Improving growth and productivity of *Cordia africana* trees using moringa leaf juice in northwestern Ethiopia

Getachew Kassa, Takle Ferde and Amsalu Nigatu

**Abstract:** A study was carried out in Bezawite tree nursery site, Bahir Dar, to evaluate the effect of *Moringa stenopetala* leaf juices on tree seedling growth and survival rates of *Cordia africana* at different doses in nursery and field condition. Seven treatments were tested, six treatments plus one control without any input, using a RCBD design with three replications were tested. 25ml and 50 ml of leaf juice were sub ministered at three different epochs, emergency, half nursery life span and 30 days before transplanting. Data on root collar diameter, height, and survival rate were collected every 6 months interval for two years in the field condition. Results showed that moringa extract increased growth and survival rate of *Cordia africana* in the field. Treatment of 50 ml MLJ at emergency shows good survival rate and growth parameters after two years in the field and there is significant difference among treatments in terms of height and root caller diameter as well as survival rate in the field (127.87 cm, 2.44 cm and 87.75%, respectively). Generally, applying moringa leaf juice on *Cordia africana* had a positive effect on growth parameters and more generally pronounced in the field condition.

**Subjects:** Environmental Sciences; Forestry; Agriculture and Food; Biodiversity & Conservation

**Keywords:** Moringa leaf juice; height; root collar diameter; *Cordia africana*

**ABOUT THE AUTHOR**

Getachew Kassa is a forest researcher in Adet Agricultural Research center, Amhara Agricultural Research Institute, Ethiopia. His overall research interest falls within the domain of forestry and natural resource problems as plant diversity in natural and plantation forest, climate change mitigation measures, introduction and adaptation of valuable forest resources and others problems related to enhancement of overall forestry problems. Getachew kassa has designed and conducted many experimental studies on natural resource, forestry and appreciates biodiversity conservation, climate changes and encourages farmers to exploit the integrated potential of cultural practices to manage forest biodiversity and sustain productivity. He is involved in many national and local projects focusing on natural resource management climate change, along with different teams.

**PUBLIC INTEREST STATEMENT**

The dependency on the use of inorganic fertilizers as a source of plant nutrients by farmers and their high cost is further associated with land and soil degradation and environmental pollution. Moringa is one of such alternative, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers. In this study, therefore, moringa leaf juice was used as a natural fertilizer for enhancement of multipurpose tree species like *Cordia africana*. And the recommendations which will assist Agricultural office, forestry commission and NGOs were raised, in nursery technology and enhancing biodiversity conservation.
1. Introduction

Cordia africana Lam. belongs to the family Boraginaceae, subfamily Cordioideae. It is distributed in tropical Africa from the Sudan, Ethiopia, and tropical Arabia in the north to northeast Transvaal in the south (Friis, 1995). In West Africa, the tree appears to be restricted to montane and sub-montane habitats, with rather limited distribution in the lowlands of the Democratic Republic of Congo. The species occurs in primary or secondary forest or woodland at altitudes ranging from as low as 550 to as high as 2,600 m. It grows better on drained red or loam soils, and prefers areas that are characterized by a moderately high amount of rainfall and sufficiently warm climate (Negash, 2010). Plant hormones can be used to increase yield per unit area because they influence every phase of plant growth and development. Traditionally, there are five groups of growth regulators which are listed: auxins, gibberellins, abscisic acid, ethylene, and cytokinins (Prosecus, 2006). Zeatin is one form of the most common forms of naturally occurring cytokinin in plants that can be found in higher quantity in fresh moringa leaves. Moringa leaves gathered from various parts of the world were found to have high zeatin concentrations, which can reach to have zeatin concentration between 5 μg g⁻¹ and 200 μg g⁻¹ of leaves (El-Awady, 2003). The role of moringa extract as a plant growth hormone that enhances seed germination, growth, and yield of crops (Foidl et al., 2001; Phiri, 2010; Anwar & Rashid, 2007) and had attracted the attention of agronomist more especially in the developing countries where crops yields are very low. Juice from fresh moringa leaves increased crops yields by 25–30% according to the reports of Foidl et al. (2001) and also has an improving effects on the growth of cowpea (Maishanu et al., 2017). Moringa leaf extract was sprayed onto leaves of onions, bell pepper, soya beans, sorghum, coffee, tea, chili, melon and maize, and was shown to increase yields of these crops (Fuglie, 2000; El-razez, 2013). The family Moringaceae having 14 species is native to India and parts of Africa including Ethiopia and Kenya (Price, 2007; Mekonnen, 1999). Among these the best studied, with regard to potential medicinal uses and the identification of compounds of potential therapeutic importance, are Moringa oleifera and Moringa stenopetala. The tree Moringa stenopetala also known as shifraw (Amharic) belongs to the family of Moringaceae, order Brassicales, genus Moringa, and consists of 13 species (Adaora & Florett, 2000). It adapts in a wide range of climates from arid to humid areas with the altitudinal ranged from 390 m to about 2,200 m a.s.l and 6–12 m tall and mostly cultivated as in terraced fields, backyard agroforestry, gardens, and small towns of the southern Ethiopia (Jiru et al., 2006). It is a multi-purpose tree has gained a lot of publicity because of its many varied uses, which range from the medicinal applications, industrial, sanitary to the nutritional. According to the Flora of Ethiopia, the species occurs in Ethiopia in the Kaffa, Gamo-Gofa and Sidamo, between 500 and 1,600 m, and may in certain conditions extend to 2,000 m (Edwards et al., 2003). Although various parts of moringa plant extracts are known to possess diverse medicinal and biological activity on human and animals, little is known scientifically about its effect as a bio-organic fertilizer on the hormonal, metabolic and antioxidant potential on plants. It is one of such alternatives, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Phiri, 2010). Moreover, several researches have indicated that moringa is a highly valued plant with multipurpose effects (Adebayo et al., 2013; Anwar et al., 2007; Mishra et al., 2011; Mayo et al., 2011; Yang et al., 2006). It is considered as one of the world’s most useful trees, as almost every part of the tree has an impressive effect of food, medication and industrial purposes (Adebayo et al., 2011; Khalafalla et al., 2010; Mayo et al., 2011). Moreover, Moringia leaf extract has the potential to promote plant growth; hence, it is used as a natural plant growth enhancer. Moringa leaf extract was sprayed onto leaves of onions, bell pepper, soya beans, sorghum, coffee, tea, chili, melon and maize, and was shown to increase yields of these crops (Muhammad, et al. 2013). In addition, it accelerates the growth of young plants, strengthened plants, improved resistance to pests and diseases, increased leaf duration, increased number of roots, produced more and larger fruits and generally increased yield by 20% and 35% (Fuglie, 2000). Therefore, the present study was planned to explore the effect of Moringa stenopetala leaf extract on growth and plant biomass productivity of Cordia africana tree.
2. Materials and methods
The effect of applying moringa leaf extract on Cordia Africana tree was evaluated in the field at Bezawite tree nursery site, Bahir Dar, Ethiopia for the last two years (2015/16). Geographically located at latitude 11.5936403 and longitude 37.39077.

The treatments were

1. 25 ml MLJ (moringa leaf juice) at emergency,
2. 50 ml MLJ (moringa leaf juice) at emergency,
3. 25 ml MLJ (moringa leaf juice) at half nursery life span,
4. 50 ml MLJ (moringa leaf juice) at half nursery life span,
5. 25 ml MLJ (moringa leaf juice) at 30 days before transplanting,
6. 50 ml MLJ (moringa leaf juice) at 30 days before transplanting and
7. Control (without any input)

2.1. Plant material
Seeds of indigenous tree species of Cordia africana were collected and directly sown in plastic containers of 12 cm in diameter and 15 cm in height. Two seeds per pot were sown, and two weeks after germination, only one healthy and vigorous seedling was left in each pot. All nursery activities were carried out following the practices used in the nurseries of the studied area. The seedlings were watered twice a day, weeded when necessary and plants were left grown under shade until plant reach the height of approximate nursery tree.

2.2. Extraction method of moringa leaf juice
The leaf were harvested from moringa plants trees in the nearby areas of moringa growing areas with appropriate leaf ages to use for deriving the extract. Extractions were made by grinding young moringa shoots (not more than 40 days old) together with 80% ethanol (about 1 l per 10 kg fresh material) as suggested by Makkar and Becker (1996). The suspension was stirred to help maximize the amount of the extract. The solution was then filtered by wringing the solution using a mutton cloth. The solution was re-filtered using Whatman filter paper. Using a method developed by Fuglie (2000), the extract was diluted with distilled water at a 1:32 ratio (v/v) and then sprayed directly onto plants. The extract was used within five hours from cutting and extracting (if not ready to be used, the extract or the solution prepared was stored at 0°C and only taken out when needed for use). Fixed amount of the solution was applied per plant in the greenhouse.

2.3. Experimental design and set up
The experiment was designed in randomized complete block design (RCBD) with three blocks. Blocking was laid out against the slope. Of the total 16 seedlings planted, the inner were sampled for measurements. Blocks were separated by 3 m while 2 m between plots and 1 m was left between each seedling.

2.4. Determination of growth
Seedling height (SH) and root collar diameter (RCD) were recorded for each plant. Measurements on these parameters were done every six month after sowing to the field. SH was measured from the soil surface to the highest tip of seedlings using a centimeter graduated glass ruler. RCD was measured on the girth of the seedlings 1 cm above the soil surface like SH every six month using a caliper. RCD and SH were measured from the inner plot seedlings but survival rate was counted in the whole plot every six month.

2.5. Statistical analysis
All the data were statistically analyzed using statistical software (SAS Version 9.0). The data were checked for normality and homogeneity of error variance. ANOVA was performed following the
GLM procedure to detect significant mean growth and biomass differences among seedlings planted in the field. When significant treatment effects were detected across treatments, means were compared by least significant difference (LSD) test. Mean differences were considered significant when $p \leq 0.05$.

3. Results and discussion

3.1. Effect of moringa leaf extract on the growth of trees in nursery

Table 1 shows the effects of Evaluation for different concentration of foliar application of moringa extract on plant height, RCD and survival percentage in the tree nursery and field condition score for the two years combined of foliar application of moringa extracts. Application of moringa leaf extract had significant effects on the growth parameters like SH and RCD (Figure 1). The highest values for plant height (65.07 cm) and RCD of (1.63 cm) (Table 1) were recorded in treatment of 50 ml EM (application of 50 ml moringa leaf extract on emergence stage). The lowest values for plant height (52.69 cm and 54.39 cm) and with RCD of (0.35 cm and 0.47 cm) (Figure 2) in the treatment of application of 25 ml and 50 ml moringa leaf extract 30 days before transplanting to the field and control, respectively and same result was also reported by Kanchani and Harris (2019). Application of moringa leaf extract with high concentration in the early stage of Cordia africana tree enhances the growth as well as diameter, but there is no effect when the extract was applied in the latter stage of the tree in the nursery. Our results were in agreement with those of Uchenna et al. (2015), which shows that early application of moringa extract increases the growth of cassava, and Abd El-Hamied and El-Amary (2015), which shows shoot length and shoot diameter were significantly affected by all treatments in both seasons by moringa extracts on “Pear trees”. However, the result obtained is not in conformity with the report of Edward and Jerry (2009) who found that growth characters of onion did not respond to foliar application of moringa. Regarding the survival percentage moringa leaf juice have no significant effect in the nursery lifespan. In tree nursery trails application of 50 ml moringa leaf juice in the emergence stage of Cordia africana tree have significantly higher than the other treatments in height parameters, and also the same result was obtained in RCD by applying 50 ml of moringa leaf juice in the emergence stage of Cordia africana in the nursery trails, while there is no significant difference among treatments in terms of survival rate.

3.2. Effect of moringa leaf extract on the growth of trees in the field condition

There is a significant effect showed by the application of moringa leaf juice on the field condition on the parameters of height on Cordia africana tree, where the data shows that (Table 1) there is a height increment when we applying moringa leaf juice on early growth. Application of 25 ml moringa leaf juice and 50 ml moringa leaf juice on emergence stage gives the higher height growth in the field with the value of 102 cm and 127.8 cm, respectively (Figure 3). In terms of their RCD, there is also a
Table 1. Effect of moringa leaf juice on tree growth parameters

| Treatments | Nursery height | Nursery rcd | Nursery% | Transplanting height | Transplanting rcd | Transplanting% |
|------------|----------------|-------------|----------|----------------------|-------------------|---------------|
| 25 ml EM   | 58.85<sup>ab</sup> | 1.19<sup>b</sup> | 100      | 102.00<sup>bc</sup> | 1.69<sup>bc</sup> | 93.75<sup>b</sup> |
| 50 ml EM   | 65.07<sup>a</sup>  | 1.63<sup>a</sup> | 100      | 127.87<sup>a</sup> | 2.44<sup>a</sup>  | 87.75<sup>a</sup> |
| 25 ml HN   | 57.62<sup>ab</sup> | 0.75<sup>c</sup>  | 100      | 48.13<sup>c</sup>  | 0.95<sup>b</sup>  | 39.58<sup>b</sup> |
| 50 ml HN   | 58.19<sup>ab</sup> | 0.90<sup>c</sup>  | 100      | 77.75<sup>bc</sup> | 1.49<sup>b</sup>  | 33.33<sup>b</sup> |
| 25 ml L30  | 52.69<sup>b</sup>  | 0.47<sup>d</sup>  | 100      | 68.93<sup>bc</sup> | 1.06<sup>b</sup>  | 60.42<sup>ab</sup> |
| 50 ml L30  | 53.62<sup>b</sup>  | 0.45<sup>d</sup>  | 100      | 78.27<sup>bc</sup> | 1.37<sup>b</sup>  | 66.67<sup>ab</sup> |
| Control    | 54.39<sup>b</sup>  | 0.35<sup>d</sup>  | 100      | 71.60<sup>bc</sup> | 1.36<sup>b</sup>  | 68.33<sup>ab</sup> |
| Mean       | 57.20           | 0.82           | 100      | 82.08               | 1.48              | 64.26         |
| cv         | 7.76            | 17.44           |          | 30.96               | 30.00             | 33.30         |
| Sig@0.05   | *              | **              | NS       | *                   | *                | *             |

NS = Not significant at p = 0.05, em = emergency, hn = half nursery life span, l30 = left 30 days for transplanting to the field.
significant difference, application of 50 ml moringa leaf juice in the emergence stage gives the higher growth with the value of 2.44 cm, whereas the smallest RCD was recorded in the treatment of application of 25 ml moringa leaf juice 30 days before transplanting to the field (Figure 4). The survival percentage in the field showed as there is significant difference among treatments. Application of 25 ml and 50 ml moringa leaf juice in emergence stage gives the highest survival percent, whereas application of moringa leaf juice in the latter growth stage of moringa tree have not increase the survival rate of the tree. Table 1 shows as application of moringa leaf juice in the early stage of tree growth can enhance the field survival condition by increasing the height and RCD of the tree. Similar researches was reported by Biswas et al. (2016) on maize, Culver et al. (2012) on tomatoes and Mvumi et al. (2012) on beans and maize. This might be due to zeatin, which is the most common cytokinin in the extract, responsible for the improved plant height at an early growth (Kanchani & Harris, 2019).
4. Conclusion
Natural plant growth hormones are intensively used nowadays for plant growing in normal and adverse conditions. Moringa stenopetala is one of the novel natural biostimulants for plant growth that play an important role in improving growth and tolerance in plants under adverse condition. The current study dealt with the effect of moringa leaf extracts on growth performance and survival rate of Cordia africana in the tree nursery and field condition. The extract showed a positive effect on tree growth parameters in the field conditions as well as in the nursery. Application of moringa leaf juice at emergency stage shows with different amount gives good performance in total mean height, mean RCD, and survival rate in the nursery and in latter performance of the test crop in the field. Generally, the effect of applying moringa leaf juice on Cordia africana have a positive effect on growth parameters and more generally pronounced in the field condition. Overall, moringa leaf juice has minimal effect on tree survival at early growth stage; in tree nursery condition application of 50 ml EM (at emergence stage) gives higher mean height, mean RCD and survival%. And also in the field condition 50 ml EM have the higher yielder, and recommended for further propagation of trees. Further research was recommended on higher amount of moringa leaf juice application in different doses and economic analysis of applying the leaf juice.

Funding
The authors received no direct funding for this research.

Competing interests
The authors declares no competing interests.

Author details
Getachew Kassa 1
E-mail: getish@gmail.com
Takle Ferde 1
E-mail: takele288@gmail.com
Amsalu Nigatu 1
E-mail: amsalu08@gmail.com
1 Amhara Regional Agricultural Research Institute, Adet Agricultural Research Center, P.O.Box 08, Bahir Dar, Ethiopia.

Citation information
Cite this article as: Improving growth and productivity of Cordia africana trees using some natural plants extracts under North Sinai conditions. IOSR Journal of Agriculture and Veterinary Science. 8(1) Ver. I, 01–09.

Adaora, V., & Florett, C. (2000). Nutritional, therapeutetic, and prophylactic properties of vigna subterranea and moringa oleifera. Food research international, 37, 355-365. https://doi.org/10.5772/57338

Adebayo, E., Oloke, J., Aine, A., & Bora, T. (2013). Antioxidant and nutritional importance of some pleurotus species. Journal of Microbiology, Biotechnology and Food Sciences, 3, 289-294.

Anwar, F., Lotif, S., Ashraf, M., & Gilani, A. H. (2007). Moringa oleifera: A food plant with multiple medical uses. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 21(1), 17–25. https://doi.org/10.1002/ptr.2023

Anwar, F., & Rashid, U. (2007). Physico-chemical characteristics of Moringa oleifera seeds and seed oil from a wild provenance of Pakistan. Pakistan Journal of Botany, 39(5), 1443–1453. http://www.pakbs.org/pjobt/pjhtmls/pjb.html

Biswa, A. K., Hoque, T. S., & Abedin, M. A. (2018). Effects of moringa leaf extract on growth and yield of maize. Progressive Agriculture, 27(2), 136–143. https://doi.org/10.3329/pan.v27i2.29322

References
Abd El-Hamied, S. A., & El-Amary, E. I. (2015, January). Improving growth and productivity of “pear” trees using some natural plants extracts under North Sinai conditions. IOSR Journal of Agriculture and Veterinary Science. 8(1) Ver. I, 01–09.
Culver, M., Fanuel, T., & Chiteka, A. Z. (2012). Effect of moringa extract on growth and yield of tomato. *Greener Journal of Agricultural Sciences*, 2(5), 207–211. doi: 10.5897/AJB12.942. http://www.academicjournals.org/AJB

Edward B., & Jerry, J. (2009). The effect of moringa leaf spray on the yield of vegetable crops ECHO. N. F. myers, FL 33917 USA.

Edwards, S., Nemomissa, S., & Hedberg, I. (2003). *Flora of Ethiopia and Eritrea*. The National Herbarium, Addis Ababa University, Addis Ababa and Dept. Systematic Botany, Uppsala University.

El-Awady, A. (2003). The moringa tree: Nature's pharmacy. *International Journal of Current Microbiology and Applied Sciences*, 4(12), 1-9. ISSN: 2319-7706. Retrieved October, 20, 2007.

El-Razek, A. E. A., El-Migeed, M. A., & Abdel-Hamid, N. (2011). Response of ‘Le Conte’Pear trees to garlic extract and GA as Budbreak dormancy agents. *Middle-East Journal of Scientific Research*, 14(11), 1407–1413. http://doi.org/10.2307/420212

Foidl, N., Makker, H. P. S., & Becker, K. (2001). The potential of *Moringa oleifera* for agricultural and industrial uses. In L. J. Fuglie (Ed.), *The miracle tree: The multiples attributes of moringa* (pp. 168). CTA and CWS.

Friis, I. (1995). Myrtaceae. In S. Edward & M. I. Hedberg (Eds.), *Flora of Ethiopia and Eritrea*, V.2, Pt 2: *Canellaceae to Euphorbiaceae* (pp. 71-106). The National Herbarium, Addis Ababa Univ. Addis Ababa Dept. Systematic Botany, Uppsala University. http://agris.fao.org

Fuglie, L. J. (2000). New uses of moringa studied in Nicaragua: ECHO’s technical network site-networking global hunger solutions. ECHO, Nicaragua.

Jiru, D., Sander, K., Alemayehu, L., Mekonen, Y., & Anjula, A. (2006). Leaf yield and nutritive value of *Moringa stenopetala* and *Moringa oleifera* accessions: Its potential role in food security in constrained dry farming agroforestry system. *Proceedings of the Moringa and other highly nutritious plant resources: Strategies, standards and markets for a better impact on nutrition in Africa* (pp. 16–18), Accra, Ghana.

Kanchani, A. M. K. D. M., & Harris, K. D. (2019). Effect of foliar application of *Moringa oleifera* leaf extract with recommended fertilizer on growth and yield of okra (*Abelmoschus esculentus*). *AGRIEAST*, 13(2), 38–34. https://doi.org/10.4038/agrieast.v13i2.73

Khalfalla, M. M., Abdellatef, E., Dafalla, H. M., Nassrallah, A. A., Aboul-Enein, K. M., Lightfoot, D. A., El-Deeb, F. E., & El-Shemy, H. A. (2010). Active principle from *Moringa oleifera* Lam leaves effective against two leukaemias and a hepatocarcinoma. *African Journal of Biotechnology*, 9(69), 8467-8471. ISSN: 1684-5315, http://www.academicjournals.org/ajbt

Maisharu, H., Mainasara, M., Yahaya, S., & Yunusa, A. (2017). The use of moringa leaves extract as a plant growth hormone on cowpea (*Vigna anguiculata*). *Path of Science*, 3(12). https://doi.org/10.22178/pos.29-4

Makkor, H. P. S., & Becker, K. (1996). Nutritional value and antinutritional components of whole and ethanol extracted *Moringaoleifera* leaves. *Animal Feed Science and Technology*, 63(14), 211–228. https://doi.org/10.1016/S0377-8401(96)01023-1

Mekonnen, Y. (1999). Effects of ethanol extract of *Moringa stenopetala* leaves on guinea-pig and mouse smooth muscle. *Phytotherapy Research*, 13(5), 442–444. https://doi.org/10.1002/(SICI)1099-1573(19990809)13:5<442::AID-PTR476>3.0.CO;2-7

Mishra, G., Singh, P., Verma, R., Kumar, S., Srivastava, S., Jha, K. K., & Khosa, R. L. (2011). Traditional uses, phytochemistry and pharmacological properties of *Moringa oleifera* plant: An overview. Der Pharmacia Lettre. Scholars Research Library, 3(2), 141–164. http://www.scholarresearchlibrary.com

Mohammed, R., Olorukooba, M. M., Akinoyi, M. M., & Kambai, E. A. (2013). Evaluation of different concentrations and frequency of foliar application of *moringa* extract on growth & yield of onion, *Allium cepa* Lam. Agrosearch, 13(3), 196–205. https://doi.org/10.4314/agrosrh.v13i3.35

Moyo, B., Masiko, P. J., Hugo, A., & Muchenje, V. (2011). Nutritional characterization of *Moringa (Moringa oleifera Lam.* leaves. *African Journal of Biotechnology*, 10(60), 12925–12933. https://doi.org/10.5897/AJB10.1599

Muhumman, M. A., Awulalu, B. M., Manga, A. A., & Jibiri, J. M. (2013). Effects of aqueous extract of *moringa* (*Moringa oleifera* Lam.) and nitrogen rates on some physiological attributes and yield of Tomato. *International Journal of Chemical, Environmental and Biological Sciences*, 1, 2320–4087. http://www.academicjournals.org/ajb

Mumuni, C., Fanuel, T., & Chiteka, A. Z. (2012). Effect of moringa extract on growth and yield of tomato. *Greener Journal of Agricultural Sciences*, 2(5), 207–211. doi: 10.5897/AJB12.942. http://www.academicjournals.org/AJB

Negash, L. (2010). A selection of Ethiopia’s indigenous trees: Biology, uses and propagation techniques. Addis Ababa University Press.

Phiri, C. (2010). Influence of *Moringa oleifera* leaf extracts on germination and early seedling development of major cereals. *Agriculture and Biology Journal of North America*, 1(5), 774–777. https://doi.org/10.5251/ajbna.2010.1.5.774.777

Price, M. L. (2007). The moringa tree. ECHO Technical Note, 17391, 1–19. http://www.echonetwork.org

Prosceus, P. (2006). *Biosynthesis-plant hormones and growth regulators: Chemistry and biology*. Biosynth Ag Co.

Uchenna, N. M., Ike, Y. C. N., & Ezekwu, P. I. (2015). Effects of *Moringa oleifera* leaf extract on morphological and physiological growth of cassava and its efficacy in controlling *Zonocerus variegatus*. *African Journal of Biotechnology*, 14(32), 2495–2500. https://doi.org/10.5897/AJB2015.14534

Yang, R. Y., Chang, L. C., Hsu, J. C., Weng, B. B. C., Palada, M. C., Chada, M. L., & Levassuer, V. (2006). Nutritional and functional properties of moringa leaves—from germplasm, to plant, to food, to health. In *Proceedings of the International Workshop “Moringa and other Highly Nutritious Plant Sources: Strategies, Standards and Markets for a Better Impact on Nutrition in Africa* (Vol. 1618, pp. 1–9), Accra, Ghana.
