More Than Meets the Eye

New Findings on How Mulch Color Can Affect Food Plants

Plant physiologist Michael J. Kasperbauer made a career of "seeing" light the way plants do: in wavelengths, some of which cannot be detected by the human eye.

This unique perspective led to studies in which Kasperbauer—who recently retired from ARS' Coastal Plains Soil, Water, and Plant Research Center at Florence, South Carolina—headed development of colored plastic-sheeting-type mulches that increase food and crop plants' yield and quality.

His best-known work involved tomatoes and strawberries. In research done with Clemson University, he and ARS soil scientist Patrick G. Hunt found that tomato plants grown over red mulch yielded about 20 percent more fruit than those grown over standard black mulch. He later found that strawberries grown over red mulch smelled better, tasted sweeter, and yielded more than those grown over black mulch.

This research, started during the 1980s, led to development of SRM-Red, a selective reflecting mulch that has been available commercially since 1996.

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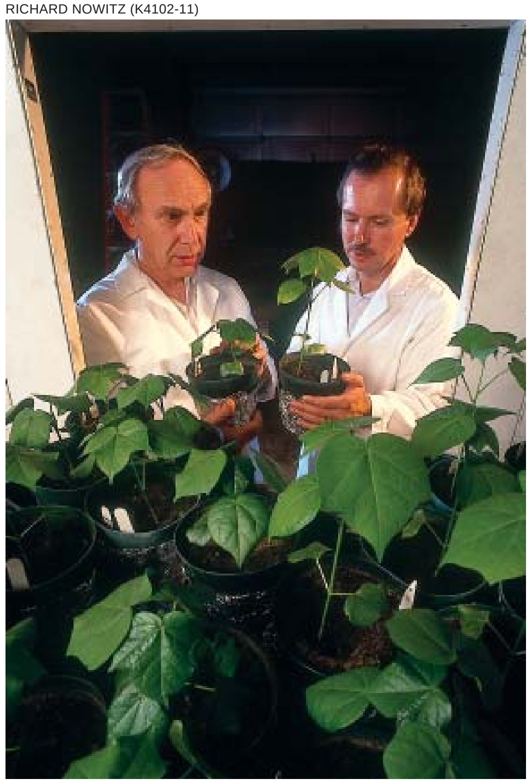

Wavelength of light affects plants both above ground and below. Plant physiologist Michael Kasperbauer (left) and Clemson University professor Bruce Fortnum examine the influence of light on cotton shoots.

Recent Findings in Carrots, Cotton, and Basil

Recently, colored-mulch studies have focused on how different wavelengths of light affect roots, stems, leaves, fruit, and seeds of many other food and crop plants. Kasperbauer and colleagues found that some colors enhanced plant products' flavor, aroma, and nutrient content.

They found that concentrations of nutrients and compounds such as beta carotene and vitamin C in the roots of food crops could be modified by reflecting the right waves of color onto the plants' leaves. This was demonstrated in carrot plants. The carrots were grown in trickle-irrigated field plots mulched with plastic sheets colored a shade of yellow that reflected low levels of blue light coupled with high amounts of red, far-red (FR), and photosynthetic light.

Beta carotene, a provitamin found in plants and their pigments, is a benign source of vitamin A and is an antioxidant with possible anticarcinogenic properties. Vitamin C helps maintain capillaries, bones, and teeth; assists in iron absorption; and is vital in the formation of a protein that gives structure to bones, cartilage, muscle, and blood vessels.

In another study, Kasperbauer discovered that cotton fibers grew longer in bolls exposed to increased FR-to-red light ratios. Length is an important component of cotton fiber quality.

"We set out to see whether cotton fibers would be as responsive to extra far-red light as the elongating cells in seedling stems are," says Kasperbauer. "We found that the difference in fiber length was influenced more by the higher FR-to-red ratio reaching the developing bolls than by increased photosynthetic light."

He concluded that the FR light reflected to developing cotton bolls can penetrate the boll walls to reach the developing fiber within and influence elongation.

Kasperbauer also headed studies with basil, which revealed that the amounts of blue, red, and FR light reflected onto developing leaves affected their size, aroma, and concentration of soluble phenolics. Phenolics are naturally occurring compounds that include tannins and pigments. They induce—among other properties—color, some flavors and odors, and antioxidant activity.

The basil was grown over six colors of polyethylene row covers. "Leaves developing over red surfaces had greater area, succulence, and fresh weight than those developing over black surfaces," says Kasperbauer. "Basil grown over yellow and green surfaces produced significantly higher concentrations of aroma compounds than did basil grown over white and blue covers."

The leaves grown over yellow and green mulches also contained significantly higher concentrations of phenolics than those grown over the other colors.

Colored-mulch technology relies greatly on "fooling" plants into behaving as if they face stiffer competition for sunlight than they actually do. This is achieved when they receive high amounts of FR light. Plants reflect FR and sense reflected FR to gauge how close and dense other vegetation around them is. To stay ahead of what's perceived as increased competition, they develop larger shoots.

Kasperbauer says the colored-mulch technology's controlling factor is not the perceived colors themselves, but how they change the amount of blue and the ratio of FR to red light that plants receive.

A Link to Photoperiodism Studies

Colored mulch research can be traced to historic USDA studies dating back to 1918 that led to the discovery of photoperiodism. A photoperiod is the day length that will lead to flowering. Some plants flower only if exposed to short days, while others fare well with longer days.

That work was followed by a USDA research project that led to the discovery of phytochrome, a dual-form plant protein that is switched back and forth by red and FR wavelengths. This switching lets phytochrome regulate photoperiodic control of flowering and other growth processes. Those studies, conducted from 1936 until the mid-1960s, were headed by botanist Harry A. Borthwick and based at the Pioneering Research Laboratory for Plant Physiology in Beltsville, Maryland.

Kasperbauer conducted postdoctoral research at Beltsville during the early 1960s. There, he worked with Borthwick and Sterling B. Hendricks, a chemist who played a crucial role in phytochrome's discovery.

The concept of colored mulch sprouted when Kasperbauer wondered whether phytochrome was equally distributed in leaves. He became curious about what would happen if light impinged on the leaf's lower, rather than upper, surface. "The plant response was the same, no matter which surface received the light," says Kasperbauer. "Although that experiment seemed somewhat unconventional in 1962, it became highly relevant about 22 years later, when we determined that red and FR reflected from the soil surface could act through the plant's phytochrome system to enhance yield and quality. That led to our colored-mulch work."

Hunt, who is now research leader at Florence, says the colored-mulch research "galvanized the imaginations of scientists and users worldwide. It has been successfully commercialized, and its market had a steady growth."—By **Luis Pons,** ARS.

This research is part of Soil Resource Management (#201) and Water Quality and Management (#202), two ARS National Programs described on the World Wide Web at www.nps.ars.usda.gov.

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At the Pioneering Research Laboratory for Plant Physiology in Beltsville, Maryland, botanist Harry A. Borthwick led early ARS studies on the effects of lights on plants from 1936 until the mid-1960s. Here, in this 1962 study, Borthwick irradiates cockleburs to control flowering.

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Prior research shows that the growth of cotton seedlings is affected by light reflectance from the surrounding soil surface. In this 1991 study, soil scientist Patrick Hunt (left) and plant physiologist Michael Kasperbauer compare the progress of plants grown in red, brown, white, and tan colored soils.

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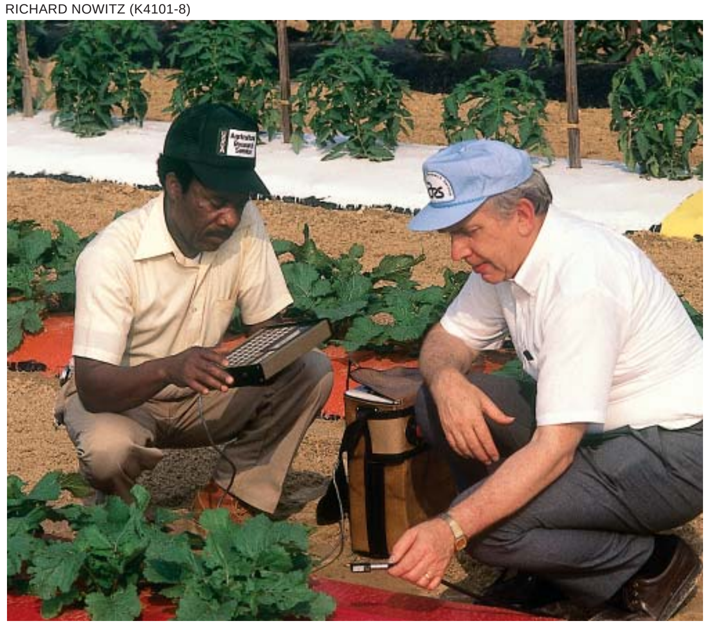

Technician Woodrow Sanders (left) and plant physiologist Michael Kasperbauer test colored plastic mulches in 1991 as yield boosters for tomatoes and other crops.