EVALUATING THE HERBICIDAL PROPERTIES OF ACETIC ACID

PRELIMINARY RESULTS

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Methodology

Greenhouse Studies

Greenhouse trials were conducted in the fall of 2004 and the spring of 2005 at the Guterman greenhouse complex, Cornell University. Acetic acid concentrations of 15, 20 (Weed Pharm product), 25, and 30% were applied to common lambsquarters (*Chenopodium album* L.), velvetleaf (*Abutilon theophrasti* Medic.), and powell amaranth (*Amaranthus powellii* S.) at the cotyledon, 2-, and 4-leaf stages. Applications were made at 34 and 68 gallons per acre (GPA). All treatments included yucca extract at .1% dilution, and each treatment was replicated 4 times. An additional trial evaluated the recommended and 2X recommended rates of three organically approved adjuvants, Natur'L Oil (.2, .4%), Yucca extract (.1, .2%), and Humasol (2.5, 5%), when added to 20% acetic acid at 34 GPA. Visual ratings for weed control and the potential for weed regrowth were taken 3 and 6 days after treatment (DAT) for each of the above trials. At 9 DAT, a percent survival rating was taken, and the remaining live plants were cut at the soil surface, dried, and weighed. To evaluate potential crop injury, selected acetic acid treatments at 34 (20 and 30%) and 68 (15 and 20%) GPA were applied to onion 'Millennium' at loop-stage, 1+, 3+ and 5+ leaves, and to corn 'Avalon' at spike stage, 2+, 4+, and 6+ leaves. Evaluations for crop injury were made 3, 6, and 9 DAT, and the plants were harvested 9 DAT, dried, and weighed. Significance values have been set at p=.05 for the greenhouse trials.

Field Studies

In the summer of 2005, field trials were conducted in sweet corn, onion, and potato at the Thompson Research farm in Freeville NY, using selected acetic acid treatments from the greenhouse screening. Acetic acid was applied at 20 and 30% concentration at 34 GPA, and at 15 and 20% concentration at 68 GPA. Applications were made to corn varieties 'Trinity' (early) and 'Avalon' (late) at 15cm and at 30-45cm. A single between row cultivation was done in each early treatment 14 DAT, and in each late treatment 17 days prior to spraying. Acetic acid treatments were applied to onion 'Highlander' at the preemergence-1LF stage and at the 2LF stage, and the crop was handweeded as necessary for the remainder of the season. Potato 'Yukon Gold' was cultivated early in the season, and a single application of acetic acid was applied when the potato had 85% ground coverage. Treatments were broadcast with a CO_2 backpack sprayer, with four replications in the sweet corn and onion, and three replications in the potato. In the corn and onion trials, selected weed species were marked prior to spraying, and the surviving weed plants were later cut at the soil surface, dried, and weighed. Evaluations were made in each crop for weed control, crop tolerance, and yield. Significance values of p=.10 were used for the field trials.

First-year Results

Greenhouse Studies

With the addition of selected adjuvants to 20% acetic acid at 34 GPA, there was some improvement in control of velvetleaf, lambsquarters, and pigweed. As figure 1 indicates, there was a decrease in dry weight in the adjuvant-added treatments compared to the 20% acetic acid alone, particularly with velvetleaf and powell amaranth. Significance tests will be conducted following the conclusion of a second year of research. The observed increase in efficacy seen when adding particular adjuvants may not occur when lower concentrations of acetic acid are used, or when acetic acid is applied to larger or more tolerate weeds, as the adjuvant potential for spreading the product may dilute it to an extent that control would actually be reduced. Second-year testing will look into this further.

Photo sets of velvetleaf, common lambsquarters, and powell amaranth sprayed at the 2-lf stage and taken 3 DAT, illustrate the burn-down effect of acetic acid and the variation in efficacy with concentration, gallonage, and weed species (Illustrations 1-6). Velvetleaf proved least susceptible to injury compared to powell amaranth and common lambsquarters. Survival rates increased with increasing weed size for all weed species, particularly once the weeds were at the 4-leaf stage. Dry weights of velvetleaf, common lambsquarters, and powell amaranth cut 9 DAT are displayed in figures 2, 3, and 4, respectively. Higher GPA and higher concentrations of acetic acid provided improved weed control and reduced weed survival when the weeds were larger at spraying. Results were more similar between gallonages and concentrations when the weeds were smaller, or when the weed species was more susceptible to injury. Fifteen percent acetic acid applied at 34GPA was often not effective beyond the cotyledon stage; although 15% acetic acid applied at 68 GPA provided consistently better control. Higher concentrations of vinegar were effective at both GPA, although, above 15% acetic acid, increasing the GPA often improved control more than increasing the concentration. Additionally, there was little difference in control, or reduction in weed biomass, between the 15% acetic acid treatment applied at 68GPA and the 30% acetic acid treatment applied at 34GPA. This suggests, at least at the tested concentrations, that a doubling in GPA (from 34 to 68 GPA) can compensate for diluting the acetic acid concentration in half (from 30% to 15%). (figures 2, 3, and 4).

Acetic acid applied to onion at the loop stage resulted in a significant reduction in harvested dry weight 9 DAT in all but the 20%, 34 GPA application (note that tested applications were 20 and 30% acetic acid at 34GPA, and 15 and 30% acetic acid at 68GPA). Onions sprayed at the 1+, 3+, and 5+ leaf stages had no significant reduction in harvested dry weight 9 DAT (figure 5), although initial crop injury 3 DAT ranged from 0-28%, depending on onion size and treatment.

Acetic acid treatments on sweet corn in the spike stage resulted in 1-6% injury 3DAT and no significant reduction in biomass by 9DAT. Twenty percent acetic acid applied to corn at the 2+, 4+, and 6+ leaf-stages did not significantly reduce harvest weight; although acetic acid treatments of 30% at 34GPA, and 15 and 20% at 68GPA, resulted in 8-20% injury 3DAT and reductions in harvest weight (figure 6).

Field Studies

Initial injuries to the sweet corn included leaf dieback and yellowing, and were more pronounced with the later application. Stunting and injury of the corn were outgrown as the season progressed. When acetic acid treatments were applied to 'Trinity' at the early timing, compared to the handweeded control, there was a 5-28% reduction in ear number, a 5-26% reduction in harvest weight, and no significant reduction in individual ear weight (figure 7). At this same timing, ear numbers and weights of 'Avalon' did not differ significantly from the handweeded control (figure 8). Injury increased in both varieties with the late-stage applications, and in almost all cases, yields were reduced more than 10%. In corn, the aboveground dry weight for sampled common lambsquarters 13 DAT (sprayed at 2-6 leaves in the early application and 12-30cm at the late application) was 88-98% less than that of the weedy check with early acetic acid applications, and 35-63% less with the late acetic acid applications. The aboveground dry weight for sampled wild buckwheat (*Polygonum convolvulus L.*) 13 DAT (sprayed at 1-6 leaves in the early application, and at 15-30 cm vine length at the late application) was 89-98% less than that of the weedy check with early applications, while only 14-38% less with the later acetic acid applications.

The early treatments in the onions caused no significant reduction in harvest numbers, and weights were significantly reduced only with the 68 GPA, 20% acetic acid application (figure 9). All late applications caused a significant reduction in both number and weight of onions (figure 9). This level of injury was more severe than the greenhouse onion trial suggested. Aboveground dry weights for powell amaranth 13 DAT (sprayed at 4-8 leaves in the early application, and 8-10 leaves in the late application) was 54-93% less than that of the non-weeded check in the early applications, and 39-71% less in the late applications. Hairy galinsoga (*Galinsoga ciliata*) aboveground dry weight was reduced by 96% in all treatments and at both timings (in each case, plants were at the 2-6 leaf stage when sprayed). The time taken for the first handweeding session of the early treatment application was reduced by 34-66%, while the later treatment applications resulted in a 7-36% reduction in initial handweeding time. Subsequent handweeding times did not differ by treatment.

Acetic acid applied on potato resulted in 48-73% leaf necrosis 1 DAT. There was a significant reduction in harvestable tuber weight in all treatments, but no significant increase in cull weight per treatment. Weed control samples were not taken from this field, as weed pressure was low after early season cultivations. Acetic acid treatments were applied 77 days after planting; earlier applications would have provided more time for the potato to regrow from injury, such that yield loss may not have been as significant. An earlier unreplicated trial of acetic acid on potato was carried out in the summer of 2004, and applied when the potato was only 8-12 cm tall. Here the potato outgrew initial injuries, and yields in the acetic acid treatments were comparable to the handweeded control.

The usability of acetic acid appears very dependant on the time of application, such that weeds are at a stage where they can be adequately controlled, and the crop is at a growth stage which minimizes injury, or allows adequate time for regrowth from injury. Weed control and crop injury increase when acetic acid is applied at 68 GPA as opposed to 34 GPA. Adequate weed control is possible with a lower concentration of acetic acid when the spray volume is increased. When applied ideally, these products have the potential to reduce weed pressure. Greenhouse and field trials will be repeated again in the summer of 2006, and a full report made thereafter.

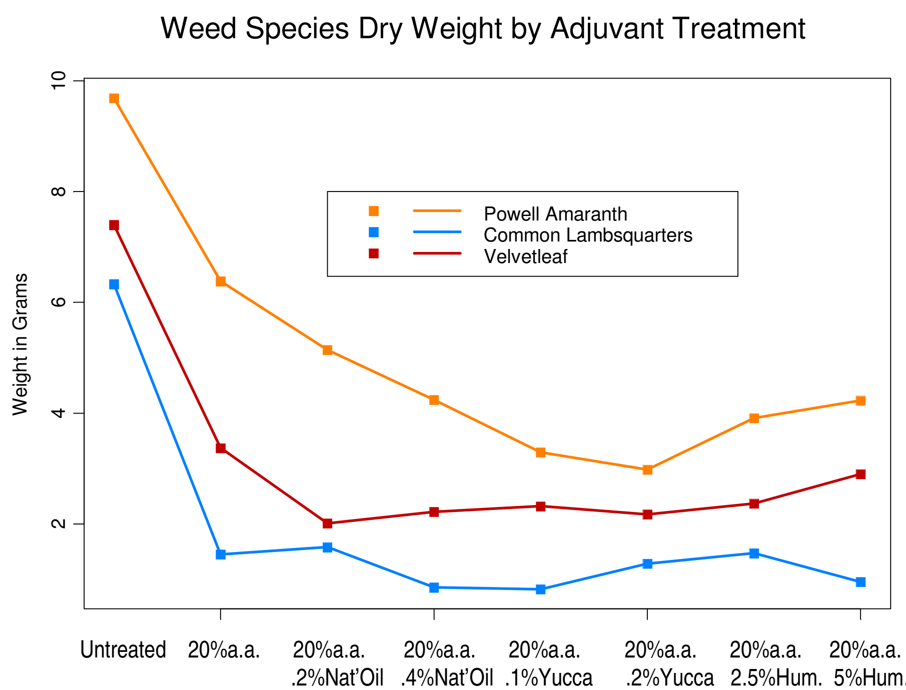


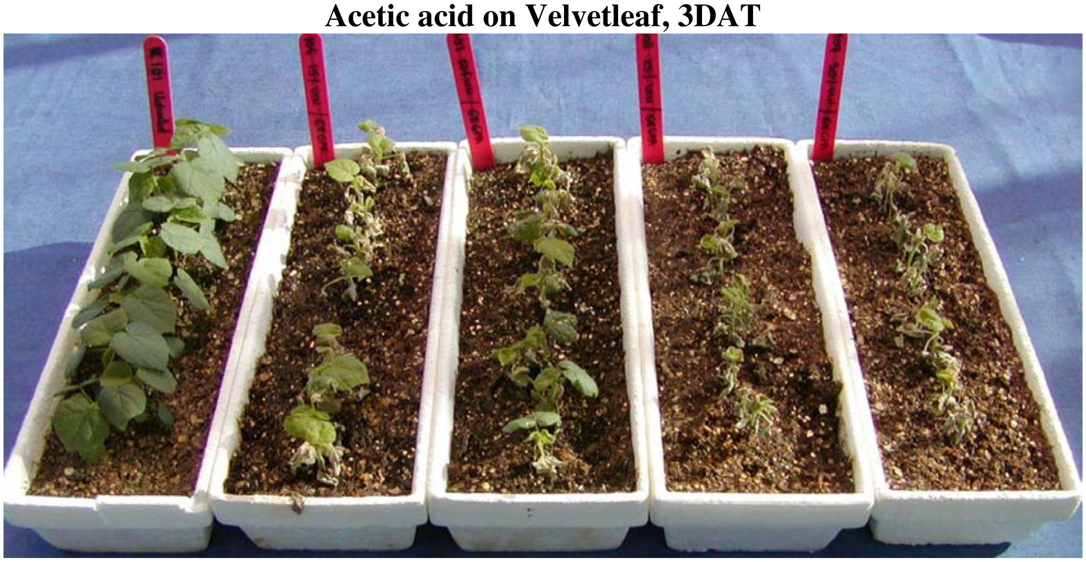
Figure 1. Powell amaranth, common lambsquarters, and velvetleaf dry weights 9DAT when treated with 20% acetic acid (a.a.) (WeedWorks) with and without the addition of Natur'L oil (Nat'Oil), Yucca extract (Yucca), or Humasol (Hum.).

Acetic acid on Velvetleaf, 3DAT

Untreated 15%, 34GPA 20%, 34GPA 25%, 34GPA 30%, 34GPA

Illustration 1. Acetic acid treatments from 15-30% applied on 2-leaf stage velvetleaf at 34 GPA, and shown 3DAT.

Acetic acid on Velvetleaf, 3DAT



Untreated 15%, 68GPA 20%, 68GPA 25%, 68GPA 30%, 68GPA

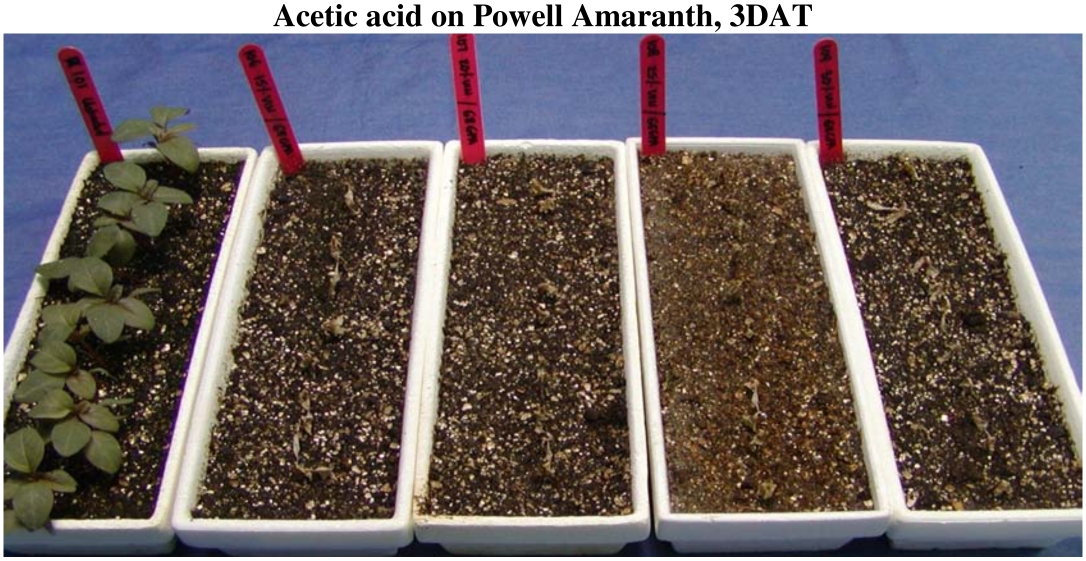
Illustration 2. Acetic acid treatments from 15-30% applied on 2-leaf stage velvetleaf at 68 GPA, and shown 3DAT.

Acetic acid on Powell Amaranth, 3DAT

Untreated 15%, 34GPA 20%, 34GPA 25%, 34GPA 30%, 34GPA

Illustration 3. Acetic acid treatments from 15-30% applied on 2-leaf stage powell amaranth at 34 GPA, and shown 3DAT.

Acetic acid on Powell Amaranth, 3DAT



Untreated 15%, 68GPA 20%, 68GPA 25%, 68GPA 30%, 68GPA

Illustration 4. Acetic acid treatments from 15-30% applied on 2-leaf stage powell amaranth at 68 GPA, and shown 3DAT.

Acetic acid on Common Lambsquarters, 3DAT

Untreated 15%, 34GPA 20%, 34GPA 25%, 34GPA 30%, 34GPA

Illustration 5. Acetic acid treatments from 15-30% applied on 2-leaf stage common lambsquarters at 34 GPA, and shown 3DAT.

Acetic acid on Common Lambsquarters, 3DAT

Untreated 15%, 68GPA 20%, 68GPA 25%, 68GPA 30%, 68GPA

Illustration 6. Acetic acid treatments from 15-30% applied on 2-leaf stage common lambsquarters at 68 GPA, and shown 3DAT.

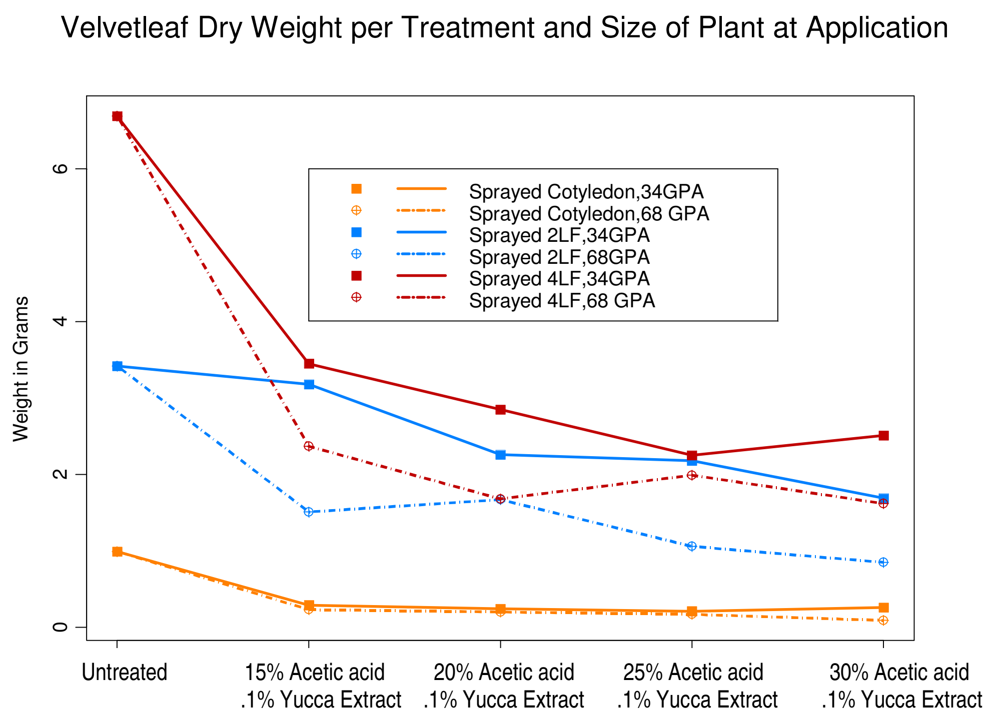


Figure 2. The mean dry weight of velvetleaf plants cut 9DAT, for each acetic acid treatment and gallonage.

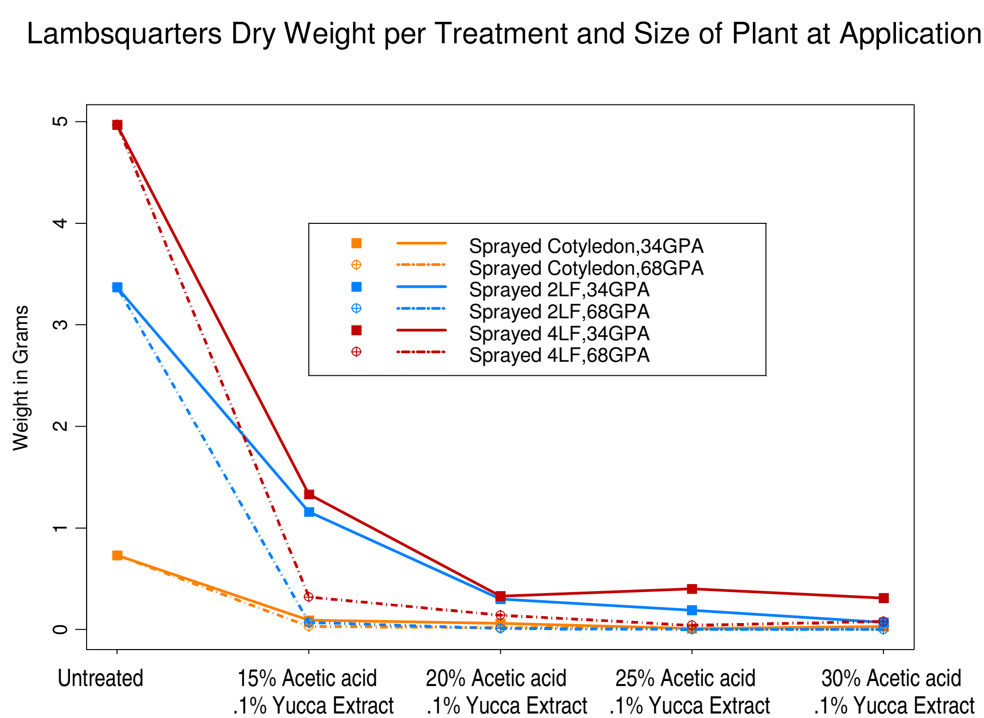


Figure 3. The mean dry weight of common lambsquarters plants cut 9DAT, for each acetic acid treatment and gallonage.

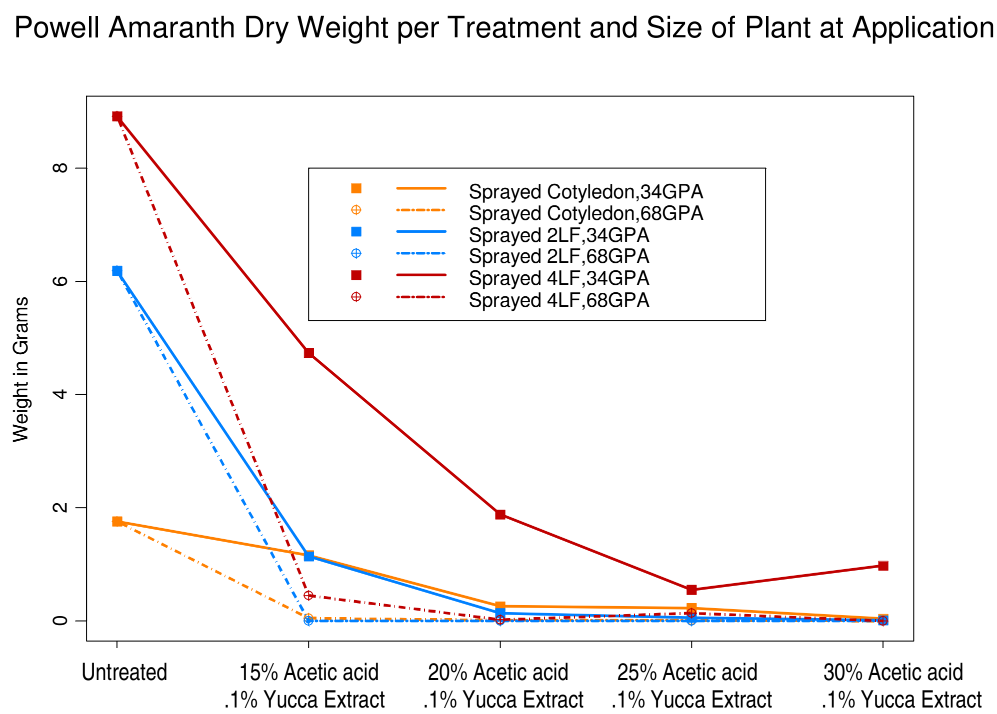


Figure 4. The mean dry weight of powell amaranth plants cut 9DAT, for each acetic acid treatment and gallonage.

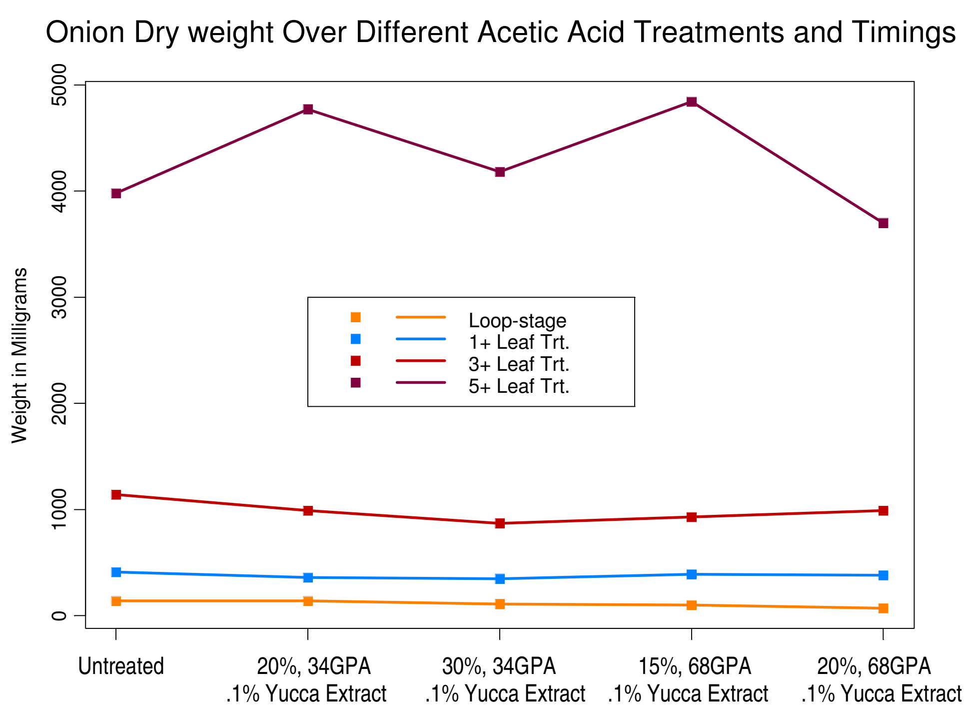


Figure 5. The mean onion treatment dry weight of plants cut 9DAT, for each acetic acid concentration and gallonage.

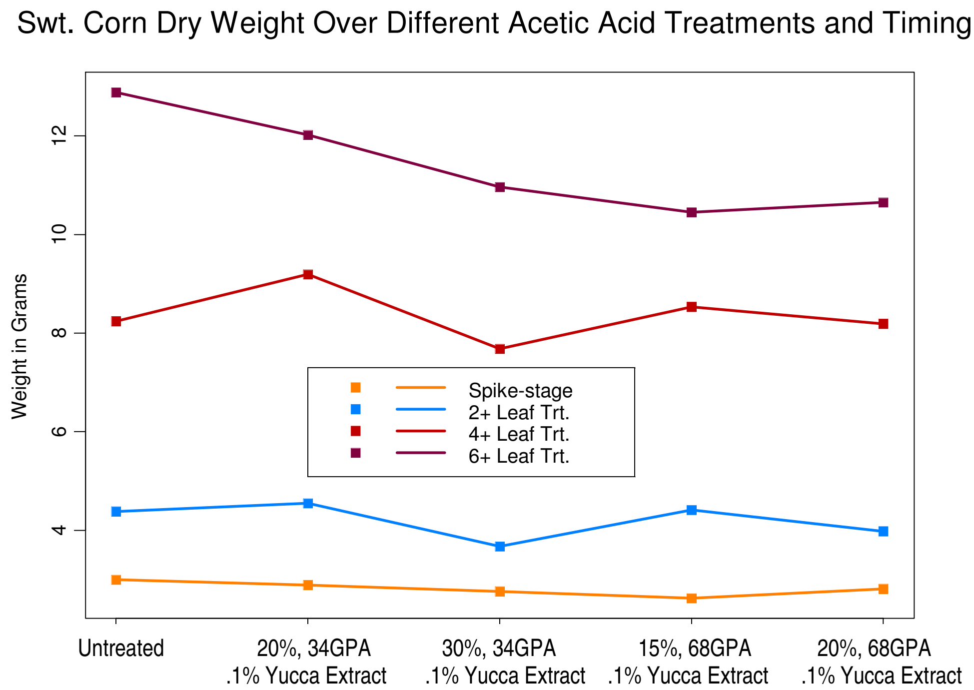


Figure 6. The mean sweet corn treatment dry weight of plants cut 9DAT, for each acetic acid concentration and gallonage.

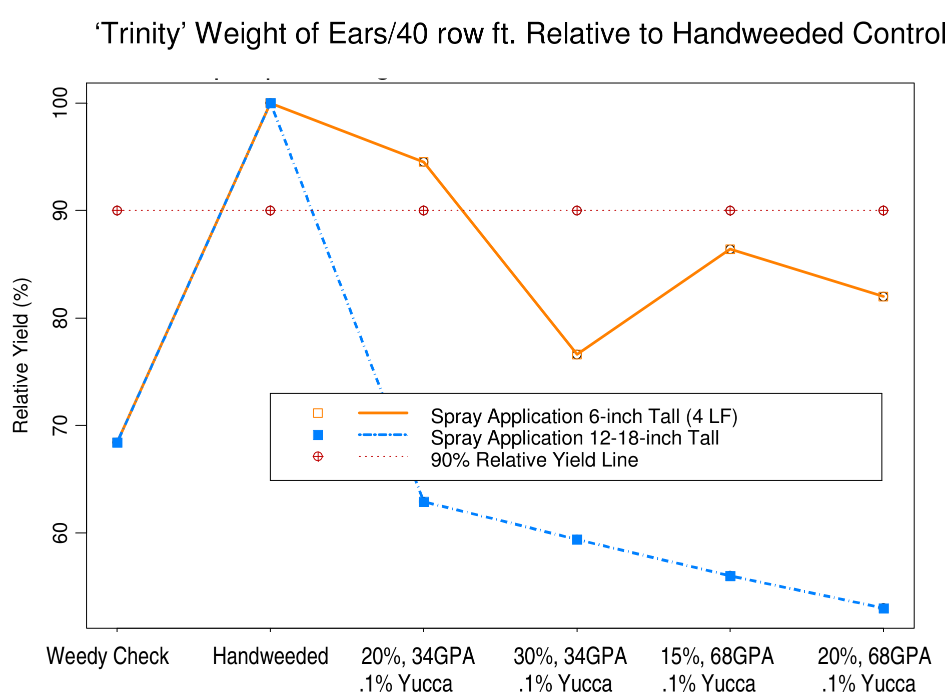


Figure 7. Sweet corn 'Trinity' yields per field treatment, relative to the yield of the handweeded control.

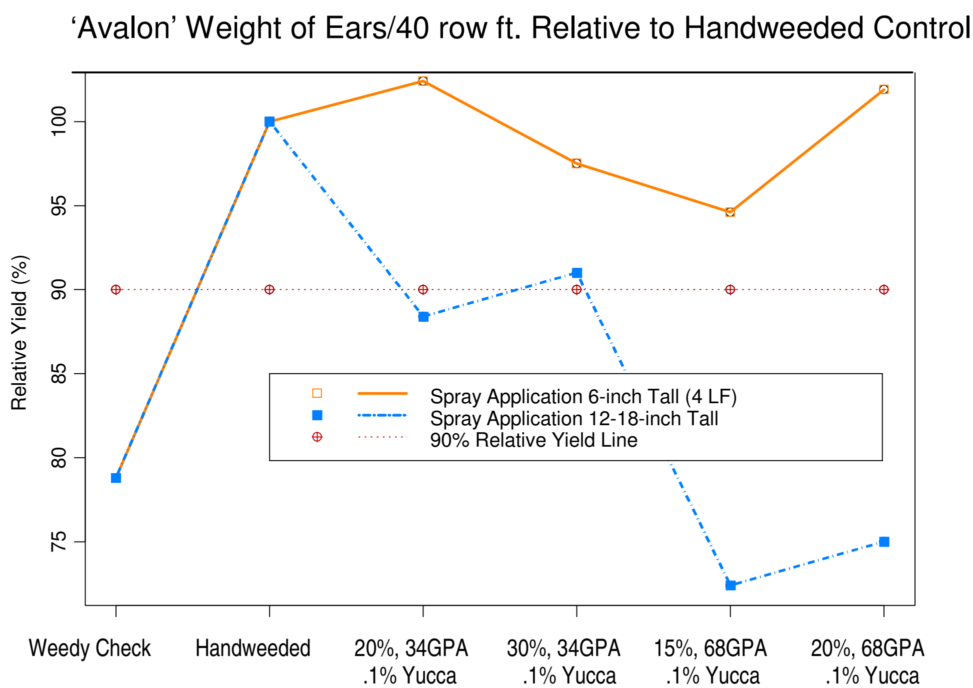


Figure 8. Sweet corn 'Avalon' yields per field treatment, relative to the yield of the handweeded control.

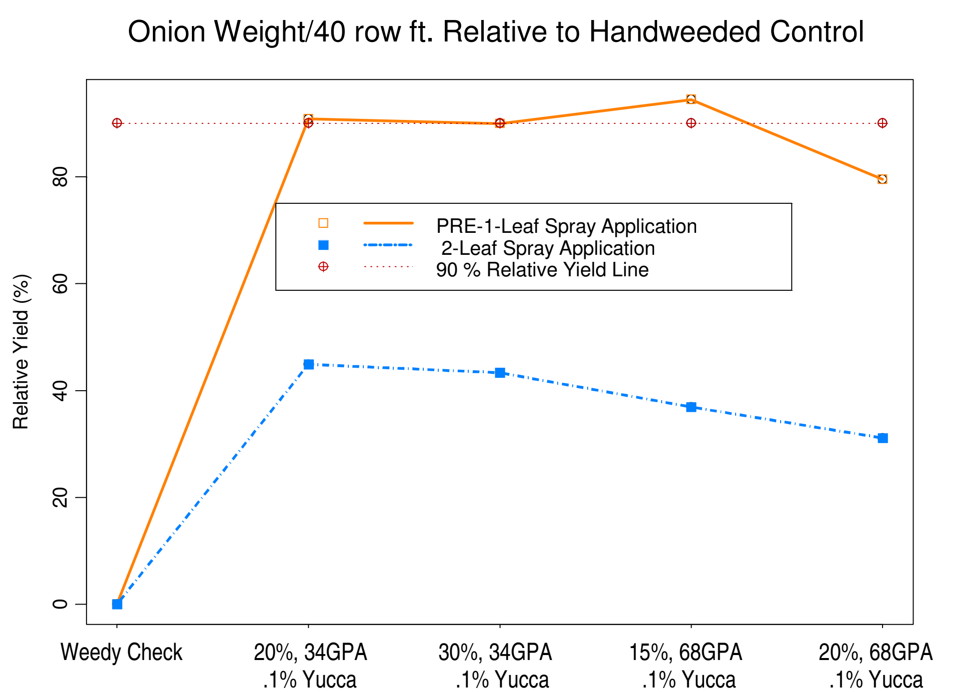


Figure 9. The onion yield (tops included) per field treatment, relative to the yield of the handweeded control.