DEVELOPMENT OF NON WOVEN BIO-DEGRADABLE MULCH MAT FOR WEED SUPPRESSION

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Abstract

Agriculture is the science and art of cultivating plants and livestock. The Research study was aimed to enhance plant growth, generally, to reduce the weed growth and to maintain the soil strength using the natural non-woven mulch mats. Mulches whether organic or synthetic type used in vegetable production is helpful in controlling weed population, reducing the impact of falling raindrops and reducing soil erosion, regulation of soil temperature and conservation of soil moisture. Moreover, mulching mat is organic and beneficial through their contribution to moisture retention in root zone depth. The mulch mats are made up of the combination of Rice Straw, Sisal blended with Cotton. The tomato plants were planted in pots and covered their stem with developed mulch mats and have observed for 60 days. These mulch mats are biodegradable and eco-friendly to the environment. The difference between the controlled sample and the developed sample used as mulch mat is analyzed and calculated. This technique was very helpful for the cultivation of plant growth and to avoid weed control.

Keywords: *Mulch mats, natural fibers, non-woven, eco-friendly, and biodegradable.*

1. Introduction

Technical textile is a textile product manufactured for non-aesthetic purposes, where function is the primary criterion. Technical textiles are generally recognized to be one of the most dynamic and promising areas for the future of the textiles industry. Technical textile material and products manufactured primarily for their performance and functional properties rather than aesthetic or decorative purposes. Textiles in agriculture are used to protect crops from extreme climatic conditions. Agro textiles are one of the growing areas of technical textiles. It is a very important segment of agriculture [1]. Woven, non-woven and knitted fabrics are used as agro textiles. Agriculture is the largest industry in the world. In this science world, due to modernization and high technological advancements, textiles are used in growing, harvesting, protection, and storage of either crops or animals. Textile fabrics play an important role to protect, gather and store agro products. Agro-textiles decrease the requirement of fertilizers, water, harmful pesticides, and herbicides and render a healthy farming culture [2].Textiles used in agriculture are technically eco-friendly.

Objectives

1. To select the natural fibers for study.
2. To study the characteristics of selected natural fibers – Rice straw and Sisal.
3. To blend the fiber with cotton waste using a needle punching with different blending ratios.
4. To develop the needle punched non-woven mat for weed control application.
5. To evaluate the non-woven mat for weed control application.
6. To study the weight loss, durability and soil burial test of weed control mat.

2. Materials and Methods

2.1 Selection of Fibers

The first step towards carrying out the project is to select the required natural fiber –Rice straw, Sisal and reclaimed Cotton. The fiber is selected as per literature and it is found out that rice straw and sisal fiber are the most suitable fiber that can be used in the project to support plant growth effectively. Cotton fiber is chosen for needle punched mat.

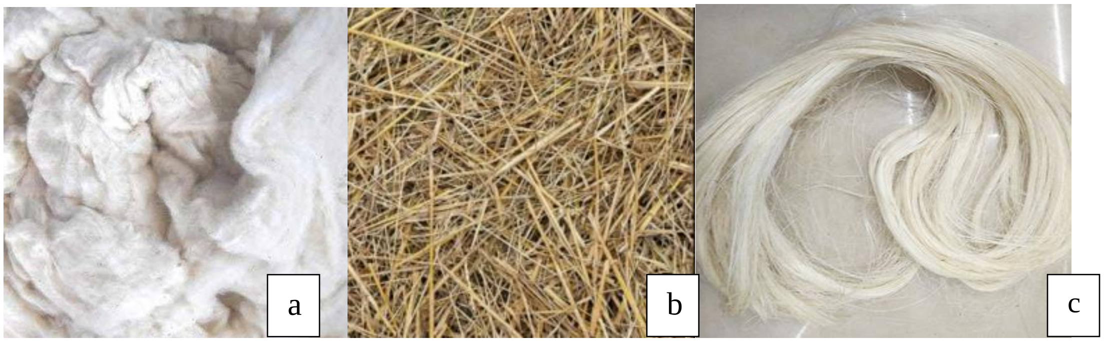

Figure 1: a) Reclaimed fiber b) Rice straw c) Sisal

2.2 Blending Ratio of Natural Fibre

The fibers are weighed accurately and blended in right proportion. The selected natural fibers have been blended in different combinations as follows:

Table 1: Blending ratio of natural fibers

FIBER	BLENDING RATIO (AS PER FIBER QUANTITY)	
Rice straw : cotton	50:50	75:25
Sisal : cotton	50:50	75:25

2.3 Nomenclature of Sample

Table 2: Nomenclature of samples

S.NO	SAMPLE CODE	DESCRIPTION
1	RC1	**RICE STRAW + COTTON (50:50)**
2	RC2	**RICE STRAW + COTTON (75:25)**
3	SC1	**SISAL + COTTON (50:50)**
4	SC2	**SISAL + COTTON (75:25)**
5	C	**COIR(COMMERCIAL MAT)**
6	**CP**	**CONTROL PLANT**

2.4 Conversion of fibers into the platform

Lap is formed in a pilot run machine. The fibers are placed on the carding machine for cleaning and then passed over the needle punching machine to convert the fibers into lap formation.

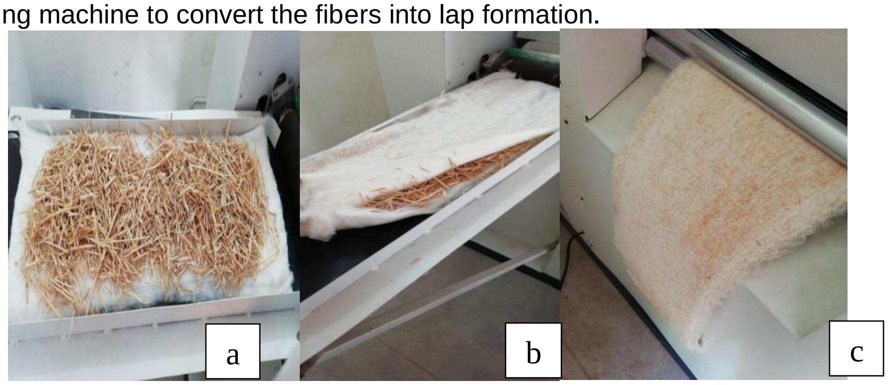

Figure 2: a) Arrangement of fibers into carding machine b) loading of fibers into carding machine c) outcome of lap from carding machine.

2.5 Lap Formation

- Rice straw lap is formed with 500 grams of fibres.
- Sisal lap is formed with 500 grams of fibers.
- Rice straw and cotton are blended in 50: 50 ratios and lap is formed.
- Rice straw & cotton are blended in 75:25 and form another lap with weight of 500 grams each fiber.
- Like sisal & cotton are blended in two different ratios i.e) 50:50 an75:25 to form two-lap with weight of 500 grams each fiber.

2.6 Preparation of Needle Punched – Non-Woven Material

Fibers are blended and opened into small tufts in fiber opening channel and fed to card feeder. The material received from the fiber opener is further opened and web is formed to feed to carding machine. The matt produced from card feeder is opened and carded and a thin sheet of carded web is formed. The thin sheet of web produced in roller carding is formed as lap and sent to needle punching machine. The lap is needle punched and the non-woven material is formed by needle punching technology.

Figure 3: Process of Needle Punching

3. Results and discussion

3.1 FTIR of Rice Straw fiber

The FTIR wavelength peaks taken between 4000cm^{-1}–500 cm^{-1} comprise bands assigned to the main components of rice straw such as cellulose, hemicelluloses, and lignin. The peak value of 3804.8 cm^{-1} to 3434.6 cm^{-1} was assigned to hydrogen bonds – OH stretching on the cellulose surface. The next peak value of 2913.91 cm^{-1} shows the CH stretching of alkyl group which shows the presence of cellulose and hemicelluloses [3]. The prominent peak of the rice straw around 1625.7 cm^{-1} is related to either the acetyl and uronic groups ester of the hemicelluloses or the ester linkage of carboxylic groups of the ferulic and the p – coumeric acids of the lignin or hemicelluloses. The band at 1058.73 cm^{-1} is due to the –C – O – C – bond in the cellulose chain. The absorption bands in the region 684.606cm^{-1} and 484.04 cm^{-1} to 447 cm^{-1} indicate the presence of aromatic rings [4].

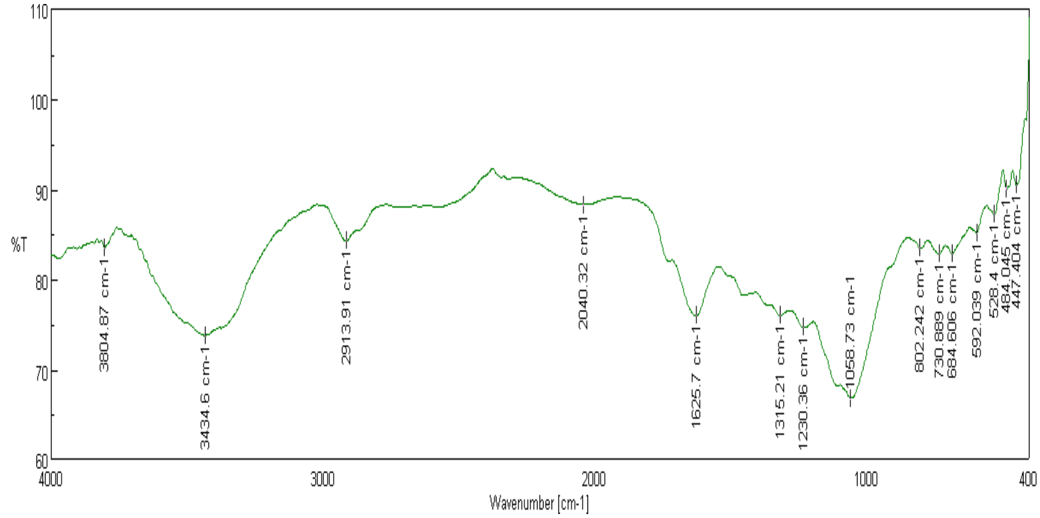

Figure 4: FTIR analysis of Rice straw

3.2 FTIR of Sisal fiber

The FTIR spectrum of sisal was taken between 4000 cm^{-1} to 500 cm^{-1}. It is observed that as a result of esterification of the hydroxyl groups by benzoylation, the intensities of the peak corresponding to the – OH stretching vibrations in the region of 3430.74 cm^{-1}. The peak at 2927.41 cm^{-1} shows the – CH stretching vibration confirms the presence of cellulose and hemicelluloses [5]. The peak value of 2352.2 cm^{-1} shows the C = O stretching of the carboxyl group and presence of lignin. A peak at 1610.27 cm^{-1} is due to the characteristics axial vibration of hydroxyl group of cellulose. The peak at around 1062.59 cm^{-1} is due to the associated hydrogen group. The presence of aromatic rings shows the wavenumbers are 667.59 cm^{-1}[6].

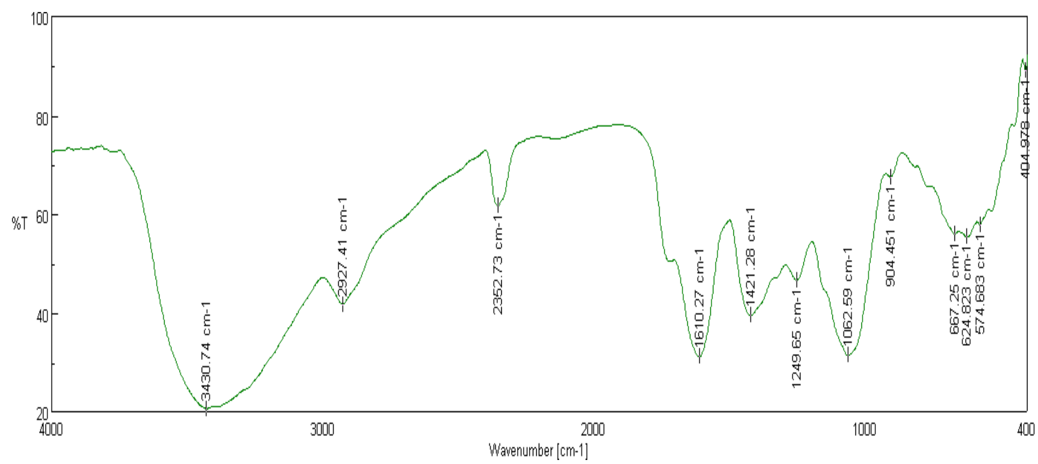

Figure 5: FTIR analysis of Sisal

3.3 Fabric weight (GSM)

Table 3: Fabric weight (GSM)

SI.NO	FABRIC	RC1(50:50)	RC2(75:25)	SC1(50:50)	SC2(75:25)
1.	Non-woven	677	790	1303	1869
2.		696	753	1200	1900
3.		654	802	1189	1760
4.		690	781	1400	1800
5.		632	788	1580	1560
MEAN VALUE		**669.8 gms**	**782.8 gms**	**1334 gms**	**1778 gms**

From Table 3, it is observed that Fabric Weight of the sample RC1, RC2, SC1, and SC2 samples showed variations. The Fabric Weight was statistically analyzed using T-Test and observed that RC1 with the value 669.8gms, RC2 with the value 782.8gms,SC1 with the value 1334gms and SC2 with the value 1778gms.SC2 value was found to be higher than the other samples.

3.4 Thickness of the Non-woven

Table 4: Thickness of the non-woven

SI.NO	FABRIC	RC1(50:50)	RC2(75:25)	SC1(50:50)	SC2(75:25)
1.	Non-woven	6.29	3.44	6.62	4.02
2.		5.92	5.24	6.09	4.39
3.		6.19	5.55	7.19	4.69
4.		6.85	5.82	6.44	5.29
5.		5.25	6.21	6.10	5.79
MEAN VALUE		**6.1mm**	**5.25mm**	**6.49 mm**	**4.48 mm**

From Table 4, it is observed that Thickness of the sample RC1, RC2, SC1, and SC2samples showed variations. The Fabric thickness was statistically analyzed using T-Test and observed that RC1 with the value 6.1mm, RC2 with the value 5.25mm,SC1 with the value 6.49mm and SC2 with the value 4.48mm.SC1 value was found to be higher than the RC1.

3.5 Air Permeability of Non-Woven

Table 5: Air Permeability of the non-woven

S.NO	FABRIC	RC1(50:50)	RC2(75:25)	SC1(50:50)	SC2(75:25)
1.	Non-woven	17.75	19.72	27.6	51.28
2.		15.77	17.75	27.6	49.30
3.		19.75	19.72	25.64	47.33
4.		13.70	17.75	23.66	45.36
5.		19.72	15.77	21.69	47.33
MEAN VALUE		**17.33 $cm^3/s/cm^2$**	**18.14$cm^3/s/cm^2$**	**25.24 $cm^3/s/cm^2$**	**28.12 $cm^3/s/cm^2$**

From Table 5, it is observed that Air permeability of the sample RC1, RC2, SC1, and SC2 samples showed variations. The air permeability of fabric was statistically analyzed using T-Test and observed that RC1 with the value17.33 $cm^3/s/cm^2$, RC2 with the value 18.14 $cm^3/s/cm^2$,SC1 with the value 25.24 $cm^3/s/cm^2$ and SC2 with the value 28.12 cm³/s/cm².SC2 value was found to be higher than other fibers and the least is RC1.

3.6 Porosity of Non-woven

Table 6: Porosity of Non-woven

S.NO	FABRIC	RC1(50:50)	RC2(75:25)	SC1(50:50)	SC2(75:25)
1.	**Non-woven**	0.94	0.97	0.97	**0.97**
2.		0.96	0.99	0.99	**0.97**
3.		0.97	0.97	0.98	**0.99**
4.		0.94	0.98	0.97	**0.96**
5.		0.96	0.97	0.98	**0.98**
MEAN VALUE		**0.95g/cm³**	**0.97g/cm³**	**0.97g/cm³**	**0.97g/cm³**

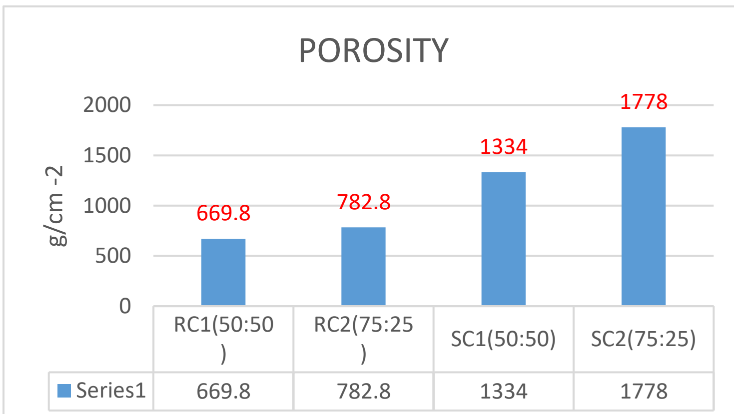

Figure 6: Porosity of Non-woven

From Table 6 and figure 6, it is observed that Porosity of the sample RC1, RC2, SC1, and SC2 samples showed variations. The Porosity of fabric was statistically analyzed using T-Test and observed that RC1 with the value 0.95 g/cm³, RC2 with the value 0.97 g/cm³, SC1 with the value 0.97 g/cm³ and SC2 with the value 0.97 g/cm³.RC2, SC1, and SC2 values were found to be equal and RC1 shows slight variation.

3.7 Soil burial test

Field method

Table 7: Soil burial test of non-woven in field

SI.NO	NO.OF DAYS	WEIGHT OF THE SAMPLE BEFORE TESTING (gms)				WEIGHT OF THE SAMPLE AFTER TESTING (gms)			
		50:50		**75:25**		**50:50**		75:25	
		RC1	**SC1**	**RC2**	**SC2**	**RC1**	**SC1**	**RC2**	SC2
1.	**70**	**0.630**	**0.860**	**0.680**	**0.650**	**0.610**	**0.850**	**0.660**	**0.630**

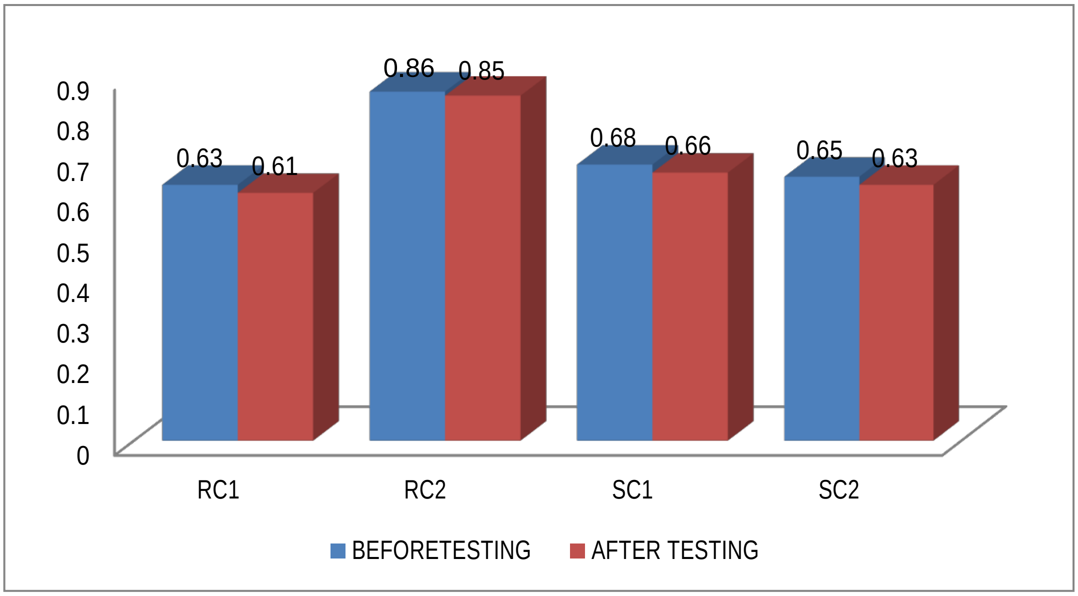

Figure 7: Soil burial test of non-woven in field

From the above Table 7 & Figure, 7 in that field method showed weight changes in a sample when compared with laboratory method. It is observed that there were weight changes with RC1 showed a value of 0.630gm before testing and 0.610gm after testing whereas RC2 showed a value of 0.680gm before testing and 0.660gm after testing. Whereas SC1 showed the value of 0.860gm before testing and 0.850gm after testing.Like that SC2 showed the value of 0.650gm of before testing and 0.630gm of after testing.

3.8 Laboratory method

Table 8: Soil burial test of non-woven in Laboratory

SI. NO	NO.OF DAYS	WEIGHT OF THE SAMPLE BEFORE TESTING (gms)				WEIGHT OF THE SAMPLE AFTER TESTING (gms)			
		50:50		75:25		50:50		75:25	
		RC1	SC1	RC2	SC2	RC1	SC1	RC2	SC2
1.	70	0.780	0.840	0.570	0.640	0.770	0.835	0.565	0.630

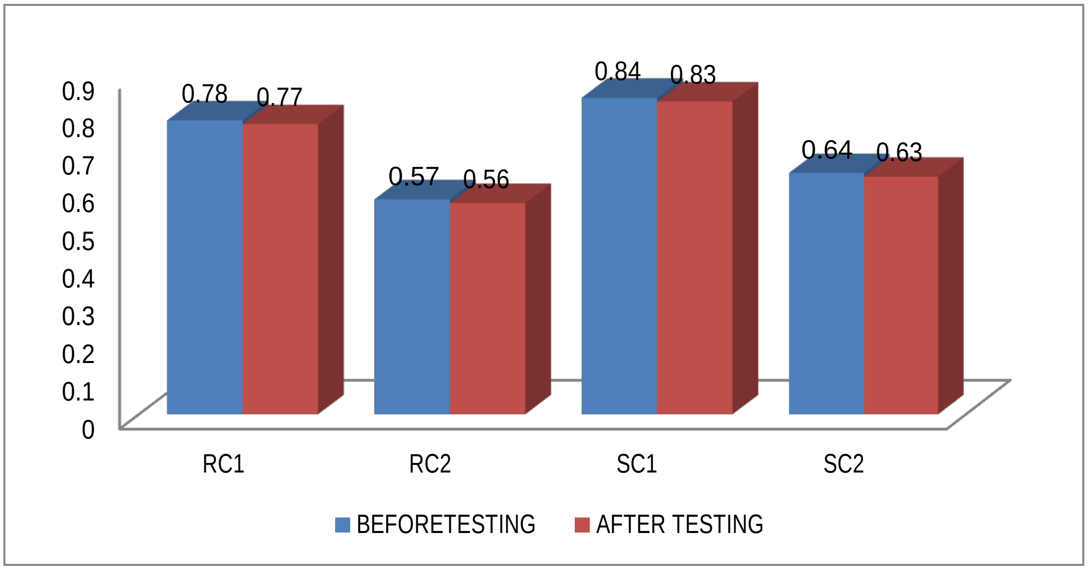

Figure 8: Soil burial test of non-woven in Laboratory

From the above Table 8 & Figure 8 in that laboratory method showed weight changes in a sample when compared with laboratory methods. It is observed that there were weight changes with RC1 showed the value of 0.780gms before testing and 0.770gms after testing whereas RC2 showed the value of 0.570gms before testing and 0.565gm after testing. Whereas SC1 showed the value of 0.840gms before testing and 0.835gms after testing.Like that SC2 showed the value of 0.640gms of before testing and 0.630gms of after testing.

3.9 Weeds growth tabulation

Table 9: Weeds growth

SI. NO	WEEKS	RC1 (50:50)	RC2 (75:25)	SC1 (50:50)	SC2 (75:25)	C	CP
1.	1	0	0	0	0	0	**0**
2.	2	0	0	0	0	0	**6**
3.	3	0	0	0	0	1	**14**
4.	4	0	0	0	0	4	**17**
5.	**5**	**1**	**1**	**1**	**1**	**5**	**23**

From the Table 9 shows a weed suppression. It is observed that there was no growth of weeds for four continuous weeks for all the developed non-woven mulch mat covered pots, whereas there was weed growth of 6 nos in 2nd week,14 nos in 3rd week,17 nos in 4th week and 23 nos in 5th week. And finally, in the last week, it is observed that there were 1 no of weed growth in RC1 & RC2 and SC1 & SC2, whereas in control plant the growth was 23.This proved that there was a great weed suppression.

3.10 Wicking

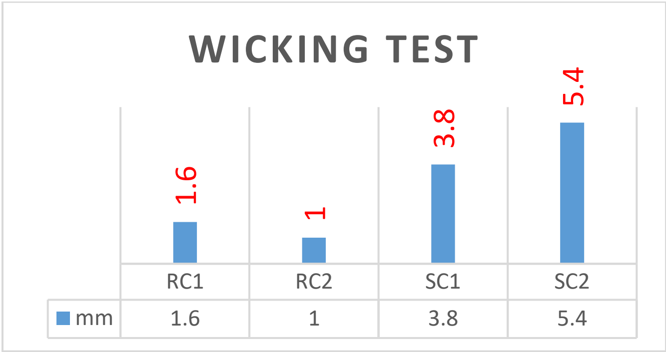

Figure 9: Wicking test

From the above Figure 9, the findings of the wicking of the needle punched fabrics are shown. SC2 has a superior wicking of 5.4 mm which was followed by sample SC1 of3.8 mm wicking. RC1 & RC2 has lower wicking of 1.6 & 1 when compared to all the samples SC1 showed good wicking.

3.11 Sinking test

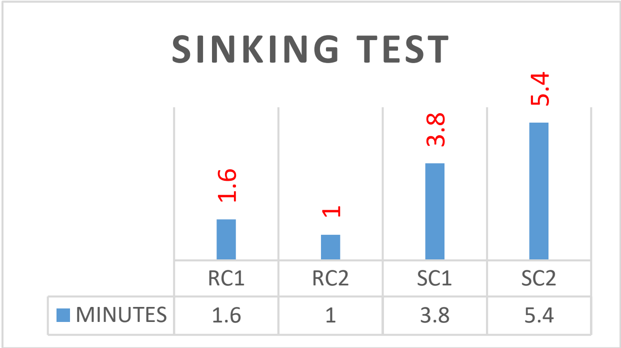

Figure 10: Sinking test

From the above Figure, 10 represents the results of the sinking test of needle-punched samples. Sample RC1 takes the maximum time of 50 mins to sink were as RC2 of 45 mins and SC1 of 20 mins and SC2 of 14 mins respectively. Thus the sample SC2 showed good results.

4. Conclusion

This study has shown the prevention of weed control and helps to grow a tomato plant easily in potted plants. Using a rice straw, sisal, and cotton mulch mat has been developed by in needle punching machine, with two different ratios. Two fibers are evaluated in FTIR analysis. Mats are evaluated in various testing like GSM, non- woven thickness, air permeability, soil burial test, porosity of non-woven, density of non-woven. The application process of mulch mat is simple and effective. This property on agriculture increases plant growth. Rice straw and Sisal fiber are abundantly available in India as well other countries. At last the developed non-woven needle-punched is eco-friendly & bio-degradable. From the research work it is found that Sisal fiber SC2 is found to be the best fiber weed suppression.

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