



Science
Societies

Coloring in crop management

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Fruit color is influenced by environmental factors—especially light, temperature, and stress. Growers can manage these conditions to improve color development through key practices such as nutrient sprays,

reflective mulches, pruning, and growth regulators that enhance pigment production or light exposure. Optimizing both plant health and environmental conditions is essential for producing high quality, well-colored fruit.

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As consumers, we expect fruits and vegetables to have specific colors. We are programmed to associate color with ripeness, flavor, nutritional value, and overall quality. Color helps define the attractiveness of fruits and vegetables and thus strongly influences the purchasing decisions of consumers.

For many years, improvements or changes to fruit color have been a major target of breeding programs across a range of crops. Additionally, growers routinely implement several on-orchard management techniques to enhance fruit color development. We should always consider the impact of environmental stress on fruit color. While the term “stress” usually conjures up negative connotations, moderate stress can enhance the concentration of numerous phytochemicals, including those that color our fruits. The timing, duration, and severity of any stress will determine the plant's response and consequent impact on color.

In most species, the main pigments are chlorophyll, carotenoids, and/or anthocyanins. They are produced in fruit as part of the ripening process, orchestrated by phytohormones and an ensuing flow of physiological changes, culminating in pigment biosynthesis.

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While this is a controlled developmental process, the production of pigments as referred to earlier can be affected by stress. Environmental conditions such as light quantity and quality, availability of water, and ambient temperature can alter coloring. If these factors intensify to stress levels, fruit tissues respond by increasing **(or ceasing)** pigment production. In many cases, if the stress is not severe, this can have a positive outcome for fruit quality. Most times, we focus management practices on the principal environmental factors (light, temperature, and water) that can influence fruit color.

Color is not just about attractive marketing. Let's look at grapes as an example. Both red and white grapes serve as a good carbohydrate and fiber source and contain a host of vitamins and minerals that fortify health. **Red grapes contain something extra.**

They contain **resveratrol** and **quercetin**. Resveratrol is a polyphenolic compound with anti-inflammatory and antioxidant properties that present health benefits, including heart disease protection, lowering bad cholesterol, and potentially improving brain function. Quercetin is a flavonoid that acts as a potent antioxidant protecting from free radical damage. In studies, quercetin has been shown to reduce the growth rate of cancer cells, lower high blood pressure, and reduce symptoms of allergies, asthma, and arthritis. **Health-conscious consumers** look to red grapes for these added benefits offered by the deeply colored fruits.



When we look at color change timing for grapes, we need to do things that can improve or even ensure good coloring. Veraison is

the color-changing stage of grapes.

Photo by Wikimedia

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For grape growers, good grape color means a more marketable product that can fetch higher prices. Poorly colored grapes can either not be sold, resulting in high levels of

waste and lost revenue, or sold for reduced rates. In some cases, poor color results in grapes not even being harvested.

Certain geographic areas are particularly hard-hit by color challenges; red table grape production is particularly problematic, and season after season, growers must deal with lack of color. With the changes in high-degree temperatures in grape-growing regions, this problem has become increasingly relevant. It has been documented that multiple occurrences of triple-digit temperatures can shut down color production.

As an agronomist, I have witnessed the reversal of coloring. As heat stress continues, the color of existing grapes appears to fade. I am called to advise how to prevent color loss and/or enhance color late in the season before harvest. Crops I have worked on include apples, cherries, blueberries, multiple varieties of peppers, tomatoes, grapes, pomegranates, citrus, and many types of stone fruit, to mention some. Going into the specifics for each crop is beyond the scope of this article; instead, I will generalize about what we know.

Key methods to improve fruit color

- **Nutrient sprays:** Foliar application of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) increases anthocyanin (red pigment) production.
- **Pre-harvest sprays:** Phenylalanine (Phe), an amino acid, can be applied 2–4 weeks before harvest to significantly boost red color in apples and mangoes.

- **Reflective mulch/fabric:** Placing reflective fabric under trees increases light intensity to the lower canopy, enhancing color.
- **Growth regulators:** Prohydrojasmon (PDJ) or abscisic acid (ABA) can be used to promote color development in specific fruits.
- **Over-fertilizing avoidance:** Limit nitrogen (N) late in the season as excess nitrogen can reduce red color development.



Placing reflective fabric under trees increases light intensity to the lower canopy, enhancing color. Photo by Alamy/JS Photo.

To increase fruit color (especially red tones), apply fertilizers high in phosphorus, potassium, magnesium, and calcium during the ripening stage or use pre-harvest foliar sprays of phenylalanine. **L-Phenylalanine is an essential amino acid** used in agriculture primarily as a **biostimulant and metabolic enhancer** to improve crop resilience, increase nutrient uptake, and boost the quality of fruits and flowers. As a precursor to specialized compounds, it is applied to help plants manage stress, defend against pathogens, and improve postharvest quality. **Complexed amino acid nutrient sprays can be extremely effective.**

Other methods include using reflective mulch to increase sunlight exposure or applying, in specific cases, growth regulators like prohydrojasmon. **Prohydrojasmon (PDJ) is a synthetic plant growth regulator (PGR)** and a derivative of jasmonic acid (JA) used in agriculture to improve fruit quality, enhance color, and strengthen stress resistance in crops. It is highly effective in promoting anthocyanin production (coloration) in fruit crops like apples and grapes, often allowing for earlier maturation and improved harvest quality.

Anthocyanin concentration is an important determinant of the color of fruit. Besides anthocyanins, the apple contains many compounds such as chlorophyll, carotenoids, and flavonoids, which can blend to produce its color. Anthocyanin accumulation in apple fruit can be affected by environmental, nutritional, and orchard management factors; the stage of maturity of the fruit; and by the microenvironment within the canopy. The biosynthesis of anthocyanins is strongly light dependent. Some preharvest practices such as pruning **and reflective mulches can also be incorporated to intensify and or transfer light to reach shaded fruit.** The use of shoot growth retardants can improve fruit skin color.

Biostimulants for improved fruit color

One of my go to practices is to use biostimulants to improve fruit color:

- **Seaweed extracts (*Ascophyllum nodosum*):** Widely used to enhance red coloration in apples and grapes, improving skin color and reducing anthocyanin deficiency.
- **Protein hydrolysates and amino acids:** Known to boost color development in grapes and fruit trees.
- **Humic and fulvic acids:** Enhances nutrient uptake and sugar transport, leading to better pigmentation in crops like grapes, cherries, and citrus.
- **Chitosan:** Known to enhance color in strawberries and other delicate fruits.

Some industry examples of biostimulant products designed for fruit coloring are:

- [Cyto-Red + Fruit & Pepper Crop Biostimulant \(Verdesian Life Sciences\)](#)
- [SUNRED \(Biolchim\)](#)
- [Colorsave \(LIDA Plant Research\)](#)

Mechanism and application

- **Color drivers:** These products increase the activity of key genes (e.g., chalcone synthase) that drive pigment synthesis.
- **Application methods:** Foliar applications directly to the fruit and canopy are most effective for immediate color impact while root drenching or fertigation promotes

overall plant health.

- **Timing:** Optimal results are achieved when applied during the fruit coloring and ripening stages.



Foliar applications of biostimulants directly to the fruit and canopy are most effective for immediate color impact. Photo courtesy of Adobe Stock/Vesna.

There is much more to discuss about fruit coloring, but for this article, I will end with a summary.

Nutrients in general are essential to healthy plants, and a healthy plant with controlled stress will produce better color in fruit. Some fruit-ripening methods that speed up ripening also speed up degradation of fruit and create short shelf lives. Desperate use

of the wrong materials can result in massive post-harvest waste. Choose products that can enhance metabolic activity for natural pigmentation changes and provide stress mitigation in your plants.

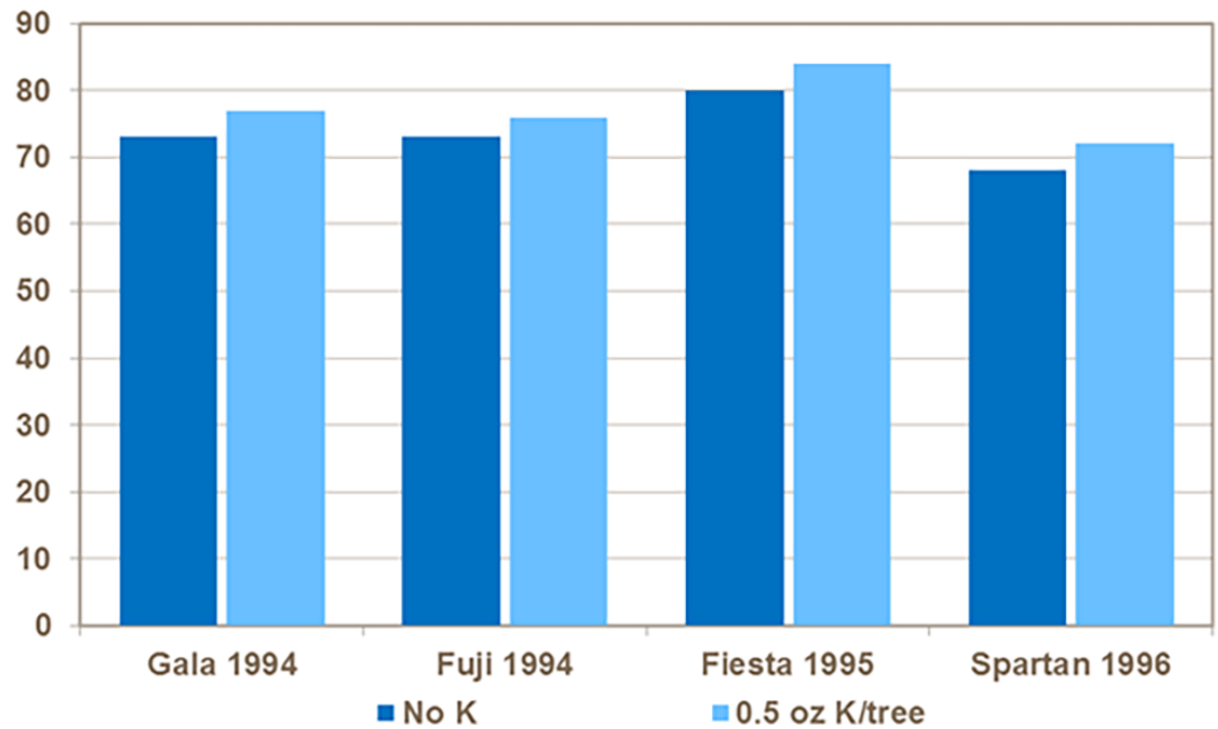
- **Potassium (potassium dihydrogen phosphate):** Crucial for sugar transport and pigment development, often combined with growth regulators.
- **Magnesium (Mg):** Increases carbohydrates, which act as building blocks for red pigments.
- **Phosphorus (P):** Boosts enzyme production necessary for anthocyanin synthesis.
- **Zinc (Zn) and manganese (Mn):** Essential micronutrients that improve overall color intensity and background color (e.g., greening in apples).
- **Boron (B):** Aids in sugar translocation, contributing to better ripening and color.

Examples of research on nutrient effects on coloring

Potassium and Fruit Color

Apple – Gala, Fuji, Fiesta, Spartan - Canada

Red Color (% solid red)

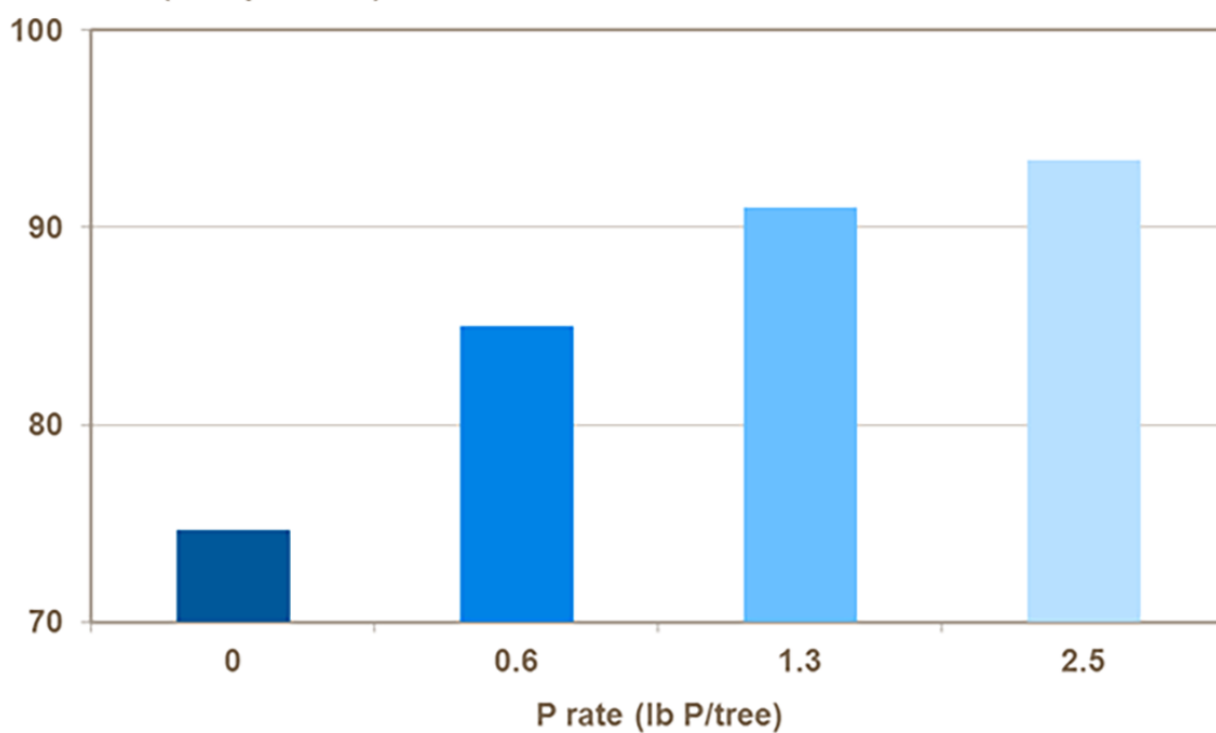


REF: Neilsen et al. 2004

Phosphorus and Fruit Color

Apple – Starking Delicious, South Africa

Fruit color (% exportable)

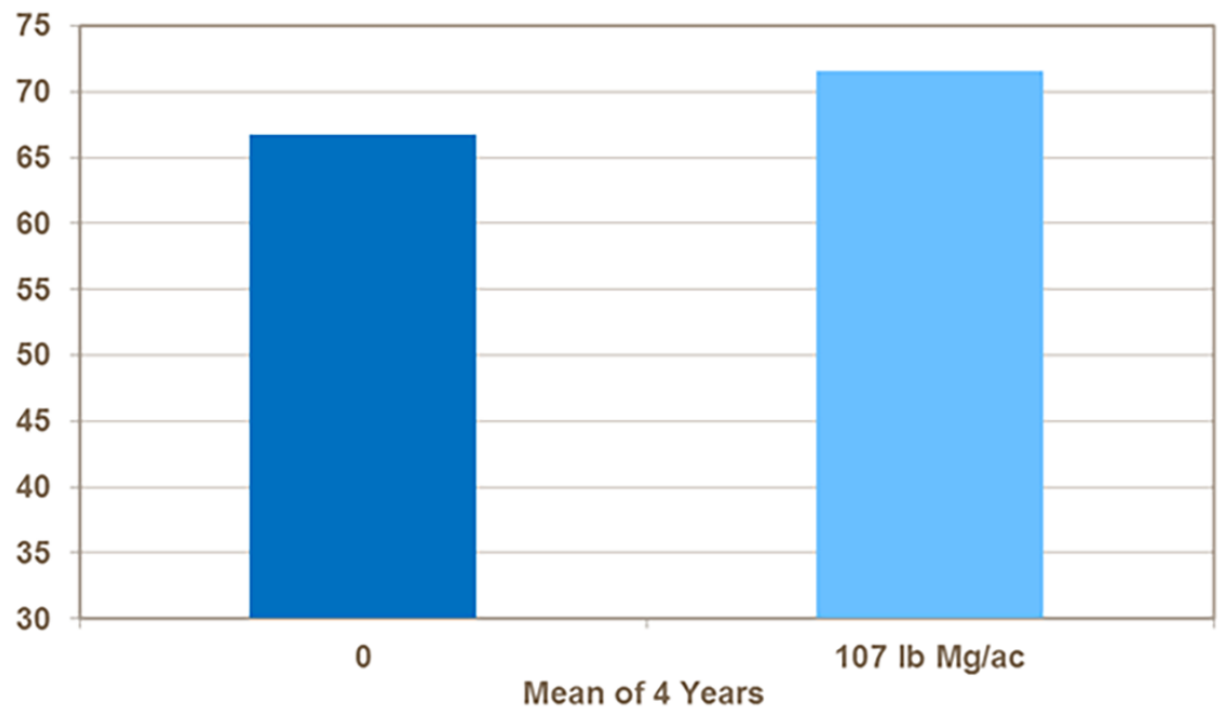


REF: Olivier et al. - 1994

Magnesium and Fruit Color

Apple – Cortland, Poland

Fruit Color (% of Surface)



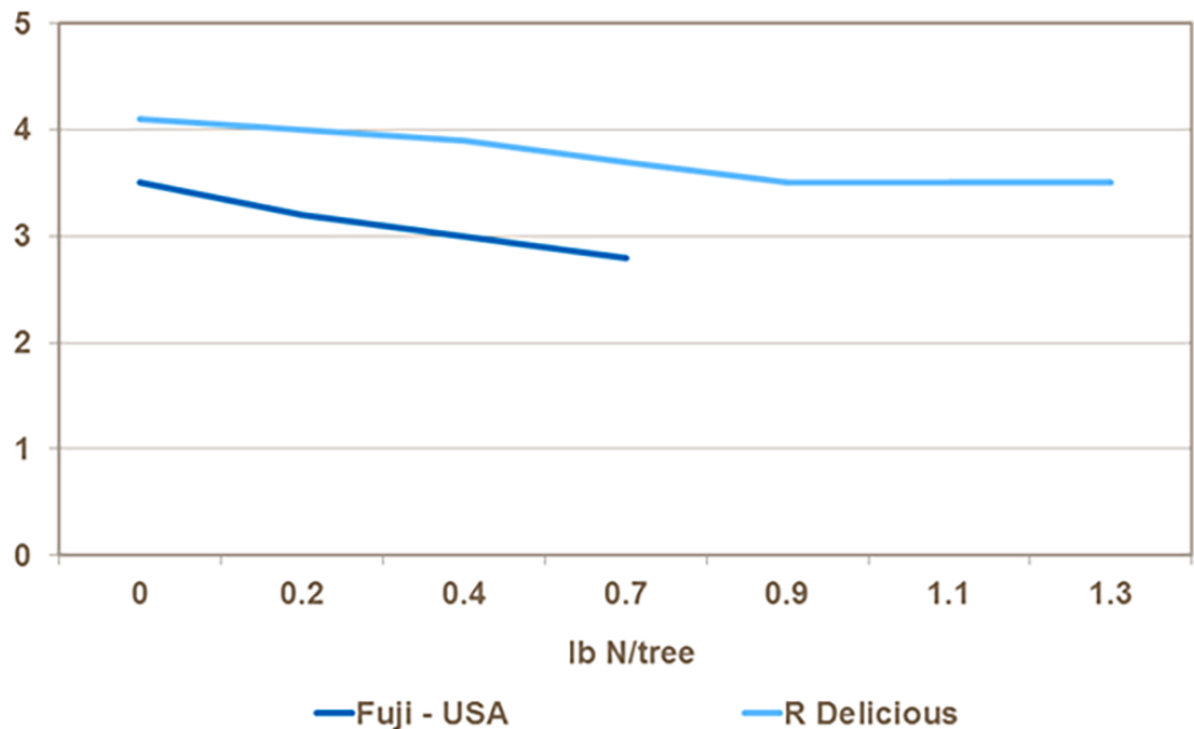
REF: Lysiak & Pacjolak - 1999

Over-use or late applications of nitrogen reduces the red coloration of red apples. This can be advantageous in green apples as it will improve greenness and minimize red colors.

Nitrogen and Red Apple Color

Apple - USA

Color Intensity (1-low, 5- high)



REF: Fallai et al – 2001

Other additive factors to keep in mind

Products and growth regulators

- **Brassinolide:** A plant growth regulator that boosts cell division and enhances anthocyanin formation.
- **Amino acids and seaweed extracts:** Biostimulants that enhance metabolic activity, improving the accumulation of anthocyanins.
- **Ethylene/ethephon:** Used in some agricultural contexts to hasten maturity and promote chlorophyll degradation, allowing red/yellow pigments to show.

Factors affecting natural coloration

- **Light exposure:** Light is essential for activating genes related to anthocyanin and carotenoid pathways.
- **Temperature:** Cool nights combined with sunny days often maximize red color development.

Suggested reading

Basile, B., Rouphael, Y., Colla, G., Soppelsa, S., & Andreotti, C. (2020). Appraisal of emerging crop management opportunities in fruit trees, grapevines and berry crops facilitated by the application of biostimulants. *Scientia Horticulturae*, 267, 109330. <https://doi.org/10.1016/j.scienta.2020.109330>

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Palta, J.P., Farag, K.M., & Weiss, L.S. (2011). *Color enhancement in cranberry fruit by using environmentally safe natural products*. University of Wisconsin–Madison. <https://fruit.webhosting.cals.wisc.edu/wp-content/uploads/sites/36/2011/05/Color-Enhancement-in-Cranberry-Fruit-by->

Ritenour, M., & Khemira, H. (2007). *Red color development of apple: A literature review*. Washington State University—Tree Fruit Research and Extension Centre

Sembok, W., & Binti, W. (2009). *Regulation of fruit colour development, quality and storage life of 'Cripps Pink' apple with deficit irrigation and plant bioregulators*. Curtin University of Technology, Western Australia.

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1. **Fruit color can be enhanced when you apply which of the following minerals in high concentration?**
 - a. Nitrogen.
 - b. Phosphorus.
 - c. Boron.
 - d. Potassium.
 - e. All of the above.

2. Best timing to apply nutrients to increase color is

- a. postharvest.
- b. blossom.
- c. during ripening stage.
- d. Both a and b.
- e. None of the above.

3. Biostimulants are used to enhance color by

- a. staining the fruit to desired color.
- b. inhibiting anthocyanin production.
- c. managing stress.
- d. adjusting the amount of light hitting the fruit.
- e. Both a and d.

4. Plant growth regulators have no effect on coloring

- a. True.
- b. False.

5. Which of the following cultural practices directly modify light exposure to fruit in order to enhance color development?

- a. Irrigation.
- b. Reflective mulch.
- c. Pruning.

d. Foliar nutrient sprays.

e. Both b and c.

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