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Effect of Sulfur Amendments on Yield and Quality in Alliums

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Do Sulfur Amendments Improve Yield and Quality in Alliums?

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Onions, leeks, and garlic are collectively known as alliums, as they are all species of the genus Allium. These vegetables produce organosulfur compounds which react with the enzyme alliinase to create the compounds which give alliums their distinctive flavors. These organosulfur compounds are also anti-microbial and may help protect the plants from fungi and bacteria. Alliums obtain the sulfur to create organosulfur compounds from the soil, and sulfur fertilization has been shown to increase the pungency of onions (Forney et al. 2010) and the alliin content of both onions and garlic (Bloem et al. 2006). Sulfur fertilization has also been shown to increase bulb size and weight of onions (Lancaster et al. 2001, Rizk et al. 2012) and to decrease storage rots of sweet onions (Cooling and Randle 2008) but not long day yellow storage onions (Forney et al. 2010).

Onions, leeks, and garlic all grow well in southern New England, and they have the potential to store well, making them good crops for fall and winter markets. Onions and softneck garlic are also amenable to being processed into value-added products such as braids, wreaths, and swags. However, alliums are susceptible to several pathogens that cause bulb rot in the field or in storage, including neck rot (*Botrytis alli*) and white rot (*Sclerotium cepivorum*). Disease susceptibility is related to onion pungency, with sweet onions being particularly susceptible. This study was inspired by increased reports from Rhode Island vegetable producers that onions and garlic were rotting in the field during maturation, as well as post-harvest during curing. We suspected that low soil sulfur levels might be causing increased bulb rot. New England's granite-based soils are naturally extremely low in sulfur, but sulfur levels were artificially elevated for centuries by atmospheric deposition of sulfur released by burning coal and other fossil fuels. Since 1970 decreased use of high-sulfur fuels and requirements for catalytic converters, smokestack scrubbers, and similar devices to reduce air pollution have dramatically decreased the sulfur deposition rate, and soil sulfur levels have declined towards the natural low levels. As a result, sulfur fertilization is increasingly recommended for crops with high levels of sulfur-containing proteins (Ketterings et al. 2012, Sahota n.d.).

Materials and Methods

Plant Materials: We tested the effects of sulfur fertilization on yellow storage onions, leeks, and garlic. The cultivars 'Infinity' and 'Copra' were used for the onion study. 'Copra' is known to be an excellent storage onions, while 'Infinity' had a high level of bulb rot in our 2011 variety trials. The varieties 'Pandora', 'Tadorna', and 'Bandit' were used for the leek trial. For the garlic trial we used the softneck cultivar 'S&H Silverwhite' and the hardneck cultivars 'Belarus', 'Music', and 'Polish Hardneck'. Because of insufficient seedstock 'Music' and 'Polish Hardneck' grown as a mix. The onion and leek trials were established from transplants produced in the URI greenhouses, while the garlic trial was established from commercially produced cloves.

Trial Location and Dates: Trials were conducted at the Greene H. Gardiner Crops Research farm in Kingston, RI on a silt loam soil with approximately 3% organic matter and a pH of 5.6 to 5.9. The onion and leek trials were established in April 2012 and in May 2013. Onions were harvested in September of both years, and leeks in October of 2012 and November of 2013. The garlic trial was established in November 2012 and harvested in July 2013. The only pest problems encountered in the field were onion thrips and purple blotch disease, caused by *Alternaria poori*. Thrips were controlled with a mixture of spinosad and azidirachtin. Bravo Weatherstik (chlorothalonil) was used to reduce the severity of purple blotch disease.

Soil Fertility Treatments: Control treatments for all trials followed the recommendations in the New England Vegetable Management Guide. Experimental treatments followed recommendations for all nutrients except sulfur and potassium. For the 2012 onion and leek trials experimental treatments were sulfur at 43 or 86 kg/ha, or a combination of 43 kg sulfur and 52 kg potassium per hectare. Sulfur was supplied as granulated sulfur; potassium was supplied as potash. For the garlic trial treatments were 140, 280, or 560 kg sulfur per hectare. In 2013 the onion and leek trials included sulfur rates of 43, 86, 172, 344, and 688 kg sulfur per hectare. Potassium fertilization was uniform across all treatments in 2013.

Experimental Design: All trials were randomized complete block designs with the soil fertility treatments replicated three times. Varieties were planted as continuous rows of a single variety that stretched across all soil fertility treatments. Only the center portion of each plot was harvested, with a 0.3 m buffer at each end. Data were analyzed using paired t-tests to compare each treatment to the control.

Results

Leeks

Leek response to treatment was evaluated using the number of leeks harvested per plot, the total weight of harvested leeks, and the average size in grams of the leeks from each plot. There were no effects of sulfur treatment on any of these yield components in either 2012 or 2013. There were significant differences between varieties. ‘Tadorna’ and ‘Pandora’ produced significantly larger leeks than ‘Bandit’ in both years. In 2013 the number of leeks varied significantly between plots, with ‘Tadorna’ producing the most and Pandora the least. Averages were 19, 17, and 15 leeks per plot for ‘Tadorna’, ‘Bandit’, and ‘Pandora’, respectively. In 2012 there were not significant differences is number of leeks per plot.

Onions

Onion response to treatment was evaluated by counting the number of marketable versus cull onions at harvest, after curing, and after storage. Marketable onions were weighed at harvest and after curing and average bulb size determined. Fresh weights included tops; all other weights were bulbs only. The data sheet with the 2012 harvest data was mislaid, so the only data available were the number of marketable onions after curing and the losses in storage.

In 2012 there were no significant differences between ‘Copra’ and ‘Infinity’, so data was pooled to analyze treatment effects. The number of marketable onions after curing decreased significantly across treatments. The control plots produced the most marketable onions, and the combination of sulfur and potassium produced the fewest. Sulfur fertilization also failed to improve storage life in 2012, as the treatment receiving the highest rate of sulfur had 96% rotten onions on December 11, while the control had only 54%.

In 2013 the two varieties were significantly different, with ‘Copra’ producing significantly more marketable onions than ‘Infinity’. However, both varieties responded in the same manner to the differing sulfur levels, so data was again pooled. There were no significant responses to sulfur fertilization. There was a trend with regards to decay during curing and in storage, with the control plots having the fewest rotten onions (3.7% at curing and an additional 3.7% after 8 weeks in storage) and the highest sulfur treatment the most (13% after curing and 12% after 8 weeks in storage). However, the differences were not statistically significant.

Garlic

There were no significant interactions between variety and sulfur amendment level with the garlic, so data was pooled across all three varieties. Effects of sulfur were evaluated by measuring plant vigor, the percentage of culled bulbs after curing, and the number and size of marketable cured bulbs. There were no significant effects of sulfur amendment. There were significant differences between varieties for all parameters except the percentage of bulbs culled after curing. This is to be expected, as bulb size and plant vigor are strongly controlled by genetics. The softneck garlic variety, ‘S&H Silverwhite’, was significantly more vigorous and produced more marketable cloves than either of the hardneck varieties. ‘S&H Silverwhite’ also produced the largest bulbs, but all three varieties differed significantly for size. Average bulb size was 32 g for ‘S&H Silverwhite’, 27 g for the ‘Polish Hardneck’/ ‘Music’ mix, and 20 g for ‘Belarus’.

Conclusions

Sulfur fertilization did not reduce rot or increase yields of Allium vegetables in Rhode Island. These results were unexpected, as our soil sulfur levels are extremely low, and other researchers have shown that higher sulfur levels positively affect bulb size, pungency, and storage life. Several possible explanations are possible for our results. The most likely difference between our study and others is soil type. Our soil is an acidic silt loam, evenly balanced between silt and sand with small percentages of clay and organic matter. Rizk et al. (2012), and Coolong and Randle (2008) grew their onions in sandy soils, while Bloem et al. (2005) and Lancaster et al. (2001) used hydroponics. Forney et al. (2010) did not provide information on their soil type. Soil type has been shown to affect sulfur availability to plants. Another possible difference is the form of sulfur used. Plants are known to take up sulfur primarily as sulfate ions, and the other researchers who grew onions in the field used sulfate salts (sul-po-mag, potassium sulfate, or ammonium sulfate) while we used ground agricultural sulfur. Rizk et al. (2012) used ground sulfur in addition to ammonium sulfate, but they were growing in an alkaline sand, and reported that the primary effect of sulfur was to increase nitrogen availability by lowering pH. It is possible that our soil conditions did not allow for sufficient conversion of sulfur to sulfate to affect plant uptake. Another possibility is that the sulfate ions bound to magnesium or calcium ions in the soil, rather than being taken up by the plants. Our soils are regularly limed to maintain pH, and have high magnesium levels. Coolong and Randle (2008) mentioned that binding of sulfate to calcium reduces sulfur availability in their slightly acidic soils.

In conclusion, sulfur fertilization appears to offer little or no benefit for allium vegetables in Rhode Island. Variety differences were much greater than the fertility effects, and growers who are experiencing issues with yield and storage life are encouraged to consider switching to better varieties.

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