

actually be used as an improvement over Pi fertilization. However research was heavily disappointing, studies on lettuce ([here](#)) , spinach ([here](#)), komatsuna ([here](#)) as well as several other plants showed that Phi fertilization provides absolutely no value in terms of P nutrition, meaning that although plants do absorb and process the Phi it does not end up being used in plant tissue to supplement or cover P deficiency in any way. Furthermore there are some negative effects when Phi is used in larger concentrations (as those required for Pi) so it quickly became clear that Phi is not a good fertilizer at all.

Why should anyone use Phi then? Well, research started to show that some of the earlier positive results of Phi fertilization were not because it was covering Pi deficiencies but mainly because it was offering a protective effect against some pathogens. Research on tomatoes and peppers and other plants ([here](#) and [here](#)) showed that phosphites had some ability to protect plants against fungi with plants subjected to Phi applications showing less vulnerability to the pathogens. However the evidence about this is also not terribly strong and a few papers have contested these claims.

Table 1
Beneficial effects of phosphite (Phi) as a biostimulator in vegetable crops.

Crop	Phosphite source (dosage)	Method of application	Improved trait/s	Reference
Celery	Phosphorous acid	Foliar spray	Yield	Rickard (2000)
Lettuce	Phosphorous acid (50% of total P as Phi)	Nutrient solution in hydroponics	Biomass dry weight, foliar area and P content in the whole plant	Bertsch et al. (2009)
Onion	Phosphorous acid	Foliar spray and soil application	Percentage of jumbo size onions	Rickard (2000)
Potato	Phosphorous acid	Foliar spray	Size and yield of US No. 1 grade potatoes	Rickard (2000)
Potato	Potassium phosphite	Foliar application	Phytoalexin and chitinase content, and yield maintenance	Lobato et al. (2011)
Potato	Potassium phosphite	Sprays applied to seed tubers and foliage	Reinforcement of the cell wall and defense response	Olivieri et al. (2012)
Potato	Potassium phosphite	Liquid solution applied to tubers	Emergence, early growth and mycorrhizal colonization	Tambascio et al. (2014)
Potato	Potassium phosphite	Foliar spray	Chlorophyll content, protection against UV-B light and activation of the antioxidant system	Oyarburo et al. (2015)
Sweet pepper	Phosphorous acid	Drip irrigation and foliar spray	Size and yield of US No. 1 grade peppers	Rickard (2000)
Tomato	Phosphorous acid (50% of total P as Phi)	Nutrient solution in hydroponics	Biomass dry weight, foliar area and P content in the whole plant	Bertsch et al. (2009)

Note: Most studies were based on the application of commercial Phi-containing products without clear indication on the labels of their precise Phi content. Therefore, Phi dosage in the table is only indicated when precise data are available in the cited articles.

Table 2
Beneficial effects of phosphite (Phi) as a biostimulator in fruit crops.

Crop	Phosphite source (dosage)	Method of application	Improved trait/s	Reference
Avocado	Phosphorous acid	Foliar spray	Yield of commercially valuable sized fruit	Lovatt (2013)
Banana	Phosphorous acid (50% P as HPO_4^{2-} and 50% as H_2PO_3^-)	Nutrient solution in hydroponics	Biomass dry weight, foliar area and P content in the whole plant	Bertsch et al. (2009)
Citrus	Phosphorous acid	Foliar spray	Yield and acid content in fruits	Lovatt (1998, 1999)
Citrus	Phosphorous acid	Foliar spray	Yield	Albrigo (1999)
Citrus	Phosphorous acid	Foliar spray	Yield	Rickard (2000)
Peach	Phosphorous acid	Foliar spray	Sugar and soluble solids content	Rickard (2000)
Raspberry	Phosphorous acid	Foliar spray	Fruit firmness	Rickard (2000)
Strawberry	Potassium phosphite	Plants soaked and irrigated	Fruit acidity, ascorbic acid and anthocyanin content	Moor et al. (2009)
Strawberry	Potassium phosphite (6.7% of total P as Phi)	Root application through a controlled watering system	Growth of roots and shoots	Glinicki et al. (2010)
Strawberry	Phosphorous acid (30% of total P as Phi)	Nutrient solution applied to the roots	Concentrations of chlorophylls, amino acids and proteins in leaves	Estrada-Ortiz et al. (2011)
Strawberry	Phosphorous acid (20% of total P as Phi)	Nutrient solution applied to the roots	Sugar concentration and firmness of fruits	Estrada-Ortiz et al. (2012)
Strawberry	Phosphorous acid (20–30% of total P as Phi)	Nutrient solution applied to the roots	pH, EC and anthocyanin concentration in fruits	Estrada-Ortiz et al. (2013)

Note: Most studies were based on the application of commercial Phi-containing products without clear indication on the labels of their precise Phi content. Therefore, Phi dosage in the table is only indicated when precise data are available in the cited articles.

Those who say that Phi is not mainly a fungicide claim that positive results are mainly the effect of Phi acting as a biostimulant ([here](#)). These groups have shown through research across several different plant species, including potatoes, onions, lettuce, tomatoes, wheat, oilseed rape, sugar beet and ryegrass that foliar or sometimes root applications of phosphites consistently yield some positive effects, meaning that there is a strong biostimulant effect from the Phi that is not related to either P nutrition or a fungicidal effect. A recent review looking at the overall biostimulant effects of Phi ([here](#)) shows how researchers have obtained evidence of biostimulation in potatoes, sweet peppers, tomatoes and several other species (the images in this post were taken from this review). The different studies mentioned in the review show increases in quality and even yields across these different plant species (see tables above).

While we know that Phi is not a good source of P nutrition and we know it can help as a fungicide in some cases it is clear now that under enough Pi nutrition Phi can provide some important biostimulating effects. Negative effects from Phi seem to be eliminated when enough Pi nutrition is present so rather than be thought of as a way to replace or supplement P nutrition it should be thought of as an additive that has a

biostimulating effect. Phi may become a powerful new tool in the search for higher yields and higher quality, while not serving as a replacement for traditional Pi fertilization.