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RESEARCH ARTICLE

COMMERCIAL AND FIELD FACTORS OF SELECTING KENAF FIBERS AS ALTERNATIVE MATERIALS IN INDUSTRIAL APPLICATIONS

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ABSTRACT

This work was carried out from 15 July 2021 in Grdarasha Field, College of Agricultural Engineering Sciences, Salahaddin University-Erbil. It aims to show the impact of using kenaf fibers as alternative materials in manufacturing. Global climate change and environment pollution cause to do this kind of researching. Kenaf (*Hibiscus cannabinus* L.) is a fast growing natural crops, belongs to the Malvaceae family. It is an industrial crop has high potential for cultivation in a tropical climate and also which resistance to various soil types and climate. Selecting the raw materials for industrial applications is more important. Actually, kenaf fibers have many advantages to use in wade range of applications, also it's fibers not just a part of plant useful as raw material but also leaves and seeds have many other advantages and uses. The results show that there is a significant between varieties on growth and fiber yield properties. The highest plant high was of FH952 by (368.33 cm), while the best values of total fresh and dry stem yields were found of HC2 and V36, by almost (219.33 and 60.93 t/ha), respectively. Providing these results through kenaf plant could be considered as substitute materials for timber and other biocomposite manufactures, and also it causes to safe environment by absorption optimal value of carbon dioxide (CO_2), then cutting of woodland trees will be decreased. Finally recommended to cultivation fiber crops (kenaf) globally to conserve environment.

KEYWORDS

kenaf, growth, yield, economy, ecology, manufacturing.

1. INTRODUCTION

Protect environment can be done by producing goods that can minimize damage to the environment. Biocomposite is produced using natural or semi-natural materials, therefore it can easily be disposed, thus, minimize harm to the environment. Kenaf is selected as an extra substitute material for making biocomposite since of its fast growing characteristics which creates it capable to deliver a great volume of raw material in a short period of time. People should encourage to respond to the government's call on green technology in order to preserve the environment (Kamal, 2014).

A researcher stated that kenaf stem can replace rubber wood particles up to 50% but the resin level must be kept at 10% or more because lower resin level (⩽8%) significantly decrease strength of the particleboard (Paridah *et al.,* 2014). Particleboard produced of kenaf stems is better than produced of bast fiber or core fiber alone. (Juliana *et al.,* 2012). Additionally, kenaf fibers were used of manufacturing medium density fiberboard (MDF), (Aisyah *et al.,* 2013).

A previous researcher stated that, market for kenaf is still uncertain. It is because this crop is very new in Malaysia, but luckily it has potentials to be commercialized as biocomposite which can be used for many industrial purposes (Kamal, 2014). Previous published studies have established that kenaf biocomposite is appropriate to be used as automotive components (Chen *et al.,* 2005; Qatu, 2011). With that impacts of woven kenaf composites for applying in automotive structural studies in Malaysia, but unfortunately they are still far from commercialization (Lee *et al.,* 2021). Thus, the outstanding mechanical properties that come with an untreated kenaf composite, suggest a useful alternative material for automotive parts generation such as dashboard and door panel (Radzuan *et al.,* 2020).

Substitution for industrial wood chips by kenaf core chips or bast fibers in experimental particleboards showed that in some cases the new products may be comparable to those made from pure industrial wood chips and therefore they may satisfy the applied standards and be accepted in the market (Grigoriou *et al.,* 2000a,b).

A group of researchers concluded that, kenaf can be planted as a major crop since their fibers have potential impact to be used as feedstock and as forage crops (Salih and Qader, 2020). Studies showed that the kenaf plant had the optimal CO_2 absorption among the other crops. It can absorb 1.5 times the carbon dioxide by its weight (Mohanty *et al.,* 2005). Moreover, the quantity of CO_2 would be reduced in the atmosphere by using kenaf fibers in concrete. However, using natural fibers as an alternative for concrete reinforcement is of interest not only due to increasing ductility and versatility of the material but also from an environmental perspective (Baghban and Mahjoub, 2020).

2. MATERIAL AND METHODS

2.1 Materials

Three kenaf varieties were selected as plant materials in this current study; FH952, V36, and HC2. Seeds for all varieties were provided by the Institute of Tropical Forestry and Forest Production (INTROP) at the

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Universiti Putra Malaysia (UPM). Additionally, chemical fertilizer as NPK was added as basal fertilizer.

2.2 Methods

2.2.1 Location

This study was conducted at Grdarasha Field, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, which is located at (Latitude 36. 10116 N and Longitude 44.00925 E), and elevation of 415 meters above sea level. Figure 1 shows the geographical location of the study site.

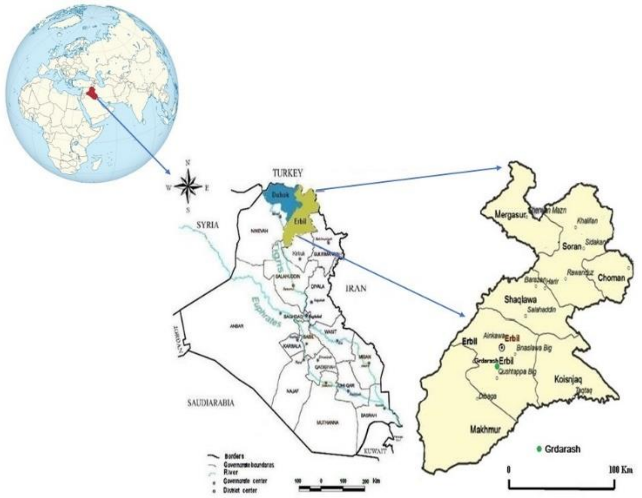

Figure 1: Geographical location of the study

2.2.2 Experimental design

Randomized Complete Block Design (RCBD) was applied as experimental design with three replications. Seeds of three kenaf varieties were selected as mentioned earlier and then sowed on 15 Jun 2021, in the depth of (2-3 cm). The plot size was 1m², distance between plants was about 10 cm, while between row to row just 30 cm, which was plant density 400000 plants/ha. 15g/m² of NPK fertilizer was added to each plot as basal fertilizer on 2 August 2021.

2.2.3 Sampling method

Five plants were randomly selected from each treatment plot, which were manually harvested on 20 November 2021. Next, growth and fiber yield were determined. Field stick measuring devices was used to measure plant height at the end stage of plant growth, stem diameter was measured by using digital caliper from 10 cm above of the ground surface. Stem, bast and core fibers were sun dried, which was indirectly as can be seen in (Figure 2).

Figure 2: Stem, bast and core fibers were sun dried

2.3 Data analysis

Data on plant growth (plant height and stem diameter), and also yield parameters such as; total fresh and dry stem yield, fresh and dry core fiber yield, and fresh and dry bast fiber yield were subjected to Analysis of Variance (ANOVA) by using SPSS Statistics (IBM SPSS Statistics 21). Least Significant Difference (LSD) at P ≤ 0.05 was used to perform the mean comparison.

3. Results and Discussion

3.1 Growth parameters

Plant height and stem diameter were significantly changed between varieties (Table 1). The highest plant high was recorded by 368.33 cm of FH952 variety, followed by V36 and HC2 (351.67 and 340.67 cm), respectively (Figure 3). Results of this current study strongly supported by (Salih *et al.,* 2014a). This was also in accordance with the study of a previous researcher which stated that different kenaf varieties have different height level (Agbaje *et al.*, 2008). Conversely, the biggest stem diameter was recorded by HC2 (31.64 mm), while smallest stem diameter was found of FH952 by (26.95 mm), (Figure 3).

Table 1: The analysis of variance (ANOVA) for the effect of varieties on the growth and fiber yield parameters of kenaf plant

Growth and yield parameters													
				PH		**SD**		**TFY**		**TDY**			
V	**DF**	**MS**	**F.V**	**P.V**	**MS**	**F.V**	**P.V**	**MS**	**F.V**	**P.V**	**MS**	**F.V**	**P.V***
	2	0.06	5.69	0.041	19.32	5.77	0.04	101.67	0.19	0.83	58.72	1.10	0.39
	2	20.25	2.05	0.17	0.44	0.46	0.51	0.03	0.12	0.73	13.44	1.23	0.28
	2	56.25	5.69	0.03	5.76	5.94	0.02	0.00	0.01	0.95	75.11	6.85	0.02
				FCY		**DCY**		**FBY**		**DBY**			
	DF	**MS**	**F.V**	**P.V**	**MS**	**F.V**	**P.V**	**MS**	**F.V**	**P.V**	**MS**	**F.V**	**P.V**
V	2	439.27	2.78	0.14	31.22	1.00	0.42	92.39	1.50	0.30	5.14	1.24	0.35

*Significant at 5%, when p-value less than 0.05 (typically ≤ 0.05).

**V= Variety (FH952, V36, HC2), PH= Plant height, SD= Stem diameter, TFY= Total fresh yield, TDY= Total dry yield, FCY= Fresh core yield, DCY= Dry core yield, FBY= Fresh bast yield, DBY= Dry bast yield, DF= Degrees of freedom, MS= Mean square, F.V= F. value and P.V= P value.

Growth and field characteristics of fiber crops especially bast fiber; kenaf, jute, and hemp are mostly important when using their fibers of industrial applications, since its affect to amount of bast and core fibers are collecting from them. Additionally, healthy growth could cause to quality augment and also end uses (Salih, 2016). Both growth characteristics plant high and stem diameter directly affected to yield parameters. Here could ask, which one is more effective? Generally, together may better, but from these results other answer may found (Figures 4-6). Additionally, increasing each other may causes to choose kenaf plant as alternative material in industrial applications.

Beside of these characteristics, rapidly growing of kenaf plant and its resistance to various soil types and climate which is encourage farmers to growing kenaf. Several months only are enough to decide of harvesting kenaf plants, while the lowest time of cutting any trees to convert to timber may need to several years. All of these field factors enhanced kenaf positions' and then could become the best source of raw material in wide range of manufacture processing. Results of a study were also helpful for the application of kenaf residues in the wood composites industry (Xu et al., 2013). Additionally, they concluded that a potential alternative material for wood in manufacturing composite boards is kenaf core fiber.

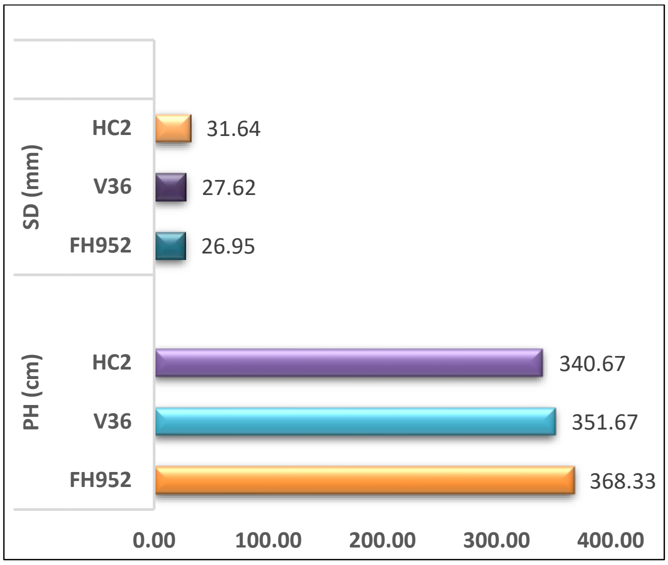

Figure 3: Effect of variety on plant height and stem diameter

3.2 Fiber yield parameters

High amount of total stem, core and bast fiber yield and their physical and mechanical characteristics of kenaf are helpful to convention it's fibers to biocomposite. Figure 4 shows influence of variety on total fresh and dry stem yield (bast and core), the highest amount of these characteristics were recorded of HC2 was almost (219.33 t/ha) of TFY, while the highest amount of TDY was found by V36 variety (57.33 t/ha). These results are in agreement with a study that determined HC2 variety had the maximum value of fiber yields as compared to the other varieties were studied (Hossain *et al.*, 2011). These results of fiber yield showed that all varieties applicable as fundamental stuff compared to forest trees. Which refers to a broad set of realization about the valuable of kenaf plant economically and ecologically for production of fibers differentiation to forest tree.

Additionally, the best results of core and bast fiber yield were recorded by V36 variety which were (109.07, 43.07, 63.73 and 17.60 t/ha), for fresh and dry core and bast fiber yields respectively (Figures 5 and 6). Based on these results, could say that V36 was better to obtain of high fiber yield than both varieties in this current study.

High quantity of production is not enough but also how to get of it is important. Which mean that, how to reduce manufacturing/production costs of proper time environmentally. As known that, world climate change is the biggest issues requested to find appropriate solving way to safe and renew environment globally. Forest protection is necessary since decrease and lost each tree meaning that rise carbon dioxide (CO_2), and then causes to climate pollution as can be seen globally. So, the best way for that purpose is encouraging farmers to growing natural fibers especially kenaf, jute and hemp. Next, the most obviously point is a create rule globally for factors and companies to use these natural fibers as alternative materials. Results from this current study should be focused by researchers and scientists to develop this kind of natural fibers because of its important which known as ecofriendly fibers. For example, beside of rainforest protection, kenaf plant absorbs CO_2 from the atmosphere more than any other crop, about 1.5 tons of CO_2 seems sufficient in order to produce 1 ton of dry matter of kenaf. It means that each hectare of kenaf consumes 30 to 40 t of CO_2 per growing cycle (Kimball and Idso, 1983).

17.60 t/ha just dry bast fiber, which is not low value (Figure 6). Furthermore, dry core fiber around (43.07 t/ha) figure 5, and total dry stem yield was (60.93 t/ha), while total fresh stem yield for each variety was above (200 t/ha), (Figure 4). That is on the time, kenaf plant is a faster growing crop as previously mentioned, so in some countries can produce it twice in the year.

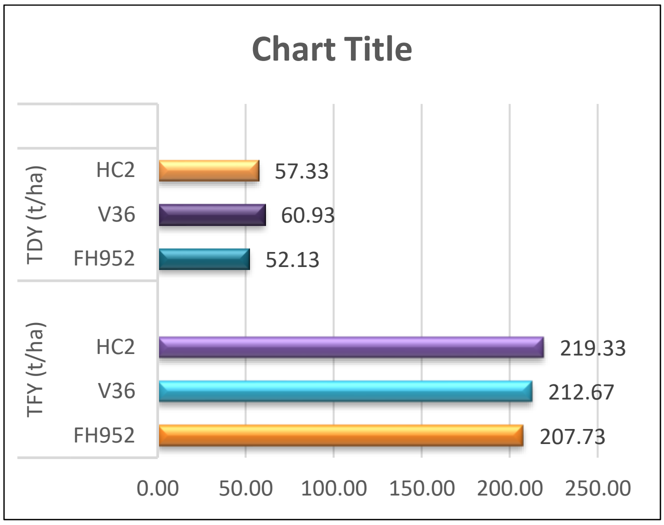

Figure 4: Effect of variety on total fresh and dry stem yield

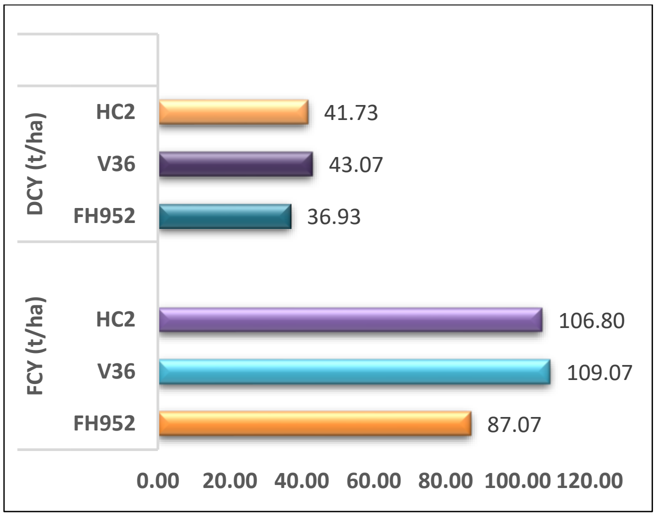

Figure 5: Effect of variety on fresh and dry core fiber yield

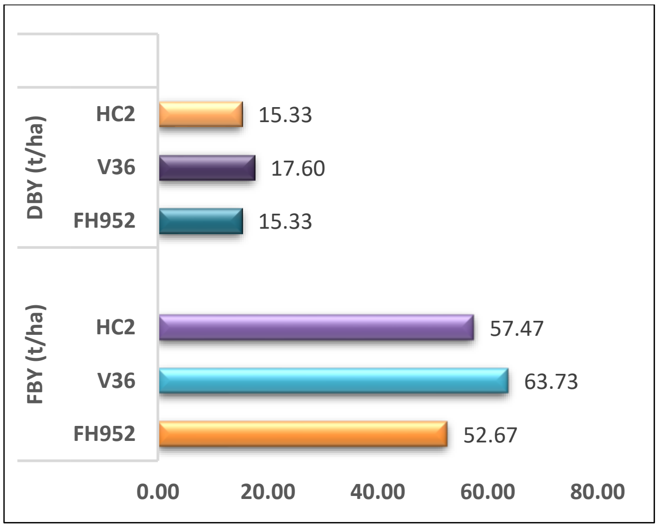

Figure 6: Effect of variety on fresh and dry bast fiber yield

On the other side, as known *Paulownia spp*. is a fast growing woody crops is a very important source for the generation of the bioenergetics biomass, and which multiple values and high adaptability with climate conditions (Icka *et al.*, 2016). Each paulownia tree after (5 to 7) years old can generate 1 m^3 timber in a surface with density of (2000 plants/ha), offering a total production of (330 t/ha), (Ates *et al.*, 2008). However, in 1974 the trees had grown with average dbh of 30.1 cm, 13.5 m height, 0.3927 m^3 individual timber volume with 400 trees per hectare totaling 153.2 m^3/timber volume/ha (Rao, 1986). Alongside of paulownia tree, populus and also eucalyptus trees were taken to comparison with kenaf plant.

Table 2 displays the natural fibers are consumption globally to product timber and biocomposite. Based on the data from this table could say that kenaf plant was prevailing on all trees about the water requirements, time of harvesting and then dry matter production.

In other point, cutting forest trees adds carbon dioxide, and then back into the atmosphere which is the main cause of climate change and rise temperature. As a researcher reported that, high concentration of carbon dioxide (CO_2) leads to increase the atmospheric temperature which will have many impacts on plant (Banwart, 2011). Furthermore, this stated from this current study strongly confirmed by a previous researcher whose reported that, the fiber yield increased 52 to 56%, when the plant was treated with doubling CO_2 in open field plot and growth chamber (Campbell et al., 2010). Also, atmospheric temperature effects on the fiber yield. So, it means that if cultivation of natural fibers increased the CO_2 absorption will be increased directly.

Many individual actions considerate worldwide to decrease global warming, but the great effort here is how to collective these actions to stop this issue. Believed that, cultivation natural fibers as kenaf plant is a key to bright the way ahead of not only researchers and scientists, but also of factors and companies due to many advantages as previously mentioned.

Table *2*: Comparison between plant density, water requirements, time of harvesting and dry matter/biomass production of Kenaf, Paulownia, Populus and Eucalyptus

Crops/Tree	Population Plant/ha	Water required mm or liters	Harvesting time	Production t/ha	References
Kenaf	400000-600000	780–1200mm	3-5 months	17-60 DM*	Current study; Bañuelos *et al.* (2002); Danalatos and Archontoulis (2010); Basri *et al.* (2014); Salih *et al.* (2014b); Salih (2016); Salih and Qader (2020)
Paulownia	2000	2000 L/tree	5-7 years	330**	Ates *et al.* (2008); García-Morote *et al.* (2014)
Populus	1111-5425	440,000 L/ha	10 years	146***	Fang *et al.* (2007); Bañuelos *et al.* (1999)
Eucalyptus	1666	20-30 L/tree/day	2.5-3.5 years	23.4-163.9***	Lima (1984); Quartucci *et al.* (2015)

*DM= Dry matter production (Stem).

** Each Paulownia tree aged 5-7 years old can generate 1 m^3 timber in a surface with density of 2000 plants/ha, offering a total production of 330 t/ha.

***At 10 years, the highest total biomass in the plantation of 1111 stems/ha, reached about 146 t/ha. Additionally, 5425 Populus trees/ha (>1.6 m^2 per tree), 440,000 L/ha of water are minimally necessary to grow this number of trees for the first 3 months under Iowa conditions (water usage would be far greater under growing conditions in Central California).

**** The density of 1666 plants per hectare, harvest was also carried out at the age of 7 years. Total biomass produced (23.4-163.9 t/ha), of the age of 1-7 years old.

4. Conclusion

Nowadays, recover and renew environment is really necessary, so climate change and global warming are the great issue should be concerned by the researchers, so this current study investigated to find other natural sources as alternative raw material usage in industrial applications, which was to reduce global warming problems by avoiding of cutting trees. Results were showed that, growth and fiber yield/dry matter of all varieties of kenaf plant could be considered as alternative materials and then it will be the best strategies to prevent deforestation.

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References

Agbaje, G.O., Saka, J.O., Adegbite, A.A., & Adeyeye, O.O., 2008. Influence of agronomic practices on yield and profitability in kenaf (*Hibiscus cannabinus L.*) fibre cultivation. African Journal of Biotechnology, 7(5).

Aisyah, H.A., Paridah, M.T., Sahri, M.H., Anwar, U.M.K., & Astimar, A.A., 2013. Properties of medium density fibreboard (MDF) from kenaf (*Hibiscus cannabinus L.*) core as function of refining conditions. Composites Part B: Engineering, 44(1), pp. 592-596.

Ates, S., Ni, Y., Akgul, M., & Tozluoglu, A., 2008. Characterization and evaluation of Paulownia elongota as a raw material for paper production. African journal of biotechnology, 7(22).

Baghban, M.H., & Mahjoub, R., 2020. Natural kenaf fiber and LC3 binder for sustainable fiber-reinforced cementitious composite: a review. Applied Sciences, 10(1), pp. 357.

Bañuelos, G.S., Shannon, M.C., Ajwa, H., Draper, J.H., Jordahl, J., & Licht, J., 1999. Phytoextraction and accumulation of boron and selenium by poplar (Populus) hybrid clones. International Journal of Phytoremediation, 1(1), pp. 81-96.

Bañuelos, G.S., Bryla, D.R., & Cook, C.G., 2002. Vegetative production of kenaf and canola under irrigation in central California. Industrial crops and products, 15(3), pp. 237-245.

Banwart, S., 2011. Save our soils. Nature, 474(7350), pp. 151-152.

Basri, M.H.A., Abdu, A., Junejo, N., Hamid, H.A., & Ahmed, K., 2014. Journey of kenaf in Malaysia: A Review. Scientific Research and Essays, 9(11), pp. 458-470.

Campbell, B.T., Saha, S., Percy, R., Frelichowski, J., Jenkins, J.N., Park, W., Mayee, C.D., Gotmare, V., Dessauw, D., Giband, M., & Du, X., 2010. Status of the global cotton germplasm resources. Embrapa Recursos Genéticos e Biotecnologia-Artigo em periódico indexado (ALICE).

Chen, Y., Chiparus, O., Sun, L., Negulescu, I., Parikh, D.V., & Calamari, T.A., 2005. Natural fibers for automotive nonwoven composites. Journal of Industrial Textiles, 35(1), pp. 47-62.

Danalatos, N.G., & Archontoulis, S.V., 2010. Growth and biomass productivity of kenaf (*Hibiscus cannabinus L.*) under different agricultural inputs and management practices in central Greece. Industrial Crops and Products, 32(3), pp. 231-240.

Fang, S., Xue, J., & Tang, L., 2007. Biomass production and carbon sequestration potential in poplar plantations with different management patterns. Journal of environmental management, 85(3), pp. 672-679.

García-Morote, F.A., López-Serrano, F.R., Martínez-García, E., Andrés-Abellán, M., Dadi, T., Candel, D., Rubio, E., & Lucas-Borja, M.E., 2014. Stem biomass production of Paulownia elongata× P. fortunei under low irrigation in a semi-arid environment. Forests, 5(10), pp. 2505-2520.

Grigoriou, A., Passialis, C., & Voulgaridis, E., 2000a. Experimental particleboards from kenaf plantations grown in Greece. Holz als Roh-und Werkstoff, 58(5), pp. 309-314.

Grigoriou, A., Passialis, C., & Voulgaridis, E., 2000b. Kenaf core and bast fiber chips as raw material in production of one-layer experimental particleboards. European Journal of Wood and Wood Products, 58(4), pp. 290-291.

Hossain, M.D., Hanafi, M.M., Jol, H., & Jamal, T., 2011. Dry matter and nutrient partitioning of kenaf (*Hibiscus cannabinus L.*) varieties grown on sandy bris soil. Australian Journal of Crop Science, 5(6), pp. 654-659.

Icka, P., Damo, R., & Icka, E., 2016. Paulownia tomentosa, a fast growing timber. Ann. Valahia Univ. Targoviste, Agric, 10(1), pp. 14-19.

Juliana, A.H., Paridah, M.T., Rahim, S., Azowa, I.N., & Anwar, U.M.K., 2012. Properties of particleboard made from kenaf (*Hibiscus cannabinus L.*) as function of particle geometry. Materials & Design, 34, pp. 406-411.

Kamal, I.B., 2014. Kenaf for biocomposite: an overview. Journal of Science and Technology, 6(2).

Kimball, B.A., & Idso, S.B., 1983. Increasing atmospheric CO_2: effects on crop yield, water use and climate. Agricultural water management, 7(1-3), pp. 55-72.

Lee, C. H., Khalina, A., Nurazzi, N. M., Norli, A., Harussani, M. M., Rafiqah, S., ... & Ramli, N. (2021). The challenges and future perspective of woven kenaf reinforcement in thermoset polymer composites in malaysia: A review. Polymers, 13(9), pp. 1390.

LIMA, W.P., 1984. The hydrology of eucalypt forests in Australia. IPEF (Piracicaba), 28, pp. 11-32.

Mohanty, A.K., Misra, M., & Drzal, L.T. eds., 2005. Natural fibers, biopolymers, and biocomposites. CRC press.

Paridah, M.T., Juliana, A.H., El-Shekeil, Y.A., Jawaid, M., & Alothman, O.Y., 2014. Measurement of mechanical and physical properties of particleboard by hybridization of kenaf with rubberwood particles. Measurement, 56, pp. 70-80.

Qatu, M.S., 2011. Application of kenaf-based natural fiber composites in the automotive industry (No. 2011-01-0215). SAE Technical Paper.

Quartucci, F., Schweier, J., & Jaeger, D., 2015. Environmental analysis of Eucalyptus timber production from short rotation forestry in Brazil. International Journal of Forest Engineering, 26(3), pp.225-239.

Rao, A.N., 1986. Paulownia in China: cultivation and utilization.

Radzuan, N. A. M., Tholibon, D., Sulong, A. B., Muhamad, N., & Haron, C. H. C. (2020). New processing technique for biodegradable kenaf composites: A simple alternative to commercial automotive parts. Composites Part B: Engineering, 184, pp. 107644.

Salih, R.F., 2016. Influence of Potassium, Boron and Zinc on Growth, Yield and Fiber Quality of Two Kenaf (*Hibiscus cannabinus L.*) Varieties.

Salih, R.F., & Qader, N.A., 2020. Environmental Effect on Growth and Yield Parameters of Ten Kenaf Varieties (*Hibiscus cannabinus L.*) in Erbil. Zanco Journal of Pure and Applied Sciences, 32(4), pp. 169-173.

Salih, R.F., Abdan, K., & Wayayok, A., 2014a. Growth responses of two kenaf varieties (*Hibiscus cannabinus L.*) applied by different levels of potassium, boron and zinc. Journal of Agricultural Science, 6(9), pp. 37-45.

Salih, R.F., Abdan, K., Wayayok, A., & Hashim, N., 2014b. Effect of potassium, boron and zinc on nitrogen content in bast and core fibers for two kenaf varieties (*Hibiscus cannabinus L.*). International Journal of Development Research, 4(12), pp. 2581-2586.

Xu, X., Wu, Q., & Zhou, D., 2013. Influences of layered structure on physical and mechanical properties of kenaf core particleboard. BioResources, 8(4), pp. 5219-5234.