Comparison of Organic and Inorganic Mulches for Heirloom Tomato Production

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Abstract

Many tomato growers face challenges in producing their crops due to stricter environmental regulations and fewer chemicals available for weed control. There is a demand for cultural practices that reduce chemical inputs and synthetic materials. Heirloom tomato varieties are becoming more popular among commercial tomato growers due to increased demand from consumers. Since most heirloom tomatoes at present are grown on small acreage, the addition of organic mulches may be a practice feasible for reducing chemical inputs for weed suppression. Heirloom tomatoes were grown using organic mulches (shredded newspaper, wheat straw and composted landscape bark) and an inorganic mulch (black plastic) plus a bare ground control to evaluate their effectiveness on heirloom tomato marketable yield and weed suppression. All treatments were grown with pre-emergence herbicide (high input) and without pre-emergence herbicide (low input). Marketable yields for the 10 treatments ranged from 3.4 to 50 MT/ha and 11.5 to 35.6 MT/ha in 2000 and 2001, respectively. Mulch x herbicide interactions were not significant for yield in either year. Mulches with and without herbicide inputs produced higher yields than unmulched plots in both years. Bare ground control with no herbicide inputs resulted in the lowest yields and highest weed densities and biomass. In an attempt to reduce chemical inputs for weed control in tomato production, organic mulching materials may be a viable option for vegetable growers.

INTRODUCTION

Methyl bromide, used as a soil fumigant to control nematodes, soil-borne pathogens and weeds in fruit and vegetable production systems, will be banned in the United States by 2005, in compliance with the U.S. Clean Air Act (Charron and Sams, 1999; Holman, 1999). Public concerns with health and environmental effects of synthetic pesticides commonly used in commercial fruit and vegetable production is prompting researchers to look at alternative, non-chemical pest control measures (Charron and Sams, 1999). As a result of consumer health and safety issues, retail sales in the U.S. organic industry reached $7.8 billion in the year 2000 (Wood et al., 2002). There is a need for cultural practices that reduce chemical inputs and synthetic materials (Abdul-Baki and Teasdale, 1993; Abdul-Baki et al., 1996; Koike and Subbarao, 2000). Production practices for vegetable and fruit production need to focus on fewer synthetic inputs, disease and weed control, reducing soil erosion, and maintaining soil structure while producing high quality fruit and profitable yields.

Fresh market tomatoes are grown for retail, wholesale and supermarket trade (Precheur et al, 2001). Fresh market tomatoes are the most frequently produced crop on small farms in the northeastern U.S. Small acreage farms are increasing in numbers across the United States and are predominately run by part-time operators (Teasdale and Colacicco, 1985). Small farms often grow and market unique or specialty produce, avoiding competition from most large-scale vegetable production operations. An increasingly popular sector of the produce industry is heirloom and ethnic vegetable crops. Heirloom varieties, particularly tomatoes, were traditionally grown in backyard gardens and are becoming more popular with small commercial growers.

One alternative to pesticides for weed and disease suppression is the use of mulch.

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Mulch is defined as any material used to cover the soil surface to prevent loss of moisture, reduce weed pressure, maintain consistent soil temperatures and promote soil productivity (Jacks et al., 1955; Carter and Johnson, 1988; Abdul-Baki and Teasdale, 1994). Mulches also aid in weed suppression (Davis, 1994). Organic mulches can be as effective as herbicides in suppressing weeds (Ozores-Hampton, 1998).

Synthetic mulch such as black polyethylene film has been used in vegetable production since the early 1960's to increase soil temperatures, conserve moisture, reduce weed pressure and increase yields (Lamont, 1991; Courter et al., 1969; Carter and Johnson, 1988; Abdul-Baki et al., 1996). However, there are disadvantages to using this synthetic material. Aside cost, which can be as high as $630/A, disposal of the material is a problem (Wiggen, 1995; Davis, 1994). Black plastic mulching materials are burned or disposed of in landfills. Since burning certain plastics give off toxic fumes such as hydrochloric acid, this mulching material is environmentally unfriendly while adding nothing to the soil structure or fertility.

Use of cover crops and living mulches for weed control and soil fertility has produced mixed results (Paine and Harrison, 1993). One problem growers face with the use of cover crops and living mulches for vegetable production is that cover crop management may interfere with spring planting and/or fall harvest (Stivers-Young and Tucker, 1999).

For cover crops to become well established and suppress weeds, the cover crop requires vigorous early growth and timely mowing to reduce its competition for water, nutrients and light (Costello and Altieri, 1994; Abdul-Baki and Teasdale, 1994; Wiles et al., 1989). The use of cover crops for weed suppression requires adequate biomass while controlling its competition with the crop to prevent yield losses (Hoffman et al., 1993). If uncontrolled, cover crop biomass may control weeds while reducing yields. In a corn-hairy vetch system hairy vetch suppressed weeds effectively without reducing corn yield, but only when corn planting coincided with precise vetch bloom time (Hoffman et al., 1993). Vegetable crop growth and yield are affected by the use of cover crop systems (Masiunas, 1998). Crop yields are generally correlated to the amount of weed suppression supplied by the cover crop mulch (Smeda and Weller, 1996). Use of living mulches has shown that competition between the crop being produced and the living mulch may cause a reduction in yield in some crops (Wiles et al., 1989). Delay in silking in sweet corn and in harvest 5-7 days were observed when red fescue and colonial bentgrass were grown as living mulches (Nicholson and Wien, 1983).

Use of organic surface mulches, which are plowed into the soil at the end of the growing season, may be a viable option for weed suppression and improving the soil structure without interfering with the crop being produced. This cultural practice would serve several purposes in the production scheme and could be an excellent addition to any IPM program for tomato production, particularly on small acreage farms (Davis, 1994). Fresh-market tomatoes which require multiple harvests may be better suited to the use of mulches than processing tomatoes which are commercially harvested with a once-over mechanical harvester (Creamer et al., 1996).

The objective of this study was to test the effect of several mulches (shredded newspaper, straw mulch, composted bark, and traditional black plastic mulch along with a bare ground control) with and without pre-emergent herbicide on the marketable yield of heirloom tomato cultivar 'Nebraska Wedding' and to test their effectiveness in reducing weed density and biomass.

MATERIALS AND METHODS

Field experiments were conducted in 2000 and 2001 at The Ohio State University (OSU) Waterman Agricultural and Natural Resources Laboratory, Columbus, Ohio. Field plots were established on raised beds in a randomized complete block design with 4 replications in a 5X2 factorial using 4 mulches (composted landscape bark, wheat straw, shredded newspaper, black plastic mulch) and an unmulched bare ground control. All mulch treatments were tested with (high input) and without (low input) pre-emergence herbicide applications. Raised beds were spaced 1.5 m apart. Plots receiving pre-emergence herbicides were treated with Dual, Treflan and Sencor and incorporated by natural rainfall. A single layer of black plastic mulch was applied to raised beds with a mechanical mulch layer. Shredded newspaper, composted tan bark and wheat straw were applied to the tops of raised beds, by hand, to a depth of 10 cm after hand transplanting tomatoes. After mulches were applied overhead irrigation was used over the entire field to help keep organic mulches intact.

The heirloom tomato cultivar used in this study, ‘Nebraska Wedding’, is a globe-shaped medium sized fruit of orange skin and flesh color. Cultivar selection was based on prior results from heirloom tomato germplasm evaluations done at The Ohio State University.

Each mulch treatment replication consisted of 3 beds side-by-side. ‘Nebraska Wedding’ was planted in the middle row and the processing tomato variety ‘Peto 696’ was planted in the other two beds allowing buffer rows on either side of treatment rows. Data were collected from the middle row only. Each treatment row per rep measured 7.6 m in length and contained 7 plants spaced 91.4 cm apart. All tomato transplants were grown in the OSU Department of Horticulture and Crop Science greenhouse and transplanted to the field at the 6-7 week stage after hardening off plants under shade cloth. Field planting occurred on June 1, 2000 and June 8, 2001. Each plant received 296 ml of 10-52-8 starter fertilizer at transplanting. Three weeks after transplant, treatment row plants were staked and tied using the Florida weave method (Marr et al., 1991). Fruit was harvested five times in 2000, from August 22 to September 22. In 2001, fruit was harvested six times from August 17 through September 24. Marketable and cull fruit were weighed and counted. Throughout the growing season hand hoeing and backpack sprayer applications of Round-up™ (Glyphosate) were used for weed control between beds only. Weeds remained on top of the beds season long. This allowed for weed counts and biomass collection at the end of the season. Two 0.5 m squares were randomly placed on the top of each raised bed on October 2, 2000 and October 1, 2001. Weeds were counted, cut at ground level and dried. Final biomass dry weights were recorded.

RESULTS AND DISCUSSION

Marketable yields for the ten treatments in 2000 and 2001 ranged from 3.4 to 50 MT/ha and 11.5 to 35.6 MT/ha, respectively (Fig. 1). Mulch x pesticide interaction were not significant for yield in either year. There were similar trends in yield among the mulch treatments in both years. Mulched plots produced higher yields than bare ground, regardless of pesticide input. Yields averaged over all mulch treatments show a lower yield from low input plots in both years (Fig. 2). Low input reduced yields by 39% and 17% in 2000 and 2001, respectively. Averaged over both pesticide levels, unmulched bare ground plots produced lower yields compared to the four mulches. There were no significant differences in yield among the four mulches in either year. This suggests that organic mulches can be as effective as black plastic on fruit yield.

In 2000, mulch x pesticide interaction was significant for broadleaf biomass and density. High input plots, regardless of mulch treatment, produced lower weed biomass compared to low pesticide input (Fig. 3). Bare ground plots with no pesticide inputs had more weed biomass than any of the mulched plots. Averaged across pesticide inputs, organic mulches reduced weed biomass by 59%, 34% and 44% for newspaper, wheat straw and bark, respectively. Black plastic resulted in an 80% reduction in weed biomass.

In 2001, there was no significant mulch x pesticide interaction for weed density and biomass. However, there was a significant mulch effect (Fig. 4). The highest weed biomass was achieved in bare ground plots, regardless of pesticide input. There were no differences in biomass between plastic and the organic mulches. Averaged across pesticide inputs, black plastic, newspaper, wheat straw and bark reduced biomass by 81%, 78%, 60%, and 67%, respectively.

In an attempt to reduce chemical inputs in vegetable production systems, alternative practices need to ensure that maximum yields are achieved while reducing weed competition. The use of organic mulching materials may aid in weed suppression and add organic matter to soil when cover crop mulches are plowed under at the end of the growing season. Organic materials, applied to a depth of 10 cm can be as effective as black plastic mulch on tomato yield and weed suppression.

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Literature Cited

Abdul-Baki, A. and Teasdale, J.R. 1993. A no-tillage tomato production system using hairy vetch and subterranean clover mulches. HortScience 28:106-108.

Abdul-Baki, A. and Teasdale, J.R. 1994. Sustainable production of fresh-market tomatoes with organic mulches. USDA/ARS Bulletin FB-2279. 9 pp.

Abdul-Baki, A., Teasdale, J.R., Korcak, R., Chitwood, D.J. and Huettel, R.N. 1996. Fresh-market tomato production in a low-input alternative system using cover-crop mulch. HortScience 31:65-69.

Carter, J. and Johnson, C. 1988. Influence of different types of mulches on eggplant production. HortScience 23:143-145.

Charron, C.S. and Sams, C.E. 1999. Inhibition of *Pythium ultimum* and *Rhizoctonia solani* by shredded leaves of *Brassica* species. J. Amer. Soc. Hort. Sci. 124:462-467.

Costello, J.J. and Altieri, M.A. 1994. Living mulches suppress aphids in broccoli. Calif. Agr. 48:24-28.

Courter, J.W., Hopen, H.J. and Vandemark, J.S. 1969. Mulching vegetables: practices and commercial applications. University of Illinois at Urbana-Champaign Cooperative Extension Service.

Creamer, N.G., Bennett, M.A., Stinner, B.R. and Cardina, J.. 1996. A comparison of four processing tomato production systems differing in cover crop and chemical inputs. J. Amer. Soc. Hort Sci. 121:559-568.

Davis, J.M. 1994. Comparison of mulches for fresh-market basil production. HortScience 29:267-268.

Jacks, G.V., Brind, W.D. and Smith, R. 1955. Mulching. Commonwealth Agricultural Bureaux. Headley Brothers Ltd., London. p. 9.

Hoffman, M.L., Regnier, E.E. and Cardina, J. 1993. Weed and corn (*Zea mays*) responses to a hairy vetch (*Vicia villosa*) cover crop. Weed Technology 7:594-599.

Holman, D. 1999. In search of a replacement. Amer. Veg. Grower Magazine. 47:33-34.

Koike, S.T. and Subbarao K.V. 2000. Broccoli residues can control Verticillium wilt of cauliflower. California Agriculture, 54:30-33.

Lamont, W.J., Jr. 1991. Does modern plastics technology have a place in organic vegetable farming systems research and farming enterprises? HortTech. 1:138.

Marr, C., Lamont Jr., W.J., Tesserat, N. Bauernfeind, B. and Gast, K. 1991. Commercial Vegetable Production – Tomatoes. Kansas State Univ. Coop. Ext. Service, Manhattan, KS. 13 pp.

Masiunas, J.B. 1998. Production of vegetables using cover crop and living mulches – a review. J. of Veg. Crop Prod. 4:11-31.

Nicholson, A.G. and Wien, H.C. 1983. Screening of turfgrasses and clovers for use as living mulches in sweet corn and cabbage. J. Amer. Soc. Hort. Sci. 108:1071-1076.

Ozores-Hampton, M. 1998. Compost as an alternative weed control method. HortScience 33:938-940.

Paine, L.K. and Harrison, H. 1993. The historical roots of living mulch and related practices. HortTechnology 3:137-142.

Precheur, R.J. (ed.) 2001. Ohio vegetable production guide. Ohio State Univ. Ext. Bull. #672, Columbus, OH. 264 pp.

Smeda, R.J. and Weller, S.C. 1996. Potential of rye for weed management in transplanted tomatoes (*Lycopersicon esculentum*). Weed Sci. 44:596-602.
Stivers-Young, L. and Tucker, F. 1999. Cover-cropping practices of vegetable producers in western New York. HortTechnology 9:459-465.
Teasdale, J.R. and Colacicco, D. 1985. Weed control systems for fresh market tomato production on small farms. J. Amer. Soc. Hort. Sci. 11:533-537.
Wiggen, J. 1995. Vetch mulch fetches more veggies. Ag. Research. 43:10-11.
Wiles, L.J., William, R.D. and Crabtree, G.D. 1989. Analyzing competition between a living mulch and a vegetable crop in an interplanting system. J. Amer. Soc. Hort. Sci. 114(6):1029-1034.
Wood, M., Chavez, L., Comis, D. and Arnold, J.. 2002. Organic grows on America! Agri. Research. 50:4-9.

Figures

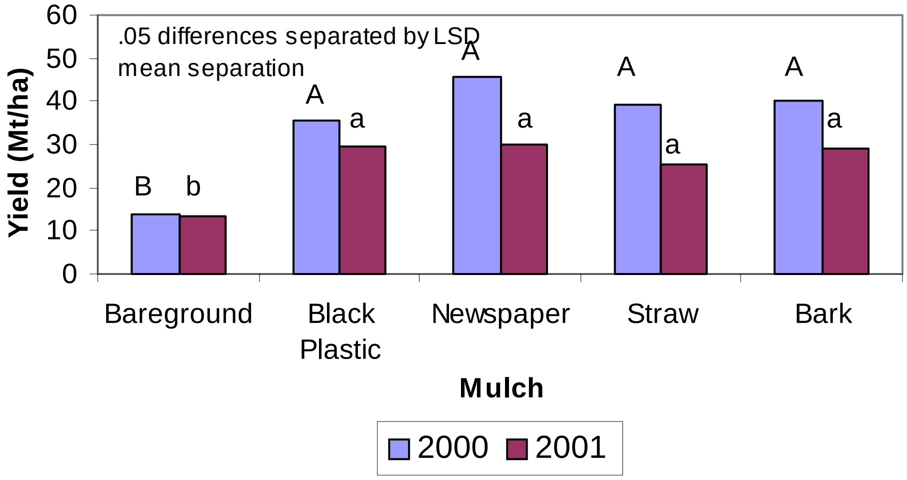

Fig. 1. Marketable 'Nebraska Wedding' tomato fruit yield for 2000 and 2001.

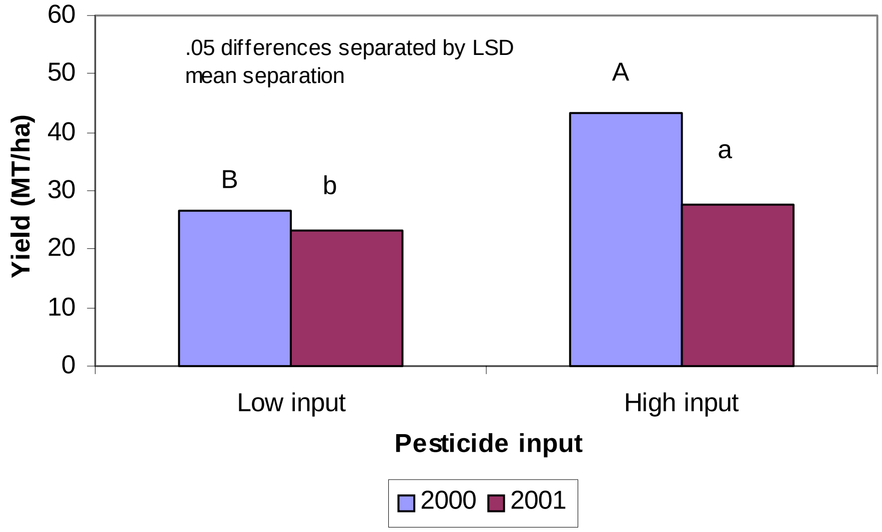

Fig. 2. Marketable yield 2000 and 2001 for pesticide levels averaged across all mulches.

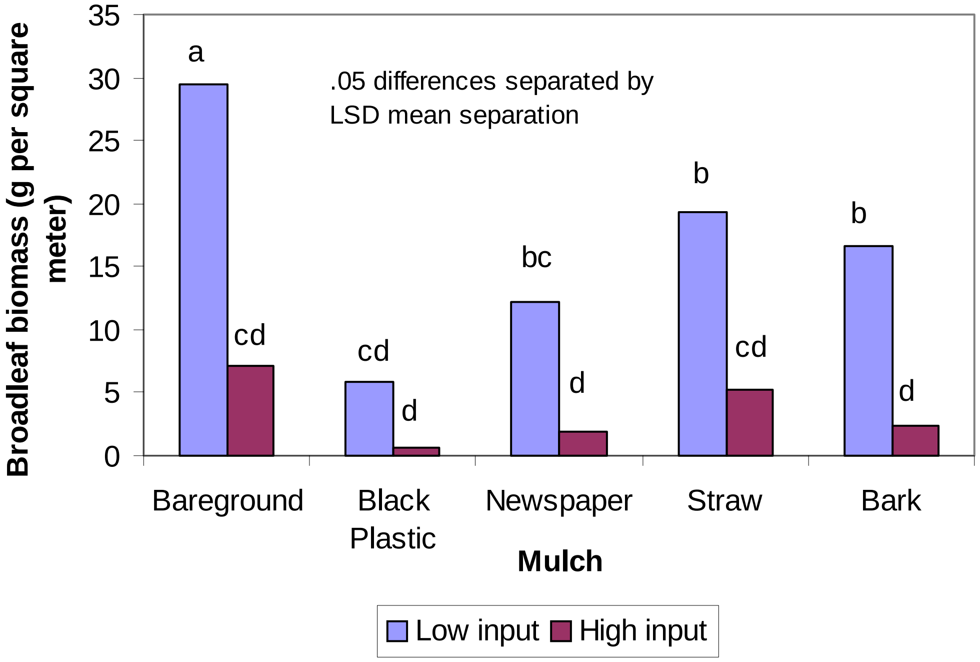

Fig. 3. 2000 Broadleaf weed biomass.

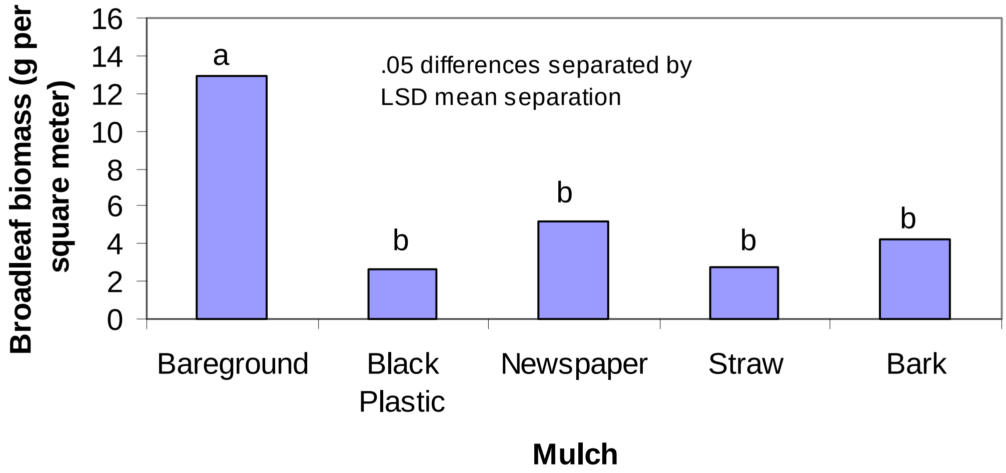

Fig. 4. 2001 Broadleaf weed biomass.