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Design of a soil-less textile cultivatıon bed for wheat grass using hydrogel

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Abstract: Due to rapid urbanization and industrialization as well as the melting of icebergs, the availability of land for agriculture is reducing and it's challenging to meet the demands of the growing population. In addition, open field agriculture is difficult as it involves large space, a lot of labor, and a large volume of water. Under such circumstances, soil-less culture can be introduced successfully. The main objective of this research is to develop a system to cultivate wheatgrass in a soil-less textile bed thereby integrating textiles with agriculture. It also aims to compare woven, knitted, and non-woven fabrics which are a total of seven fabrics and their ability to function as a textile cultivation bed for wheatgrass by keeping plants growing in soil as standard. The method here is to introduce hydrogel, a super absorbent polymer, within the textile to provide root support to grow plants. Organic fertilizer is used to provide the required nutrients. From this research, we could arrive at the findings that wheatgrass grows in all the fabrics but at a considerably low rate compared to soil. In conclusion, this soil-less cultivation represents the few new opportunities that we should fully explore especially if we are serious about living our lives in balance with the rest of the life forms on earth without further endangering both theirs and ultimately ours.

Index Terms **- Agriculture, hydrogel, soilless, textile cultivation bed, wheatgrass.**

I. INTRODUCTION

Due to fast urbanization and industrialization just as softening of ice sheets (as an undeniable effect of a worldwide temperature alteration), arable land involving soil under cultivation is further going to diminish [1]. Soil, is typically the most accessible developing mode for plants. It gives supplements, air, water, and so on for plant development. Be that as it may, soils do present genuine constraints for plant development as well. Some of them are nearness of infection causing living beings and nematodes, inadmissible soil response, ominous soil compaction, helpless waste, corruption because of disintegration and so on.

Also, open field agriculture is troublesome as it includes huge space, parcel of work and enormous volume of water. In generally urban and modern zones, soil is less accessible for crop developing, or in certain zones, there is shortage of fruitful cultivable arable terrains due to their horrible geological or geographical conditions. Different difficult issue experienced is to recruit work at ordinary occasions for customary open field farming. Under such conditions, soil-less culture can be presented effectively [2].

Soil-less culture can be characterized as "any technique for developing plants without the utilization of soil as an establishing medium, wherein the inorganic supplements consumed by the roots are provided by means of a nutrient solution.". The fertilizers containing the nutrients to be supplied to the crop are dissolved in the appropriate concentration in the irrigation water and the resultant solution is referred to as "nutrient solution" [3]. Soil-less agriculture would let the land around our urban areas come back to an un-spoilt biological system of woods or prairies, helping the battle against a dangerous atmospheric devation and environmental change on one hand and lift up country economy through condition well disposed cultivating framework [4].

Plants developed in soil-less culture has reliably unrivaled quality, high return, quick collect, and high supplement content. Soil less culture offers a method for authority over soil-borne sicknesses and bugs, which is particularly attractive in the tropics. Around the world, a high level of soil-less cultivation utilizes inorganic developing media, for example, rock fleece, sand, perlite, vermiculite, pumice, muds, extended polystyrene, urea formaldehydes and others, while just about 12% uses natural developing media, for example, peat, bark, wood buildups (leaf shape, sawdust, barks), coir, bagasse, rice frames and others. The most well known developing media for nursery creation of vegetables is rockwool, which is produced using basalt rock and chalk. Rockwool is the favored material since: 1) it is basically synthetically and naturally inactive, making it liberated from any expected vermin, sicknesses, and weed seeds; 2) rockwool pieces and squares can be inundated as often as possible as they channel uninhibitedly and would thus be able to be figured out how to give an ideal proportion among air and water for crop creation all through the developing season [3].

Man made fibres (like poly-olefins) are favored for agriculture than the common strands for the most part because of their positive value execution proportion, light weight with high quality and long assistance life, yet natural fibres can be utilized in agriculture in some particular field where attributes like high dampness maintenance, wet quality, biodegradability are successfully misused [5]. Be that as it may, very little examination is done in investigating the manners by which materials can be utilized as cultivation beds for plants.

Since, reduction of agrochemicals, maximization of crop production on minimum land are getting prime issues in case of agriculture nowadays, this paper shows a solution to the matters of integrating textile with agriculture. The main objectives are to develop a system to cultivate wheat grass in a soil-less textile bed by integrating textiles with agriculture and to promote textile waste management. The study also compares woven, knitted and non-woven fabrics and their ability to function as a textile cultivation bed for wheat grass by keeping plants growing in soil as standard [6].

Here a system presents textile based cultivation where wheatgrass is grown on textile fabric basements. Wheat grass is sold as a dietary supplement in tablet, capsule, powder and liquid forms. Wheatgrass is often used for juicing or added to smoothies. Wheatgrass provides a concentrated amount of nutrients, including iron, calcium, magnesium, amino acids, chlorophyll, and vitamins A, C and E. Wheatgrass claims to be rich in nutrient content boosts immunity, kills harmful bacteria in the digestive system, and rids the body of wastes [7]. Hydrogel, a superabsorbent chemical will be introduced within the textile fabric to make root support to grow plants. Organic fertilizer will be used to provide the required nutrients (micro and macronutrients). Hydrogels have been widely proposed over the last 40 years for agricultural use with the aim to ameliorate water availability for plants, by increasing water holding properties of soil [6]. This method uses hydrogel in a different growing medium, which is textile.

With the above literature, the number of technological options available for reducing our agricultural impact on the land and the oceans, while at the same time sustaining a growing human population is very limited. This soil-less cultivation represents one of the few new opportunities that we should fully explore over the next 10–20 years [8].

II. MATERIAL AND METHODS

2.1 Material

The seeds chosen for this cultivation are organic wheat grass which was sourced from a local organic store in Tirupur. Aloevera, used for germinating the seeds was also obtained locally. The seven fabrics chosen to do soil-less textile cultivation bed were all sourced locally and are clearly stated in the Table 1 below along with their composition.

Table 1: Materials used for soil-less cultivation

Code	Materials	Composition
S1	Woven	100 % Jute
S2	Woven	100 % Polyester
S3	Woven	100 % Cotton
S4	Knitted, air-tex fabric	100 % Cotton
S5	30:70 ratio, knitted	Cotton – Poly blend
S6	50:50 ratio, woven	Silk Cotton blend
S7	Non-Woven	Cotton-Poly blend
PA	Soil	Red soil

Hydrogel, highly absorbent crystals were used in the textile cultivation bed for the required water and chemical ingredients cushion. When they absorb water, they become swollen, soft & rubbery and resemble the living tissue, exhibiting excellent biocompatibility [9]. Hydrogels possess the highest absorption capacity, the lowest price, the highest durability and stability in the swelling environment and during the storage, the highest biodegradability without formation of toxic species following the degradation, colorlessness, odorlessness, and absolute non-toxic [10]. Also, to provide the plants with required macro and micronutrients, a fertilizer containing Nitrogen, Phosphorous and Potassium was used.

2.2 Method

2.2.1 Preparation of nutrient solution

The fertilizer containing Nitrogen, Phosphorous and Potassium (NPK) is mixed with water of required amounts in order to solubilize the salt content within the fertilizer which is shown in Figure 1 [11]. This NPK fertilizer is used because it's a complex fertilizer where Nitrogen is good at making the leaves grow, Phosphorus improves fruit and/or flower production as well as root growth, Potassium is great for overall plant health [12]. This mixture is then filtered using filter paper, and the filtered solution is collected. Thus, the organic nutrient solution for plant growth is ready. Heat treatment of nutrient solution 20-22 C has also been found effective in keeping the root-zone free of pathogens [1].

Figure 1: Preparation of nutrient solution

2.2.2 Preparation of agro-textile cultivation bed for soil-less cultivation

The concept here was to introduce the nutrient solution onto the fabric samples S1 to S7. The fabric sample S1- woven 100% jute fabric was taken and laid out in a tray. Then, hydrogel crystals were spread onto the pores of the fabric to hold the nutrient solution for long time in this fabric base. Then, the prepared nutrient solution was sprayed over the bed onto the hydrogel till the hydrogel crystals reached saturation and this is clearly shown in Figure 2. This same way all the seven samples were prepared. The best time to administer the nutrient solution was between 6.00 and 8.00 am, though water requirements will vary considerably throughout the day, and from one day to another. The solution should be applied to the roots, trying to avoid wetting the leaves to prevent damage and the appearance of diseases. Heat treatment of nutrient solution 20-22 C was also found effective in keeping the root-zone free of pathogens. Nutrients are fed directly to the roots, as a result plants grow faster with smaller roots, plants may be grown closer, and only 1/5th of overall space and 1/20th of total water is needed to grow plants under soil-less culture in comparison to soil-based culture [1].

Figure 2: Textile cultivation bed with swollen hygrogel crystals

2.2.3 Preparation of soil bed for conventional farming method

This bed was created solely for comparison purpose with the soil-less cultivation. Here, red soil was used because of its high iron content making it an appropriate choice for agriculture. This red soil was filled in a pot and this set up was called 'PA'. In this pot, wheat grass seeds are sown at the same time as to when seeds are sown in the textile cultivation bed.

2.2.4 Sowing seeds

The farming beds were placed in a place where the plants can get easy access of the required natural light and free air to grow well [13]. Before sowing the organic wheat-grass seeds onto both the soil and soil-less the beds, they were spread on aloevera. Aloevera was sliced into half and the wheatgrass seeds were spread onto its gel for germination overnight which is shown in Figure 3. After germination, the seeds were transferred to the seven agro-textile bed as well as the soil bed softly and carefully. Then the seeds were allowed to grow on the textile beds.

Figure 3: Germinated seeds for sowing

2.2.5 Observation and data collection

Once the seeds were sown, each morning the beds were observed for 1 month. The beds were sprayed with fresh water to maintain the moisture, and the growth was observed and recorded in terms of height in centimeters (cm) [14].

2.2.6 Harvesting

The plants were harvested in about a month. They were cut from their respective cultivation beds.

III. RESULTS AND DISCUSSION

Based on the above methods, soil-less cultivation beds were prepared, observed and the results are discussed below in Table 2 and represented graphically in Figure 4.

Table 2: Ranking order of the beds

Code	Number of days	Growth in centimeter	Growth percentage	Ranking
S1	27	11	40.74	Second
S2	15	4	26.66	Fifth
S3	15	7.5	50	Third
S4	15	7	46.66	Fourth
S5	12	0.5	4.16	Eighth
S6	15	3	20	Sixth
S7	15	1.75	11.66	Seventh
PA	18	23	78.26	First

The soil-less cultivation bed made of 100% jute woven fabric (S1) shows a considerable growth of 11 cm in 27 days without dying. It is understood that jute fibre serves not only the functional purposes, but also has biodegradability and acts as a natural fertilizer [8]. This is why it was chosen. The growth percentage of wheatgrass in S1 is 40.74% thus securing second rank. The soil-less cultivation bed made of 100% polyester woven fabric (S2) shows a growth of 4 cm in 15 days after which it did not

thrive. It was used because manmade fibers (like poly-olefins) have favorable price performance ratio, light weight with high strength and long service life [9]. The growth percentage of wheatgrass in S2 is 26.6% which is low in comparison to the other fabric beds. Thus, it secures rank five. The soil-less cultivation bed made of 100% cotton woven fabric (S3) shows a growth of 7.5 cm in 15 days after which it did not thrive. The growth percentage of wheatgrass in S3 is 50% thus securing rank three. The soil-less cultivation bed made of 100% cotton knitted fabric (S4) shows a growth of 7 cm in 15 days after which it did not thrive. The growth percentage of wheatgrass in S4 is 46.66% thus securing rank four. Natural fibers are used in agro textiles in specific areas where characteristics like high moisture retention, wet strength, bio-degradability are effectively exploited [9]. So, 100 % cotton is chosen in both woven and knitted fabrics. The soil-less cultivation bed made of knitted cotton polyester blend (30:70) (S5) showed the least growth growing only 0.5 cm in 12 days even though it was given the same amount of sunlight, air and nutrient solution. The growth percentage of wheatgrass in S5 is 4.16%. It has secured the last rank (eighth) due to this least growth. The soil-less cultivation bed made of woven silk cotton blend (50:50) (S6) showed a growth of 3 cm in 15 days. The growth percentage of wheatgrass in S6 is 20%. It has secured rank six in terms of growth. The soil-less cultivation bed made of non-woven cotton-polyester blend (S7) showed a growth of 1.75 cm in 15 days. The growth percentage of wheatgrass in S7 is 11.66%. It has secured rank seven in terms of growth. PA (Pot A) taken for comparison purpose, had a cultivation bed made of red soil because it has high iron content making it a perfect choice for cultivation. This showed the maximum growth by growing 23 cm in 18 days. The growth percentage of wheatgrass in PA is 78.26% thus securing rank one. So, the ranking order of the growth of wheatgrass in the seven textile beds and pot A in terms of cm is as follows,

PA > S1 > S3 > S4 > S2 > S6 > S7 > S5.

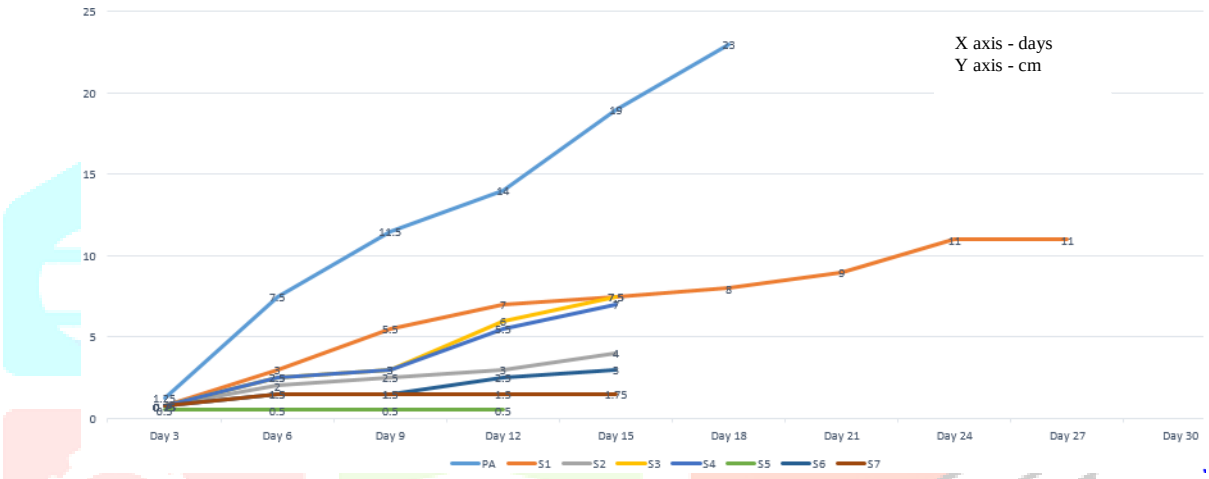

Figure 4: Growth of wheatgrass in different cultivation beds

IV. CONCLUSION

Soil-less agriculture would let the land around our cities return to an un-spoilt ecosystem of forests or grasslands, aiding the fight against global warming and climate change on one hand and boost up rural economy through environment friendly farming system. Since, reduction of agrochemicals, maximization of crop production on minimum land are getting prime issues in case of agriculture nowadays, this paper shows a solution to the matters of integrating textile with agriculture. The main objectives were to develop a system to cultivate wheat grass in a soil-less textile bed by integrating textiles with agriculture and to promote textile waste management. The study also compared woven, knitted and non-woven fabrics and their ability to function as a textile cultivation bed for wheat grass by keeping plants growing in soil as standard. Although, more literature on soil-less culture is available, standard, precise and authentic information's are still lacking. This area of research is new and still so many questions are unanswered but we thrive in the hope that they will be answered when we leave no stone unturned. In conclusion, this soil-less cultivation represents the few new opportunities that we should fully explore especially if we are serious about living our lives in balance with the rest of the life forms on earth.

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