The Effect of Biological and Synthetic Mulch Types on Tomato (*Lycopersicon esculentum*) Yield

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Abstract

Most tomatoes are produced with black plastic mulch (polyethylene sheeting or film) to suppress weeds, maintain soil moisture, and warm soil temperature. Alternatives to such plastic are desirable since it is made from petroleum and becomes soil waste after the growing season. Three additional mulches plus no mulch were used to test the effect of mulch type upon tomato production. The five treatments were applied at Brook Farm, New Paltz, NY, a diversified organic vegetable farm, during the 2006 growing season. The four mulches were black polyethylene, woven polypropylene groundcover, straw, and 4" of compost. These mulches plus the bare treatment were randomly assigned among two 100' rows. Each treatment was planted with both Markovitch (slicing tomatoes) and Red Agate (paste tomatoes), as a split plot. Data was collected twice weekly until first frost. Healthy tomatoes were collected and weighed. The results were analyzed in order to determine which mulch type was the most effective for producing maximum biomass output. Markovitch and Red Agate tomatoes had highest yield with compost and straw mulches. Surprisingly, Red Agate yield was lowest with polyethylene, while Markovitch yield with polyethylene was intermediate among the five treatments. The results support the advantages of using locally-available compost and straw for tomato production. These two mulches will also improve soil organic matter and nutrient content.

Introduction

Increased energy, labor, and material costs have placed pressure on farmers to develop more efficient agricultural methods and management techniques. Agricultural ecologists research the most practical and cost-efficient methods for weed suppression and increased yield of agricultural crops. Although herbicides may be a successful method of controlling a population of weeds, there are ecological impacts which must be considered such as contamination of local water sources and the development of genetically resistant strains. Mulches are effective alternatives to herbicides, and there are several materials commonly used.

Synthetic mulches such as groundcover constructed from woven propylene yarn are a low-maintenance, cost effective means for increasing crop health and yield. Groundcover does not rot or mildew and is resistant to most chemicals. Polyethylene film (plastic sheeting) is used more extensively in agriculture. Studies have found that this mulch treatment is effective for increasing soil moisture and temperature, which hastens earlier fruit maturity (Abdul-Baki et al., 1996). Early germination has also been observed with the application of black polyethylene as well as increased agricultural yields (Liang et al., 2002). These properties provide increased economic benefit for the farming industry. However, black polyethylene mulch has been found to increase runoff volume, create solid waste problems, and is restricted in "Certified Organic" production as a long-term management strategy (USDA/AMS, 2002). Non-synthetic "natural" mulches contain fibers or residues from plants or animals and are used as an alternative method which can provide many benefits including weed suppression, soil moisture conservation and improved water filtration, enhanced soil stabilization and porosity, microbial population activity, and decreased plant disease (Duppong et al., 2004). Straw mulch, which contributes organic matter to the soil (Tindall et al., 1991), has additional advantages including reduced tillage, reduced soil evaporation, and reduction of soil runoff and wind erosion (Liang et al., 2002). Biological mulches such as straw have proven more effective than black polyethylene with regard to yield in systems which use both treatments for tomato production (Tindall et al., 1991).

The study examined the differences in tomato production among two natural mulches (compost and straw) and two synthetic mulches (plastic and groundcover). Two species of tomato, Markovitch and Red Agate, were chosen for the study and observed over one growing season.

- **The purpose of the experiment was to examine the effect of varying mulch treatments, both natural and synthetic, on tomato yield.**
- **H_0; No difference in yield is expected among mulch type or tomato variety.**
- **H_1; Mulch type and tomato variety will have an effect on yield.**

Materials & Methods

- Location: Brook Farm Project, New Paltz, NY
- Each plot was planted with both Markovitch (slicing tomatoes) and Red Agate (paste tomatoes).
- Five mulch treatments:
  - Bare (served as control)
  - Compost
  - Plastic (black polyethylene sheeting)
  - Groundcover (*Lumite* 994)
  - Straw
- Mulch treatments replicated three times and applied to the soil in randomized plots:

WEST

	B1	G1	S1	C1	B2	P1	S2	P2	
SOUTH	B2	C2	G2	B3	P3	C3	S3	G3	NORTH

EAST

B	Bare
C	Compost
P	Plastic
G	Ground Cover
S	Straw

- Data was collected twice-weekly until first frost.
- Healthy tomatoes were collected and weighed using a gram scale (22 lbs. max).
- Healthy tomatoes were defined as ripe fruit without any noticeable pest invasions.

(left): Tomato Plots.
(right): Amanda Rollizo harvests tomato fruits.

Results

- **Statistical Analysis:**
  - Data analyzed as simple two-way ANOVA with the two variants being tomato type and mulch treatment (Table 1).
  - **Tomato type and mulch treatment were both significant, indicating that yields depended on both the type of tomato (p-value < 0.012) and on mulch treatment (p-value < 0.001).**
  - H_0 can be rejected with great certainty especially with regard to mulch treatment ($p < 0.001$).
  - H_1 can be accepted.

Table 1. Statistical analysis (Two-Way ANOVA) of tomato output with respect to tomato variety and mulch type.

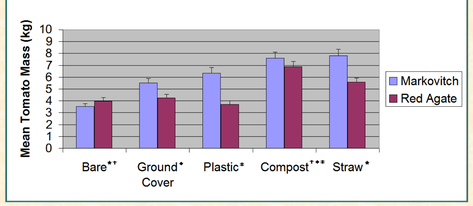
	Df	Sum Sq	Mean Sq	F Value	P (>F)
Tomato Variety	1	12184539	12184539	7.5317	0.0124993*
Mulch Type	4	48765896	12191474	7.536	0.0007144*
Tomato:Mulch	4	9103675	2275919	1.4068	0.2678243
Residuals	20	32355212	1617761		

*Tomato effect significant at $P < 0.012$; Mulch effect significant at $P < 0.001$

- **Markovitch (slicing tomatoes):**
  - Straw and compost mulch treatments yielded the largest biomass with straw producing 23.412 kg total and compost producing 22.772 kg total (Figure 1). Bare soil performed the poorest, yielding only 10.537 kg total (Figure 1). The synthetic treatments, groundcover and plastic, reflected intermediate performance (Figure 1).

- **Red Agate (paste tomatoes):**
  - Compost (20.621 kg) and straw (16.402 kg) yielded the highest total output, though compost performed significantly better (Figure 1). Results for the three remaining mulch treatments were comparable (Figure 1).

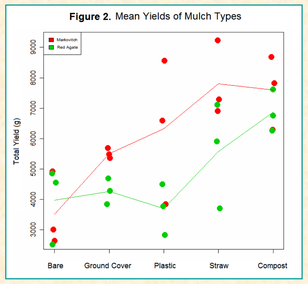
Figure 1: Average Tomato Yield Among Mulch Type



**, †, ♦, ‡, significant at P = 0.005, 0.001, 0.033, 0.046, respectively. All other relationships among mulch types non-significant. Error bars denote standard error of mean.*

- **Mean Yield of Mulch Types:**
  - Compost produced highest yield (43.393 kg) with the least variance around the mean. Groundcover showed little variance around the mean but produced low yield (29.301 kg). Bare performed the poorest overall with the lowest yield (22.436 kg) and some variance around the mean. Plastic and straw produced intermediate yields with great variance around the means (Figure 2).

Figure 2. Mean Yields of Mulch Types



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- **Weekly Output:**
  - Treatments responded similarly over time (Figure 3 & Figure 4).

Figure 3: Weekly Output (g) of Experimental Mulches [Markovitch]

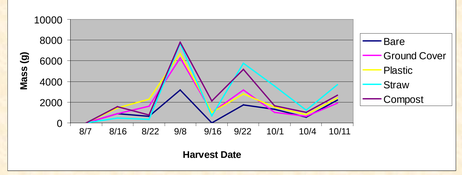
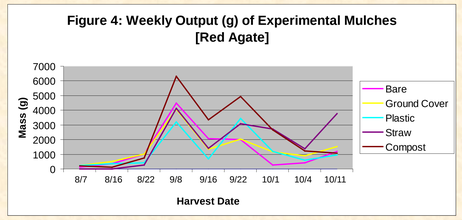


Figure 4: Weekly Output (g) of Experimental Mulches [Red Agate]



Discussion & Conclusions

The purpose of the experiment was to examine the effect of varying mulch treatments, both natural and synthetic, on tomato yield. The null hypothesis (H_0) was rejected based on statistical analysis which supports H_1; mulch type and tomato variety will have an effect on yield. Tomato type and mulch treatment were both significant, indicating that yields depended on both the type of tomato ($p < 0.012$) and on mulch treatment ($p < 0.001$). Results similar to those seen in previous studies were observed. In a fresh-market tomato system cultivated with several biological mulches as well as black polyethylene, the organic mulches produced higher yields than the black polyethylene with the average fruit weight for the organic mulches also higher when compared to other treatments (Abdul-Baki et al., 1996). Tomato production was further examined in a study where straw mulch performed significantly better than black polyethylene (Tindall et al., 1991). Though black polyethylene has proven effective for stimulating early germination and fruiting (Abdul-Baki et al., 1996), evidence suggests that tomatoes grown under plastic may suffer from nutrient deficiency due to high temperatures and evaporation rates (Tindall et al., 1991). Though tomato yield mass for early harvest dates is somewhat increased for black polyethylene when compared to other mulch treatments, this study provides no significant data to support the hypothesis that polyethylene stimulates early fruiting (Figure 3 & Figure 4).

The experiment examined the comparative advantages of using synthetic versus biological mulches. Biological mulches continue to emerge as an alternative to synthetic applications and boast benefits which include increased crop yield, weed suppression, soil moisture conservation and improved water filtration, enhanced soil stabilization and porosity, microbial population activity, and decreased plant disease (Duppong et al., 2004). Results highlight additional advantages for the use of biological mulches including the reduced variance around the mean observed for the compost treatment (Figure 2). The data indicating a reduced variance and a high overall yield for compost provides a farmer with a reliable cultivation plan and results which are likely to be reproduced in subsequent plantings.

Literature

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