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Studies on the Suitable Rot-Proof Processes for Manufacturing More Sustainable Jute Based Nursery Pot

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Abstract— **Cellulosic jute fabric was treated with different types of rot proofing agent for increasing the durability of the jute based nursery pot. Different types of rot-proofing salts were found in the market but among these it was found that copper compound was the best chemical to use as a rot proofing agent. In this experiment, two different types of processes were optimized. These processes were a) Carpet backing clothes (CBC) were treated with different concentrations of a mixture of copper sulphate and sodium carbonate solution and b) jute fabrics were treated with different concentrations of comsol solutions. The treated jute fabrics were tested and evaluated for determination of liquor pick-up, tensile strength, copper deposition, cost analysis, soil effect, and plant growth rate to optimize the longevity of the natural product as jute nursery pot. Seeds were sown in the jute based nursery pots. This experiment was conducted in the soil condition. The longevity of the jute based nursery pots were increased by rot-proofing treatment. After certain period, jute nursery pots were converted into biomass. This product does not create any harmful effect on the environment for plantation and their production, use and disposal. It was observed that, 25% comsol solution treated jute nursery pots exhibited a maximum longevity of fourteen months but10% copper sulphate mixed with 2% sodium carbonate treated jute nursery pots showed durability about fifteen months. Comsol is a costly chemical but copper sulphate salt is cheap. From the experiments, it was found that by increasing the percentage of copper sulphate solution (12% and14%) for the treatment of jute nursery pot, the percentage of copper deposition was increased but tensile strength of the fabric was decreased. The longevity of more sustainable jute nursery pot was about fifteen months and it was achieved by 10% copper sulphate solution treatment. The treated nursery pots rather showed better growth rates of the plants in comparison to those plants of control pot. This treatment did not change the neutral nature of the soil. It was found from soil analysis that jute nursery pot converted into biomass. Jute is a 100% biodegradable and eco-friendly material and do not pollute our environment like poly pot. We should encourage the uses of jute products so that we can contribute to our environment to make our planet a clean and healthy place to live.**

Index Terms— **environment, Jute, longevity, nursery, poly pot**

I. INTRODUCTION

The chemical composition of jute is quite different from other natural fibers. It contains 63-65% cellulose, 22-24% hemi cellulose and 12-14% lignin [1]. Green fiber like jute, which is being used for sustainable diversified products and jute fiber will be the future raw materials not only for the textile industry but also for the modern eco-friendly geo-textiles. Global trends towards sustainable development have brought to light natural, renewable, biodegradable raw materials, among them natural bast fibers. Jute is one of the natural bast fibers. Manufacturing of jute based rot-proof nursery pot (Np) is more sustainable product. Np provides environmental, social and economic benefits while protecting plants/public health and environment over their whole life cycle, from the extraction of raw materials until the final disposal. Nps are friendly to environment. Obviously with increasing awareness of environmental pollution and ecological balance natural fibrous materials like jute, kenaf, cotton, banana fiber etc. can be identified as the ideal raw materials for the manufacturing of Np in place of synthetic, non destructible pollutative ones.

In Bangladesh, jute is our main "cash crop" for earning foreign currency. Jute is a natural fiber, which abundantly grows in South Asian region. Jute is harvested every six months in a year. It is biodegradable and recyclable, eco-friendly, cheap, high tensile strength and is available in the market. Jute has an intense relationship with the environment. It is bestowed with natural process to clean the air. One hectare of jute plants can consume up to 15 MT of carbon dioxide and release 11 MT of oxygen during the jute growing season (about 100 days)[2].

Save our environment from pollution by using environment friendly jute products. Jute products usually decompose faster than what is required for some applications like geo-textile. This method is protecting jute fabric against micro-biological attack depending on the introduction of a substance into or on the surface of jute fiber/product so that it acts as deterrent or provide toxicity to the micro-organisms and prevents its reproduction and growth[3].

Polythene pot was non-biodegradable, cost-effective. Huge amount of poly pots were used in daily life but a small portion of these pots were recycled. These plastic bags will likely take about 1,000 years to decompose [4]. Polythene bags were extensively used for shopping purpose. It was not eco-friendly. But we are consciously or unconsciously polluting air, water and soil by using polythene. The drainage and sewerage systems have gone out of order due to throwing of polythene bags hither and thither. We use polythene bags in our daily life and throw them in the environment and it destroys our soil fertility. In order to deduce the extent of pollution problem**,** efforts have been made throughout the world to use rot-proof hessian for making nursery pot for seedling to solve global environment problem. In the rot

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proofing processing the jute fabric is treated with copper compound.

Copper, as a metal, is cheap, easily available, heat-resistant, and not harmful for the environment and damage area can be sealed very easily. This compound can be used to treat jute fabric for extending the longevity. Copper compound like copper sulphate is being used for antimicrobial treatment or preservative for vegetable since long[3].This rot-proofing method is protecting jute fabric against micro-biological attack depending on the introduction of a substance into or on the surface of jute fibre/product so that it acts as deterrent or provide toxicity to the micro-organisms and prevents its reproduction and growth [3]

Bangladesh is a green land. In rainy season, basic requirement was tree plantation in our country. In this time approximately four core Nps were needed. If we use poly pot for plantation, it would have a dangerous effect on our environment. But when we use rot proof jute based Np alternative of plastic pot, we protect our environment from pollution. If we calculate regular basis, jute bags are more profitable than using polythene bags. Jute bags have proved to be an ideal replacement for plastic bags. Bags made from these natural fibers are bio-degradable, eco-friendly, reusable and at the same time helps to create awareness to the disadvantages of using plastic bags.

Jute based Nps does not create any harmful effect in the environment for plantation, and whether in their production, use and disposal. The jute based products while throwing them in soil, it degrades and becomes biomass. When polythene pot is used for plantation, excess water does not pass through the polythene pot. As a result, the root of the plant is damaged for excess water. That's why the plant is sown in the soil without poly pot. The burring of these poly pots emits toxic materials like CO, CO_2 etc. So, the polythene pots are polluting our environment. On the other hand rot-proof jute based Nps save our environment from pollution.

II. MATERIALS AND METHODS

The experiment was conducted at Bangladesh Jute Research Institute, Dhaka to determine the longevity of differently treated nursery pots.

A. Experimental sample

Specification of the jute fabric was 750 (gm/m^2) GSM, ends/inch=14, Picks/inch=14.

B. Chemicals

1) Commercial grade copper sulphate ($CuSO_4.5H_2O$)
2) Commercial grade soda (Na_2CO_3)
3) Comsol solution.

Here, we need all these chemicals for the rot-proofing processes. At the same time, padding machine is very essential for this treatment.

C. Experimental procedure

Jute fabrics were treated with two rot-proofing processes. These are:

1) Six samples were treated with commercial grade copper sulphate solutions (4%, 6%, 8%, 10%,12% and 14%) and were added 2% sodium carbonate in a padding machine at the speed of 2 m/min under 2 bar pressure. The treated samples were air-dried.

2) Another six samples were treated with comsol solutions (4%, 6%, 10%,15%, 20% and 25%) and were added 2% sodium carbonate in a padding machine at the same speed and pressure and air-dried.

The two processes were optimized by the longevity of the jute based sustainable nursery pots in soil condition.

D. Liquor pick-up

Liquor pick-up

$$= \frac{\text{Weight after padding - Weight before padding)}}{\text{Weight before padding}} \text{X100}$$

Table I
Liquor pick-up of the jute fabric constraints for two different processes

Sl. No.	Copper sulphate solution treated samples	Liquor pick-up (%)	Comsol solution treated samples	Liqu-or pick-up (%)
1.	4% $CuSO_4$+ 2% Na_2CO_3	106	4% Comsol solution+ 2% Na_2CO_3	98
2.	6% $CuSO_4$+ 2% Na_2CO_3	102	6% Comsol solution+ 2% Na_2CO_3	105
3.	8% $CuSO_4$+ 2% Na_2CO_3	98	10% Comsol solution+ 2% Na_2CO_3	106
4.	10% $CuSO_4$+ 2% Na_2CO_3	104	15% Comsol solution + 2% Na_2CO_3	98
5.	12% $CuSO_4$+ 2% Na_2CO_3	102	20% Comsol solution + 2% Na_2CO_3	101
6.	14% $CuSO_4$+ 2% Na_2CO_3	99	25% Comsol solution + 2% Na_2CO_3	102

E. Determination of the tensile strength

The tensile strengths of the treated samples were measured by ASTM method.

F. Copper content determination

The copper contents of the rot-proof fabrics were determined by iodometric titration method [5].

G. Preparation of the nursery pot

Each rot-proof sample was prepared with the dimensions of 6"x7". A total number of 80 (Eighty) nursery pots were prepared from the treated fabrics. Eight nursery pots were prepared from untreated fabrics, these were named control pots.

H. Preparation of compost

The compost was prepared by mixing 50% (w/w) cow dung and 50% (w/w) soil. 600-700gms compost was filled in each nursery pot.

I. P^H Determination of the soil

The p^H of the soil was determined individually for each sample at initial time during sowing, after three, six and twelve months. At the initial time, the p^H of the control soil was 7.05. After three months, six months and twelve months, the p^H of all the experimental samples were 6.88 to 7.03, 6.89 to 7.13and 6.91 to 7.21 respectively.

J. Field Trial

Eighty nursery pots were set-up in the experimental field. Six pots were prepared for each treatment. Jack fruit is our national fruit of Bangladesh. Jack fruit seeds were sown in the nursery pot. Eight pots were prepared from untreated fabrics. It was found that untreated nursery pot lost its strength within fifteen days and was damaged within one month of plantation. The untreated pot degraded very easily due to the growth of fungi and other micro-organisms [6].All these treated fabrics were exposed in the soil condition.

Fig.1. Rot-proof jute based nursery pots in the experimental field.

Fig.2. Rot-proof jute based nursery pots.

K. Determination of the longevity

The control pot lost its strength within fifteen days and damages within one month for plantation. The untreated nursery pots were degraded very easily due to the growth of fungi and other micro-organisms. On the other hand, the duration of rot-proof nursery pots were increased by the treatment. The duration of jute based Nps were observed and the longevity of the Nps was compared with the copper content percentages. The effects of copper content percentages on longevity of nursery pots were shown in the Fig.3.

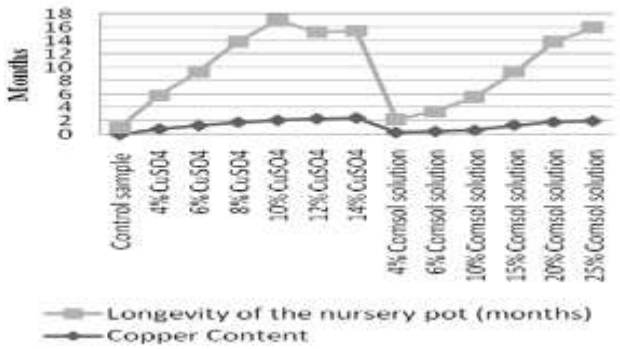

Fig.3. Effect of copper content (%) on the longevity of nursery pots.

L. Soil Test

Plants build up their biomass using water from soil, carbon dioxide from air, energy from sunlight and nutrients from soil. For optimum plant growth, nutrients must be available as solutes in soil water [7]. The plants growth rates of jack fruits were monitored regularly by measuring the plant heights. It appears that there was no significant change in plants growth for using of various percentage of copper sulphate. Plants freshness, liveness and color developed as like seasonal plant day after day.

After six months, the soil was collected from the Np and tested. The chemical parameters such as P^H, organic matter, mineral content such as nitrogen(N), phosphorus(P), potassium(K), copper Cu) of the soil were determined. The results are shown in Table. 2.

Table 2
Analytical data of mineral content

Sl. No.	Recipe of the treated solution	K meq/ 100g	N %	P (µg /g)	S (µg /g)	Cu (µg / g)	Organic matter content (%)
1.	Control sample	0.27	0.22	105.98	27.80	1.33	3.63
2.	4% $CuSO_4$	0.24	0.20	96.77	26.16	1.36	3.45
3.	6% $CuSO_4$	0.26	0.20	101.44	27.70	1.31	3.70
4.	8% $CuSO_4$	0.27	0.21	105.67	31.35	1.34	4.17
5.	10% $CuSO_4$	0.25	0.22	103.34	30.55	1.36	3.85
6.	12% $CuSO_4$	0.25	0.22	106.78	27.58	1.33	3.69
7.	14% $CuSO_4$	0.27	0.20	102.49	29.32	1.30	4.08
8.	4% Comsol solution	0.24	0.24	97.11	27.71	1.36	3.66
9.	6% Comsolsolution	0.26	0.22	109.47	28.50	1.35	3.83
10	10% Comsol solution	0.26	0.22	99.63	27.51	1.35	3.56
11	15% Comsol solution	0.27	0.20	108.44	30.33	1.33	3.35
12	20% Comsol solution	0.27	0.22	97.14	29.21	1.33	3.78
13	25% Comsol solution	0.25	0.21	102.78	29.56	1.36	3.92

It was observed from Table. 2 that the micronutrients such as N, S, P and K of the soil remained almost unaffected by the exposure to the nursery pots. Copper is an essential micronutrients for the plant growth [7]. Copper plays an essential role in chlorophyll formation and enzyme activity [8]. The quantity of copper in the treated pot was found slightly higher than the control pot. This increased copper content may indeed increases the growth rates of the plants in the treated pot ultimately.

M. Cost analysis

Fifteen nursery pot (size: 6"x7") will be manufactured from one meter jute fabric. The cost of the one meter fabric is 0.90 $.Nursery pot (Np) was manufactured in the laboratory scale. The cost of the each rot-proof Np (size: 6"x7") is 0.15 $. But in commercial scale, the cost of the rot proof Np is 0.125 $.

III. RESULTS AND DISCUSSION

Jute based rot-proof Np does not create any harmful effect in the environment and save from pollution. From the experiments, it was found that by increasing the percentages of copper sulphate for the treatment of jute Np, the strengths of the fabric were decreased. Treatment with 6% copper sulphate solution ensuring 1.3% copper content was required to achieve longevity of more than 6 months. The duration of 8% copper sulphate solution treated nursery pot was more than 9 months. 10% copper sulphate solution treated nursery pot gave the longevity maximum one year to 14 months. But 12% copper sulphate solution treated nursery pot gave the longevity maximum thirteen months. Another nursery pot gave about thirteen months longevity for 14% copper sulphate solution treatment. So, 12% and 14% copper sulphate solution mixed with 2% soda treatment processes were not cost-effective and longevity of those nursery pots were not increased. The optimum copper sulphate concentration for rot–proof process was found to be 10%, which results in longevity about fifteen months.

The life of the treated nursery pots is longer than that of the untreated nursery pots. When pots were being exposure with the environment, the life time of the nursery pot was gradually increased with the increasing of copper content concentration. The lowest limit of comsol solution was found to be 4%, for treatment below the concentration of the solution Np degraded very rapidly. 10% comsol solution treated Np was required to achieve longevity of more than 4 months. Treatment with 15% comsol solution was required to obtain longevity more than 8 months. In this way, increasing the percentage of the comsol solution with the processes longevity of the Np also increases. 20% of comsol solution treated Npwas achieved longevity about 12 months. 25% was the highest concentration of comsol solution treated Np is required to achieve longevity maximum 14 months for jute based rot-proof nursery pot.

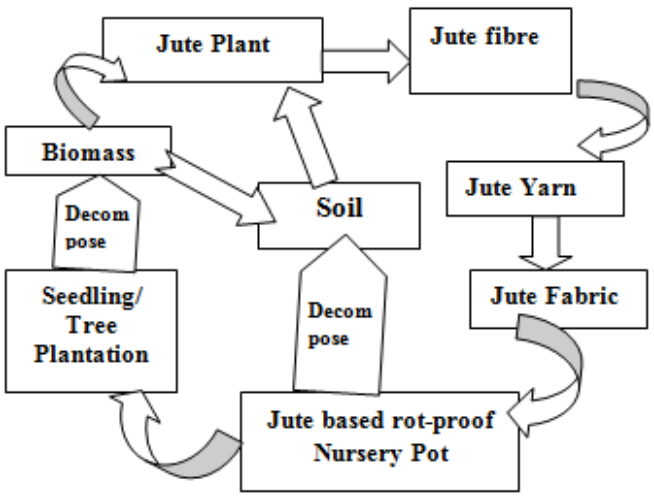

Fig.3. Recycle process between rot-proof nursery pot and soil

IV. SUMMARY

In Bangladesh nursery pots were essential for plantation. Approximately three core nursery pots were required for plantation in Bangladesh Forest Division, Private sector and NGO. From past, plant was sown in earthen pot. But now people use polythene bags, plastic bottles and plastic container. Polythene is harmful and hazard for our environment and water should not pass through the poly pot. That's why root of the plant was damaged with excess water. Excess water can pass through the jute based nursery pot and after certain period Np converted into biomass. The optimum copper sulphate concentration for rot–proof process was found to be 10%, which results in longevity about fifteen months. From analysis, it was found that the cost of each rot-proof nursery pot (size: 6"x7")=0.15$. The cost of the Np is not so high for the people to buy it. Poly pot is cheaper than jute based nursery pot but it pollutes our environment. Though jute based nursery pot is quite expensive, it plays an important role on our environment. So, jute based nursery pots treated with rot-proofing agents were more sustainable, natural, bio-degradable, eco-friendly and cost-effective jute products.

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