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The ecophysiological response of Bombax ceiba L. to soil of industrial areas

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ABSTRACT

The knowledge about the ecology and relationship among plant-soil is required to increase the vegetation cover around the industrial units. However, no information is available about this aspect on seedling growth performance of commercially important timber tree, *B. ceiba*. This study was designed with the purpose to record the effects of soil of different industrial areas on seedling growth performances of *B. ceiba* in pot culture. The comparison of the results showed variable effects on plant height, cover, leaf size, seedling dry and fresh weight of *B. ceiba* raised in different industrial soil variably affected due to industrial activities. The assessment with the treatment of soils of Universal Chemicals showed maximum reduction in plant height and leaf area of *B. ceiba*. The treatment of National Foods Ltd. soil positively increased the growth for *B. ceiba*, as it may contain more nutrient supply required for proper growth of *B. Ceiba*. It was concluded that the soil of Universal Chemicals factory was found less favorable for growth variables of *B. ceiba*. The findings suggests that the plantation of *B. ceiba* around the industrial units would be helpful in increasing the vegetation cover.

Contribution/Originality: Industrial activities polluting the immediate environment. In recent years the indiscriminate discharge of different types of pollutant from industrial units are deteriorating the quality of soil and affecting plant growth. The pollutants from industrial activities accumulating in soil of the area and playing an important role in changing the soil properties and plant growth.

1. INTRODUCTION

Bombax ceiba L. (Bombacaceae) is an attractive promising tree and known as cotton or sumbal. It is found in tropical, subtropical and many countries, Philippines, Australia, Indonesia, and Malaysia including Pakistan. The wood is famous for furniture and silky cotton is for mattresses, seed oil, ethanol, quilts and splints [1-5] and stem bark have seven aromatic compounds likewise simalin and B, shamiminol [6]. Its branches (4-5 in each) are found in whorls [7] and used in match box and plywood industry which make it an industrial crop. *B. ceiba* is used for treatment of cough [8] and as traditional medicine in Asin countries [9]. *B. ceiba* is reported to grow on dry and moist soil [10]. *B. ceiba* is also considered a suitable species for municipal greening and minimizing the determinately effect of air pollution [11-13]. *B. ceiba* can grow in harsh climatic conditions i.e. in dry valleys or used as fuel [14, 15]. The soil provides nutrients and water for the maintenance of plant life [16]. The studies of plant and soil interactions play key role for restoration ecology and plant growth. The interaction of soil and plant can play a major tool for the growth of invasive species and varies from place to place according to prevailing climatic conditions [17, 18]. *B. ceiba* is a common deciduous tree and indigenous to Pakistan and found in Punjab and Sindh [19, 20]. Many studies have been founded on plant soil relation and influence on seedling growth. The literature on the soil plant relationship for *B. ceiba* in Pakistan is not available. The study aims to experimentally to find out the role of industrial area soil on seedling of and economically and ecologically important multipurpose fast growing tree species, *B. ceiba*.

2. MATERIALS AND METHODS

This experiment was carried out in the greenhouse of the Department of Botany, University of Karachi's Pakistan. The composite soil samples were taken from 30 cm depth from five location of A = Karachi University Campus; B = Indus Battery factory; C = Universal Chemicals Factory; D = Haroon Textile Factory and E = National Foods Limited for testing the seedling growth performances experiments.

2.1. Seedling Growth Experimental Design

The seeds of *B. ceiba* were collected from this species growing in University Campus and sown in a garden soil at 1.00 cm depth in earthen pots. The germinated seedlings of same size were transferred to plastic pots of 20 cm in diameter and 9.8 cm in depth. One seedling was planted in each pot for different soil treatment and the plants were watered regularly. Every week the rearrangement of pots was changed to prevent any chance of greenhouse effects. The experiment was completely randomized with five replicates for each soil treatment.

2.2. Measurements / Reading of Seedling Growth Characteristics

The seedling growth parameters in term of root, shoot, leaves number, plant cover was recorded at the end of experiment. The treated seedlings were removed carefully from the pots. The harvested seedlings were washed with tap water to remove soil particles. The seedlings were dried in an oven at for 24 hours at 80 °C for the determination of their seedling dried weights.

The seedling growth data were statistically analyzed with one-way Analysis of Variance (ANOVA) by SPSS version 13.0 software. Duncan Multiple Range Test was used to assess the level of significance differences within each experimental treatments at $p<0.05$ level and analysis of correlation among growth with soil worked out.

3. RESULTS AND DISCUSSION

The application of different industrial soil types T1-T5 showed variable response to seedling growth and seedling dry weight of *B. ceiba* shown in Table 1 and Table 2 and Figure 1 and Figure 2. The seedling height, number of leaves and seedling dry weight performance of *B. ceiba* was found highest and best out come in soil treatment T5 with comparison to treatments of control T1 as compared to other area soil.

Table 1. The effects of industrial area soil on in terms of seedling growth and biomass production of Bombax ceiba.

Treatments	Root length (cm)	Shoot length (cm)	Seedling height (cm)	Plant cover (cm)	Number of leaves	Total plant dry weight (g)
T1	5.66±0.13b	13.34±0.40b	19.00±0.52b	37.92±5.25ab	7.80±0.66c	0.47 ± 0.02b
T2	5.74±0.46b	14.68±0.69b	20.42±1.09b	29.80±3.55b	11.40±0.75b	0.51 ± 0.02b
T3	4.60±0.22c	11.56±0.40c	16.16±0.56c	29.42±1.15b	12.80±0.86b	0.49 ± 0.03b
T4	5.94±0.10b	14.18±0.34b	20.12±0.27b	33.96±1.70b	18.40±1.36a	0.50 ± 0.03b
T5	7.10±0.22c	20.00±0.62a	27.10±0.70a	45.06±3.53a	20.00±1.41a	0.72 ± 0.01a
L.S.D. (p<0.05)	0.76	1.49	2.01	9.95	3.12	0.07

Note: Symbols: [Soil sampling site T1 = Karachi university campus; T2 = Indus battery factory; T3 = Universal chemicals factory; T4 = Haroon textile factory; T5 = National foods factory]. Means followed by the same letter in the same column are not significantly different according to Duncan Multiple Range test at $p<0.05$ level. ± Standard error, L.S.D. Least significant difference.

For the different soil treatments T3 soil generally showed a highly significant reduction in seedling dry weight of *B. ceiba* and threatened growth performance with relative to control Table 1. Industrial activities have strong environmental impact on germination and plant growth. The obtained results demonstrated a different resistance to some growth characteristics of *B. ceiba* in soils of different industrial areare. A higher value in number of leaves of *B. ceiba* was exhibited with the T5 treatment soil. Previously studies illustrated that the industrially polluted soil of mining area influenced on needles and tree ring of pine [21].

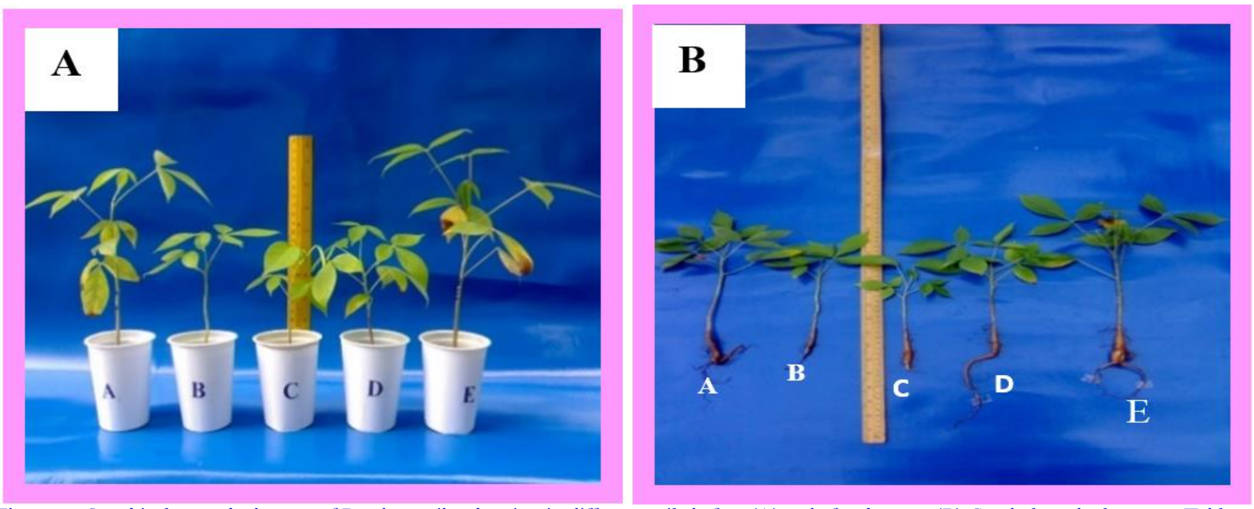

Figure 1. Graphical growth abstract of Bombax ceiba showing in different soils before (A) and after harvest (B). Symbol used: please see Table 1.

This study successfully approach and provides the beneficial improvement and hazardous role of *B. ceiba* seedlings raised in industrial area. Additionally, the data reflects clearly the changing and noticeable behavior of different soil treatment before and after harvest to seedling growth of *B. ceiba* is shown in Figure 1. The seedling growth parameters were periodically increased prominently in soil of T5 and decreased in T2 and T1 soil Figure 2.

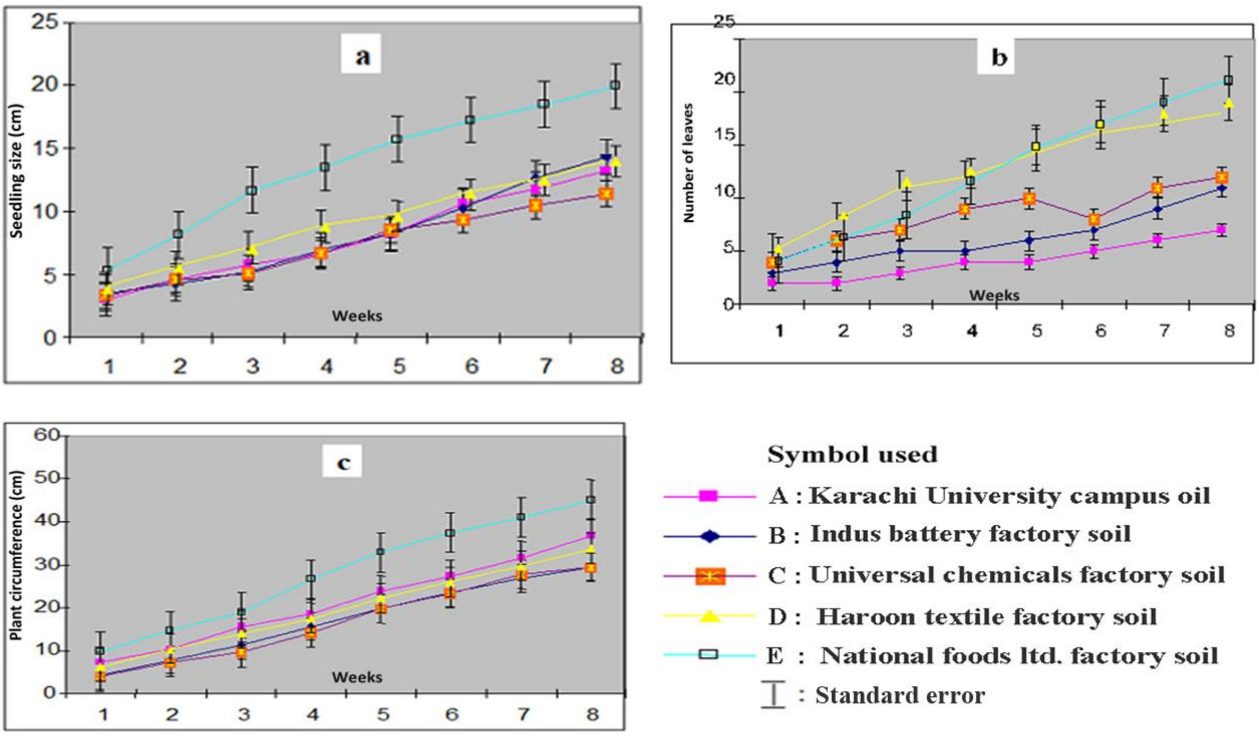

Figure 2. Seeding side (a). number of leaves (b) and plant circumference (c) of Bombax ceiba growth in soils different areas.

Table 2. Pearson's correlation of physicochemical soil characteristics and growth parameters of *B. ceiba*.

Growth parameters	M.W.H.C	B.D.	Porosity	$CaCO_3$	Chloride	pH	Organic matter	E.C.	Sodium	Potassium
Root length	0.077	0.044	-0.037	0.200	-0.161	0.574**	-0.030	-0.215	-0.633**	-0.678**
Shoot length	0.128	0.178	-0.176	0.155	-0.232	0.732**	-0.045	-0.316	-0.680**	-0.853**
Seedling size	0.119	0.150	-0.147	0.170	-0.221	0.713**	-0.043	-0.300	-0.686**	-0.833**
Plant cover	-0.260	0.215	-0.202	-0.114	-0.153	0.596**	-0.249	-0.350	-0.549**	-0.530**
Number of leaves	-0.042	0.558**	-0.565**	-0.263	0.498*	0.416*	-0.445*	-0.610**	-0.004	-0.313
Leaf area	-0.143	0.312	-0.304	-0.071	0.055	0.677**	-0.313	-0.484*	-0.547**	-0.638**
Seedling fresh weight	0.297	-0.085	0.087	0.402*	-0.217	0.536**	0.142	-0.092	-0.674**	-0.755**
Root dry weight	0.108	0.346	-0.350	0.014	0.140	0.610**	-0.218	-0.463*	-0.396*	-0.654**
Shoot dry weight	0.371	-0.281	0.284	0.528**	-0.364	0.385	0.317	0.124	-0.659**	-0.662**
Leaf dry weight	0.036	-0.177	0.192	0.328	-0.489*	0.602**	0.129	-0.025	-0.867**	-0.755**
Total plant dry weight	0.154	0.021	-0.015	0.272	-0.259	0.649**	0.036	-0.196	-0.728**	-0.804**

Note: *, ** Correlation is significant at the $p<0.05$ and $p<0.01$ levels, respectively (2-tailed).
Abbreviation: $CaCO_3$ = Calcium carbonate; C. = Electrical conductivity; K = Potassium.

The distribution of plant species in desert environments depends on physical environmental variables [22] and influenced by underling factors [23, 24]. In parallel the abiotic stress might have strong effect on seedling of *B. ceiba*. Concerning the soil influence in different treatment, the increase or decrease in different seedling growth and seedling dry weight parameters of *B. ceiba* indicated that the physico-chemical properties of soil affected growth variables. Different growth parameters may be correlated with different physico-chemical properties of soil. The proper and balance supply of nutrient is a basic requirement for plant growth. *B. ceiba* seedlings grew better in soil of National Foods Ltd., Factory due to better physical soil conditions, bulk density and soil porosity Table 2. Eco physiological response of *B. ceiba* to fine particle of dust pollution recorded [25]. *B. ceiba* seedlings prefer noticeably to grow with less moisture content and total porosity. The present findings confirmed that the availability of nutrients, industrial activities and underlying environmental factor significantly influenced seedling growth performance of *B. ceiba*. Soil characteristics favor or inhibit growth and development of plant. Industrial activities can lead to accumulation of heavy metals and soil vulnerability in the environment [26-30].

The physico-chemical role of soil with growth of *B. ceiba*. These properties determine the suitable response on plant growth. There was a significant changes on plant growth in different soil of industrial area recorded. Correlation in different growth parameters and physico-chemical properties of soil revealed in that maximum water holding capacity was not correlated with any growth variables while bulk density and porosity showed correlation with number of leaves at significant level ($p<0.01$). However, soil texture was correlated with growth variables of *B. ceiba* at significant level ($p<0.01$). Whereas, fine soil particles showed negative correlation at the same significance level of ($p<0.01$). In chemical properties of soil $CaCO_3$, chlorides and organic matter did not show any significant ($p<0.01$) correlation root and shoot growth. While, pH and sodium were significantly ($p<0.01$) correlated with growth variables. Seedling size of *B. ceiba* were reduced in soil of Universal Chemical factory. Low pH and organic matter may be responsible for reduced growth of species.

The Pearson's correlation coefficient between growth and soil physical and chemical characteristics showed critically significant negative correlation Table 2. The importance of soil pH taking into account showed a significantly positive correlation matrix with all the seedlings variable. The seedlings of *B. ceiba* responded differently in soil of industrial site areas. Therefore, further studies on other native plant species is required on this issue.

4. CONCLUSIONS

Various kinds of industrial activities in Karachi are playing a critical role in economy and also influencing on local environment and quality of soil. The present study described that the treatment of soils of Universal Chemicals significantly ($p<0.05$) reduced the seedling biomass of *B. ceiba*. The soil of National Foods Ltd. significantly increased the seedling growth of *B. ceiba*, as it may able to tolerate the prevailing edaphic conditions and can be planted around such types of industries. *B. ceiba* might be consider a suitable for afforestation of new ground to increase and improvement of forest areas in Pakistan.

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REFERENCES

[1] K. M. Siddiqui, "Forestry and environment." Pakistan: Pakistan Forest Institute Peshawar, 1997, pp. 169-185.

[2] S. Chand and A. Singh, "In vitro propagation of bombax ceiba L.(Silkcotton)," *Forest Genetics*, vol. 48, no. 6, pp. 313-317, 1999.

[3] G. S. Nair and Y. Bai, "Ethnobotanical value of dry fallen ovaries of bombax ceiba L. (Bombacaceae: Malvales)," *Journal Threatened Taxa*, vol. 4, no. 15, pp. 3443–3446, 2012. https://doi.org/10.11609/jott.o2936.3443-6

[4] X. Guang-Kai *et al.*, "Effects of ethanol extract of bombax ceiba leaves and its main constituent mangiferin on diabetic nephropathy in mice," *Chinese Journal of Natural Medicines*, vol. 15, no. 8, pp. 597-605, 2017. https://doi.org/10.1016/s1875-5364(17)30087-0

[5] M. M. Bora, C. Deka, S. A. Tapadar, D. K. Jha, and D. K. Kakati, "Alkyds from red silk-cotton bombax ceiba seed oil and investigation on their microbial degradation," *Progress in Organic Coatings*, vol. 124, pp. 71-79, 2018. https://doi.org/10.1016/j.porgcoat.2018.08.008

[6] K. R. Joshi, H. P. Devkota, and S. Yahara, "Simalin A and B: Two new aromatic compounds from the stem bark of bombax ceiba," *Phytochemistry Letters*, vol. 7, pp. 26-29, 2014. https://doi.org/10.1016/j.phytol.2013.09.005

[7] M. A. A. Quraishi, "Basics of forestry and allied disciplines. A-one publishers." Lahore: Urdu Bazar, 2000, p. 315.

[8] T. O. Vieira, A. Said, E. Aboutabl, M. Azzam, and T. B. Creczynski-Pasa, "Antioxidant activity of methanolic extract of bombax ceiba," *Redox Report*, vol. 14, no. 1, pp. 41-46, 2009. https://doi.org/10.1179/135100009x392485

[9] Y. Gao *et al.*, "De novo genome assembly of the red silk cotton tree bombax ceiba," *Giga Science*, vol. 7, no. 5, pp. 1-7, 2018. https://doi.org/10.1093/gigascience/giy051

[10] P. F. A. F. Plants for A Future, "Bombax ceiba L. Retrieved from: https://pfaf.org/user/Plant.aspx?LatinName=Bomba.x+ceiba.2020.Visited," 2020.

[11] P. Changlian, W. Dazhi, S. Zijian, L. Guizhu, L. Zhifang, and K. Guohui, "Response of some plants for municipal greening to air pollutants," *Journal of Tropical and Subtropical Botany*, vol. 10, no. 4, pp. 321-327, 2002.

[12] A. M. El-Hagrassi, M. M. Ali, A. F. Osman, and M. Shaaban, "Phytochemical investigation and biological studies of bombax malabaricum flowers," *Natural Product Research*, vol. 25, no. 2, pp. 141-151, 2011. https://doi.org/10.1080/14786419.2010.518146

[13] Y. Gao *et al.*, "De novo genome assembly of the red silk cotton tree bombax ceiba," *Giga Science*, vol. 7, no. 5, pp. 1-7, 2018. https://doi.org/10.1093/gigascience/giy051

[14] Z. Zhou, H. Ma, and K. Lin, "RNA-seq reveals complicated transcriptomic responses to drought stress in a nonmodel tropic plant," *Bombax Ceiba L. Evol. Bioinform*, vol. 11, no. 1, pp. 27–37, 2015. https://doi.org/10.4137/ebo.s20620

[15] M. Yasin *et al.*, "Industrial sawdust waste: An alternative to soilless substrate for garlic allium sativum L," *Journal of Applied Research on Medicinal and Aromatic Plants*, vol. 18, p. 100252, 2020. https://doi.org/10.1016/j.jarmap.2020.100252

[16] B. Onwuka and B. Mang, "Effects of soil temperature on some soil properties and plant growth," *Advances in Plants and Agriculture Research*, vol. 8, no. 1, pp. 34-37, 2018. https://doi.org/10.15406/apar.2018.08.00288

[17] S. K. Maiti and D. Ghosh, "Chapter 24 - plant–soil interactions as a restoration tool editor(s): Majeti Narasimha Vara Prasad," *Marcin Pietrzykowsk Climate Change and Soil Interactions Elsevier*, pp. 689-730, 2020. https://doi.org/10.1016/B978-0-12-818032-7.00024-2

[18] L. Stack, B. Soil, and A. Plant Nutrition, "Gardener's perspective. Maine master gardener volunteers manual the university of Maine cooperative extension 5741 Libby Hall Orono Maine. pp. 4469-5741." Retrieved from: https://extension.umaine.edu/gardening/manual/soils/soil-and-plant-nutrition/visited, 2016.

[19] M. O. Hassan, "Leaf litter of bombax ceiba L. Threatens plant cover and floristic diversity in a new urban ecosystem," *Flora*, vol. 242, pp. 22-30, 2018. https://doi.org/10.1016/j.flora.2018.03.004

[20] M. I. Sheikh, "Trees of Pakistan win rock institute for agricultural development/ GOP-USAID forestry planning and development project." Islamabad Pakistan: Pictorial Printers, 1931, p. 42.

[21] J. Wang *et al.*, "Thallium and potentially toxic elements distribution in pine needles tree rings and soils around a pyrite mine and indication for environmental pollution," *Science of The Total Environment*, vol. 828, p. 154346, 2022. https://doi.org/10.1016/j.scitotenv.2022.154346

[22] N. Enright, B. Miller, and R. Akhter, "Desert vegetation and vegetation-environment relationships in Kirthar National Park Sindh Pakistan," *Journal of Arid Environments*, vol. 61, no. 3, pp. 397-418, 2005. https://doi.org/10.1016/j.jaridenv.2004.09.009

[23] M. Shafiq and M. Z. Iqbal, *Impact of automobile pollutants on plants*. Saarbrucken Germany: LAMBERT Academic Publishing GmbH & Co. KG Heinrich-Böcking-Str, 2012, pp. 6-8.

[24] M. Shafiq, M. Z. Iqbal, M. Kabir, Z. U. Farooqi, and L. Poison, *Vegetation of disturbed and polluted areas in Pakistan*. U.S.A: Strategic Book Publishing & Rights Agency, 2019, p. 173.

[25] M. F. Nawaz *et al.*, "Effect of dust types on the eco-physiological response of three tree species seedlings: Eucalyptus camaldulensis conocarpus erectus and bombax ceiba," *Atmosphere*, vol. 13, no. 7, p. 1010, 2022. https://doi.org/10.3390/atmos13071010

[26] M. Ahmed-Fariz, W. Zuhairi, T. Raihan, and S. Rahim, "Ground and soil vulnerability in the largest basin Malaysia," *European Journal of Scientific Research*, vol. 27, pp. 628-635, 2009.

[27] I. Grigalavičienė, V. Rutkovienė, and V. Marozas, "The accumulation of heavy metals Pb Cu and Cd at roadside forest soil," *Polish Journal of Environmental Studies*, vol. 14, no. 1, pp. 109-115, 2005.

[28] R. Hussain, A. Chaudhry, and M. Khan, *Review of existing agroforestry systems in the Punjab. Punjab forest sector division project agro-forestry research series # 4*. Lahore Pakistan: Punjab Forest Department, 1991.

[29] World Bank, *World development report 1992. Development and the environment*. New York: Oxford University Press, 1992.

[30] G. Xu *et al.*, "Effects of ethanol extract of bombax ceiba leaves and its main constituent mangiferin on diabetic nephropathy in mice," *Chinese Journal of Natural Medicines*, vol. 15, no. 8, pp. 597-605, 2017. https://doi.org/10.1016/S1875-5364(17)30087-0