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Evaluation of Fiber Characteristics in some weeds of Arunachal Pradesh, India for Pulp and Paper Making

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Abstract

Fiber characteristics in some common weeds of Arunachal Pradesh were investigated and compared with those of Pinus kesiya and Gmelina arborea to see their potential for making pulp and paper. The studies revealed that all selected species except Scoparia dulcis were rich in fibers. Fiber characteristics were measured to determine Runkel's ratio, slenderness ratio, flexibility coefficient and Luce's shape factor to see their suitability for pulp and paper making. Mean values of fiber length, fiber diameter and wall thickness varied from 734.45± 98.03µm (Ageratum conyzoides) to 1578.80± 378.02µm (Urena lobata), 22.03± 4.8µm (Urena lobata) to 34.79±9.8µm (Solanum torvum), 3.36±0.90µm (Ageratum conyzoides) to5.17±2.01µm (Scoparia dulcis) respectively and comparable with both Pinus kesiya and Gmelina arborea. The studies showed that all selected weeds had Runkel's ratio less than 1 and slenderness ratio more than 33. The flexibility coefficient was maximum in Solanum torvum (80.30) and Ageratum conyzoides (74.41) and between 60-69 in other species. Luce's shape factor ranged from 0.19 (Solanum torvum) to 0.50 (Eupatorium odoratum).

Keywords: Fiber length, weeds, pulp and paper, derived indices.

Introduction

Paper is an important medium for preserving and recording of history since from time immemorial. It is one of the most versatile and common product of modern societies[1]. The global consumption of paper is 400 million tons per year and expected to increase its consumption to 500 million tons by 2020[2], while in India, the consumption of paper and paper board is estimated to be double from 10 million tons per year by 2020[3]. Though the softwoods and hardwoods have desirable characteristics of fibers for pulp and paper making, but over exploitation of these woods for different purposes has resulted continuous decline in their production from natural forests[4]. Therefore, intensive work has been done on utilization of new alternative resources as raw materials to overcome global shortage of paper. Existing literature reveals that different workers have explored different non wood plant species and agricultural residues for search of a substitute for wood pulp[5-7].

In India, efforts have been made to fill the gap between demand and supply of pulp and paper by using various agricultural crops[8,9] and weeds[10-15].

Arunachal Pradesh is rich in its plants wealth due to unique topography and varied climatic condition. A number of weeds having well developed wood are available in this region which may provide a large biomass as raw materials for pulp and paper. With this perspective, an attempt has been made to study fiber characteristics of some common weeds of Arunachal Pradesh in relation to softwood and hardwood to see their suitability for pulp and paper making.

Material and Methods

Collection of plant materials: The present study was carried out on different weeds species namely *Ageratum conyzoides* L., *Bidens pilosa* L, *Crotolaria pallida* Aiton., *Eupatorium odoratum* Linn., *Scoparia dulcis* Linn., *Sida cordifolia* L, *Solanum torvum* Sw., *Urena lobata* L, *Vernonia cinerea* L. collected from Nirjuli and adjoining areas located in Papumpare district of Arunachal Pradesh (figure- 1). These weeds were selected on the basis of their availability and well developed wood .Some of the plant parts were also collected during flowering season for proper identification. These were identified by existing literature and photographed. For comparing the fiber morphology of weeds with wood, samples of each softwood (*Pinus kesiya*) and hardwood (*Gmelina arborea*) were selected as reference material[12, 13]. These samples were already available in Wood Science and Forest Products laboratory of NERIST. A total number of 5 plants for each weed species were taken for present study.

Preparation of samples and maceration: The leaves, branches, flowers and roots were removed and the main stems were washed thoroughly with distilled water and air dried. For each species, 3-4 cm long stem were taken from basal portion. They were cut into splinter size and macerated with Franklin's solution by keeping in an oven at 60˚C for 24 hours. The splinters were thoroughly washed with water and stained with safranine solution. Various xylem elements were separated by shaking the test tube and these were mounted in 50% glycerol for making temporary slides. Morphological characteristics of fibers namely fiber length, fiber diameter, lumen diameter and

cell wall thickness were studied in randomly selected 30 no. of fibers from each sample. Fiber lengths were measured at 40x while other cell dimensions like fiber diameter, lumen diameter and wall thickness were measured at 400x with an ocular micrometer fitted in one of eyepieces of research microscope. Thus, for each selected species a total of 150 fibers were studied. The frequency of each xylem elements (fiber, vessel and parenchyma) per unit area was determined from average of 10 different fields. For this purpose, unit area used is the field of microscope at 40x.The derived indices like Runkel's ratio, slenderness ratio, flexibility ratio and Luce's shape factor were calculated by using various fibrous dimensions[16].

The selected weeds were photographed in the field and photomicrographs of their xylem elements were taken by Leica DFC camera attached to Leitz Labrolux research microscope.

Results and Discussion

Fibers are narrow, elongated sclerenchyma cells with lignified wall and provide support to plants. Morphological characteristics of fiber like length and width are important parameter to estimate the pulp quality. In addition, cell wall thickness and lumen size also affect the rigidity and strength of paper. The result presented in the table-1 show that abundant fibers are present in all selected species (except *Scoparia dulcis*) which are higher than *Gmelina arborea* and less than *Pinus kesiya.* Thus all species may be selected as an alternative resource of raw materials in pulp and paper making industries.

The characteristics of fibers like fiber length, fiber diameter and wall thickness are important parameters to estimate pulp quality of fibers in lignocellulose raw materials. An average fiber length of 0.60 mm in *Ipomea carnea* and *Chanopodium album*, 1.2 mm and 1.58mm in *Passiflora* and some forest weeds were reported[11,14,15]. The present study shows that mean fiber length of selected weeds ranges from 735.45 ± 98.03 µm (*A.conyzoides*) to 1578.8 ± 378.02 µm (*Urena lobata*). The observed values of all weeds (except *A. conyzoides, S. dulcis and S. torvum*) are close to fiber length of *G. arborea* (1478.97 ± 210.43 µm) and lower than *Pinus kesyia* (3119.5 ± 808.47 µm) (table-2, figure-2). The mean fiber diameter varies from 22.03 ± 4.8 µm (*Urena lobata*) to 34.79 ± 9.8 µm (*Scoparia dulcis*) and wall thickness varies from 3.36 ± 0.98 µm (*Ageratum conyzoides*) to 5.17 ± 2.01 µm (table-2). The present investigations are in confirmation with the finding of other workers[5,11,12]. Runkel's ratio, slenderness ratio, flexibility coefficient and Luce's shape factor are important derived indices to determine the suitability of material for pulp and paper making. The fibers with Runkel's ratio less than 1 are good for paper making because fibers are more flexible, collapse easily and form a paper with large bonded area while, fibers with Runkel's ratio more than 1 are stiff, difficult to collapse and form bulkier paper with less bonded area[9,18]. In the present investigation, the Runkel' ratio of all selected weeds are less than 1 and varies from 0.25 (*Solanum torvum*) to 0.69 (*Sida cordifolia*) (table-2, figure-3). From this point of view, fibers of all selected species can be considered for pulp and paper making.

Table- 1
Frequency (per unit area)* of xylem elements in selected species

S. No.	Species name	Fiber	Vessel	Parenchyma
1	*Ageratum conyzoides*	(12-114) 61	(1-25) 11.07	(6-54) 28.13
2	*Bidens pilosa*	(11-99) 66.74	(0-10) 6.26	(4-36) 27
3	*Crotolarea pallida*	(12-115) 68	(0-5) 2.74	(5-46) 29.35
4	*Eupatorium odoratum*	(18-98) 63.95	(0-15) 5.08	(9-63) 31
5	*Scoparia dulcis*	(22-95) 47.09	(1-17) 6.06	(17-119) 46.85
6	*Sida cordifolia*	(13-128) 55.26	(0-11) 3.92	(9-115) 40.81
7	*Solanum torvum*	(16-133) 67.97	(0-6) 1.75	(8-65) 30.27
8	*Urena lobata*	(8-133) 57.09	(0-7) 2.25	(2-126) 41
9	*Vernonia cinerea*	(17-142) 73	(1-12) 7	(5-58) 20.46
10	*Gmelina arborea*	(12-127) 55	(3-24) 15.56	(8-54) 25.87
11	*Pinus kesiya*	(26-178) 90	Nil	(2-14) 7.5

*Unit area is the field of view of the microscope at 40x.

Table- 2
Fiber dimensions of xylem elements in selected species.

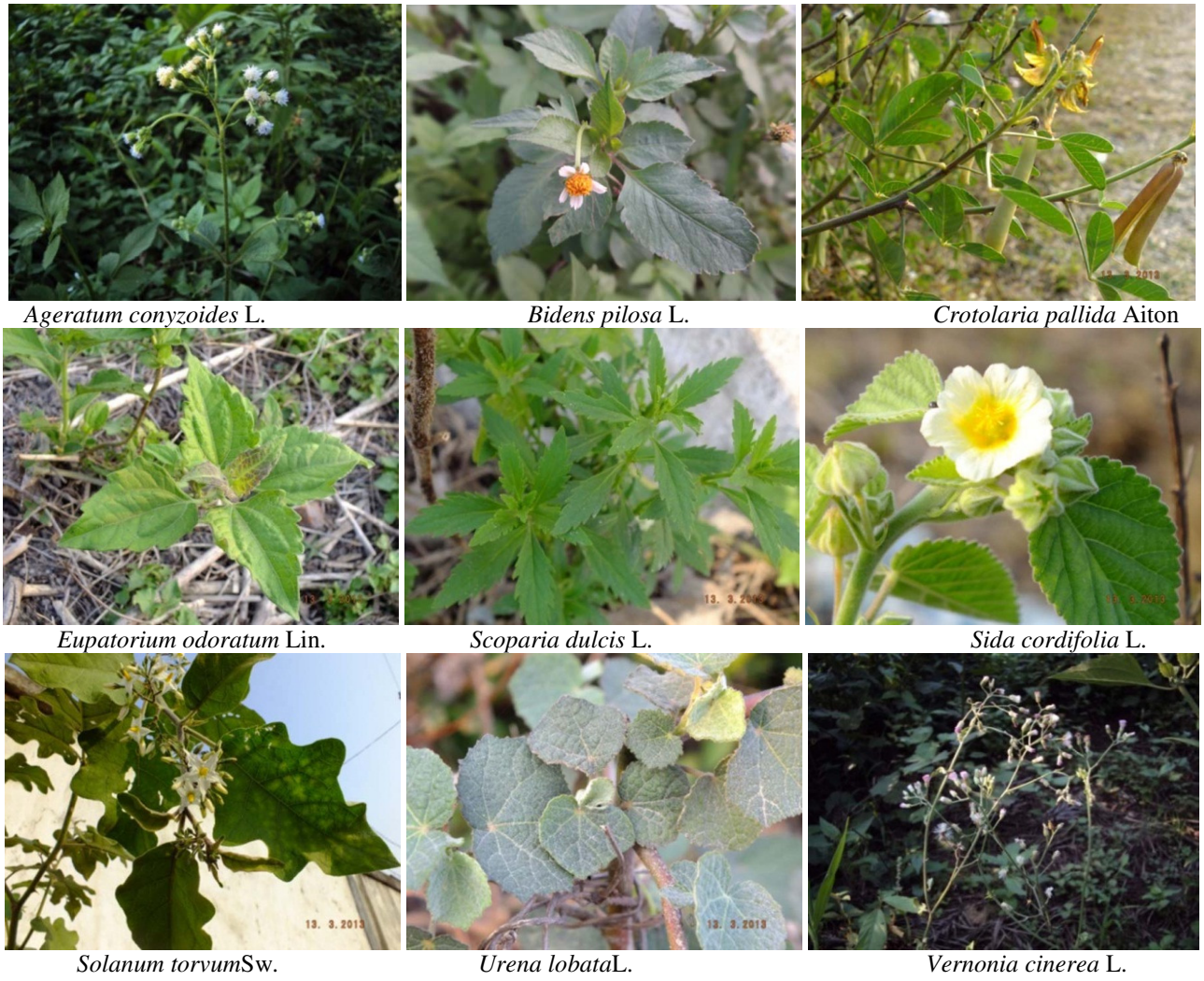
S. No.	Species name	Fiber length (µm)	Fiber diameter (µm)	Fiber lumen diameter (µm)	Fiber wall thickness (µm)
1	*Ageratum conyzoides*	499.89-1131.33 (735.45±98.03)	15.6-39.0 (26.33±4.65)	7.8-33.8 (19.6±4.9)	1.3-6.5 (3.36±0.98)
2	*Bidens pilosa*	631.44-1262.88 (927.16±127.79)	15.6-39 (24.2±5.58)	7.8-33.8 (16.67±5.85)	1.3-7.8 (3.76±1.16)
3	*Crotolarea pallida*	526.2-2420.52 (1242.2±44.95)	13-46.8 (25.15±5.86)	5.2-39 (15.86±5.9)	1.3-10.4 (4.64±2.11)
4	*Eupatorium odoratum*	526.20-2052.18 (1077.3±324.41)	13-49.4 (25.58±5)	5.20-44.2 (16.81±5.59)	1.3-10.4 (4.37±1.53)
5	*Scoparia dulcis*	694.06-1210.26 (930.15±105.6)	18.2-44.2 (27.14±4.4)	5.2-33.8 (16.81±5.95)	1.3-10.4 (5.17±2.01)
6	*Sida cordifolia*	552.51-2262.66 (1299.9±361.27)	10.4-36.4 (22.74±5.38)	2.6-31.2 (14.0±6.84)	1.3-9.1 (4.37±1.91)
7	*Solanum torvum*	631.44-1105.02 (848.41±98.3)	18.2-57.2 (34.79±9.8)	5.2-52 (27.99±10.15)	1.3-9.1 (3.39±1.1)
8	*Urena lobata*	684.06-2525.76 (1578.8±378.02)	13-39 (22.03±4.81)	2.6-36.4 (13.4±6.11)	1.3-9.1 (4.32±1.72)
9	*Vernonia cinerea*	631.44-1289.19 (940.32±138.83)	13-41.6 (22.59±4.87)	5.2-33.8 (14.09±5.87)	1.3-7.8 (4.25±1.29)
10	*Gmelina arborea*	1131.33-2131.11 (1478.97±226.68)	28.60-52.00 (37.96±4.89)	18.20-44.20 (28.86±4.86)	2.60-11.70 (4.55±1.80)
11	*Pinus kesiya*	1736.5-5104.1 (3119.5±808.47)	46.8-83.2 (63.61±11.07)	28.6-72.8 (52±12.5)	2.6-7.8 (5.81±1.77)

Table-3
Derived indices for selected species

S. No.	Species name	Runkel's ratio	Slenderness ratio	Luce's shape factor	Flexibility coefficient
1	*Ageratum conyzoides*	0.35	27.97	0.27	74.41
2	*Biden spilosa*	0.46	47.33	0.33	69.01
3	*Crotolarea pallida*	0.60	50.65	0.40	63.56
4	*Eupatorium odoratum*	0.52	42.30	0.50	65.81
5	*Scoparia dulcis*	0.62	34.27	0.41	61.89
6	*Sida cordifolia*	0.69	58.22	0.41	61.83
7	*Solanum torvum*	0.25	24.62	0.19	80.30
8	*Urena lobata*	0.66	71.81	0.41	60.78
9	*Vernonia cinerea*	0.61	47.12	0.39	62.36
10	*Gmelina arborea*	0.32	39.09	0.26	76.03
11	*Pinus kesiya*	0.22	49.04	0.19	81.74

Slenderness ratio, a measure of tearing property of pulp in paper making is determined from fiber length and fiber diameter. The fibers with high slenderness ratio are long, thin and have high tearing resistance where as short and thick fibers have less slenderness ratio and tearing resistance. It is reported that slenderness ratio of fibrous material more than 33 is considered good for pulp and paper production[19]. All selected species have slenderness ratio more than 33 (except *A. conyzoides* and *S. torvum*) and are also comparable with *G. arborea* (39.09) and *P. kesiya*(49.04). Luce's shape factor is an important fiber index and derived from fiber diameter and lumen diameter. It is directly related to paper sheet density. It varies from 0.19 (*S. torvum*) to 0.50 (*E. odoratum*) (table- 2, figure-3).The value of these indices are also comparable with other weeds and non woody plants[11,12,21].

Flexibility coefficient is one of the important derived indices to determine strength properties of paper and is governed by lumen diameter and fiber diameter. It determines the degree of fiber bonding in paper sheet. The values for hardwood and softwoods are 55-70 and 75 respectively[21]. The fibers having flexibility coefficient more than 75 and between 50-75 are considered as highly elastic and elastic fibers[22]. In the present study the flexibility ratio of *G. arborea* and *P. kesiya* is 76.03 and 81.74, whereas for other weeds this value is reported maximum in *S. torvum* (80.30) and *A. conyzoides* (74.41) and between 60-69 in other selected species. It indicates that fibers in all selected species are flexible and satisfies the requirement for their suitability for pulp and paper making (table- 2, figure-3).

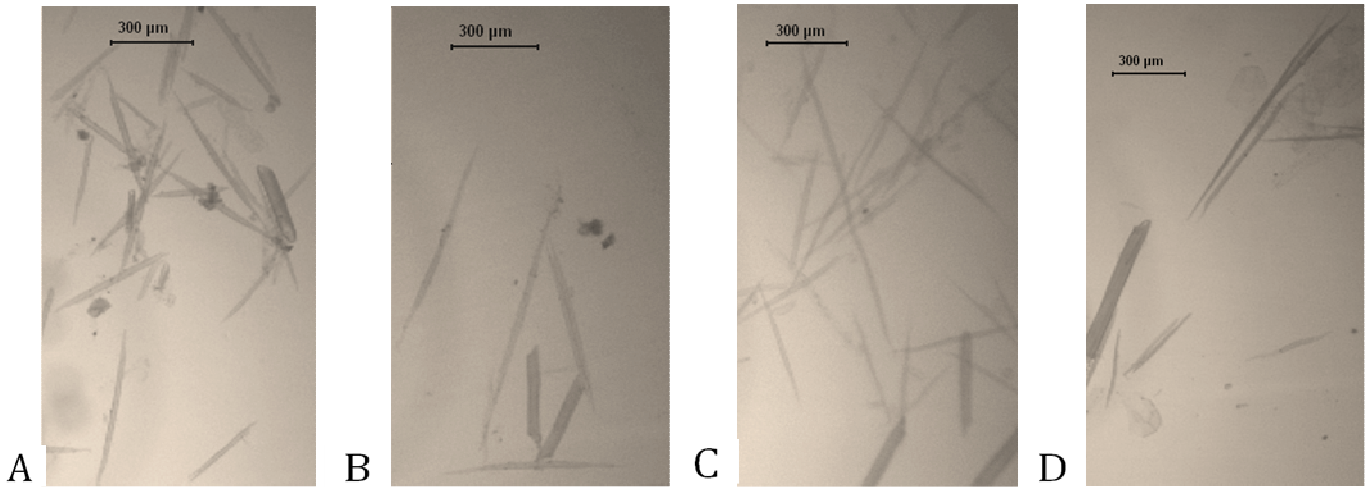


Ageratum conyzoides L. *Bidens pilosa* L. *Crotolaria pallida* Aiton

Eupatorium odoratum Lin. *Scoparia dulcis* L. *Sida cordifolia* L.

*Solanum torvum*Sw. *Urena lobata*L. *Vernonia cinerea* L.

Figure-1
Images of selected species



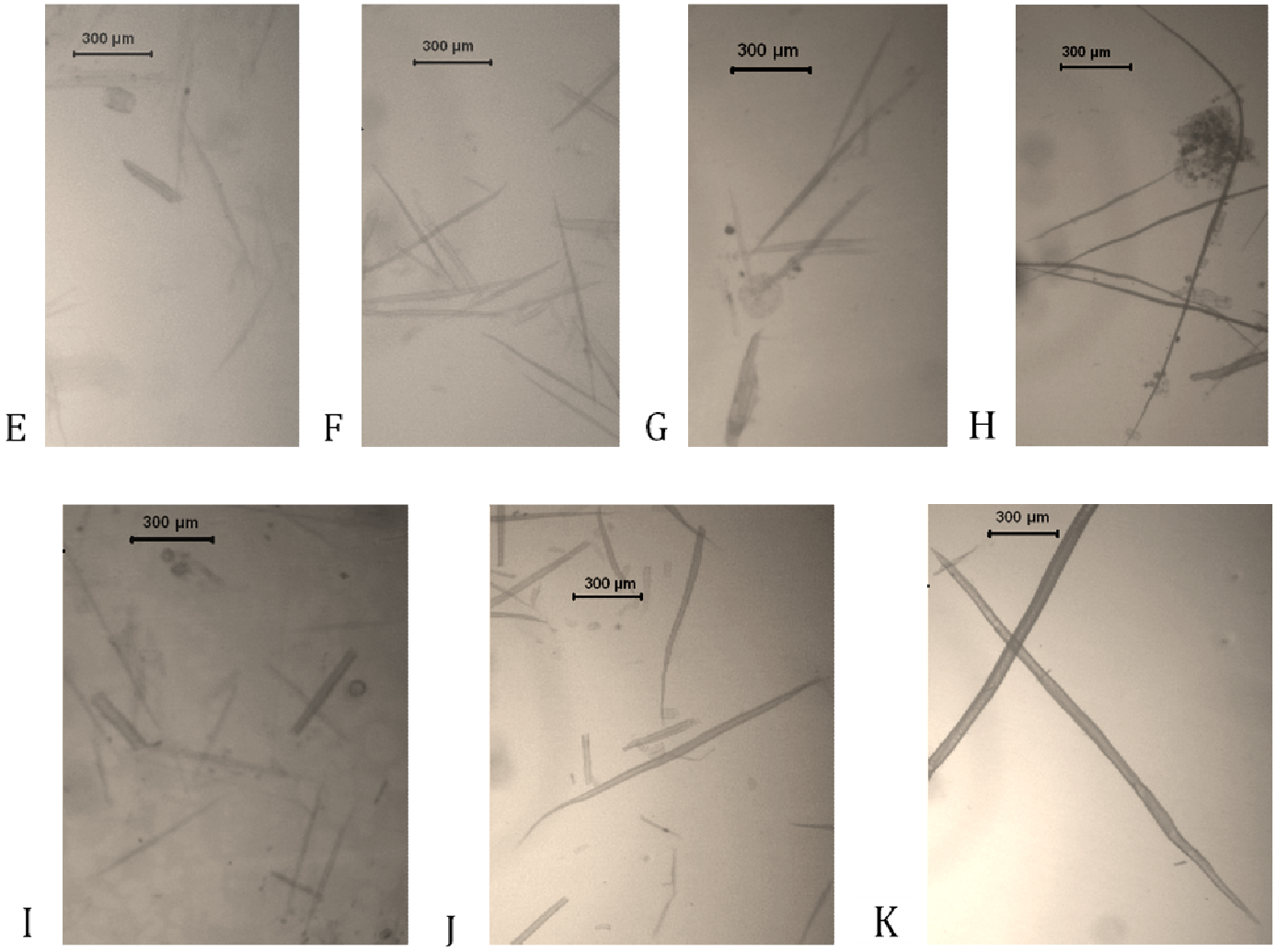
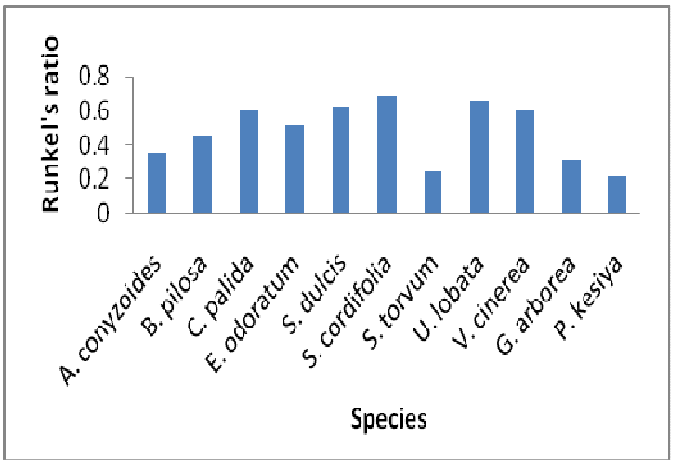
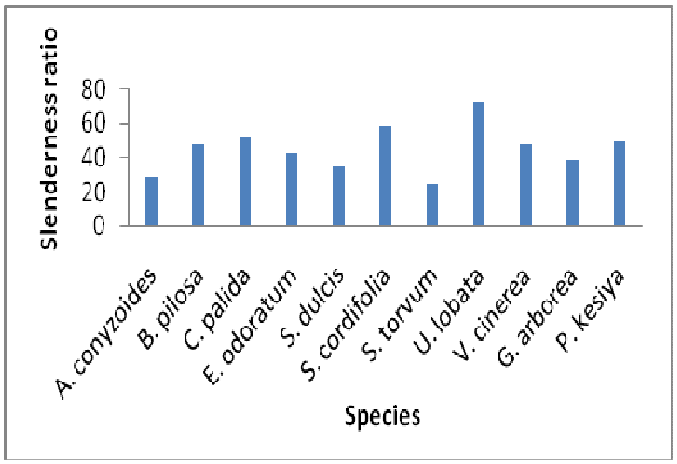


Figure-2
Xylem elements of*Ageratum conyzoides* L.(A), *Bidens pilosa* L.(B), *Crotolaria pallida* Aiton.(C), *Eupatorium odoratum* Lin.(D), *Scoparia dulcis* L.(E) , *Sida cordifolia* L.(F), *Solanum torvum* Sw.(G), *Urena lobata* L.(H), *Vernonia cinerea* L.(I), *Gmelina arborea* Roxb.(J), *Pinus kesiya* Royle ex Gordon (K)





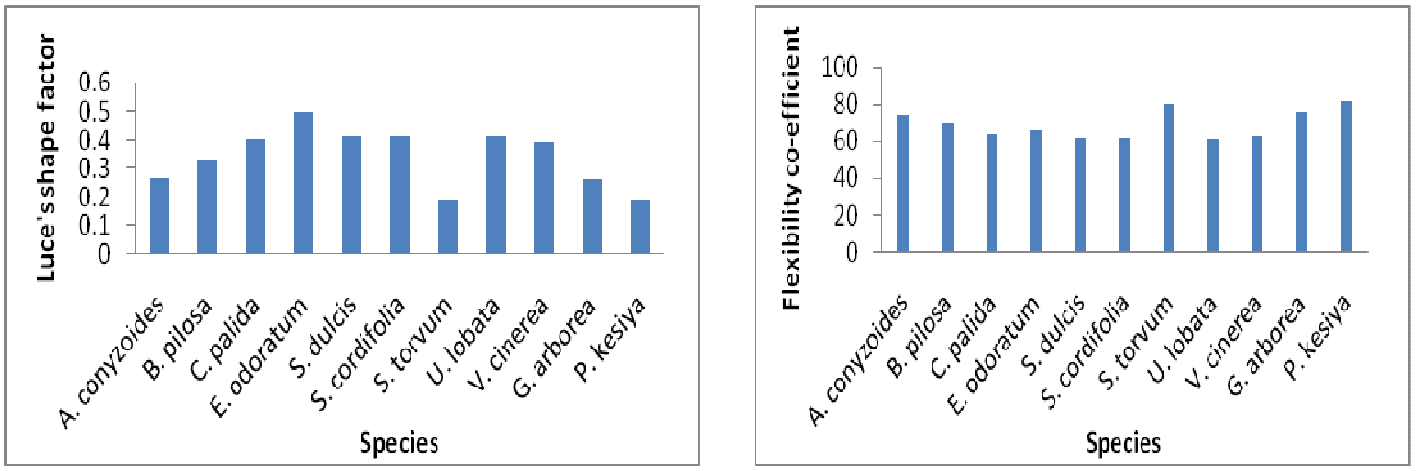


Figure - 3
Histograms showing derived indices of selected species

Conclusion

The present study shows that all selected weed species are very common in Arunachal Pradesh. Fibers are abundant in all selected species except *Scoparia dulcis* and have desirable derived indices for pulp and paper production. Thus fiber characteristics of selected weeds fulfill the criteria to utilize them for pulp and paper production. The chemical analyses of these weeds are urgently required to assist their suitability for pulp and paper making.

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References

1. Carboni G., Making and recycling paper at home, *Fun Science Gallery,* (www.funsci.com) **(2005)**

2. WWF, About pulp and paper production use.www.panda.org/what_we_do/footprint/Forestry/sustainable pulp paper/ about pulp paper production use (retrieved on 01.02.13) **(2010)**

3. Mishra M., http://www.ipma.co.in/paper-industry-overview.asp **(2011)**

4. Ashori A., Non-wood fibers- potentials source of raw materials in papermaking. *Polym-Plast Technical Eng. Journal,***45(10),** 1133-1136 **(2006)**

5. Olotuah, O.F., Suitability of some local bastfibre plants in pulp and paper making, *Jour. of Bio. Sc.,***6(3)**, 635-637 **(2006)**

6. Enayati A.A., Hamzeh Y., Mirshokraie and Molaii M., Paper making potential of Canola stalks, *Bioresources,* **4**, 245-256 **(2009)**

7. Housseinpour R., Latibari A.J., Farnood R., Fatehi, P. and Sepiddehdam S.J. Fiber morphology and chemical composition of Rapeseed *(Brassica napus*) stems, *IAWA*, **31(4),** 457-464 **(2010)**

8. Agnihotri S., Dutt D., Tyagi C.H., Complete characterization of bagasse of early species of *Saccharum officinerum*-Co 89003 for pulp and paper making, *BioResources,* **5(2)**, 1197-1224 **(2010)**

9. Dutt D., Upadhyaya J.S., Singh B.andTyagi, C. H.,Studies on *Hibiscus cannabinus* and *Hibiscus sabdariff a*as an alternative pulp blend for softwood: An optimization of kraft delignification process, *Ind. Crops Prod.*, **29**, 16-26 **(2009)**

10. Bhardwaj K.R., Potential use of an aquatic weed *Salvinia molesta* in paper industry, *Bulletin of National Institute of Ecology,* 145-151 **(2005)**

11. Goswami T., Kalita D. and Rao P.G., Utilization of certain forest weeds and agro-waste materials for pulp and paper making, *Proceedings of Papertech India*, 116-123 **(2008)**

12. Naithani S. and Pande P.K., Evaluation of *Lantana camara* L. stem for pulp and paper, *Indian Forester,* **135(8),** 1081-1087 **(2009)**

13. Dutt D. and Tyagi C.H**.,** Studies on *Ipomea carnea* and *Cannabis sativa* as an alternative pulp blend for softwood: Optimization of soda pulping process, *J. Sci. Ind. Res.,* **69(6),** 460-467 **(2010)**

14. Brindha D., Vinodhini S. and Alarmelumangai K., Fiber dimensions and chemical contents of fibers from *Passiflora foetida* L. and their suitability in paper production, *Sci. Res. Reporter,* **2(3),** 210-212 **(2012)**

15. Dutt D., Sharma A.K., Agnihotri S. and Gautam A. Characterization of Dog tooth grass and its

delignification by soda pulping process, *J. Sci. Tech.*,**1(8),** 434-447 **(2012)**

16. Oshima J., Yokota S., Yoshizawa N. and Ona T., Examinations of within tree variations and the heights representing whole tree values of derived wood properties for quasi-non-destructive breeding of *Eucalyptus camaldensis* and *Eucalyptus globulus* as quality pulpwood, *J. Wood Sci.,***51**,102-111 **(2005)**

17. Ashori A. and Nourbakhsh A., Studies on Iranian cultivated Paulownia- a potential source of fibrous raw material for paper industry*, Eur. J. Wood Prod.*, **67**, 323-327 **(2009)**

18. Jang H. F. and Seth R. S., Using confocal microscopy to characterize the collapse behavior of fibers, *Tappi J.*, **(81)5,** 167-174 **(1998)**

19. Xu F., Zhang F.C., Sun R.C. and Lu Q., Anatomy, ultrastructure and lignin distribution in cell wall of *Caragana korshinskii*. *Ind. Crops Prod.*, **24**, 186-193 **(2006)**

20. Ververis C., Georghiou K., Christodoulakis N., Santas P. and Santas R., Fiber dimensions, lignin, cellulose content of various plant materials and their suitability for paper production, *Ind. Crops Prod.*, **19**, 245-254 **(2004)**

21. Smook G.A. Handbook for Pulp and Paper Technologists, Angus Wilde Publications, Vancouver **(1997)**

22. Bektas I., Tutus A., Eroglu H,. A study of the suitability of Calabrian pine (*Pinus brutiaten*) for pulp and paper manufacture, *Turk. J. Agri. For.*, **23**, 589-599 **(1999)**