

Heat Stress and Heat Tolerance in Broccoli for Late Summer Harvest

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Many vegetable growers in central and southern New England avoid growing summer broccoli because head quality suffers from the heat. Some grow it all summer, but have to deal with lower quality and more head rot during the hottest part of the summer. As part of a SARE-funded project on Brassica crops, in the summer of 2005 & 2006 we looked at possible variety and planting schedule combinations for a late August or early September broccoli harvest. Growers in this project saw a good market potential for broccoli and would like to harvest in late summer, around Labor Day. This means the crop will begin developing heads during hot weather. We were looking to find varieties that would have the best chance of producing a decent crop at that time.

Research done by Thomas Bjorkman at Cornell University, using the cultivar Galaxy, found that the critical period for heat sensitivity in broccoli only lasts for roughly ten days. This ‘window’ of sensitivity corresponds to the time when the growing tip shifts from vegetative growth to flower bud initiation. This is a period of about 10 days *prior* to when a tiny crown is visible in the center of the plant. Temperatures above 35 degrees Celsius (95 degrees Fahrenheit) for more than four days during that period causes uneven bud development at the bud initiation stage, resulting in heads that were uneven and poorly shaped. Other references suggest that temperatures above 85 degrees can cause heat injury. The amount of time for which the young plants are exposed to high temperatures makes a difference – higher temperatures will cause damage more quickly than lower temperatures.

In addition, Broccoli and cauliflower can be triggered to flower too soon if they are stressed, by heat or by other factors. This results in a head that is abnormally small - an inch or less in diameter after three or four weeks in the field. This can be avoided by reducing stress and shock to the plants. Larger transplants (6 weeks and older) are closer to flowering and are more sensitive to the shock of transplanting. Plants that have not been adequately hardened off will be more sensitive, and high levels of fertilizer in the greenhouse prior to transplanting will increase the incidence of transplant shock. The best solution is to use transplants no more than 4 weeks old. For the last week, reduce - but don't eliminate - the fertilizer. Let the plants dry out a little more between waterings. Add fertilizer at transplant and make sure the transplants have adequate water to ease the transition as much as possible.

2005 Variety Trials

At the UMass Crops Research and Education Center* in the summer of 2005 , we monitored two plantings of eight different varieties of broccoli to determine how quickly each variety reaches the critical stage, and how long each variety takes to reach harvest after the critical period has passed. We selected varieties that are considered to have some degree of heat tolerance. These varieties include Asmodeus, Gypsy (Johnny's), Hepathlon (Noresco), F71-29A (Know-You), BL 10, Concord, Marathon (Rupp), and Windsor (Harris). We also took harvest samples and compared the severity of heat damage across the different varieties and planting dates. This allowed us to assess the quality of each variety and planting date for a late summer broccoli harvest.

The first planting was transplanted on June 28, 2005. For most of the varieties, we first saw tiny heads forming on August 8th - although there were a handful of individual plants that were pretty far along in head development at that point, most of them were just getting started. We can assume that most of the plants reached the critical period about 7-14 days prior to that point. Looking back at the high temperatures during that period, we saw days well into the 90's; so we were looking forward to seeing some nasty broccoli. This is good because it really allows us to see the differences between the varieties in terms of how hard they get hit by the heat. The two longer season varieties – concord and marathon – started showing head development about a week later, and the plants made the shift from vegetative to reproductive growth over a much longer period of time. Looking back at the temperature record, we can see that these plants were also almost certainly exposed to high temperatures during the critical period.

The second round of transplants went into the ground on July 22. These guys started showing head formation around August 26th, with marathon and concord again coming in behind the pack by about a week. Temperatures had again spiked into the 90's about a week prior to this, so we were expecting to have another round of broccoli that had experienced exposure to high temperatures.

The majority of the first planting was harvested between 8/22 and 9/5, except for marathon and concord, which came in between 9/12 and 9/19. Those two varieties took about a week longer to initiate head development, and took roughly an additional week to go from head initiation to harvest, compared to Asmodeus, Gypsy, Hepathlon, F71-29A, BL 10, and Windsor.

We harvested, scored, and weighed the heads roughly every three days throughout the harvest period. Heads were scored for several different heat-related injury factors – bud evenness, head evenness, bud damage, and number of leaves in the head. We also rated the head as wholesale quality, farmers market quality, and unsaleable. We based these categories on personal observations of the quality available in each market.

Out of the first planting, a variety called F71-29A that we got from a Taiwanese seed company performed the best in terms of low heat damage. Asmodeus, Gypsy, Hepathlon, and Windsor all performed reasonably well, though due to some unevenness and the propensity for leaves to form in the head, many heads from all of these varieties may have only been suitable for farmers markets. BL10, Concord, and Marathon were highly susceptible to all forms of heat damage – particularly Concord and Marathon. We saw very few decent heads from these varieties until the end of the second planting.

In the second planting, Gypsy, Asmodeus, and BL10 lead the pack in terms of quality. Windsor and Hepathlon had fairly even heads but were plagued by a large number of leaves developing within the head. Concord and Marathon continued to be poor until the very end – the latest heads from these varieties were actually pretty nice, but all of the earlier heads were poor in terms of head and bud evenness, damage, and leaves in the head.

- **2006 Variety Trials**

In 2006 we began another summer broccoli trial using an early planting date to ensure that harvest began well before Labor Day. We chose most of the same varieties we used in 2005, except that we substituted **Arcadia (Johnny's)** for BL 10 (Rupp). We planted out our 5 week old seedlings on 6/28. Our first harvest date was August 9. They certainly experienced high enough heat over the summer to damage most broccoli, and indeed some of the heads were a mess. The earliest producers were the F71-29A, Windsor, and Hepathlon. Out of those earliest varieties, the F71-29A and the Windsor were of the best quality, with Hepathlon having suffering some heat damage. Based on the two years of research we would recommend those two varieties more highly than any of the others for late summer production. It should be noted, however, that these trials were by no means extensive enough to provide conclusive results. We feel comfortable saying that these varieties would probably be worth testing in your own fields and under conditions particular to your farm. We had relatively decent results with them, but your mileage will certainly vary.

Growing quality broccoli through the hottest part of the summer is a tricky proposition, and while these aren't silver bullet varieties that will ensure a perfect crop, they can provide an acceptable harvest. F71-29A develops into a dome-shaped head with short branches and a tight bud pattern. It runs a little on the smaller side, with heads averaging about 325 grams or $\frac{3}{4}$ lbs. We've been able to secure source for this seed, and anyone who is interested in testing it should contact the UMass vegetable program at umassvegetable@umext.umass.edu. Windsor was similar in shape and size to F71-29A, though a little smaller. This variety had issues in the 2005 trials with developing an excess of leaves in the head, though these can easily be removed at harvest. In 2006 we did not experience the same problem.

Other factors in addition to heat can cause reduced head quality and increased susceptibility to disease. These include inadequate nutrients, improper nutrient balance, and uneven or inadequate soil moisture. Water stress, as well as excessive or uneven watering play a role in head quality; it is best to water regularly in smaller doses. Boron deficiency increases likelihood of hollow stem, which is often not noticeable until harvest. However, hollow stem can also be exacerbated by excessive nitrogen fertilizer, imbalance of nitrogen and boron, or rapid growth after head initiation. Cauliflower, turnip and rutabaga are also very sensitive to boron deficiency. Conventional fertilizers can be purchased with added boron. For broccoli, use 2-3 lb. actual boron if the soil test level is low (0 to 3.5 ppm), or half that much if the soil test is medium (0.35 to 0.7 ppm).

Lime should probably be applied and incorporated separately. B is less available as the soil pH goes up. Work that John Howell and George Hochmuth did with cauliflower showed that B was effective only if applied just before planting. Side-dressing was of little to no value. The same is probably true for broccoli and other brassicas.

Organic farmers need other options. Organic soil amendments such as compost or manure and cover crops may not provide adequate boron. Additional boron can be added using one of several OMRI-approved sources of boron, providing that there must be a documented deficiency of boron in the soil for the brassica crop. These include Solubor, Biomin Boron, Fertibor, Granubor and Phyto-Plus Boron and Twenty Mule Team Borax; however check with your certifier as these may be on the restricted list. Solubor, and possibly other sources of boron, can be mixed in water and sprayed onto the soil surface. This is a practical way to apply a small amount per unit of area. Use a dilute enough mixture so that it is easy to cover the whole area.

* new name for the South Deerfield Research Farm

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