Characteristics of Hairy Vetch-Tomato System

This system is defined by no-tillage planting of tomato transplants into a killed hairy vetch cover crop. Details of this production system are described in the following farmers' bulletin.

Abdul-Baki, A.A., and J.R. Teasdale. 1997. Sustainable production of fresh-market tomatoes and other summer vegetables with organic mulches. USDA-ARS Farmers' Bull. No. 2279 (Revised Aug. 1997). Available at http://www.ars.usda.gov/is/np/tomatoes.html

Higher marketable yield and net returns

Research over a ten-year period showed higher tomato yields and net returns using the hairy vetch system compared to the conventional black polyethylene system. The degree of yield advantage to the vetch system is related to the amount of rainfall received. Years with adequate to abundant rainfall evenly distributed throughout the growing season usually show the highest advantage to the vetch compared to the black polyethylene system. Years with extended periods of drought often show little yield advantage to the vetch system. Under dry conditions, the soil in the beds dry out, insufficient nitrogen is released from the vetch residue on the surface of soil, and little foliar disease pressure is present (foliar diseases are usually higher in the plastic than vetch system, see below).

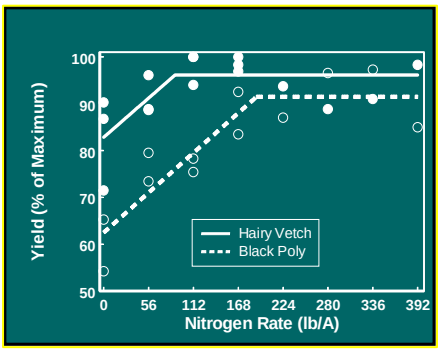
Abdul-Baki, A.A., J.R. Teasdale, R.F. Korcak, D.J. Chitwood, and R.N. Huettel. 1996. Fresh-market tomato production in a low-input alternative system using cover-crop mulch. J. Amer. Soc. Hort. Sci. 31:65-69.

Kelly, T.C., Y.C. Lu, A.A. Abdul-Baki, and J.R. Teasdale. 1995. Economics of a hairy vetch mulch system for producing fresh-market tomatoes in the mid-Atlantic region. J. Amer. Soc. Hort. Sci. 120:854-860.

Reduced input of nitrogen fertilizer

Tomatoes grown in black polyethylene required 119 lb/acre of fertilizer nitrogen to achieve yields equivalent to those following unfertilized hairy vetch. Minimum nitrogen rates required to achieve optimum tomato yield were 80 lb/acre in the hairy vetch system and 170 lb/acre in the black polyethylene system. Use of a hairy vetch cover crop allowed reduction of nitrogen application to tomatoes by approximately one-half relative to that required for application to black-polyethylene-grown tomatoes.

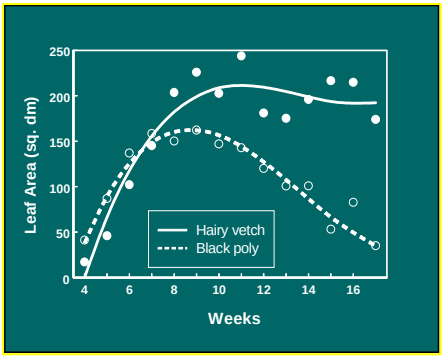
Abdul-Baki, A.A., J.R. Teasdale, and R.F. Korcak. 1997. Nitrogen requirements of fresh-market tomatoes on hairy vetch and black polyethylene mulches. HortScience 32:217-221.



Higher leaf area and leaf area duration

Tomatoes in black polyethylene mulch initially grew at a faster rate than those in hairy vetch mulch, presumably because of faster soil warming under the black polyethylene. Later in the season, tomatoes produced greater leaf area and maintained that leaf area over a longer period in the hairy vetch mulch than in the black polyethylene mulch. Leaf area duration, a measure of leaf area across time, is often highly correlated to yield and can explain the higher yield of tomatoes in the hairy vetch mulch. Higher leaf areas are associated with delayed leaf senescence and reduced foliar disease in the hairy vetch grown tomatoes.

Teasdale, J.R., and A.A. Abdul-Baki. 1997. Growth analysis of tomatoes in black polyethylene and hairy vetch production systems. HortScience 32:659-663.



Reduced foliar diseases and fungicides

One factor contributing to maintenance of a high leaf area is reduced foliar disease. Early blight epidemics of tomato in association with four soil mulching practices on raised beds were studied over three years. A hairy vetch mulch that completely covered the soil surface reduced soil particle dispersal by raindrops compared to dispersal by the other treatments that left part or all of the soil bare during the early weeks of the season. A similar pattern of response to mulch treatments was observed for development of early blight epidemic on tomato foliage suggesting a causal relationship. Thus, a mulch of hairy vetch residue that provides complete ground cover can reduce spread of foliar diseases by acting as a physical barrier that reduces dispersal of soil and water borne pathogens. Tomatoes in a hairy vetch mulch had negligible yield loss from early blight whereas yield loss by tomatoes in bare soil averaged 13% of that obtained in the disease-free plots treated with a weekly fungicide.

Mills, D.J., Coffman, C.B., Teasdale, J.R., Everts, K.B., and Anderson, J.D. Factors associated with foliar disease of staked fresh market tomatoes grown under differing bed strategies. Plant Dis. 86:356-361. 2002.

Mills, D.J., Coffman, C.B., Teasdale, J.R., Everts, K.B., Abdul-Baki, A.A., Lydon, J. and Anderson, J.D. Foliar disease in fresh-market tomato grown in differing bed strategies and fungicide spray programs. Plant Dis. 86:955-959. 2002.

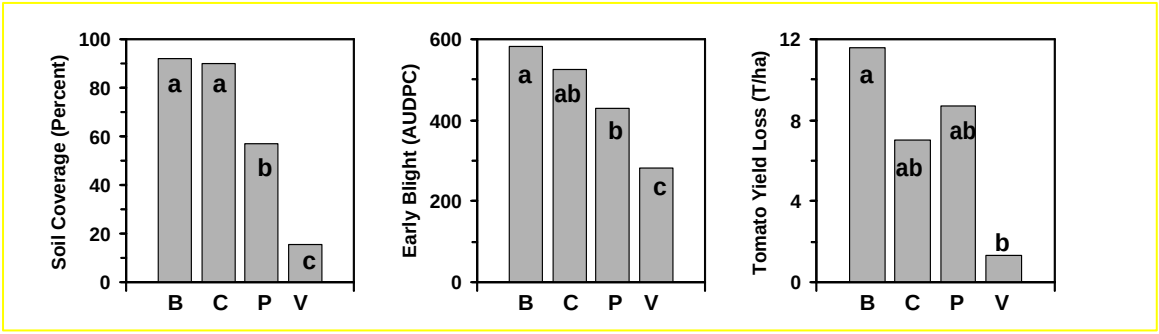


Figure. Coverage of splash panels by soil after rainfall events during the first half of June, area under the early blight disease progress curve for the lower and middle tomato canopy in the absence of fungicide, and yield loss from tomatoes grown with versus without fungicide in beds with bare soil (B), incorporated compost (C), black polyethylene mulch (P), or hairy vetch mulch (V). Bars with the same letter are not significantly different (P=0.05).

Reduced Colorado Potato Beetle

A study was conducted to compare the effects of black plastic and hairy vetch mulch killed by either mowing with a flail mower or rolling with a drum fitted with angle iron on Colorado potato beetle colonization of and damage to plots of staked fresh-market tomatoes. Overwintered beetles were collected from other locations and released. Vertical aluminum barrier strips were placed around each block to facilitate beetle establishment. Insects were counted at weekly intervals on all plants in each plot. Colorado potato beetle establishment occurred at a lower rate on tomatoes transplanted into hairy vetch than on those transplanted into black plastic mulch. These findings illustrate that an additional benefit of using a hairy vetch organic mulch in the production of staked fresh-market tomatoes is greater resistance of the crop to invasion and damage by this pest. Yield of tomatoes in black polyethylene suffered a 19% loss whereas those in hairy vetch had only a 5 to 7% loss due to Colorado potato beetle damage.

Teasdale, J.R., Abdul-Baki, A.A., Mills, D.J., and Thorpe, K.W. Enhanced pest management with cover crop mulches. Acta Horticulturae 638:135-140. 2004.

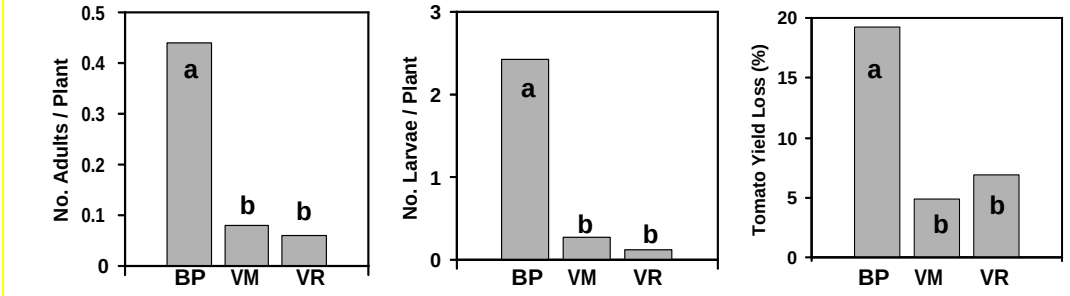


Figure. Effects of black polyethylene mulch (BP) or hairy vetch killed by mowing (VM) or rolling (VR) on establishment of Colorado potato beetle adults and larvae and on tomato yield loss when grown with versus without insecticide. Bars with the same letters are not significantly different (P=0.05).

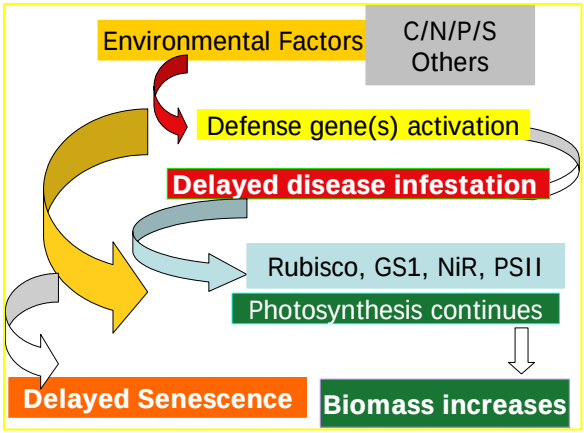
Gene activation

There is a molecular basis for delayed leaf senescence and tolerance to diseases in tomato plants cultivated in a hairy vetch mulch. In hairy vetch-cultivated plants, expression of specific and select classes of genes is up-regulated compared to those grown on black polyethylene mulch. These include N-responsive genes such as NiR, GS1, rbcL, rbcS, and G6PD; chaperone genes such as hsp70, and BiP; defense genes such as chitinase and osmotin; a cytokinin-response gene CKR; and gibberellic acid 20 oxidase. The transcripts of these genes are at a higher steady-state level in vetch-grown tomato leaves, which is an indication of efficient utilization and mobilization of N, higher photosynthetic rates, higher carbon mobilization, sustained reducing power, and defense promotion. The net result is that these tomato plants live longer, have delayed leaf senescence, and are tolerant to diseases.

Kumar, V., Mills, D.J., Anderson, J.D., and Mattoo, A.K. An alternative agriculture system is defined by a distinct expression profile of select gene transcripts and proteins. Proc. Natl. Acad. Sci. USA. 101:10535-10540. 2004.

Kumar, V., Abdul-Baki, A., Anderson, J.D., and Mattoo, A.K. Cover crop residues enhance growth, improve yield and delay leaf senescence in greenhouse-grown tomatoes. HortScience 40:1307-1311. 2005.

Mattoo, A.K., and Abdul-Baki, A. Crop genetic responses to management: Evidence of root-to-leaf communication. pp. 221-230 In Uphoff, N. Ball, A.S. Fernandes, E. Herren, H. Husson, O. Laing, M. Palm, C. and Thies, J. (eds.) Biological Approaches to Sustainable Soil Systems. CRC Taylor & Francis, Boca Raton, FL. 2006.



Reduced runoff losses of water, soil, and pesticides

Current vegetable production systems use polyethylene mulch and require multiple applications of agrochemicals. During rain events, runoff is enhanced because 50-75% of the field is covered with an impervious surface. In this research, field plots were instrumented with automated flow meters and samplers to measure and collect runoff, which was filtered, extracted, and analyzed to determine soil and pesticide loss. Seasonal losses of 2 to 4 times more water and 5 to 15 times more sediment were observed from plots with black polyethylene than those with hairy vetch mulch. Total pesticide loads for chlorothalonil, alpha and beta endosulfan were 19, 6, and 9 times greater from polyethylene than from vetch mulched plots, respectively. Runoff from polyethylene plots was more toxic to aquatic life than runoff from vetch plots in 10 out of 15 runoff event assays.

Rice, P.J., L.L. McConnell, L.P. Heighton, A.M. Sadeghi, A.R. Isensee, J.R. Teasdale, A.A. Abdul-Baki, J.A. Harman-Fetcho, and C.J. Hapeman. 2001. Runoff loss of pesticides and soil: A comparison between vegetative mulch and plastic mulch in vegetable production systems. J. Environ. Qual. 30:1808-1821.

Rice, P.J., L.L. McConnell, L.P. Heighton, A.M. Sadeghi, A.R. Isensee, J.R. Teasdale, A.A. Abdul-Baki, J.A. Harman-Fetcho, and C.J. Hapeman. 2002. Comparison of copper levels in runoff from fresh-market vegetable production using polyethylene mulch or a vegetative mulch. Environmental Toxicology and Chemistry 21:24-30.