# Development and Research of Sustainable Mulch Mats from End-of-Use Cotton Textiles

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Cotton fibers are widely used in apparel and home textile products. The huge amount of textile and apparel production and consumption resulted in 17.03 million tons of textile waste sent to the landfills in the U.S. in 2018 (U.S. Environmental Protection Agency, 2021). Agrotextiles, with a global market value of 9.05 billion U.S. Dollars in 2020 (Grand View Research, 2021), are textiles used for agriculture, horticulture, fishing, landscape, animal husbandry, aquaculture, gardening, forestry, and agro engineering (Azam & Ahmad, 2020). One important application of agrotextile is mulch mats used in agriculture, horticulture, and floriculture. Mulch mats can inhibit weeds, maintain soil hydration, control temperature and frost effects, stabilize and help the separation of soils, reduce nutrient leaching, improve soil organic matter or nutrient content, alter insect and disease pressures, increase soil porosity, and contribute to the germination and growth of plants (Manna, Kundu, Saha, & Ghosh, 2018; Restrepo-Osorio, Álvarez-López, Jaramillo-Quiceno, & Fernández-Morales, 2019). Mulch mats can be nonwoven and woven textiles made from natural (jute, flax, hemp, coir) or synthetic (polyethylene, polypropylene, polyester) textiles or films (Restrepo-Osorio et al., 2019). Textile mulch mats have better permeability and flexibility than film mats. Synthetic fibers are not biodegradable and at the end of their use, they must be removed from the crop and sent to landfills, incinerated or buried in the agricultural field, which is harmful to the environment; while natural fibers are biodegradable and will provide nutrients to the soil in the biodegradation process to contribute to the growth and survival of plants (Restrepo-Osorio et al., 2019).

The purpose of this research is to use end-of-use cotton textile products to develop biodegradable mulch mats that have potential benefits than synthetic mulch mats. The researchers collected used cotton (100% cotton and cotton blends with more than 80% cotton fiber) apparel products that cannot be sold in Goodwill stores and shredded them four times using a textile shredder (Taskmaster® Model TM8512). After carding a mixture of fabric shreds and a small amount of new cotton fibers to develop batts and using end-of-use cotton fabric as the supporting material, researchers developed needle punched nonwoven fabrics using a Feltloom (Model Lexi, Feltloom, Sharpsburg, KY). The samples were felted 4 times to make the nonwoven mulch mats. For comparison, three commercial weed control fabrics, i.e., 100% polypropylene (PP) dual layers fabric, 100% natural burlap (100% jute) fabric, and 100% polyethylene (PE) plastic sheet, were acquired.

The researchers measured thickness, thermal resistance ($R_{ct}$), and air permeability of the samples. The thickness was measured using a portable gauge (SDL Atlas, Rock Hill, SC). Air permeability was measured by an Automatic Air Permeability Tester (Aveno Technology Co., China) in accordance with ASTM D737 standard (Standard Test Method for Air Permeability of

Textile Fabrics). $R_{ct}$ was measured by a sweating guarded hotplate (Thermetrics, Seattle, WA) in accordance with ASTM F1868 standard (Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate). The researchers tested the weed control in a vegetable farm in summer. Before the test, the researchers removed weeds from areas of approximately 2-foot x 2-foot between the squash plants. The mulch mat samples (10-inch x 10-inch) were placed in the field, and the numbers of weeds grown from underneath the mulch mats were counted after approximately 5 weeks. There were 3 or 4 replications for each test. The researchers tested the biodegradation of the mulch mats in a greenhouse. The tests were conducted in pots. The researchers put the 4-inch x 8-inch samples in pots and then added soil into the pots. The researchers observed and measured biodegradation (weight loss) after 6 weeks and 10 weeks. There were 3 replications for each sample. The material weight loss after biodegradation was calculated:

$$\text{Weight loss} = \frac{\text{weight before biodegradation} - \text{weight after biodegradation}}{\text{weight before biodegradation}} \text{ x } 100\%$$

Table 1. Textile tests, weed control and biodegradation results

| Sample | Thick-ness (mm) | Air permeability (mm/s) | $R_{ct}$ (˚C·m$^2$/W) | No. of weed | Weight loss (%) | |
|---|---|---|---|---|---|---|
| | | | | | 6 weeks | 10 weeks |
| No mulch mats | -- | -- | -- | 30 to 40 | -- | -- |
| PP dual layers | 0.853 ± 0.342 | 418.9 ± 28.8 | 0.085 ± 0.002 | 0 | 0 | 0 |
| Burlap | 1.282 ± 0.054 | 9295.0 ± 711.6 | 0.038 ± 0.001 | 18 ± 10 | 78.0 ± 25.7 | 52.5 ± 24.9 |
| PE sheet | -- | -- | -- | 0 | 0 | 0 |
| Cotton blend nonwoven | 3.202 ± 0.654 | 294.80 ± 9.78 | 0.103 ± 0.007 | 0 | 29.9 ± 7.0 | 42.8 ± 5.8 |
| 100% cotton nonwoven | 3.330 ± 0.463 | 321.13 ± 38.90 | 0.093 ± 0.001 | 0 | 51.6 ± 23.4 | 67.8 ± 5.2 |

The results are in Table 1. The nonwoven mulch mats made from cotton textile waste are thicker than commercial mulch mats. Due to the high thickness, the nonwoven mulch mats made from cotton textile waste have lower air permeability than the commercial PP dual layers mulch mat. The two mulch mats made from cotton textile waste have higher thermal resistance than commercial PP dual layers and burlap mulch mats, indicating nonwoven made from cotton waste can better maintain soil temperature. The nonwoven mulch mats made from cotton waste can completely inhibit weed growth, which are significantly better than commercial burlap mulch mats and are similar to the two commercial synthetic mulch mats. The nonwoven mulch mats made from cotton waste showed significant biodegradation within 10 weeks, which was

significantly faster than commercial synthetic mulch mats and comparable to commercial burlap mulch mats. Nonwoven made from 100% cotton waste also has better biodegradability than nonwoven made from cotton blend (>80% cotton) waste. The two commercial synthetic mulch mats did not biodegrade at all. It should be noted that the weight loss data in Table 1 are underestimated due to soil and dirt attached on the mulch mat materials. As a reference, the PP dual layers had as high as 80-90% weight "gain" after the biodegradation test due to the higher density of soil and their rough texture to shed soil. The PE plastic sheet had about 8-9% weight "gain" after the biodegradation test due to their relatively smooth texture.

The results of this research indicate that nonwoven textile made from end-of-use cotton apparel can be used as biodegradable mulch mats to control weeds. This research provides a sustainable solution of the solid textile waste problem that can complete a circular nutrient flow to benefit agriculture.

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