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Experimental Analysis of Water Absorption and Retention from Waste Biomass for Composite Application in Agriculture

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ABSTRACT

The water absorption and retention of five (5) plant biomass was determined to evaluate their water absorption and holding capacity for composite application in agriculture for soil water remediation against early draught in cereal crop production in Northern part of Nigeria. Some biomass material has the ability to absorb and retain moisture which may be release when incorporated with soil for use by the plant. The experiment was conducted in the laboratory and in the field to test the water absorption and retention capacity of the raw biomass and to test the performance of fabricated MOISTUREGRANULS made from raw biomass tested with higher affinity to absorb and retain moisture. The choice of each biomass material was based on their physical affinity to absorb and retain water and their availability as waste material in the area.

The choice of these bulky and abundance agriculture waste will provide reasonable economic means to recycle these products in an environmentally user friendly manner. Sample of biomasses was collected from dumped site and was measured, oven dried before test. Water holding capacity was determined using gravimetric method where weight of the wet sample and weight of the dry sample was determined. Samples determine with significant water absorption and retention capacity was selected to fabricate moisture granules. The result shows that Saw dust (SD) and sugar cane baggasse (SCB) has the highest water absorption and retention capacity then Rice Husk (RH), Paper wste (PW) and Millet Husk (MH) respectively. The result for the performance of fabricated granules indicated that granules made from SCB and PW and RH has higher water holding can capacity when compared with control. All samples used in this experiment have greater potentials for improve water absorption and retention in planted seeds.

Keywords: water, Absorption and Retention, waste biomass

1. INTRODUCTION

Previous studies have made several contributions in evaluating water absorption and retention capacity of different organic and inorganic materials in to their application in textile and building materials. Yen L. *et al,* (2011) evaluated the water absorption and retention capacity of building and decorative materials for suitability in building construction. Water absorption refers to the ability of material to absorb water when immersed in it and is represented with water Yen L., *et al,* 2011). It is the ratio of the weight of water absorbed by a material in saturated state over the weight of the dry matter/ WHC is defined as the amount of water bound to the biomass matrix without the application of an external force (e.g., atmospheric pressure). WRC is defined as the amount of water that remains bound to the hydrated biomass matrix after the application of an external force (e.g., negative pressure or centrifugation) (Raghavendra et al., 2004, Robertson and Eastwood, 1981, Robertson et al., 2000). These notions have been applied to specific materials in the textile (Wang and Gao, 2014) and food (Raghavendra et al., 2004, Robertson et al., 2000) industries. However, WHC and WRC concepts were loosely defined in the original references, resulting in a lack of standard measuring methods. These two characteristics can artificially manipulate to achieve form.

Several agricultural plant base waste biomasses has been used to improved water absorption and retention in many composite application such in bioenergy remediation, building and most especially in soil amendment Chacha *et al* (2019). Like in soil, soil amendment is any material added to the soil to improve its physical properties such as water retention, permeability, water infiltration, drainage, aeration and structure. Several organic biomasses and inorganic substances have been used for soil amendment such Sugar cane bagasse, sawdust, tree and fruit pulp and rice husk with promising results. The most common problem associated with poor water retention in soil is the immediate wilting and death plant due drought.

In northern Nigeria where rainfall is not stable especially at the onset of rainy season death of juvenile plant seedlings is the common experiences which may call for second or third replanting before rain stabilize. To mitigate this unforeseen circumstances used of water absorbent and retention material may be very useful. The current research work is to evaluate water absorption and retention capacity of some selected agricultural waste biomasses that can be used to fabricate granule to be incorporated with seeds during planting. The granules will remain in the soil even after germination absorbing extra water to be retained for plant use.

2. MATERIAL AND METHODS

Study Site

The study was conducted in the biology laboratory facility and biological garden of kebbi state polytechnic Dakingari located at Lat. 11.66632, N11°40'59.766'' and Log. 4.06248, E4°3'44.88''.

Sample collection and Preparation

Sample of Rice husk, paper waste, Sugar Cane baggasse, Millet husk and Saw dust were collected from dumping site in Dakingari town of kebbi State Nigeria. The samples collected were screamed for impurities, air dried, measured and grinded. The grounded samples were later sieved using standard laboratory sieve with 2mm diameter to make a fine powder.

Test for water Absorption

To test the water absorption capacity of different biomasses 10g of each sample was immersed in a beaker containing 150ml of water for 12 hours. The saturated sample was removed from the beaker and allows to stand for 10 minute to allow unabsorbed water to drop out. Water absorption was determined from the weight of water gain of saturated sample against the weight of dried samples of biomass. The calculation was done using the formula below as in Sa`idu A, *et al,* 2024.

$$W abs = \left(\frac{Wet\ Weight - Dry\ wieght}{Wet\ weight}\right) X\ 100$$

Fig.1. test for water absorption

Test for water Retention (WR)

50g of each sample was also soak in a beaker of 200ml of water and allowed to stand for 12 hours to absorb water. Weight of the saturated samples was measured using digital weighing balance. Each sample was later compressed with a pressure of 5kg for 12 hours. The amount of water retained was determined using the formula applied above. The sample can further be test in the desorption chamber constructed after Aslam *et al* 2022.

Fabrication of MOISTGRANULS

Samples of the raw biomasses with higher water absorption and retention capacity were used to prepare the MOISTGRANULS. The granules were made by incorporating 1kg of the sample with 10g of the starch binder. This was later mixed with appropriate quantities of water to make a daw which was molded in to small granules of comparable size called MOISTGRANULS. The granules were compressed and completely dehydrated in an oven to remove all the moisture.

Test for the performance of MOISTGRANULS

To find out the performance of the fabricated prototype MOISTGRANULS, the granules were tested in the laboratory following the same procedures with biomass test above. The performance tested granules were later confirmed by incorporating 2g, 2,5g and 3g of the granules with millet seeds which were sown in a separate polythene bag. Appropriate quantity of water was applied to the planted seeds until germination. The germinated seeds were allowed to stand without water until the plant wilt. The time taken for each plant without watering was measured against the control. The performance of the surviving seedlings compared with control group was evaluated.

3. RESULT AND DISCUSSION

3.1. Table 41. Show the water absorption capacity of five (different) locally available. The result indicted there is a significant water absorption capacity of the entire sample used in this experiment. The results show that SCB and SD have the highest percentage water absorption with 71.70% and 70.60% respectively. Other samples with higher water absorption were PW, RH and MH with 62.09%, 56.82%, and 50.69% respectively. The ability of a material to absorb water depends on its porosity and hydrophobocity of biomass. Gray, *et al*, (2014) observed the effect of hydrophobity in biochars water absorption capacity than porosity. But he also reported that Douglas fir took more water than hazelnut shell biochars due to porosity. Zhang (2013) also observed a significant effect of porosity on water absorption of wood char and concluded that average pore volume and the average pore diameter affect water absorption of the biomass material. This means that the sample of biomass used has higher average pore volume to absorbed more water. Biomass with low Pore surface and low porosity will absorb less water than the biomass with higher pore surface. SCB, CD, RH, MH and Paper show super absorbency capacity of more 5o% increase from the original. This shows that the materials can be use to enhance water absorption capacity of other media.

The rate of water absorption shows that SD, SCB and PW have the highest water rate of water absorption potentials with 5.98%, 5.88% and 5.17% respectively. Other biomass such as R and MH has low water retention capacity then the former. The rate of water absorption is very crucial in the application of biomass for soil water radiation against early drought. This means the material can be able to absorb more water in a limited time possible no matter the quantity of rain or water fed.

The result for water retention (table4.2) also shows that SD has the highest percentage water retention 50.2%, followed by SCB with 45.45% respectively. Ribbeiro *et al.* (2020) recorded higher percentage water retention of mortar added with 20% baggasse. Water retention is primarily dependent upon the texture or particle size distribution of the biomass, and the structure or particles. The chemical composition of the particular biomass can also determine it water retention ability. Water retention dynamics were influence by the repellency and particle size of the material Lentz *et al,* (2019), and that sawdust has long lasting effect on water retention. This report is similar with current finding where sawdust was observed with highest water retention capacity.

Table 4.1. Water absorption capacity of (5) different biomass (Rice husk, Sugar cane bagasse, Sawdust, Paper waste and Millet husk)

Biomass	Weight of Dry sample/g	Wet Weight of Dry sample	Wet gain or water Absorbed	%water or wet gain	Water Absorption Rate/h
RH	10	23.16	13.16	56.82	4.74
SCB	10	34.02	24.02	70.60	5.88
PW	10	26.38	16.38	62.09	5.17
SD	10	35.34	25.34	71.70	5.98
MH	10	20.28	10.28	50.69	4.22

RH= Rice Husk, SCB= Sugar Cane Bagasse, PW= Paper waste , SD= Saw Dust and MH= Millet Husk.

Table 4.2 Water retention capacity of (5) different biomass (Rice husk, Sugar cane bagasse, Sawdust, Paper waste and Millet husk)

Biomass	Weight of Dry sample/g	Wet Weight of Dry sample/kg	Wet gain or water Absorbed/kg/h	%water or wet gain
RH	1kg	1.46	0.46	31.50
SCB	1kg	1.84	0.84	45.45
PW	1kg	1.67	0.67	40.11
SD	1kg	2.01	1.01	50.24
MH	1kg	1.56	0.56	35.89

3.3. Fabricated MOISTUREGRANULES incorporated with Millet seedlings

MOISTUREGRANULES are granules made from biomass produced after evaluation of water absorption and retention of the biomass material that can be incorporated during planting of cereal crops to mitigate the effect of early drought especially in the Northern part of Nigeria. The granules when planted with seeds will absorb and retain water that may be release in when water will insufficient in the soil for plant growth. The fabricated granules were tested for their performance. The result of the performance of moisturegranules confirmed with what was recorded with result of raw biomass.

Fig.2. Fabricated MOITUREGRANULES

4.CONCLUSION

Waste agricultural biomass evaluated for their possible application in agriculture for improve water absorption and retention in incorporated cereal seeds show greater potentials in water absorption and retention. Sawdust and sugar cane bagasse has the highest water absorption and retention capacity. All other sample used can be use can be to improve water retention in militating against early drought.

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