Annals of Agricultural Science, Moshtohor (ASSJM)
https://assjm.journals.ekb.eg/

www.fagr.bu.edu.eg

ISSN:1110-0419

Original Article Vol. 61(3) (2023), 599 – 610 **DOI:** 10.21608/ASSJM.2024.234082.1245

CrossMark

Theoretical and Experimental Physicomechanical Properties of Cultivating Pots Made from Different Materials

Manar E. Elashry[1], El-Sayed G. Khater[1], Samir A. Ali[1] and Khaled Y. Farroh[2]
[1]Agricultural and Biosystems Engineering Dept., Faculty of Agriculture, Benha University
[2] Nano technology Advanced Materials Cen. Lab, Agric. Res. Center, Egypt
[*]**Corresponding author:** alsayed.khater@fagr.bu.edu.eg

Abstract

The main aim of this work is to study the effect of using different materials (sugarcane bagasse, compost, peat moss, vermiculite and activated carbon) on the physicomechanical properties of cultivating pots. Water absorption, density, elastic modulus were studied. Also, theoretical analytical models are employed to predict these properties. The results indicate that the water absorption was 10.73, 8.74, 18.23, 15.56 and 12.98 % for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite, respectively. The highest values of the theoretical and actual density (5.15 and 5.05 g cm^{-3}) were found with fillers made from sugarcane bagasse, while the lowest values of the theoretical and actual density (1.74 and 1.72 g cm^{-3}) were found with fillers made from compost. The tensile strength for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite were 6.84, 11.02, 4.00, 10.97 and 13.24 MPa, respectively. The elastic modulus for these materials were measured at 4.85, 10.66, 0.11, 8.37 and 15.00 MPa for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite, respectively. The highest values of theoretical elastic modulus for sugarcane bagasse, compost, peat moss, activated carbon and vermiculite (2.67, 5.94, 4.08, 4.94 and 2.31MPa) were found with Guth model. While, the lowest values of theoretical elastic modulus for sugarcane bagasse, compost, peat moss, activated carbon and vermiculite (0.06, 0.15, 0.10, 0.12 and 0.25 MPa) were found with Bowyer-Bader model. The germination ratio ranged from 80 to 100% for different pots made from different raw materials.

Keywords: Physicalmechanical properties, Composite, Pots, Tensile strength, density

Introduction

Green composites play a crucial contribution toward promoting environmental sustainability. Biodegradable cultivating pots play a crucial role in reducing plastic waste, thus reducing greenhouse gas emissions, in addition to supporting plant growth, and their physical and mechanical properties are of paramount importance in ensuring optimal performance. Utilizing various fillers in the fabrication of these pots offers opportunities to enhance their characteristics. The physical characteristics of various fillers significantly influence their water management capabilities, density, and structural integrity. Parameters such as water absorption, density, and void space play integral roles in determining the overall efficiency of water retention and root aeration. The incorporation of sugarcane bagasse, compost, peat moss, and vermiculite as fillers facilitates oxygen access (Balaguer et al., 2016) and activated carbon, which attains more absorption capability due to its high surface area (Ayyaswamy et al., 2019), provides a diverse range of attributes that impact the physical characteristics of the composite materials.

Water absorption reflects the potential for moisture retention, while density influences the compactness of the mix. Void space, on the other hand, influences root penetration and aeration. In addition to physical attributes, the mechanical properties of those mixes significantly contribute to the stability and support of plant growth. Tensile strength and elongation are key mechanical attributes that determine the ability of the mix to withstand mechanical stresses and maintain structural integrity. The incorporation of various fillers contributes to the composite material's mechanical attributes, with each filler type offering distinct reinforcement mechanisms that can impact tensile strength and elongation properties. High stiffness and tensile strength values have been demonstrated for natural fibers. The reinforcing employed in composites is a major determinant of tensile strength. As a result, natural fibers and matrices can create the necessary mechanical qualities for a particular application **(Bhat *et al.*, 2021)**.

The use of the cereal residues or by-products as a filler or reinforcement in the production of plastic composites alleviate the shortage of wood resources and can have the potential to start a natural fiber industry in countries where there are little wood resources left. The composite industries are looking into alternative low cost lignocellulose sources, which can decrease overall manufacturing costs and increase properties of the materials. Agro husk raw material could be a potential alternative replacing wood for making composites material particularly for automobile, packaging and construction applications. Last couple of years, cereal lignocellulose raw material (straw, cornstalk, bagasse) has been used for making composites with polypropylene, polyethylene, polyester, polyvinyl acetate, polyurethane, poly (3-hydroxybutyrate-co-3- hydroxyvalearate), polylactic acid and Novolac resin **(Jahan and S.P. Mun, 2009 and Bledzki *el al.*, 2010)**. Apart from composite materials, the particleboards from agro by-product could be another potential alternative **(Davis and Song, 2006)**.

The main aim of this work is to study the effect of using different materials (sugarcane bagasse, compost, peat moss, vermiculite and activated carbon) on the physicomechanical properties of cultivating pots. Water absorption, density, elastic modulus were studied. Also, theoretical analytical models are employed to predict these properties. Furthermore, the potential ecotoxicity effects of the composite extracts on germinating cucumber seeds are assessed, contributing to our understanding of the environmental impact of these materials.

Materials and Methods

The experiments were carried out at the Agricultural and Bio-Systems Engineering Department, Faculty of Agriculture, Moshtohor, Benha University, during the months of October and November, 2022 season.

2.1. Materials:

Sugarcane bagasse was collected from local farms dried and milled to get the powders. Different fillers, including compost, peatmoss, vermiculite, and activated carbon were purchased from local suppliers. Palm wax was obtained from the local market. Sorbitol was added as a plasticizer and brought from a local provider.

2.1.1. Cultivating pots fabrication:

Eight sets of filler mixes were configured for fabricating cultivating pots. The cultivating pot composites were fabricated by melt-blending and compression molding. Palm wax was heated and mixed well with each neat filler in a ratio of 4:3, 0.42:1, 0.63:1, 1:2, and 2:1 by weight for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite, respectively, then poured in a pre-prepared steel mold for hot pressing and forming at 160 bar and 60 ^{O}C); afterwards, it was left at room temperature for curing. Sorbitol was added to fillers at a 0.5: 2 weight percentage before mixing with palm wax. Specimens were cut from fabricated composite pots for further measurements as shown in fig. (1).

Fig. (1): Biodegradable cultivating pots fabricated from a neat type of filler

2.2. Methods:

2.2.2.1. Physical Properties:

- Water absorption (WA):

The water sorption (WA) by the composite specimens was measured by taking the initial weight (W_0) before immersing them in a beaker filled with water for approximately 24 h, then removing out, surface drying using tissue paper to remove the excess water up to reach equilibrium state and recording their weight (W) frequently using a digital balance with a 0.1 mg accuracy. Average value was calculated considering three reps of square specimens (20 × 20 mm). The water absorption was calculated according to the following formula according to **Fuentes *et al.* (2021)**:

$$WA\,(\%) = \frac{W - W_o}{W_o} \times 100 \tag{1}$$

Where:

WA is the water sorption, %

W_o is the initial weight, g

W is the weight at any time, g

- **Theoretical density (ρ_{ct}):**

The theoretical density of composites in respect of weight fraction is attained using the following generalized equation for an arbitrary number of constituents **(Werber, 1980)**:

$$\rho = \frac{1}{\sum_{i=1}^{n} (wi/\rho i)} \tag{2}$$

Where:

W_i is the weight fraction

ρ_i is the density of constituent of the filler, Kg m^{-3}

- **Porosity or Voids (V):**

As the bulk density may not agree with the actual density due to voids existence in the composites, the actual density was determined experimentally by means of a simple gravimetrical water immersion technique and the voids were determined by the ratio of difference between densities to the theoretical one as given as follows:

$$V = \frac{\rho - \rho_a}{\rho} \tag{3}$$

Where:

V is the porosity

ρ_a is the actual density, g cm^{-3}

2.2.2.2. Mechanical Properties:

- Tensile strength (TS):

Seedling pots face numerous forces emanating from the inside of the pots due to plant growth and handling in a greenhouse setting **(Juanga-Labayen and Yuan, 2021)**. Therefore, tensile strength is an important indicator of internal bonding and pots stability. Uniaxial tensile strength was conducted on the specimens with dimensions 500 × 250 mm cut from the fabricated pots wall using a universal testing machine (UTM) instrument equipped with 5 kN load cell at a crosshead extension speed of 2- ~5 mm/min at room temperature.

$$TS = \frac{P}{bh} \tag{4}$$

Where:

P is the load, kN

b is the width of a sample at the gauge region, m

h is the height of the sample at the gauge region, m

Triplicates of each composite were tested as shown in Fig. 2 and the average value is reported according to **Prasad *et al.*, (2020)**.

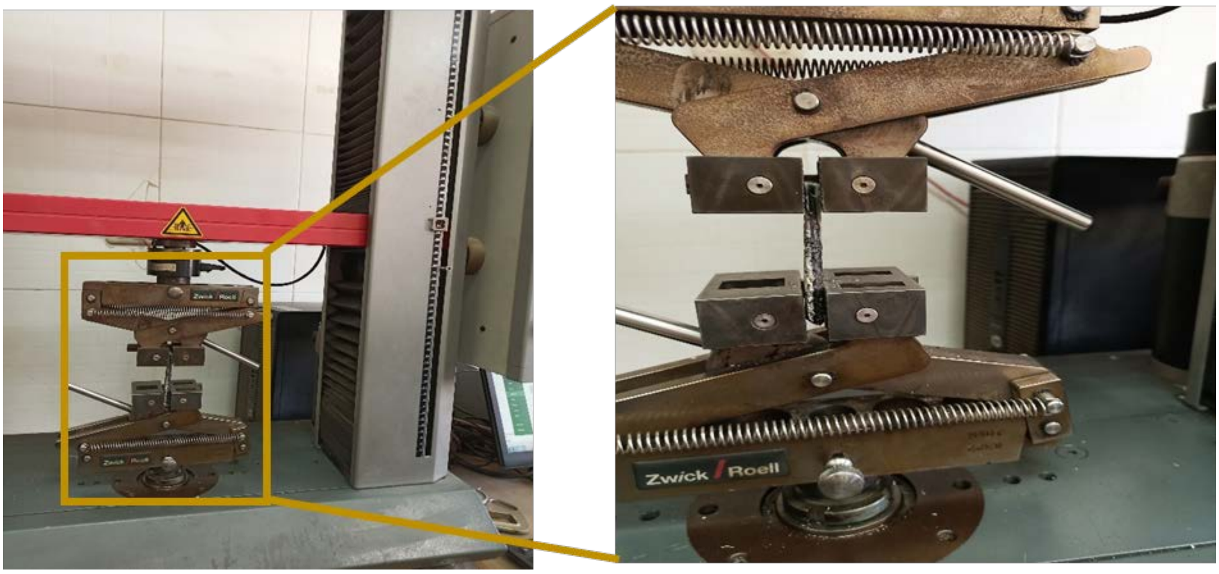

Fig. (2): Tensile strength measurement of the samples.

- **Elongation at break (E):**

Elongation of the composites was detected at the break point at the ultimate tensile strength.

1.3. Theoretical analytical models of the composites:

Seven analytical models were studied for prediction of the theoretical tensile strength and elastic modulus of the composites, namely the rules of mixture (ROM) (parallel), inverse rule of mixture (IROM) (series), Guth, Halpin–Tsai equation **(Werber, 1980, Behera *et al.*, 2014)**, modified Halpin-Tsai **(Facca *et al.*, 2006)**, Hirsch model, and Bowyer–Bader model **(Kalaprasad *et al.*, 1997)** as denoted in the following equations:

Rule of mixtures (ROM) (parallel):

$$\mathrm{Tc} = \sum_i^n T_i V_i \qquad (5)$$

$$\mathrm{Ec} = \sum_i^n E_i V_i \qquad (6)$$

Inverse rule of mixtures (IROM) (series):

$$\mathrm{Tc} = \frac{1}{\sum_i^n T_i V_i} \qquad (7)$$

$$\mathrm{Ec} = \frac{1}{\sum_i^n E_i V_i} \qquad (8)$$

Guth model:

$$\mathrm{Tc} = \mathrm{Tm}\,(1 - \mathrm{Vf}^{\,2/3}) \qquad (9)$$

$$\mathrm{Ec} = \mathrm{Em}\,[\,1 + 2.5\,\mathrm{V_f} + 14.1\,\mathrm{Vf}^{2}] \qquad (10)$$

Halpin-Tsai equation:

$$\mathrm{Tc} = \mathrm{Tm}\,\left(\frac{1+\zeta\eta Vf}{1-\eta Vf}\right) \qquad (11)$$

$$\mathrm{Ec} = \mathrm{Em}\,\left(\frac{1+\zeta\eta Vf}{1-\eta Vf}\right) \qquad (12)$$

Modified Halpin-Tsai equation:

$$\mathrm{Tc} = \mathrm{Tm}\,\left(\frac{1+\zeta\eta Vf}{1-\eta\psi Vf}\right) \qquad (13)$$

$$\mathrm{Ec} = \mathrm{Em}\,\left(\frac{1+\zeta\eta Vf}{1-\eta\psi Vf}\right) \qquad (14)$$

Hirsch model:

$$Tc = x\,(T_m V_m + T_F V_F) + \frac{(1-x)T_m T_F}{T_m V_f + T_f V_m} \quad (15)$$

$$Ec = x\,(E_m V_m + E_F V_F) + \frac{(1-x)E_m T_F}{E_m V_f + E_f V_m} \quad (16)$$

Bowyer and Badar’s model:

$$Tc = a_v T_f V_f + T_m V_m \quad (17)$$

$$Ec = a_v E_f V_f + E_m V_m \quad (18)$$

Where:

T is the tensile strength,

E is the elastic modulus

V is the volume fraction of the constituent,

c, m, and f are symbols of composites, matrix, and filler, respectively,

i is arbitrary number of constituents n,

ζ, ɳ, ψ, x, a_v are empirical parameters explained later.

2.4. Ecotoxicity effect:

A saturated aqueous composite extract with a 1:5 mass ratio of grinding composites to water suspension from each filler was soaked at room temperature for 24 hours of incubation. The leachate extract was filtered with a mesh cloth before use **(Wan Mohd Zamri *et al.*, 2021)**. The saturated aqueous extract was deployed in germinating cucumber seed to analyze the toxicity effect of the composites on the plants. Ten identical seeds were spread evenly and placed in plastic containers. The aqueous extract was provided in equal amount as equal as needed to keep the seeds wet. The plastic containers were placed in a greenhouse tunnel. The seeds were monitored daily, and the number of germinated seeds (SG) was counted, as in the following equation according to **Juanga-Labayen and Yuan (2021)**.

$$SG = \frac{Number\ \text{of germinated seeds}}{Number\ \text{of total seeds}} \times 100 \quad (19)$$

Results and Discussions

1. Physical properties:

1.1. Water absorption properties:

Fig. (3) shows the water absorption for different fillers made from different (sugarcane bagasse, compost, peat moss, activated carbon and vermiculite). It could be seen that the water absorption was 10.73, 8.74, 18.23, 15.56 and 12.98 % for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite, respectively. The results indicate that the highest value of the water absorption (18.23 %) was found with fillers made from peat mass, while the lowest value of the water absorption (8.74 %) was found with fillers made from compost. The statistical analysis showed that the differences between the obtained data of the water absorption for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite was significant.

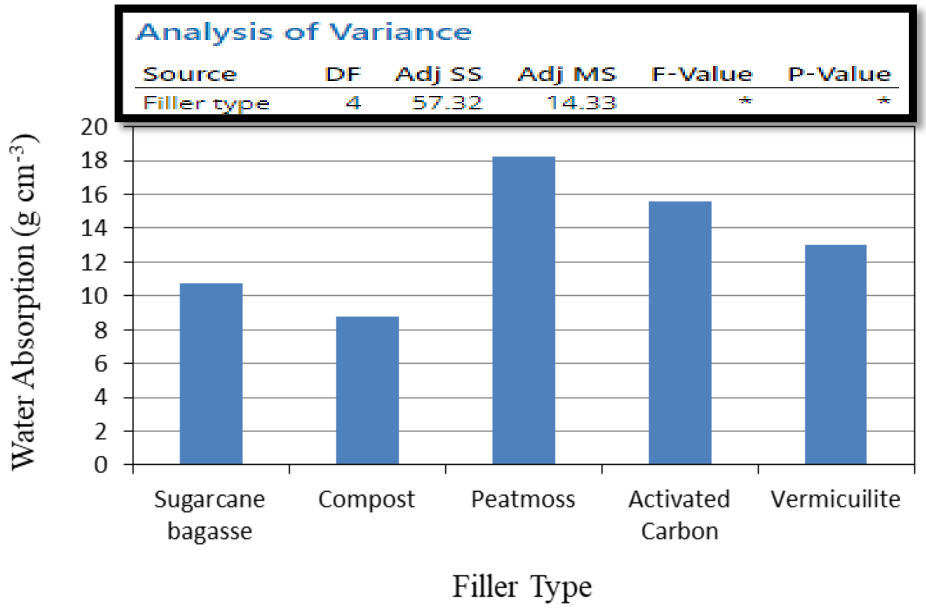

Fig. 3: Water absorption properties of the fillers.

1.2. Theoretical and actual density:

Figs. (4 and 5) show the theoretical and actual density for different fillers made from different (sugarcane bagasse, compost, peat moss, activated carbon and vermiculite). It could be seen that the theoretical density was 5.15. 1.74, 1.93, 4.46 and 2.32 g cm^{-3} for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite, respectively. The results also indicated that the actual density was 5.05, 1.72, 1.91, 4.07 and 2.26 g cm^{-3} for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite, respectively. The results indicate that the highest value of the theoretical and actual density (5.15 and 5.05 g cm^{-3}) were found with fillers made from sugarcane bagasse, while the lowest value of the theoretical and actual density (1.74 and 1.72 g cm^{-3}) was found with fillers made from compost. The statistical analysis showed that the differences between the obtained data of the theoretical and actual density for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite was significant.

Regression analysis was carried out to find a relationship between the theoretical and the actual density for fillers made from different materials with coefficient of determination as follows:

$$\rho = 0.978\rho_a + 0.007 \qquad R^2 = 0.99 \qquad (20)$$

Analysis of Variance for the theoretical density

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Filler type	4	9.142	2.286	*	*

Analysis of Variance for the actual density

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Filler type	4	8.752	2.188	*	*

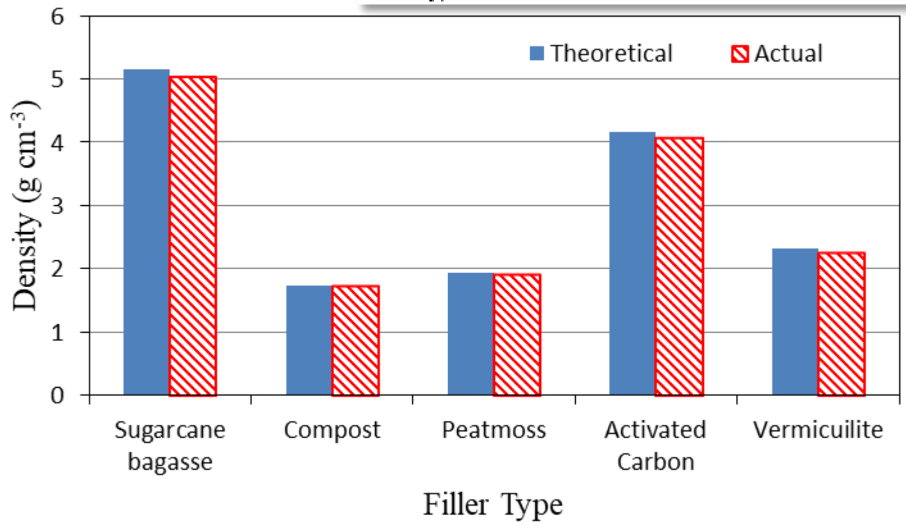

Fig. (4): Theoretical and actual density of the fillers.

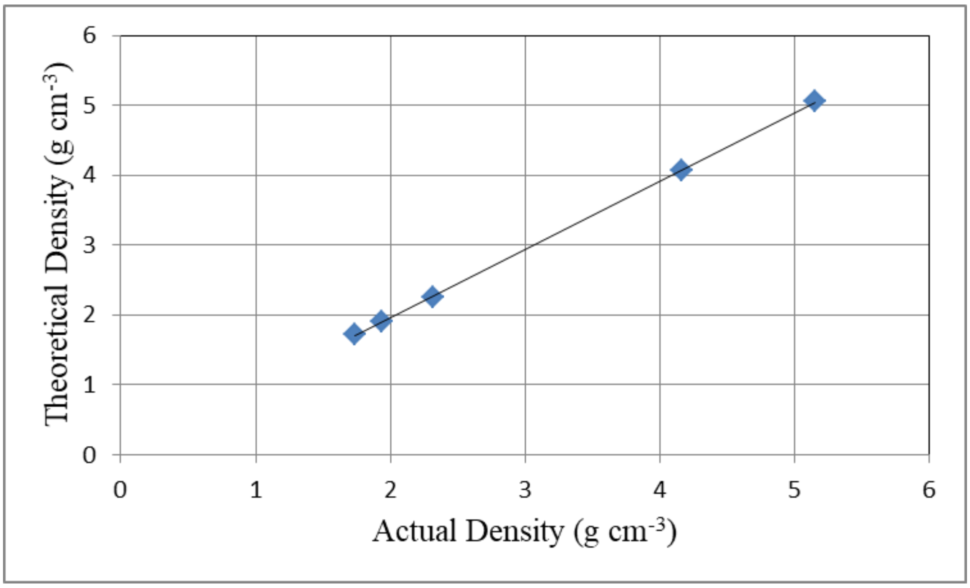

Fig. (5): Comparison between the theoretical and actual density of the fillers made from different materials.

2. Experimental mechanical properties of the filler-based composites:

The mechanical properties of the filler-based cultivating pots, encompassing tensile strength, elastic modulus, and elongation were illustrated in Fig. (6). The results indicate that the tensile strength for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite were 6.84, 11.02, 4.00, 10.97 and 13.24 MPa, respectively. The elastic modulus for these materials were measured at 4.85, 10.66, 0.11, 8.37 and 15.00 MPa for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite, respectively. The elongation values were 1.40, 5.21, 0.68, 2.00 and 5.00%, respectively. The choice of filler significantly influenced the mechanical attributes with vermiculite exhibiting the most substantial mechanical properties while peat moss demonstrated the least.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Filler type effect on the tensile strength	4	55.38	13.84	*	*
Filler type effect on the elastic modulus	4	128.2	32.05	*	*
Filler type effect on the elongation	4	17.73	4.431	*	*

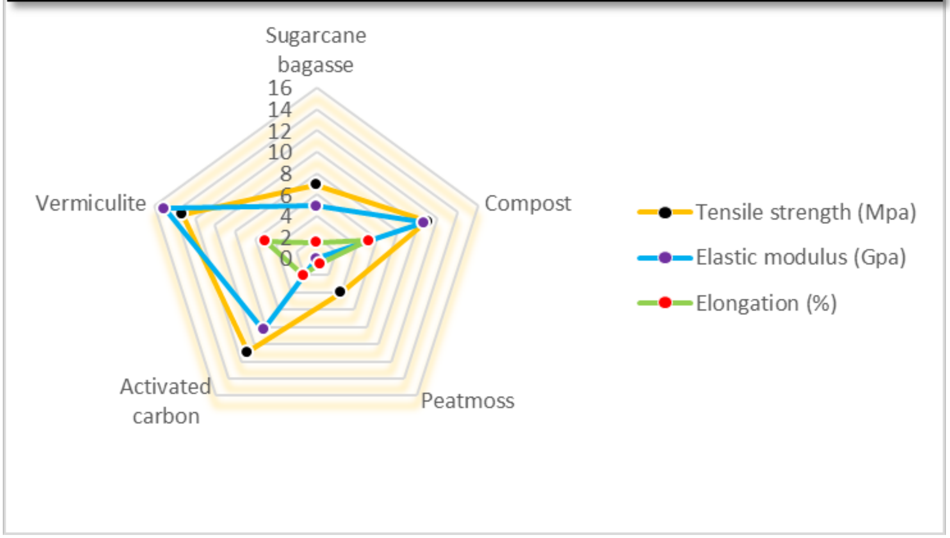

Fig. (6): The effect of fiber types on the mechanical properties of the composites.

3. Theoretical mechanical properties of the filler-based composites:

Fig. (7) shows the theoretical tensile strength for different fillers made from different (sugarcane bagasse, compost, peat moss, activated carbon and vermiculite) by using different models (parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader). The results indicated that the theoretical tensile strength for sugarcane bagasse by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 19.93, 16.14, 1.99, 2.57, 2.40, 16.51 and 0.29 MPa, respectively. These results agreed with those obtained by **Abidi *et al.* (2016), Li and Zhang (2017) and Gholampour and Ozbakkaloglu (2020)**. The theoretical tensile strength for compost by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 0.60, 3.24, 1.94, 1.74, 1.83, 2.98 and 0.39 MPa, respectively. Also, the theoretical tensile strength for peat moss by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 0.36, 2.46, 1.97, 1.65, 1.88, 2.25 and 0.35 MPa, respectively. The theoretical tensile strength for activated carbon by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 37.12, 15.82, 1.96, 3.86, 2.67, 17.95 and 0.37 MPa, respectively. The theoretical tensile strength for vermiculite by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 0.26, 3.87, 2.00, 1.88, 1.96, 3.51 and 0.27 MPa, respectively.

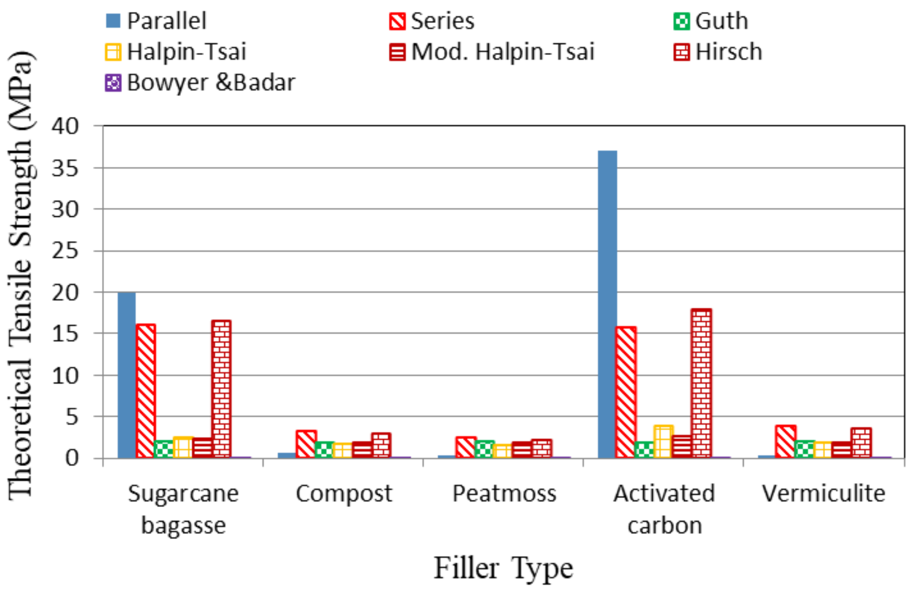

Fig. (7): Theoretical tensile strength for different fillers made from different by using different models.

Fig. (8) shows the theoretical elastic modulus for different fillers made from different (sugarcane bagasse, compost, peat moss, activated carbon and vermiculite) by using different models (parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader). The results indicated that the theoretical elastic modulus for sugarcane bagasse by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 1.53, 1.21, 2.67, 0.19, 0.18, 1.24 and 0.06 MPa, respectively. The theoretical elastic modulus for compost by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 2.09, 1.16, 5.94, 0.32, 0.27, 1.25 and 0.15 MPa, respectively. Also, the theoretical elastic modulus for peat moss by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 2.19, 1.19, 4.08, 0.26, 0.22, 1.29 and 0.10 MPa, respectively. The theoretical elastic modulus for activated carbon by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 1.35, 1.15, 4.94, 0.28, 0.24, 1.17 and 0.12 MPa, respectively. The theoretical elastic modulus for vermiculite by using parallel, series, Guth, Halpin-Tsai, modified Halpin-Tsai, Hirsch and Bowyer-Bader models were 0.71, 1.21, 2.31, 0.17, 0.17, 1.16 and 0.25 MPa, respectively.

The results indicate that the highest values of theoretical elastic modulus for sugarcane bagasse, compost, peat moss, activated carbon and vermiculite (2.67, 5.94, 4.08, 4.94 and 2.31MPa) were found with Guth model. While, the lowest values of theoretical elastic modulus for sugarcane bagasse, compost, peat moss, activated carbon and vermiculite (0.06, 0.15, 0.10, 0.12 and 0.25 MPa) were found with Bowyer-Bader model. These results agreed with those obtained by **Villagran, Leon *et al.* (2020)**.

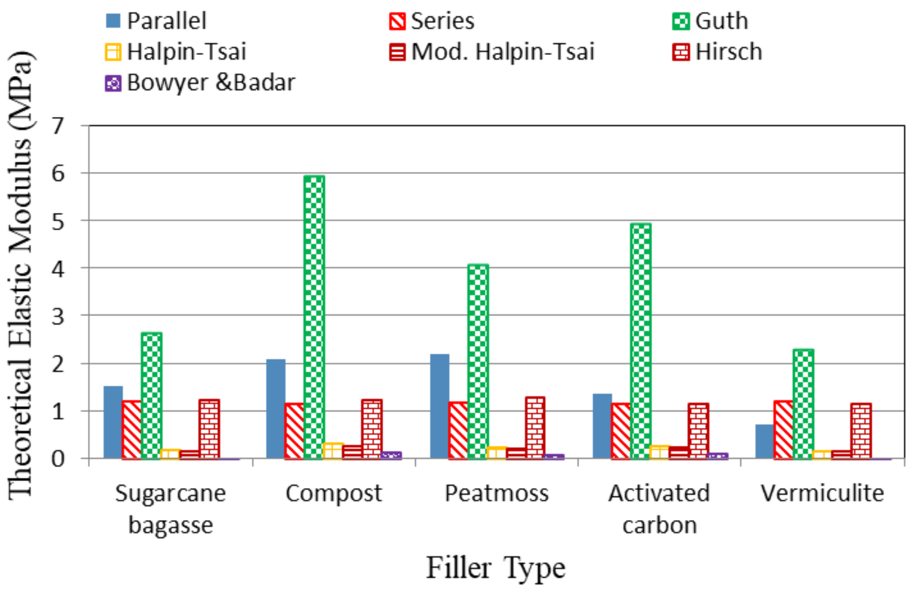

Fig. (8): Theoretical elastic modulus for different fillers made from different by using different models.

The IROM model demonstrated superior predictive capability in estimating tensile strength for a range of fillers, except for sugarcane bagasse, where the Halpin-Tsai model exhibited a better fit. This divergence in model performance could be attributed to the fact that the series model is better suited for fine particulate structures, whereas sugarcane bagasse consists of long fibers. Conversely, in terms of elastic modulus, the Guth model proved to be the most suitable for the various fillers, except for peat moss, where Bowyer and Badar's model emerged as the optimal choice.

4. Germination test:

Fig. (9) shows the germinated cucumber plant using aqueous extracts from the different fillers in the fabricated pot. The results indicate that the germination ratio ranged from 80 to 100% for different pots made from different raw materials. This confirms that all the cultivating pots do not have a toxic effect on seed germination.

Fig. (9): Germination test for cucumber seeds in different pots.

Conclusion

The experimental study was carried out successively to study the effect of using different materials (sugarcane bagasse, compost, peat moss, vermiculite and activated carbon) on the physicomechanical properties of cultivating pots. Water absorption, density, elastic modulus were studied. Also, theoretical analytical models are employed to predict these properties. The obtained results can be summarized as follows:

- The water absorption was 10.73, 8.74, 18.23, 15.56 and 12.98 % for fillers made from sugarcane bagasse, compost, peat moss, activated carbon and vermiculite, respectively.
- The highest values of the theoretical and actual density (5.15 and 5.05 g cm^{-3}) were found with fillers made from sugarcane bagasse.
- The tensile strength for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite were 6.84, 11.02, 4.00, 10.97 and 13.24 MPa, respectively.
- The elastic modulus for these materials were measured at 4.85, 10.66, 0.11, 8.37 and 15.00 MPa for sugarcane bagasse, compost, peat moss, activated carbon, and vermiculite, respectively.
- The highest values of theoretical elastic modulus for sugarcane bagasse, compost, peat moss, activated carbon and vermiculite (2.67, 5.94, 4.08, 4.94 and 2.31MPa) were found with Guth model. While, the lowest values of theoretical elastic modulus for sugarcane bagasse, compost, peat moss, activated carbon and vermiculite (0.06, 0.15, 0.10, 0.12 and 0.25 MPa) were found with Bowyer-Bader model.

References

Abidi, S., Y. Joliff and C. Favotto (2016). Impact of perlite, vermiculite and cement on the Young modulus of a plaster composite material: experimental, analytical and numerical approaches. Composites Part B: Eng., 92: 28-36.

Ayyaswamy, J. P. K., S. Sattanathan, B. Ramachandran and M. Nadarajan (2019). Banana Stem Based Activated Carbon as Filler in Polymer Composites for Automobile Applications. SAE Technical Paper, 28 - 93. https://doi.org/10.4271/2019-28-0093.

Balaguer, M. P., C. Aliaga, C. Fito and M. Hortal (2016). Compostability assessment of nano-reinforced poly (lactic acid) films. Waste manag., 48: 143-155.

Behera, A. K., S. Avancha, S. Manna, R. Sen and B. Adhikari (2014). Effect of nanoclay on physical, mechanical, and microbial degradation of jute-reinforced, soy milk-based nano-biocomposites. Polymer Eng. Sci., 54(2): 345-354.

Bhat, K. M., J. Rajagopalan, R. Mallikarjunaiah, N. N. Rao and A. Sharma (2021). Eco-friendly and biodegradable green composites, IntechOpen London, UK.

Bledzki, A.K., A.A. Mamun and J. Volk (2010). Physical, chemical and surface properties of wheat husk, rye husk and soft wood and their polypropylene composites. Composites Part A: Applied Sci. Manufacturing, 41 (4): 480-488.

Davis, G. and J.H. Song (2006). Biodegradable packaging based on raw materials from crops and their impact on waste management. Indus. Crops. Prod., 23(2): 147-161.

Facca, A. G., M. T. Kortschot and N. Yan (2006). Predicting the elastic modulus of natural fibre reinforced thermoplastics. Composites Part A: Applied Sci. Manufacturing, 37(10): 1660-1671.

Fuentes, R. A., J. A. Berthe, S. E. Barbosa and L. A. Castillo (2021). Development of biodegradable pots from different agroindustrial wastes and byproducts. Sust. Materials and Technolo., 30: e00338.

Gholampour, A. and T. Ozbakkaloglu (2020). A review of natural fiber composites: Properties, modification and processing techniques, characterization, applications. J. Materials Sci. 55(3): 829-892.

Haghighat, M., A. Zadhoush and S. N. Khorasani (2005). Physicomechanical properties of α-cellulose–filled styrene–butadiene rubber composites. J. Applied Polymer Sci., 96(6): 2203-2211.

Jahan, M.S. and S.P. Mun (2009). Studies on the macromolecular components of nonwood available in Bangladesh. Indus. Crops. Prod. 30(3): 344-350.

Juanga-Labayen, J. P. and Q. Yuan (2021). Making biodegradable seedling pots from textile and paper Waste—Part A: factors affecting tensile strength. Int. J. Env. Res. Public Health, 18(13): 6964.

uanga-Labayen, J. P. and Q. Yuan (2021). Making biodegradable seedling pots from textile and paper waste—Part B: Development and evaluation of seedling pots. Int. J. Env. Res. Public Health, 18(13): 7609.

Kalaprasad, G., K. Joseph, S. Thomas and C. Pavithran (1997). Theoretical modelling of tensile properties of short sisal fibre-reinforced low-density polyethylene composites. J. materials sci., 32(16): 4261-4267.

Li, Y. and M. Zhang (2017). Mechanical properties of activated carbon fibers. Activated carbon fiber and textiles, Elsevier: 167-180.

Prasad, L., A. Kumain, R. Patel, A. Yadav and J. Winczek (2020). Physical and mechanical behavior of hemp and nettle fiber-reinforced polyester resin-based hybrid composites. J. Natural Fibers, 19(3):1-16.

Villagran, E., R. Leon, A. Rodriguez and J. Jaramillo (2020). 3D numerical analysis of the natural ventilation behavior in a Colombian greenhouse established in warm climate conditions. Sustainability, 12(19): 8101.

Wan Mohd Zamri, W. M. I., F. Sjahrir, N. S. Yaacob, N. F. Dzulkafli, M. F. Ahmad, H. Abdullah, M. N. Maniyam, E. F. Hashim, N. Kawasaki and K. Komatsu (2021). Assessment of Aqueous Extraction Methods on Extractable Organic Matter and Hydrophobic/Hydrophilic Fractions of Virgin Forest Soils. Molecules, 26(9): 2480.

Werber, F. (1980). Analysis and performance of fiber composites, BD Agarwal and LJ Broutman, Wiley-Interscience, New York, 1980, 355 pp. Price: $24.50, Wiley Online Library.

الخصائص الطبيعية والميكانيكية النظرية والتجريبية لأصص الزراعة المصنوعة من مواد مختلفة

منار العشرى[1]، السيد جمعه خاطر[2]، سمير أحمد على[2]، خالد يحيى فروج[3]

[1]طالب دراسات عليا – كلية الزراعة بمشتهر – جامعة بنها

[2]استاذ الهندسة الزراعية – كلية الزراعة بمشتهر – جامعة بنها

[3]رئيس بحوث – المعمل المرزى لتكنولوجيا النانو والمواد المتقدمة – مركز البحوث الزراعية

إن الهدف الرئيسي من هذه الدراسة هو دراسة تأثير استخدام مواد مختلفة (تفل قصب السكر والسماد العضوى المكمور (الكمبوست) والبيتموس والفيرميكوليت والكربون المنشط) على الخصائص الطبيعي والميكانيكية لأصص الزراعة. ولتحقيق ذلك تم تم دراسة امتصاص الماء، الكثافة، معامل المرونة. كما تم استخدام النماذج التحليلية النظرية للتنبؤ بهذه الخصائص. واظهرت النتائج أن امتصاص الماء كان 10.73و8.74 و18.23و15.56 و12.98% للاصص المصنوعة من تفل قصب السكر والكمبوست والبيتموس والكربون المنشط والفيرميكوليت، على الترتيب. كانت أعلى قيم للكثافة النظرية والفعلية 5.15 و5.05 جم سم$^{-3}$ للاصص المصنوعة من تفل قصب السكر، بينما كانت أقل قيم للكثافة النظرية والفعلية 1.74 و1.72 جم سم$^{-3}$ للاصص المصنوعة من الكمبوست. وكانت قيمة قوة الشد لتفل قصب السكر والكمبوست والبيتموس والكربون المنشط والفيرميكوليت هى 6.84 و 11.02و 4.00 و10.97 و13.24 ميجا باسكال، على الترتيب. كانت قيمة معامل المرونة لهذه المواد هى 4.85، 10.66، 0.11، 8.37 و 15.00 ميجاباسكال لتفل قصب السكر والكمبوست والبيتموس والكربون المنشط والفيرميكوليت، على الترتيب. كانت أعلى قيم لمعامل المرونة النظري لتفل قصب السكر والكمبوست والبيتموس والكربون المنشط والفيرميكوليت (2.67 و5.94 و4.08 و4.94 و2.31 ميجا باسكال) باستخدام نموذج Guth. بينما كانت أقل قيم لمعامل المرونة النظري لتفل قصب السكر والسماد والبيتموس والكربون المنشط والفيرميكوليت (0.06 و0.15 و0.10 و0.12 و 0.25 ميجاباسكال) باستخدام نموذج Bowyer–Bader. وتراوحت نسبة الإنبات من 80 إلى 100% للأصص المختلفة المصنوعة من مواد أولية مختلفة.

الكلمات المفتاحية: الخصائص الطبيعية الميكانيكية – الخليط – امتصاص المياه – الكثافة