Preliminary Evaluation of Wiry love grass (Eragrosti atrovirens) for Pulp and Paper Production

O. Otitoju[1*], T.K. Fagbemigun[2], O.D. Fagbemi[3], E.Mgbachiuzor[4], C.C. Igwe[5]

Abstract: Perennial grasses have been identified as close substitutes for hardwood trees for pulp and paper making; Wiry love grass (Eragrostis atrovirens**)** is an erect, tufted perennial grass that grows up to 100 cm high which reproduces from seeds. It is also often found in bush re-growths and road sides. It is particularly abundant in Nigeria. The physico-chemical analysis of wiry love grass was determined using standard procedures for the determination of Cellulose, Hemi-cellulose and Lignin contents. The grass had cellulose and lignin contents of 49.2 and 19.5%, respectively. The pulp yield obtain using soda process, was 49.5%. The fibre length determined using Zeiss microscope was 1.41mm. The corresponding Kappa number was 12 and Ash contents obtained is 3.87%. These characteristics demonstrate the suitability of wiry love grass for pulp and paper production.

Key words *- Cellulose, fiber length, Pulp, paper, Soda pulp, Wiry love grass, lignin.*

1. INTRODUCTION

Wood has been largely, the conventional raw material for pulp and paper production [1]. In 2004, 70% of global wood fibre was from round wood and chips, the remaining 30% being from manufacturing or forest residues [2] This is on the backdrop of a projected global papermaking fibre consumption of 425 million tonnes by the year 2010. An estimated 2.5 million tons of new pulp production capacity are needed annually [4]. Until recently non-wood fibre was mainly produced in the developing world [5] and non-wood pulping capacity has been growing at a faster rate than wood pulping capacity [3]. Non-wood pulp capacity was estimated at 5% of total paper making capacity in 2004 [1]. A convergence of environmental concerns and wood fibre shortage constraints has led to an increase in non-wood fibre production even in seemingly forest rich regions like Canada and USA [6]. The renewed interest in non-wood fibre sources is not in vain because they offer several advantages in the pulp and paper industry. These include annual production in agricultural systems (renewable resource) compared to the long growth cycles for wood. Because of the lower lignin contents, chemical processes for non-wood pulping are generally more benign than with the pulping of wood sources [7][8]. Non-wood fibres can be used in every grade of paper and board, fibre board [3] [9] and composite materials [10]. However, compared to wood, non-wood fibres sources present challenges with their seasonal (and not year round) availability; handling, given their high-volume-low density and the large volumes of silica that have to be removed during processing [11]. Until now, there has not been any study concerning the investigation of using wiry love grass for pulp and paper making. Wiry love grass (*Eragrostis atrovirens*) is a wide spread weed of field of crops in the Savanna zone. It is often found in bush re-growths and road sides. It is particularly abundant in Nigeria. The objective of this study was to evaluate soda pulping characteristics and pulp properties of wiry love grass as alternative source for pulp and paper making.

Otitoju olawale has completed his M.Tech degree from Federal University of Technology Akure and is currently working as a research officer, Federal Institute of Industrial Research Oshodi Nigeria: +2347063923677. E-mail: olawaleotitoju@gmail.com.

T.K. Fagbemigun, O.D. Fagbemi, E.Mgbachiuzor, C.C. Igwe are currently working at, Federal Institute of Industrial Research Oshodi Nigeria.

2. MATERIAL AND METHODS

2.1. Chemical characterization of wiry love grass

The raw materials analyzes for cellulose, hemicelluloses and lignin: [13] was used. Procedure for chemical analysis: 2g of wiry love grass sample was weighed and boiled in 100ml of ethanol for (4 times) for 15min, washed thoroughly with distilled water and kept in an oven for dry weight at 40^0C over night, then divided into

two parts in which one part is considered as [A] fraction. Second part of the residue was treated with 24% KOH for 4 hours at 25 ^{0}C, washed thoroughly with distilled water dried at 80^{0}C over night and dry weight taken as [B] fraction. The same sample again treated with 72% H_2SO_4 for 3 hours to hydrolyze the cellulose and then reflux with 5% H_2SO_4 for 2 hours. H_2SO_4 was removed completely by washing it with distilled water, dried at 80^{0}C in oven for overnight and dry weight taken as [C] fraction.

Where,
Cellulose =B-C
Hemicelluloses = A-B
Lignin = C itself.

Ash, Alcohol-cyclohexane extractable, 1% alkaline solubility, cold and hot water extraction were carried out in accordance with the TAPPI Standard Methods (1992-1993); namely: T-211, T-204, T-212 and T-207, respectively [23]. The results of chemical characterization as percentage of the oven-dry weight sample has been presented in table 1.

2.2. Pulping study and Pulp Characterization

The air dried samples of the grass were cut into bits of 2 cm length and washed with water to remove adhering soil particles, air dried, and stored at less than 15% moisture content. Sub-samples of the grass, 50g weight were pulped using a 5% Sodium hydroxide (NaOH), using liquor to grass ratio of 5:1, excluding moisture. The cooking trials were carried out in 5 L pressure pot using soda pulping process and pulped at 100^{0}C, 80 KPa pressure for 1 hour. At the end of pulping, the pulps were fully washed with water to remove residual cooking liquor, pulp yield was determined as percentage of oven dry weight matter obtained on the basis of oven dried raw material. Accepted pulps were disintegrated by laboratory disintegrator for 15 min. The permanganate (Kappa) number was determined in accordance with TAPPI standard method, T 236 om-93 by [19]. Table 2 shows the result of pulp characterization.

2.3. Fibre Morphology

Fibre morphology was investigated using the method by [18]. Fibre length, fibre diameter, lumen width and cell-wall thickness were measured using a stage graticule and an eye piece micrometer under a Zeiss microscope (Standard 25) x 80 magnification. Twenty fibres were measured from fibre suspension to keep error below 5% and for a 95% confidence level. Table III shows the result of fibre morphology.

2.4. Laboratory paper sheet Formation

After thorough mixing of pulp, a hand paper sheet was formed on the paper mould which was sun dried for about four hours. After drying, the paper formed was carefully removed from the mould and then left on the sun for further drying. The strength properties of the hand sheets were determined using Instron universal testing machine (Testometric M500-25N) in accordance with TAPPI standard methods, T 494 om-96 was used [22].

3. RESULTS AND DISCUSSIONS

3.1. Chemical composition

Main chemical composition and some solubility values of the wiry love grass were determined. The results in table 1, show that wiry love grass contains cellulose and lignin content, of 49% and 19.5% respectively. Both cold and hot water extractives from wiry love grass were comparable with switch grass with values 1.91% and 3.80% respectively as reported by [12]. While the lignin content of the wiry love grass value is also comparable to all non-wood as reported by [8][9] of *Miscanthus* spp and various switch grasses. They are, however, higher than values reported for kenaf *Hibiscus* spp., 14.7%; [15]; 15%; [9] and lower than those of wood based materials 26 - 30%; [14].

Fig. 1: The results of Chemical properties

Chemical component	(%)
Ash	3.87
Cellulose	49.2
Hemi-Cellulose	22.1
Lignin	19.5
Extractives	
Cold water	2.15
1% Alkaline solubility	31.5
Hot water	4.25
Alcohol-cyclohexane extractable (1:2 v/v)	2.1

3.2. Pulping study and Pulp characterization

The results from Table II show that, the small amounts of rejects and the low kappa number obtained indicated that the soda pulping process provides adequate defibering. Wiry love grass produced quality pulp as indicated by a lower kappa number which indicates extent of delignification and hence completeness of pulping. The 49.5% pulp yield from wiry love grass is comparable to the one reported for Switch and Elephant grass values of 48 and 50% respectively by [12]. The higher pulp yield of almost 50% in wiry love grass is attributable to its low

lignin content and high alkali solubility according to [12] as reported for Elephant grass.

Fig. 2: The results of Pulp study and pulp characteristics

Parameters	*Values*
Total yield (%)	49.5
Rejects (%)	1.13
Kappa number	12

3.3. Fibre Dimensions

The average fibre length of wiry love grass was found to be 1.41mm which is longer than the average fibre length for hard wood with value of 1.25mm [17] .Its fibre diameter was found to be 8.56µm. These results are presented in table 3. These properties depend on some factors which include maturity of the plant, soil conditions and geographical location [16]. Their values determine the strength properties of the paper sheets produced from the source.

Fig. 3: The results of Fibre Characteristics

Parameters	*Dimension*
Fibre length (mm)	1.41 ± 0.5
Fibre diameter (µm)	8.56 ± 3.2
Lumen width (µm)	4.09 ± 2.3
Cell wall thickness (µm)	2.23 ± 1.8

3.4. The Strength properties of hand sheet.

The results of the strength properties of the sample sheets in table IV shows, that average tear resistance for love wiry grass was 106.00Nm which is lower than silk cotton tree 956.48Nm as reported by [21]. The tear factor was found to be 172.53m² which is greater than the minimum standard of The Nigeria Paper Mill, Jebba, Kwara state Nigeria which is 120m² [20]. Hence all its paper products are good for writing and printing applications. However, the tensile strength index of wiry love grass was found to be 1.506Nm/g which is lower than silk cotton tree 9.20Nm/g [21].

Fig. 4: The results of hand sheet Strength properties.

Parameters	*Values*
Tearing resistance (Nm)	106
Basis weight (g/m²)	6.144
Breaking weight (N)	1.850
Tensile strength (Nm/g)	15.06
Tear factor (m²)	172.53
Modulus of elasticity	467.65

4. CONCLUSION

Wiry love grass was evaluated for the production of pulp and papers. The results showed that it has cellulose and hemicelluloses content, of 49% and 22%, respectively, short fibre length of 1.41 mm And low lignin content of 19.5%. This study has established the feasibility of using wiry love grass as a good source of raw materials for pulp and paper production.

Acknowledgement

We would like to appreciate the input of all members of the task force; we would especially like to thank entire management of Federal Institute of Industrial Research Oshodi, for the provision of grant for this research work.

5. REFERENCES

1. Smook GA (1992). Handbook for pulp and paper technologists, 2nd ed.,p. 210. Vancouver, Canada, Angus Wilde Publications.

2. Sececa Creek Associates (SCA), Wood Resources International (WRI)(2007). Wood paper: Fiber sourcing in the global pulp and paper industry. Paper prepared for American Forest and Paper Association. December, 2007 Rev.

3. Hurter WR (1998). Will Non woods Become an Important Fiber Resource for North America? Presented at the 1998 world wood summit, Chicago, Illinois. http:// www. hurterconsult.com/ north_america_nonwoods_.htm

4. Lammi M (2006). Pulp production growing in new areas. Index (Metso Investor Magazine) 1(200): 16-32.

5. Forest products year book. 1983-1994. FAO For. Series No. 29. FAO, Rome, Italy FAO (1994).

6. Kissinger M, Fix J, Rees WE (2006). Wood and non wood pulp production: Comparative ecological foot printing on the Canadian prairies. Ecol. Econ., 62: 552-558.

7. Paavilainen L (1994). Fine paper from certain grass species. Paper presented at the Non-wood Fibres for Industry Conference. Pira Int. Silsoe Res. Inst. Joint Conf. Pira Int. Leatherhead, Surrey, UK.

8. Madakadze IC, Radiotis T, Li J, Smith DL (1999). Kraft pulping characteristics and pulp properties of warm season grasses. Bioresource Technol., 69: 75-85.

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

10. Sain M, Panthapulakkal S (2006). Bioprocess preparation of wheat straw fibers and their characterization. Ind. Crops. Prod., 23: 1-6.

11. Pande H (1998). Non-wood fibre and global fibre supply. Unasylva. 193 (49): 2- Global fibre supply. FAO.

12. I. C. Madakadze T. M. Masamvu, T. Radiotis, J. Li and D. L. Smith.(2010), African Journal of Environmental Science and Technology Vol. 4(7), pp. 465-470.

13.Moubasher M.H, Abdel-Hafez S.H, Abdel-Fattah and Mohanram A.M (1982). Direct estimation of cellulose, Hemicellulose and Lignin. J.Agricu. Res.46.1467-1476.

14. Moore G (1996). Nonwood fibre applications in paper making. Pira Int., Surrey, United Kingdom.

15. Mittal SK (1990). Processing of kenaf as fibrous raw material for paper making marketable grade pulp. A pulp mill's experience in Thailand. Proceedings of the workshop on kenaf pulping and alkaline paper making. Dec 1990. Bangkok, Thailand.

16. James P. Casey (1980) Pulp and Paper Chemistry Technology, volume1, John Wiley and Sons, New York pp 402,534,626,&665.

17. Hurter, RW (2006) Agricultural Residues TAPPI Nonwood Fibres Short Courses Note, Hurter Consult Incorporated.

18. Jorge G, Quilho T, Pereira H , Variability of fibre length in wood and back in Eucalyptus globules, IAWA journal, 2000-bio, keleuven. Be (1999) 21(1):4148.

19.Tasman, J. E., and Berzins, V. (1957)."The Permanganate Consumption of Pulp Materials," *Tappi* **40** (9): 691 (1957); *Pulp Paper Mag. Canada* **58**(10): 145

20.The Nigeria Paper Mill Limited, Jebba , Laboratory Manual, Jebba (1991).

21. Ibrahim .H, Bugaje I.M., Famuyide O.O. and Mohammed I.A, Scholarly Journal of Agricultural Science . (2012.) Vol. 2(12), pp. 303-308.

22.Van den Akker, J. A., and Hardacker, K. W. (1958). "Instrument Studies. LXXXI. The Automatic Recording of the Load Elongation Characteristics of Paper. III. The Table Top Model Instron (Universal Testing Machine)," *Tappi* **41** (8): 224A .

23. Technical Association of Pulp and Paper Industries. Test Methods 1992-1993. TAPPI Press, Atlanta, Georgia. TAPPI (1992).