INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 1, January 2026 | ISSN: 2456-4184 | IJNRD.ORG

BIO BASED PLANTING SOLUTIONS: HARNESSING ARACHIS HYPOGAEA FOR SUSTAINABLE GARDENING PRACTICES

Eco-Shell Pottery: Performance and Acceptability of Peanut-Shell Pots as a Biodegradable Alternative to Black-Plastic Containers

[1]Ruchi Sharma, [2]Manasvi Kapur [3]Alka Sahni, [4]Deepak Jindal

[1]TGT Science, Maharaja Agarsain Public School, Ashok Vihar, New Delhi, [2] Student Researcher, Maharaja Agarsain Public School, Ashok Vihar, New Delhi, [3]Principal, Maharaja Agarsain Public School, Ashok Vihar, New Delhi, [4]Chairman, Maharaja Agarsain Public School, Ashok Vihar, New Delhi
[1]Department of Science,
[1]Maharaja Agarsain Public School, Ashok Vihar, New Delhi, India

Abstract: Black-plastic nursery pots dominate containerized horticulture but generate enduring plastic waste and can suppress plant growth. This study fabricates and evaluates "Shell-Eco Pottery," a six-ingredient peanut-shell pot (peanut shells 30 %, Fullers earth 30 %, sweet-lemon peel 20 %, neem leaves 10 %, coconut husk 5 %, alum 5). A bifurcated survey of 265 Delhi stakeholders documents strong willingness to adopt biodegradable containers, with 84 % of residents and 73 % of nurseries accepting a 15 % price premium. Rajma (*Phaseolus vulgaris*) seeds grown for 21 days in raw soil (Group A), conventional plastic pots (Group B), and peanut-shell pots (Group C) showed that Group C achieved the greatest mean root length (7.5 cm), shoot length (19.1 cm), leaf count (22), balanced percolation (0.75 mL s^{-1}), and stable soil pH (6.5). Statistical analysis (one-way ANOVA; $\alpha = 0.05$) revealed significant inter-group differences ($p < 0.05$) with large effect sizes (Cohen's $d = 0.9$–1.4). The lignocellulosic matrix enhanced aeration, moderated moisture, and released nutrients gradually. Combined with high stakeholder acceptability, peanut-shell pots present a viable pathway toward plastic-waste reduction and improved early-stage plant performance. Future work should include season-long field trials and life-cycle assessment to confirm durability, economic viability, and environmental impact.

***IndexTerms* - Biodegradable pots, peanut shells, plastic pollution, Phaseolus vulgaris, sustainable horticulture**

I. INTRODUCTION

INTRODUCTION

Since the advent of polyethylene in the 1950s, global plastics production has risen exponentially; by 2015 an estimated 8.3 billion t of plastic had been produced, 79 % of which now resides in landfills or natural ecosystems (Geyer, Jambeck, & Law, 2017). Black-plastic nursery pots, prized for low cost and durability, are a notable contributor: estimates for Indian urban nurseries exceed 300 million units annually. Once discarded, these containers photodegrade into micro-plastics that alter soil structure, disrupt nutrient cycling, and threaten soil biota (Rodrigues et al., 2020).

Biodegradable pots derived from agricultural residues decompose into benign organic matter, integrating seamlessly into circular-economy models. Coir, rice husk, and paper pulp have been examined, yet each material carries trade-offs: coir pots often collapse under irrigation, and paper pulp lacks tensile strength (Ghimire, Richardson, & Koeser, 2016, *HortScience*, 51(6), 730-737. https://doi.org/10.21273/HORTSCI.51.6.730). Peanut shells present an under-utilised option. Rich in lignin, cellulose, and calcium oxide, they exhibit porosity that enhances aeration while gradually releasing macro- and micro-nutrients (Sud, Mahajan, & Kaur, 2008). India produces >6 million t of peanut shells annually, much of which is burned or discarded.

NEED OF THE STUDY.

Despite promising physicochemical properties of peanut shells, field-scale evaluations of peanut-shell pots remain scarce. Existing studies often test coir or paper bio-pots under greenhouse conditions; few juxtapose peanut-shell containers against plastic controls for early vegetative growth. Likewise, stakeholder willingness to adopt biodegradable alternatives in Indian megacities is poorly documented.

Objective. The present study
(i) fabricates a peanut-shell pot fortified with Fullers earth and botanicals,
(ii) compares its horticultural performance with plastic pots and bare-soil controls, and
(iii) quantifies consumer and nursery willingness to adopt biodegradable containers.

2.1 Plastic Container Impacts

Thermal stress induced by dark-coloured polymer containers can inhibit root elongation. Koeser et al. (2014) observed >15 % biomass reductions in *Hydrangea macrophylla* grown in black versus white containers. Beyond thermal effects, micro-plastic leachates may serve as vectors for hydrophobic contaminants, altering microbial community composition (Rodrigues et al., 2020). Soil micro-plastic concentrations as low as 0.1 % (w/w) reduced earthworm biomass by 15 % in controlled trials (Lwanga et al., 2017).

2.2 Progress on Biodegradable Pots

Ghimire et al. (2016) evaluated paper-fiber containers and reported adequate seedling performance but rapid structural degradation under daily irrigation. Nambuthiri, Ingram, and Ruter (2015) catalogued biocontainer research, highlighting water-use efficiency gains yet noting inconsistencies in strength (*HortTechnology*, 25(1), 50-63). Karaivazoglou, Kalderis, & Diamadopoulos (2021) found lignocellulosic pots from olive pruning residues to withstand 35 N compressive force but did not test agronomic outcomes.

2.3 Agro-Residue Synergies

Peanut shells contain lignin, hemicellulose, and calcium oxide; their porous architecture supports microbial colonisation and aeration (Sud et al., 2008). Neem leaves carry azadirachtin, disrupting insect hormonal pathways (Isman, 2020). Fullers earth, a hydrous aluminium silicate, enhances binding and regulates moisture. Integration of these materials into a single pot represents a novel composite with multifunctional benefits

RESEARCH METHODOLOGY

3.1 Formulation Process

Dried peanut shells, sweet-lemon peel, neem leaves, and coconut husk were pulverised to <2 mm. Dry ingredients were combined to achieve the percentages in Table 1. Fullers earth and alum were dissolved in water (1:4 w/v) to create a slurry, then mixed with dry matter to yield a mouldable paste. Pots (10 cm diameter, 8 cm height) were compression-moulded and air-cured for 24 h at 30 °C; hardness exceeded 15 N in penetrometer testing. Ingredient proportions and functional roles are summarised in Table 3.1.

Table 3.1: Eco Shell Pottery formulation

Ingredient	Proportion (% by weight)	Functional Contribution
Peanut shells	30 %	Aeration; gradual N & K release
Fullers earth	30 %	Binder; moisture regulation
Sweet-lemon peel	20 %	Insect-repellent volatiles; moisture buffer
Neem leaves	10 %	Azadirachtin for pest deterrence
Coconut husk	5 %	Water retention; pH buffer
Alum	5 %	pH stabiliser; structural hardening

3.2 Survey Methodology

The questionnaire included Likert-scale items on environmental concern, pot preferences, and willingness-to-pay (WTP). Cronbach's α for environmental-attitude items was 0.81, indicating good internal consistency. Data collection followed the CHERRIES checklist for e-surveys; ethical consent obtained.

3.3 Experimental Design

Seed selection, pot filling, and irrigation followed the protocol in the PDF appendix. Growth chambers maintained 28 ± 2 °C and 60 % RH. Soil pH measured via pH meter (Eutech pH 700) on leachate samples. Percolation assessed by Darcy cylinder; three replicates per group.

3.4 Statistical Procedures

ANOVA executed in R 4.3. Post-hoc Tukey HSD identified pairwise differences. Effect sizes interpreted as small (0.2), medium (0.5), large (0.8). Survey WTP analysed via ordinal logistic regression.

IV. RESULTS AND DISCUSSION

4.1 Results

4.1.1 Root and Shoot Growth

Root elongation in peanut pots (7.5 ± 0.3 cm) was significantly greater than plastic (6.5 ± 0.4 cm) and soil controls (5.8 ± 0.5 cm). Tukey contrasts indicated Group C > B ($p = 0.007$) and C > A ($p = 0.002$). Shoot length differences paralleled root findings. Cohen's d between peanut and plastic pots was 1.39 (root) and 0.92 (shoot), indicating very large and large effects, respectively. Peanut pots produced a 15 % longer root system than plastic controls.

Table 4.1: Day-21 growth and soil metrics (mean ± SD, n = 3)

Parameter	Raw Soil (A)	Plastic Pot (B)	Peanut Pot (C)	ANOVA p
Root length (cm)	5.8 ± 0.5	6.5 ± 0.4	7.5 ± 0.3	0.008
Shoot length (cm)	17.5 ± 0.6	17.9 ± 0.4	19.1 ± 0.5	0.012
Leaves (no.)	19 ± 1	20 ± 1	22 ± 1	0.015
Soil pH	6.6 ± 0.03	6.4 ± 0.02	6.5 ± 0.05	0.08 (n.s.)
Percolation (mL s^{-1})	0.60 ± 0.02	0.80 ± 0.03	0.75 ± 0.02	0.041

n.s. = not significant at $\alpha = 0.05$

4.1.2 Leaf Proliferation and Chlorosis Incidence

Peanut pots exhibited highest leaf initiation (22 leaves), with negligible chlorosis. Plastic pots recorded occasional marginal yellowing, likely from heat stress; raw-soil plants showed wilting under fluctuating moisture.

4.1.3 Soil Physicochemical Parameters

Soil pH remained 6.5 ± 0.05 in peanut pots, whereas plastic pots dropped to 6.4 and raw soil to 6.6. Differences were non-significant ($p = 0.08$) but trend suggests buffering by alum. Percolation rate of 0.75 mL s^{-1} in peanut pots provided balanced hydraulic conductivity; plastic pots showed faster run-off (0.80 mL s^{-1}) and raw soil slower (0.60 mL s^{-1}). Hydraulic conductivity differed among treatments.

4.1.4 Stakeholder Survey

Mean WTP for biodegradable pots among residents was ₹21 (± 6) above plastic baseline; nurseries indicated logistical barriers (shelf stacking) but remained positive. Ordinal regression showed environmental concern score ($\beta = 0.62$, $z = 5.3$, $p < 0.001$) predicted WTP, accounting for 38 % of variance. Survey responses indicate strong market readiness (Table 4.4)

Table 4.4: Stakeholder willingness-to-pay (WTP)

Respondent Type	% willing to pay 15% premium	Mean WTP (₹)
Residents (n = 250)	84 %	21 ± 6
Nurseries (n = 15)	73 %	18 ± 5

4.2 Discussion

4.2.1 Agronomic superiority of peanut-shell pots

Porosity facilitated oxygen diffusion, mitigating the hypoxic stress Koeser et al. (2014) observed in black pots. Gradual nutrient release corroborates Sud et al.'s (2008) adsorption-desorption findings, explaining enhanced leaf proliferation. The 15 N hardness threshold surpasses the 12 N minimum Ghimire et al. (2016) deemed acceptable for nursery handling.

4.2.2 Comparisons with other lignocellulosic containers

Unlike coir pots that collapsed after eight weeks in Ghimire et al. (2016), Shell-Eco pots retained form during 21 days and anecdotal field curing (six weeks). Neem integration offers antimicrobial action absent in plain paper pots. Fullers earth functions similarly to bentonite in olive-pruning composites (Karaivazoglou et al., 2021), enhancing load tolerance.

4.2.3 Market readiness and policy implications

High WTP aligns with urban consumer environmental consciousness documented by Nambuthiri et al. (2015). Policy incentives such as GST concessions for biodegradable horticulture products could catalyse market penetration. Nurseries highlight stacking concerns; future prototypes should incorporate interlocking designs or reinforcement rims.

4.2.3 Limitations and future directions

Short trial precludes assessment of pot longevity under extended irrigation cycles. Mechanical testing under cyclic loading is needed. Life-cycle assessment (LCA) would quantify energy savings versus plastic. Research should also evaluate pot decomposition rate in situ to ensure micro-plastic-free degradation.

II. ACKNOWLEDGMENT

REFERENCES

[1] Geyer, R., Jambeck, J.R. and Law, K.L. 2017. Production, use, and fate of all plastics ever made. Science Advances, 3(7): e1700782.
[2] Ghimire, S.R., Richardson, B., Koeser, A.K. et al. 2016. Physical properties and durability of paper-fiber biocontainers. HortScience, 51(6): 730–737.
[3] Isman, M.B. 2020. Commercial neem extract formulations as plant insecticides. Journal of Pest Science, 93: 623–628.
[4] Koeser, A.K., Beeson, R.C. and Fulcher, A. 2014. Impact of container color on root-zone temperature and plant growth. HortTechnology, 24(1): 47–55.
[5] Lwanga, E.H. et al. 2017. Effects of microplastics on earthworms. Environmental Science and Technology, 51: 7811–7818.
[6] Nambuthiri, S., Ingram, D.L. and Ruter, J. 2015. Biocontainers in ornamental crop production: A review. HortTechnology, 25(1): 50–63.
[7] Rodrigues, M.O., Abrantes, N., Gonçalves, F.J.M. et al. 2020. Impacts of microplastics in soil ecosystems: A review. Environmental Pollution, 267: 115336.
[8] Sud, D., Mahajan, G. and Kaur, M.P. 2008. Agricultural waste material as potential adsorbent for sequestering heavy metal ions. Bioresource Technology, 99(14): 5440–5447.
[9] Jenkins, B.M. and Ebeling, J.M. 1985. Correlations of physical and chemical properties of terrestrial biomass with conversion. In Energy from Biomass and Wastes. Institute of Gas Technology, Des Plaines, IL, USA: 371–403.
[10] Sheng, C. and Azevedo, J.L.T. 2005. Estimating the higher heating value of biomass fuels from basic analysis data. Biomass and Bioenergy, 28: 499–507.
[11] Yin, C.Y. 2011. Prediction of higher heating values of biomass from proximate and ultimate analyses. Fuel, 90: 1128–1132.

[12] Graboski, M. and Bain, R. 1979. Properties of biomass relevant to gasification. Survey of Biomass Gasification, 2: 21–65.
[13] Callejón-Ferre, A.J., Velázquez-Martí, B., López-Martínez, J.A. and Manzano-Agugliaro, F. 2011. Greenhouse crop residues: Energy potential and models for the prediction of their higher heating value. Renewable and Sustainable Energy Reviews, 15: 948–955.
[14] Channiwala, S.A. and Parikh, P.P. 2002. A unified correlation for estimating HHV of solid, liquid and gaseous fuels. Fuel, 81: 1051–1063.
[15] Bridgwater, A.V., Double, J.M. and Earp, D.M. 1996. Technical and Market Assessment of Biomass Gasification in the United Kingdom. ETSU Report, UKAEA, Harwell, UK.
[16] Tillman, D.A. 1978. Wood as an Energy Resource. Academic Press, New York, USA.
[17] Annamalai, K., Sweeten, J.M. and Ramalingam, S.C. 1987. Estimation of gross heating values of biomass fuels. Transactions of the ASAE, 30: 1205–1208.
[18] Demirbas, A. and Demirbas, A.H. 2004. Estimating the calorific values of lignocellulosic fuels. Energy Exploration and Exploitation, 22: 135–143.
[19] Jimenez, L. and Gonzales, F. 1991. Study of the physical and chemical properties of lignocellulosic residues with a view to the production of fuels. Fuel, 70: 947–950.
[20] Zhao, X., Chen, J. and Du, F. 2012. Potential use of peanut by-products in food processing: A review. Journal of Food Science and Technology, 49: 521–529.
[21] Rinaldi, A., Schweiker, M. and Iannone, F. 2018. On uses of energy in buildings: Extracting influencing factors of occupant behaviour by means of a questionnaire survey. Energy and Buildings, 168: 298–308.
[22] Nogués, F.S. 2010. Energía de la Biomasa. Prensas Universitarias de Zaragoza, Zaragoza, Spain.
[23] Mata-Sánchez, J., Pérez-Jiménez, J.A., Díaz-Villanueva, M.J. et al. 2013. Statistical evaluation of quality parameters of olive stone to predict its heating value. Fuel, 113: 750–756.
[24] García, R., Pizarro, C., Lavín, A.G. and Bueno, J.L. 2014. Spanish biofuels heating value estimation. Part I: Ultimate analysis data. Fuel, 117: 1130–1138.
[25] García, R., Pizarro, C., Lavín, A.G. and Bueno, J.L. 2017. Biomass sources for thermal conversion: Techno-economical overview. Fuel, 195: 182–189.
[26] Arranz, J.I., Miranda, M.T., Montero, I. et al. 2015. Characterization and combustion behaviour of commercial and experimental wood pellets in south west Europe. Fuel, 142: 199–207.

Copyright & License: