P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 7; SP-Issue 6; June 2024; Page No. 179-182

Received: 15-04-2024
Accepted: 25-05-2024

Indexed Journal
Peer Reviewed Journal

Banana fibre pots: A green solution for sustainable agriculture

Bhawana Sharma[1] Dr. S Lakshmi Pooja[2] Dr. Lakshmi Challa[3] and Dr. M Preethi [4]

[1]M.Sc. Scholar, Department of Apparel and Textiles, College of Community Science, PJTSAU, Saifabad, Hyderabad, Telangana, India

[2]Assistant Professor, Department of Apparel and Textile Science, College of Community Science, PJTSAU, Saifabad, Hyderabad, Telangana, India

[3]Assistant Professor, Department of Apparel and Textile Science, College of Community Science, PJTSAU, Saifabad, Hyderabad, Telangana, India

[4]Professor, Extension, Education Institute Rajendranagar, Hyderabad, Telangana, India

DOI: https://doi.org/10.33545/26180723.2024.v7.i6Sc.733

Corresponding Author: Bhawana Sharma

Abstract

This study addresses the environmental issues caused by plastic waste in agriculture sector by developing biodegradable pots from banana fiber as it is abundantly available in India. These eco-friendly alternatives aim to reduce plastic pollution and enhance sustainable agriculture. Biodegradable pots were manufactured using banana fiber as a reinforcement and guar gum, tamarind seed kernel powder (TSKP), and epoxy as matrices. Various formulations of these raw materials were made and the best ratios were selected for further evaluation. The pots have been tested for water absorbency and plant growth test to check its practicality in real situation. The water absorption test showed that BP_5 had the highest absorption rate at 274.47%, might be due to its high guar gum content, while BP_7 had the lowest at 37.63%, due to the use of epoxy as a binding agent. In plant growth tests, BP_5 demonstrated the best overall performance, supporting healthy growth and retaining water effectively. BP_3 (banana fibre, TSKP and epoxy) showed no plant growth, indicating unfavourable conditions. The study highlights the importance of selecting appropriate materials for manufacturing biodegradable pots to promote sustainable agriculture.

Keywords: Agro-waste, Banana fiber, Bio-composites, Biodegradable pots, Green pots, Sustainable pots

Introduction

Over the past twenty years, plastic waste has emerged as the most significant environmental issue. Because petroleum-based plastics like polystyrene, polyethylene, and polypropylene are difficult to degrade, they constitute a significant environmental risk. The accumulation of plastic garbage can negatively impact soil fertility and function, as well as cause harm to living organisms via bioaccumulation and bio-magnification. Environmental contamination is greatly increased by the widespread use of plastic pots in gardening and agriculture. Numerous issues are brought about by these single-use containers, including garbage accumulation, soil contamination, water pollution, air pollution, and so on. To address these environmental challenges, there is a dire need of promotion and development of biodegradable pots made from various natural materials especially natural fiber from agro waste.

Natural fibers from agro and processed waste are widely available, biodegradable, economical and safe for both animal and human health. Additionally, it is thought that natural fiber-reinforced fibers will be a good substitute for fibers derived from fossils and petroleum in the future (Sapuan *et al.*, 2006) [6].

Natural fibers are derived from various parts of the plants and are categorized accordingly. It is an interesting fact that natural fibers such as coir, jute, sisal and banana are available a lot in agriculture-based countries like India (Venkateshwaran *et al*., 2010) [7]. Banana fruit which is widely cultivated in India produces almost 90% of the banana biomass per tree as a waste (Akubueze *et al.*, 2015) [1]. Worldwide about 114.08 million metric tons of banana waste loss are generated, leading to environmental problems such as excessive emissions of GHGs. The banana waste is made up of high amount of cellulose, hemicellulose and natural fibers which can play role of high quality reinforcement material (Chauhan *et al*., 2022) [3] in the production of bio-composites like biodegradable pots.

Moreover, the inherent properties of banana fiber such as moisture retention capabilities, high strength, good flame retardant properties and breathability (Nguyen and Nguyen, 2021) [5] can improve the overall health and vitality of cultivated plants. The planters can replace the plastic pots which are causing adverse effects on the environment of agro eco system, leading to huge mountains of plastic waste or landfills thus building a sustainable ecosystem.

The objective of this present research work was to develop banana fiber-reinforced bio degradable pots using variable concentrations of guar gum, TSKP (Tamarind Seed Kernel

Powder) and epoxy as the matrices. The efficiency of the developed pots was evaluated using water absorption test and field test to observe plant growth and development.

Materials and Methods

The production and evaluation process of the green pots is described under the following subheadings.

Selection of raw materials

Reinforcement and matrices

Raspador machine extracted banana fiber was procured from vendors to use it directly for the manufacturing of biodegradable pots.

Matrices/ binding agents namely guar gum, TSKP and epoxy (resin + hardener) were purchased from the local market in Hyderabad.

Fig 1: Banana fiber

Fig 2: Shredded banana fiber

Fig 3: Pulverised banana fiber

Selection of moulds for the process of manufacturing

Male and female die of two inches length and diameter whereas thickness of 0.5mm was used for molding of the pots. The die used is shown in the Figure 4.

Fig 4: Aluminium pots mould

Preparation of biodegradable pots

The banana fibre was first shredded manually and then with the help of pulveriser it was converted into fine powdered form. The fine powder was used along with the different concentration of matrices in order to optimize the percentage of matrices showing best results. Finally the pulp was formed by uniformly blending the reinforcement, matrices to produce highly efficient pots. The pulp was later moulded in the shape of the pot using the die at a curing temperature of 100 ^{0}C for 3 hours except BP_7 having curing time of 1 hour at the given temperature.

Fig 5: Banana fiber pots

Evaluation of biodegradable pots

Water absorption (WA) test

Firstly, the green pots were cured in an oven at 40 ^{0}C for 15 minutes and then they were allowed to cool. Once cooled, the specimens were weighed. Then a container was filled with water at a controlled temperature (around 35 °C). The dried pots were submerged in water (up to 2 cm height) to absorb water for around 60 minutes (Jirapornvaree *et al.*, 2017). At regular intervals (every 15 minutes), the pots were removed from the water and weighed. Finally after 60 minutes they were dried with a lint-free cloth. The pots were weighed again after water absorption. The water absorption was calculated by comparing the weight before and after the test using the given equation and later calculating the average value from it.

$$W_A = (M_h – M_0 / M_0) \times 100$$

Where, W_A represents the water absorption rate (%), M_0 is the initial pot weight (g), and M_h indicates the pot weight after water absorption over time (min).

Fig 6: Water absorption test of pots

Fig 7: Weighing the pots

Plant growth test

Tomato plants were cultivated in the pots for the time period of thirty days (Anirudh *et al.*, 2024) in the month of May at Saifabad, Hyderabad. Red soil and coco-peat in the ratio 2:1 was used for the cultivation and the saplings were watered two times a day to keep the soil moisturise during heavy summers. The growth of the plants was recorded every week and further the pots were evaluated among different combinations of banana fiber and matrices and finally the growth was compared to petroleum based plastic pots which are more commercially used in nurseries.

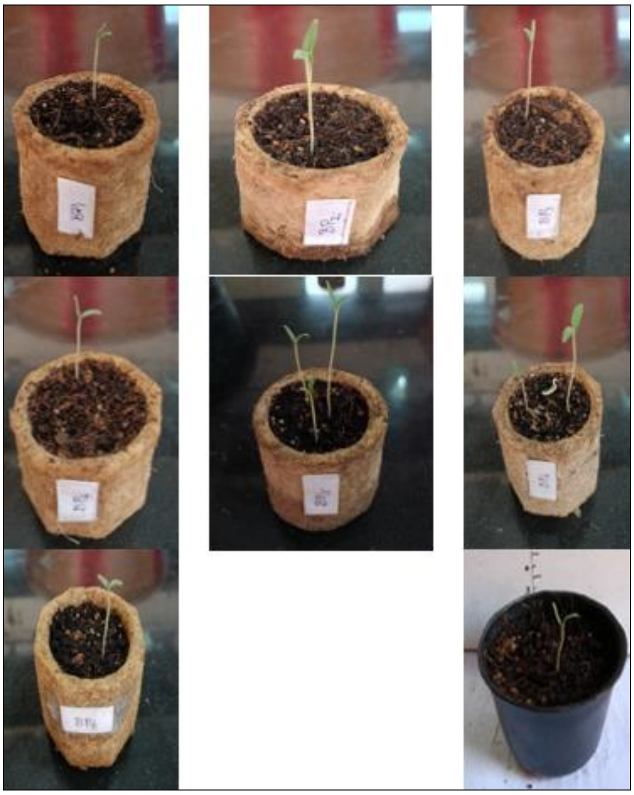

Fig 8: Banana fiber & plastic pots with tomato saplings

Results and Discussion

The biodegradable pots were developed by optimising the appropriate quantity of raw materials and have undergone several quality tests which are discussed in the given section.

Optimization of the fiber and matrices concentration

The optimized concentration of reinforcement i.e. fiber and matrices was finalised after manufacturing the pots with different ratios of fibre and matrix and checking their durability. The optimisation table for the production of pots is given below:

Table 1: Optimized concentration of fibre and matrices

Pot Code	Fibre (gm)	Guar gum* (ml)	TSKP (ml)**	Epoxy (ml)***
BP_1	15	22.5	22.5	5
BP_2	15	25	25	-
BP_3	15	-	45	5
BP_4	15	45	-	5
BP_5	15	50	-	-
BP_6	15	-	50	-
BP_7	15	-	-	30

***Prepare gum from powder by adding 2 gm per 100ml of cold water

****Prepare gum from powder by adding 10 gm per 100ml of hot water

*****Quantity involves both resin and hardener in the ratio 3:1

Water Absorption Test

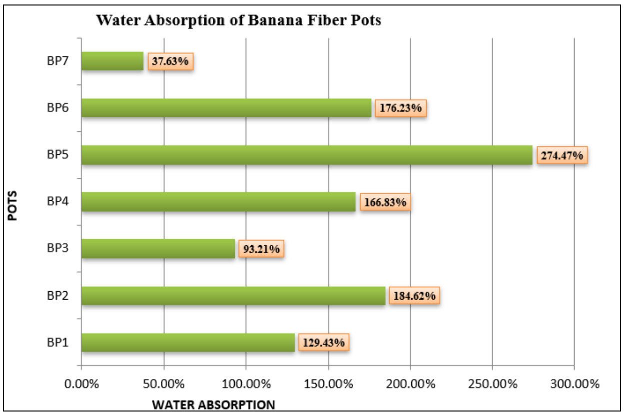

Fig 9: Water Absorption test of pots

The graph demonstrates varying water absorption rates of pots made from banana fiber, ranked from highest to lowest. BP_5 excels with the highest absorption rate at 274.47%, making it ideal for water retention which might be due to the guar gum used as a matrix for the pots. BP_2 follows with a rate of 184.62%, showing strong water retention capabilities enhanced by the use of guar gum and TSKP gum as a matrix during its manufacturing. BP_6, with a rate of 176.23%, also exhibits good absorption, supported by TSKP gum as a binding agent. BP_4, at 166.83%, indicates decent water absorption and BP_1, absorbing water at a rate of 129.43%, which is comparatively less due to the use of epoxy as a binding agent along with guar gum and TSKP gum. In contrast, BP_3 has a lower rate of 93.21% and BP_7 has the poorest absorption rate at 37.63%, likely due to the use of epoxy as a matrix for binding banana fibers together. Overall, the significant variation in water absorption rates among these pots is due to the critical impact of different ratios of binding agents used in manufacturing of the pots.

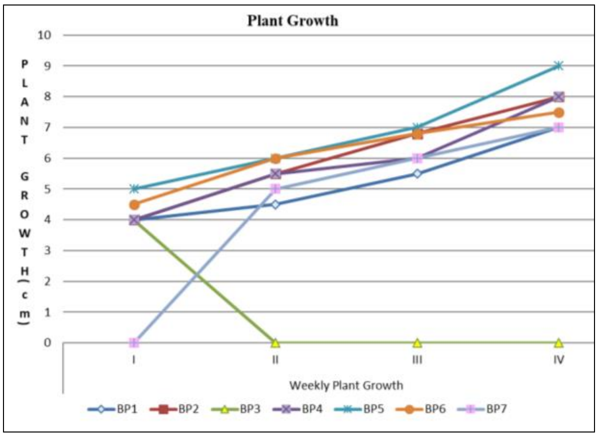

Fig 10: Plant growth test of pots

Plant growth test

The graph shows weekly measurements of tomato plant growth in seven different pots (BP_1 to BP_7) over thirty days. BP_1 and BP_2 both reached 4 cm during first week and grow steadily to 7 cm and 8 cm, respectively, indicating healthy growth. Unfortunately, BP_3, remains at its initial height of 4 cm and does not grow, suggesting unfavourable conditions or any inappropriate nutrient released in the soil due to the composition of pots. BP_4 showed the growth rate of 4 cm in first week to 6 cm by the third week, and finally reaches to 8 cm by the fourth week, showing positive growth. BP_5 was 5 cm during the first seven days and grew robustly to 9 cm by the fourth week. The growth in pot BP_6 was recorded 4.5 cm which reached 7.5 cm by the fourth week, following a steady pattern. BP_7 showed late germination may be due to less water absorbency of the pot which later grew consistently from the second week and reaches 7 cm by the fourth week.

Overall, most of the pots exhibit growth, with BP_3 remaining stagnant and BP_7 catching up after late germination. The best pot for plant growth parameter among all the seven with different fibre and matrices combinations was BP_7 with the fastest germination and growth rate recorded in early thirty days with similar temperature, water and sunlight for all the plants.

The growth of tomato plants in banana fibre pots were further compared with the plants in commercially available plastic pots of the same dimensions. It was concluded that all the seven different bio composite pots were superior to plastic pot in plant growth parameter.

Conclusion

In conclusion, the study highlights the potential of banana fiber pots as a sustainable alternative to plastic pots in agriculture, horticulture, home gardens, urban landscaping and commercial nurseries. The water absorption tests highlighted significant variations, with BP_5 exhibiting the highest absorption rate at 274.47%, likely due to the high concentration of guar gum, while BP_7 had the lowest rate at 37.63%, attributed to the use of epoxy. The plant growth tests showed that most pots supported healthy growth, except for BP_3, which did not grow beyond its initial height, indicating possible unfavourable conditions or inappropriate nutrient release. Further, it was found that BP_5 possess best water retention property along with the fastest germination and growth rate among all pots, suggesting that the specific combination of fiber and matrices, play a crucial role in plant health. These findings demonstrated the importance of selecting appropriate materials and manufacturing processes for biodegradable pots to enhance their performance and contribute to sustainable agriculture. In future the research can be supported by incorporating fillers to the bio-composites and further analysing them to improve the quality of bio degradable pots.

Acknowledgement

The authors would like to thank the department of Apparel and Textiles, College of Community Science, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, India for providing an opportunity to carry out this research work.

Conflict of interest

All authors declare that they have no conflict of interest.

References

1. Akubueze EU, Ezeanyanaso CS, Orekoya EO, Ajani SA, Obasa AA, Akinboade DA. Extraction and Production of Agro-Sack from Banana (*Musa sapientum*) and Plantain (*Musa paradisiaca* L) Fibres for Packaging Agricultural Produce. International Journal of Agriculture and Crop Sciences. 2015;9(1):9-14.
2. Anirudh MK, Lal AMN, Harikrishnan MP, Jose J, Thasim J, Warrier AS. Sustainable seedling pots: Development and characterisation of banana waste and natural fibre-reinforced composites for horticultural applications. International Journal of Biological Macromolecules. 2024;3:270. doi: 10.1016/j.ijbiomac.2024.132070.
3. Chauhan S, Gupta TK, Srivastava VS. Applicability of Banana Fiber as Reinforcement in Composites. Computational and Experimental Methods in Mechanical Engineering. 2022;239:77-91. doi: 10.1007/978-981-16-2857-3_9.
4. Jirapornvaree I, Suppadit T, Popan A. Use of pineapple waste for production of decomposable pots. International Journal of Recycling of Organic Waste in Agriculture. 2017;6:345–350. doi: 10.1007/s40093-017-0183-5.
5. Nguyen AT, Nguyen HT. Banana Fiber-Reinforced Epoxy Composites: Mechanical Properties and Fire Retardancy. Hindawi International Journal of Chemical Engineering. 2021. doi: 10.1155/2021/1973644.
6. Sapuan SM, Leenie A, Harimi M, Beng YK. Mechanical properties of woven banana fibre reinforced epoxy composites. Materials and Design. 2006;27(8):689–693.
7. Venkateshwaran N, Elayaperumal A. Banana fiber reinforced polymer composites—a review. Journal of Reinforced Plastics and Composites. 2010;29(15):2387–2396.