area (2-8 °C soil temperature, 40-52% soil moisture content, 54-65% water holding capacity, 0.20-0.40 g cm^{-3} bulk density with 84-92% porosity, 5.26-5.46 soil pH, 0.41-0.88% soil nitrogen, 6-8.82 $\mu g\ g^{-1}$ available phosphorus, 0.052% soil potassium and 6.36-9.93% soil organic carbon) are conducive for its growth. Like 'Rui' bamboo, the distribution and growth of many bamboo species have been linked to the climatic and soil conditions (Yadav, 1964; Uchimura, 1981; Chung and Ramm, 1990; Tewari *et al.*, 1994; Wang *et al.*, 1998).

CONCLUSION

A. maling has very specific habitat preference. The physiographic, edaphic and climatic conditions prevailing in the Jang area of Arunachal Pradesh in the eastern Himalaya appear to be quite favourable for the growth of this rare and endemic bamboo. Increasing population, road construction and encroachment on the periphery of the Rui bamboo forest for human habitation are the main anthropogenic factors causing further shrinkage of the bamboo forest. Over extraction of the bamboo for a variety of domestic uses and

Table 4. Temporal variation in soil available phosphorus ($\mu g\ g^{-1}$) at the three elevation sites in the *A. maling* forest

Elevation sites	Soil depths (cm)	2001 - 2002					2002 - 2003				
		April	July	October	January	Mean	April	July	October	January	Mean
Low	0-10	3.58	11.94	6.32	10.54	8.10	5.69	14.25	8.67	12.90	10.38
		± 1.49	± 1.70	± 3.65	± 0.07		± 0.08	± 0.38	± 0.09	± 0.13	
	10-20	1.76	8.28	2.36	6.26	4.67	3.87	10.59	4.71	8.62	6.95
		± 0.98	± 1.85	± 1.36	± 0.07		± 0.08	± 0.48	± 1.21	± 0.07	
	20-30	1.74	3.70	1.16	2.86	2.36	3.85	6.01	3.51	5.22	4.65
		± 0.72	± 0.48	± 0.09	± 0.01		± 0.15	± 0.61	± 3.65	± 0.25	
Medium	0-10	10.56	10.92	4.90	13.62	10.00	12.67	13.23	7.25	15.98	12.28
		± 0.66	± 1.04	± 1.21	± 0.67		± 0.16	± 0.62	± 0.23	± 0.01	
	10-20	9.66	6.28	1.68	12.20	7.46	11.77	8.59	4.03	14.56	9.74
		± 0.20	± 0.61	± 0.38	± 0.25		± 0.20	± 0.82	± 0.81	± 0.06	
	20-30	6.26	5.80	1.40	8.90	5.59	8.37	8.11	3.75	11.26	7.87
		± 0.16	± 0.82	± 0.23	± 0.13		± 0.66	± 1.85	± 3.50	± 0.24	
High	0-10	6.25	6.94	5.70	8.04	6.73	8.36	9.25	8.05	10.40	9.02
		± 0.15	± 1.07	± 0.81	± 0.24		± 0.72	± 1.70	± 0.81	± 0.07	
	10-20	4.76	6.40	5.30	7.26	5.93	6.87	8.71	7.65	9.62	8.21
		± 0.08	± 0.62	± 3.67	± 0.30		± 0.98	± 0.82	± 1.36	± 0.25	
	20-30	5.88	6.00	4.80	6.50	5.80	7.99	8.31	7.15	8.86	8.08
		± 0.08	± 0.38	± 3.50	± 0.06		± 1.49	± 1.04	± 3.67	± 0.67	

± Indicates SE (n = 3).

Table 5. Temporal variation in soil total potassium (%) at the three elevation sites in the *A. maling* forest

Elevation sites	Soil depths (cm)	2001 - 2002					2002 - 2003				
		April	July	October	January	Mean	April	July	October	January	Mean
Low	0-10	0.041 ± 0.001	0.055 ± 0.001	0.050 ± 0.005	0.051 ± 0.001	0.049	0.042 ± 0.001	0.064 ± 0.004	0.050 ± 0.002	0.051 ± 0.004	0.052
	10-20	0.049 ± 0.001	0.053 ± 0.001	0.061 ± 0.007	0.052 ± 0.004	0.054	0.051 ± 0.003	0.065 ± 0.001	0.056 ± 0.001	0.052 ± 0.002	0.056
	20-30	0.048 ± 0.002	0.053 ± 0.003	0.052 ± 0.005	0.054 ± 0.003	0.052	0.047 ± 0.004	0.061 ± 0.002	0.052 ± 0.003	0.054 ± 0.004	0.054
Medium	0-10	0.047 ± 0.001	0.054 ± 0.001	0.054 ± 0.002	0.041 ± 0.001	0.049	0.049 ± 0.002	0.058 ± 0.003	0.054 ± 0.004	0.047 ± 0.001	0.052
	10-20	0.051 ± 0.001	0.057 ± 0.002	0.053 ± 0.004	0.045 ± 0.005	0.052	0.054 ± 0.001	0.064 ± 0.001	0.053 ± 0.005	0.050 ± 0.001	0.055
	20-30	0.051 ± 0.002	0.057 ± 0.001	0.055 ± 0.001	0.045 ± 0.003	0.052	0.054 ± 0.004	0.059 ± 0.001	0.055 ± 0.001	0.044 ± 0.003	0.053
High	0-10	0.045 ± 0.003	0.052 ± 0.003	0.056 ± 0.003	0.046 ± 0.002	0.050	0.049 ± 0.002	0.051 ± 0.002	0.056 ± 0.002	0.042 ± 0.001	0.049
	10-20	0.046 ± 0.001	0.052 ± 0.001	0.065 ± 0.001	0.048 ± 0.002	0.053	0.051 ± 0.001	0.049 ± 0.003	0.065 ± 0.001	0.047 ± 0.002	0.053
	20-30	0.050 ± 0.002	0.052 ± 0.002	0.055 ± 0.002	0.046 ± 0.001	0.051	0.047 ± 0.003	0.050 ± 0.001	0.050 ± 0.004	0.041 ± 0.001	0.047

± Indicates SE (n = 3).

burning of the bamboo forest for bringing the land under 'jhum' (shifting cultivation) are the two major factors responsible for the fragmentation and consequential degradation of the natural habitat of the 'Rui' bamboo in Arunachal Pradesh.

In the eastern Himalaya, particularly in Arunachal Pradesh, 'Rui' bamboo is the largest among the temperate and alpine bamboo species with durable culms. Hence, priority needs to be accorded to develop conservational strategies for the wise use of this rare and important bamboo.

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