



AGRONOMIC SPOTLIGHT



BENEFITS OF GLUCOSINOLATES IN BROCCOLI

- » Broccoli plant tissues contain glucosinolate compounds that may have beneficial properties for plants and humans.
- » Glucosinolates break down into isothiocyanates, which may contribute to the suppression of plant pests and pathogens.
- » Other factors associated with broccoli soil amendments may have additional effects to those of glucosinolates in the development of disease suppressive soils.

Growers have relied on broccoli and other brassica crops in crop rotations to help manage soil health and reduce disease pressure. These crops contain compounds called glucosinolates that may play a role in disease suppression.

WHAT ARE GLUCOSINOLATES?

Glucosinolates are sulfur-containing compounds found naturally in *Brassica* species, such as broccoli and cabbage.¹ When broken down by the enzyme myrosinase, also present in *Brassica* plants, glucosinolates are converted into other compounds including isothiocyanates (ITCs). ITCs have been found to protect plants against some diseases and pests and to be useful in biofumigation when *Brassica* plants are incorporated into the soil as green manures.

Over 130 different glucosinolate compounds have been characterized. Different compounds are produced by different *Brassica* species, and various glucosinolates can be found in different tissues (roots vs. leaves) in the same plant.² Glucosinolate compounds commonly found in broccoli include sinigrin, glucoraphanin, and gluconapin, with the highest levels typically found in broccoli leaves, flower buds, seeds, and sprouts. The level of glucosinolates produced in broccoli tissue is affected by soil and weather conditions, as well as levels of fertilization, methods of cultivation, and the cropping season (spring vs. fall).²

Glucosinolates and their ITC derivatives have become a focus of research because of their role in plant defense, their effects on soil health, and the potential health benefits for people who consume *Brassica* vegetables such as broccoli. A study on the effects of glucosinolates produced by several *Brassica* crops on two bacterial pathogens and two fungal pathogens found that glucosinolate derivatives inhibited the growth of the pathogens in culture and that the level of inhibition depended on the amount of the compound tested. This study also showed that the different pathogens responded differently to the specific compounds, showing that the ability of a plant to suppress a pathogen depends on the compounds present in the plant and the particular strains of the pathogen involved.³

SOIL HEALTH

In addition to being a factor in the disease resistance properties of a plant, glucosinolates and ITCs may be useful for pest management by affecting pathogens and pests in the soil. Biofumigation is the process in which the residue of certain *Brassica* species, such as broccoli, are incorporated into the soil for purposes of suppressing bacteria, fungi, nematodes, and weeds.^{4,5} This suppression is thought to be due, in part, to the release of ITCs from the macerated and decomposing tissue.

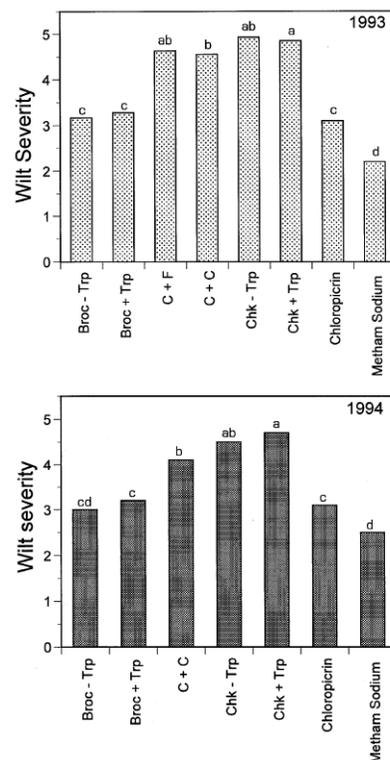


Figure 1. The effects of broccoli residue, with and without tarping, cauliflower followed by cauliflower, cauliflower followed by fallow, check treatment with tarp, check treatment without tarp, and two soil fumigants on the level of Verticillium wilt. Courtesy K. Subbarao—© APS. Reproduced, by permission, from Subbarao, K. V., Hubbard, J. C., and Koike, S. T. 1999. Evaluation of broccoli residue incorporation into field soil for Verticillium wilt control in cauliflower. *Plant Dis.* 83:124-129.

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BENEFITS OF GLUCOSINOLATES IN BROCCOLI

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biofumigation with *Brassica* species, such as broccoli, to suppress soilborne pathogens can be greatly influenced by methods of crop destruction and incorporation and various soil environmental factors.¹²

A field study published in 1999 found that incorporating broccoli residue into the soil effectively suppressed the levels of *Verticillium* wilt in following broccoli and cauliflower plantings (Figure 1).⁴ A follow-up study found that rotating winter broccoli crops with summer strawberry crops in California reduced the level of the pathogen *Verticillium dahliae* in the soil, lowered the severity of *Verticillium* wilt on strawberry, and increased growth of the strawberry plants and fruit yield, when compared with rotations not including *Brassica* crops.⁶

Other studies have shown that soil amendments with *Brassica* crop residues can inhibit a range of plant pests including bacterial pathogens such as *Ralstonia solanacearum*, *Pseudomonas marginalis*, and *Streptomyces scabies*, nematodes including root-knot nematodes and potato cyst nematodes, and fungal and fungal-like pathogens such as *Sclerotinia minor*, *Sclerotinia sclerotiorum*, *Verticillium dahliae*, *Rhizoctonia solani*, *Aphanomyces euteiches*, and *Pythium ultimum*.^{7,8,9}

Applications of mustard crops residues as mulch were shown to reduce disease levels of lettuce drop, caused by the fungus *Sclerotinia minor*, and to increase lettuce yields. Lettuce plants also produced larger heads in plots treated with the mustard variety 'Ida Gold', which produces high levels of glucosinolates.¹⁰ Other studies looking at the effects of cover crops and green manures on lettuce drop have found little to no disease suppression associated with *Brassica* treatments.¹¹ The effects of *Brassica* biofumigation and the role of glucosinolates in the suppression of soilborne diseases are still unclear and topics of continuing study.

Compounds other than glucosinolates found in broccoli and other *Brassica* crops also appear to be involved in pathogen suppression. The addition of broccoli residue to soil was found to stimulate the naturally occurring community of biocontrol organisms in the soil, and the activity of these antagonists also suppressed soilborne pathogens.⁷ Other *Brassica* crops, including canola, rapeseed, radish, turnip, yellow mustard, and Indian mustard have been studied for their effects on soil disease suppression.^{9,13} The advantage of using broccoli as a green manure is that it is also a valuable horticultural crop that provides farm revenue, and broccoli fits well in rotation schedules with other vegetable crops.

BROCCOLI AND HUMAN HEALTH

The consumption of broccoli, cabbage, and other *Brassica* vegetables has long been considered to contribute to a

healthy diet, and studies have found that some of those benefits may result from glucosinolates and isothiocyanates. The results from a group of studies looking at the health benefits of eating *Brassica* vegetables showed an association of eating more *Brassica* vegetables with reductions in risks of several types of cancer and a reduced risk of myocardial infarction (heart attack).^{5,14}

Broccoli varieties with enhanced levels of glucosinolates have been developed, primarily for their potential human health benefits.¹⁵ These varieties may also be useful in managing soilborne plant pathogens and the diseases they cause.

Sources:

- James, D., Devaraj, S., Bellur, P., Lakkanna, S., Vicini, J., and Boddupalli, S. 2012. Novel concepts of broccoli sulforaphanes and disease: Induction of phase II antioxidant and detoxification enzymes by enhanced-glucoraphanin broccoli. *Nutrition Reviews* 70 :654–665.
- Motisi, N., Montfort, F., Doré, T., Romillac, N., and Lucas, P. 2009. Duration of control of two soilborne pathogens following incorporation of above- and below-ground residues of *Brassica juncea* into soil. *Plant Pathology* 58:470–478.
- Sotelo, T., Lema, M., Soengas, P., Cartea, M., and Velasco, P. 2015. In vitro activity of glucosinolates and their degradation products against *Brassica*-pathogenic bacteria and fungi. *Appl Environ Microbiol* 81:432–440.
- Subbarao, K., Hubbard, J., and Koike, S. 1999. Evaluation of broccoli residue incorporation into field soil for *Verticillium* wilt control in cauliflower. *Plant Dis.* 83:124-129.
- Traka, M. and Mithen, R. 2009. Glucosinolates, isothiocyanates and human health. *Phytochem Rev* 8: 269-282.
- Subbarao, K., Kabir, Z., Martin, F., and Koike, S. 2007. Management of soilborne diseases in strawberry using vegetable rotations. *Plant Dis.* 91:964-972.
- Shetty, K., Subbarao, K., Huisman, O., and Hubbard, J. 2000. Mechanism of broccoli-mediated *Verticillium* wilt reduction in cauliflower. *Phytopathology* 90:305-310.
- Larkin, R. 2015. Soil health paradigms and implications for disease management. *Annual Review of Phytopathology* 53:199–221.
- Larkin, R. and Griffin, T. 2007. Control of soilborne potato diseases using *Brassica* green manures. *Crop Protection* 26:1067–1077.
- Daugovish, O., Downer, J., and Mochizuki, M. 2007. Mustard-derived biofumigation for lettuce in coastal California. *Hortscience* 42:953-953.
- Bensen, T., Smith, R., Subbarao, K., Koike, S., Fennimore, S., and Shem-Tov, S. 2009. Mustard and other cover crop effects vary on lettuce drop caused by *Sclerotinia minor* and on weeds. *Plant Dis.* 93:1019-1027.
- Matthiessen, J. and Kirkegaard, J. 2006. Biofumigation and enhanced biodegradation: opportunity and challenge in soilborne pest and disease management. *Critical Reviews in Plant Sciences* 25: 235-265.
- Debode, J., Clewes, E., De Backer, G., and Hofte, M. 2005. Lignin is involved in the reduction of *Verticillium dahliae* var. *longisporum* inoculum in soil by crop residue incorporation. *Soil Biol. Biochem.* 37:301-309.
- Johnson, I. 2002. Glucosinolates in the human diet. Bioavailability and implications for health. *Phytochemistry Reviews* 1: 183–188.
- Sarikamis, G., Marquez, J., MacCormack, R., Bennett, R., Roberts, J., and Mithen, R. 2006. High glucosinolate broccoli: a delivery system for sulforaphane. *Molecular Breeding* 18:219-228.

* Please note that any consumer product labels that bear broccoli-related health or nutrient content claims would need to be in compliance with FDA regulations applicable to such claims.

For additional agronomic information, please contact your local seed representative. Developed in partnership with Technology Development & Agronomy by Monsanto.

Individual results may vary, and performance may vary from location to location and from year to year. The information provided in this communication may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible. The recommendations in this article are based upon information obtained from the cited sources and should be used as a quick reference for information about the association of glucosinolates with suppression of plant pathogens and pests. The content of this article should not be substituted for the professional opinion of a producer, grower, agronomist, plant pathologist, or similar professionals dealing with this topic.

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