Final Report: Investigation of skin hardening and splitting disorders in sweetpotatoes

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Executive Summary

The ‘‘Georgia Jet’ clone maintained by the LSU AgCenter showed increased incidence of storage splitting when grown with nitrate relative to ammonium as source of nitrogen. Storage root splitting can be unambiguously observed as early as 20 to 30 days after planting. In addition, the periderm color of storage roots grown in nitrate was substantially lighter relative to the roots grown with ammonium. Two experiments were conducted to investigate the possible role of phosphorus in ‘Georgia Jet’ storage roots provisioned with nitrate. The first experiment showed a trend for reduced splitting with increased phosphorus but extreme variability in response masked any likely statistical differences. A replicate experiment failed to show splitting in the controls. However, storage root size was significantly reduced when storage roots were grown with ammonium. It is noteworthy to mention that the replicate experiment was conducted during the summer, where the ambient greenhouse temperatures were relatively higher. It is hypothesized that nitrate presence predisposes ‘Georgia Jet’ storage roots to splitting, and this response is influenced by temperature. Based on the experimental data, follow-up studies need to account for temperature in addition to the nitrogen source. Experimental evidence also support the hypothesis that phosphorus and boron are directly or indirectly involved in storage root splitting in susceptible varieties.

General conditions for the greenhouse studies

The greenhouse experiments are being conducted at the LSU AgCenter Sweet Potato Research Station, Chase, La, USA (32º6’N, 91º 42’W). Plant materials are obtained either from bedded virus-tested storage roots or extant plants derived from virus-tested in vitro plants. Unless otherwise indicated, the nutrient solution used is half-strength Hoagland nutrient solution with nitrogen supplied as nitrate only (Solution 1). This is the same formulation used in trials at the Bundaberg Research Facility. Cuttings are typically planted (2 nodes under the growth substrate surface) in 10-cm-diameter polyvinyl chloride pots (height=30 cm) with detachable plastic bottoms. The growth substrate is washed sand of uniform particle size (majority in the 0.05-0.2-mm range). The greenhouse temperature regime is 29C for 14 hr (day) and 18C for 10 hr (night). Supplementary lighting is provided using LED grow light for 14 hr per day. Photosynthetic photon flux (PPF) typically ranges from 300 to 800 m^{-2} s^{-1}. The moisture of the growth substrate is maintained at ≈65 to 75% of field capacity (≈12% volumetric water content). Growth substrate moisture is measured with ECH2O soil moisture sensors (Model EC-5 Decagon Devices Inc.) inserted vertically at the 2-7 cm depth. All experiments are arranged in a randomized complete block design where a pot (one plant per pot) was considered a replicate. The number of replicates vary from four to five depending upon the availability of lighted bench space.

Study 1. Exposure to simulated and natural low temperature and splitting (1 Aug to 22 Oct 2019)

Rationale

Exposure to low temperature has been implicated with increased incidence of splitting in sweetpotato grown in field conditions. In radish and carrots, there is evidence to suggest that temperature affects firmness by influencing strength of cell walls. Currently, there is limited data on the possible effects of low temperature on storage root splitting in sweetpotato. This study attempted to generate preliminary data on the possible role of low temperature on storage root splitting in sweetpotato.

Approach

The cultivars used were ‘Evangeline’, ‘Bellevue’ and ‘Beauregard’. Low substrate temperatures were simulated by wrapping pots in coils attached to a water chiller (Fig. 1A). Pots in the control treatment were also wrapped in coil and insulation but not chilled. All plants were initially grown with the standard temperature regime. After 60 days, low night substrate temperature treatments (substrate temperature = 15C) were imposed on designated pots. Storage root samplings were made 10 and 20 days after the imposition of the low temperature treatments (Fig. 1B). Some pots were also taken outside and exposed to near freezing (below 5C; Fig. 2) temperatures during the early to middle part of October 2019.

Results

No splitting was observed in all storage root samples subjected to low temperature treatments. All storage roots were subjected to simulated drops to replicate conditions during harvest. These simulated drops on hard surfaces also did not result in splitting.

Figure 1. Experimental setup for simulating low temperature in growth substrate (A). ‘Bellevue’ storage roots subjected to low temperature treatment (B).

Figure 2. Some experimental units were taken out of the greenhouse and exposed to near-freezing night temperatures in mid-October 2019.

Study 2. Ammonium vs. nitrate effects on storage root splitting (23 Oct to 12 Dec 2019)

Rationale

The LSU 'Georgia Jet' clone routinely splits under field conditions. In greenhouse conditions, splitting can be observed as early as 30 days. Although the 'Georgia Jet' storage root splitting might be a different system compared to splitting at harvest in Australian growing conditions, it can provide some insights about the mechanism of splitting and possible ways to reduce this incidence. In prior preliminary studies, 'Georgia Jet' plants that were supplied with nitrate form of nitrogen produced storage roots with increased splitting incidence relative to plants that were supplied with ammonium. Very little data is available about the response of other cultivars like 'Beauregard' and 'Evangeline' to ammonium and nitrate treatments. Such findings could shed light on the possible role of nitrogen source on storage root splitting.

Approach

The varieties used were 'Georgia Jet', 'Beauregard', and 'Evangeline'. Plants were provided with half strength Hoagland's nutrient solution with either nitrate or ammonium as the nitrogen source. Storage roots were sampled at 50 days and assessed for splitting.

Results

- Splitting was observed in 'Georgia Jet' storage roots sampled from plants grown with nitrate relative to plants supplied with ammonium (Figs. 3, 4)
- No splitting was observed in 'Evangeline' and 'Beauregard'

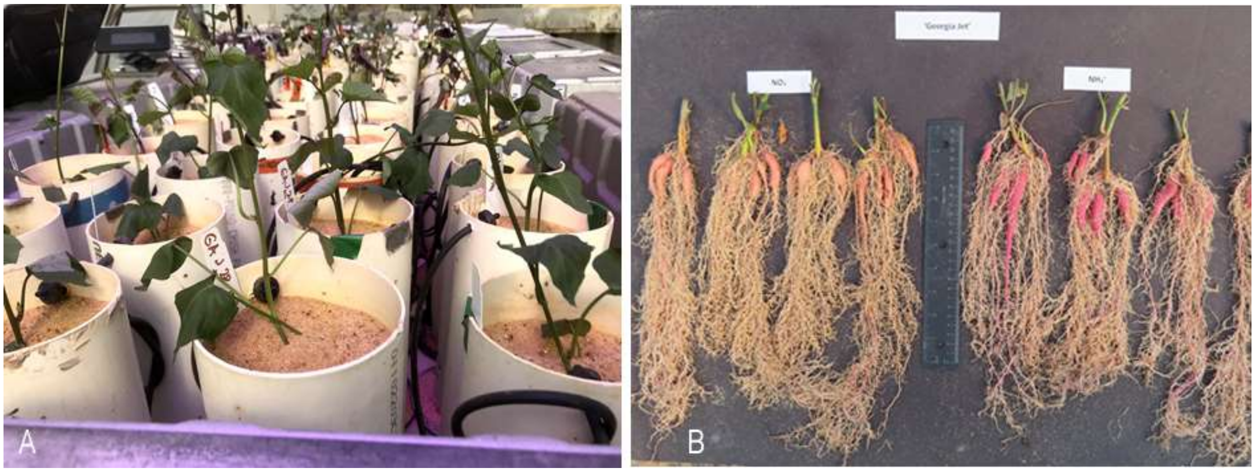

Figure 3. General view of the trial (A). ‘Georgia Jet’ storage root sampled at the conclusion of the study (B).

Figure 4. Detail views of Georgia Jet storage roots from plants grown with ammonium (A) and splitting in storage roots from plants grown with nitrate (B).

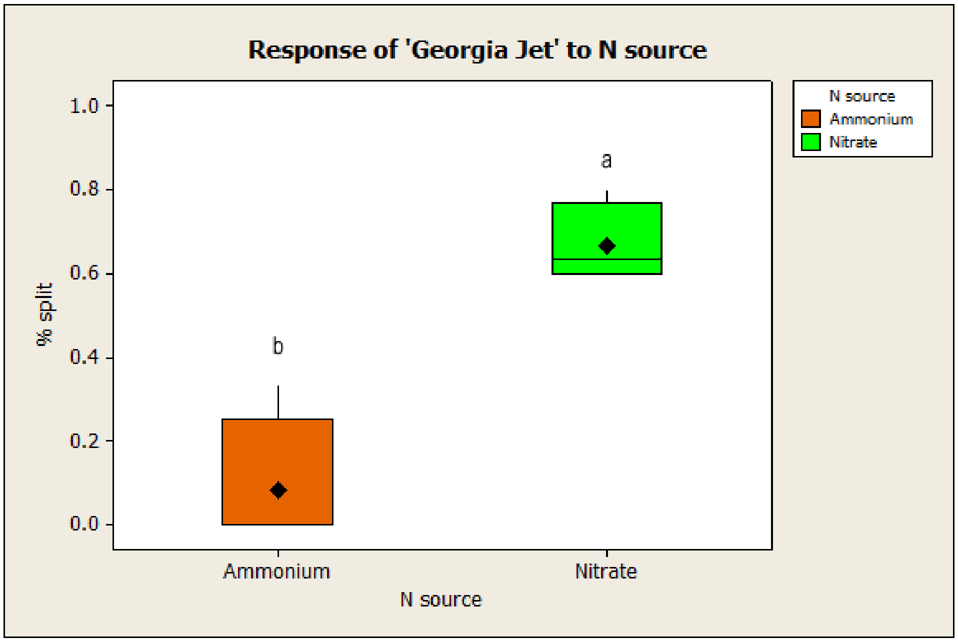

Figure 5. Box plots of ‘Georgia Jet’ storage root percent splitting response to ammonium and nitrate treatments. Bold horizontal lines indicate median values. Boxes represent the interquartile range (IQR, or middle 50%) of values for each feature. Upper box plot whiskers represent the last data point within the range of 75% quantile + 1.5 IQR, lower box plot whiskers represent the last data point within the range of 25% quantile–1.5 IQR. Dots represent outliers (values smaller or larger than the median ± 1.5 times the interquartile range).

Study 3. Phosphorus and storage root splitting follow-up work (12 Jan to 17 March 2020)

Rationale

In the prior study, it was observed the splitting was more prevalent in plants grown with nitrate as the nitrogen source vs ammonium. This follow-up work investigated the possible role of phosphorus (P) availability in Ga Jet plants provided with nitrate as the N source. P was given priority due to its well-documented role in root architecture development and root system adaptations to variation in P availability.

Approach

Three experimental treatments were used in this study: Hoagland’s nutrient solution without P (0P), 16 ppm P (1X), and 32 ppm P (2X).

Figure 6. ‘Georgia Jet’ storage roots from plants grown with 0, 16 (1X) and 32 ppm (2X) P and sampled at 50 days (A). Storage root samples from plants provided with 0 P (B).

Figure 7. ‘Georgia Jet’ storage root samples from plants provided with 16 ppm P (1X) (A) and 32 ppm P (2X) (B).

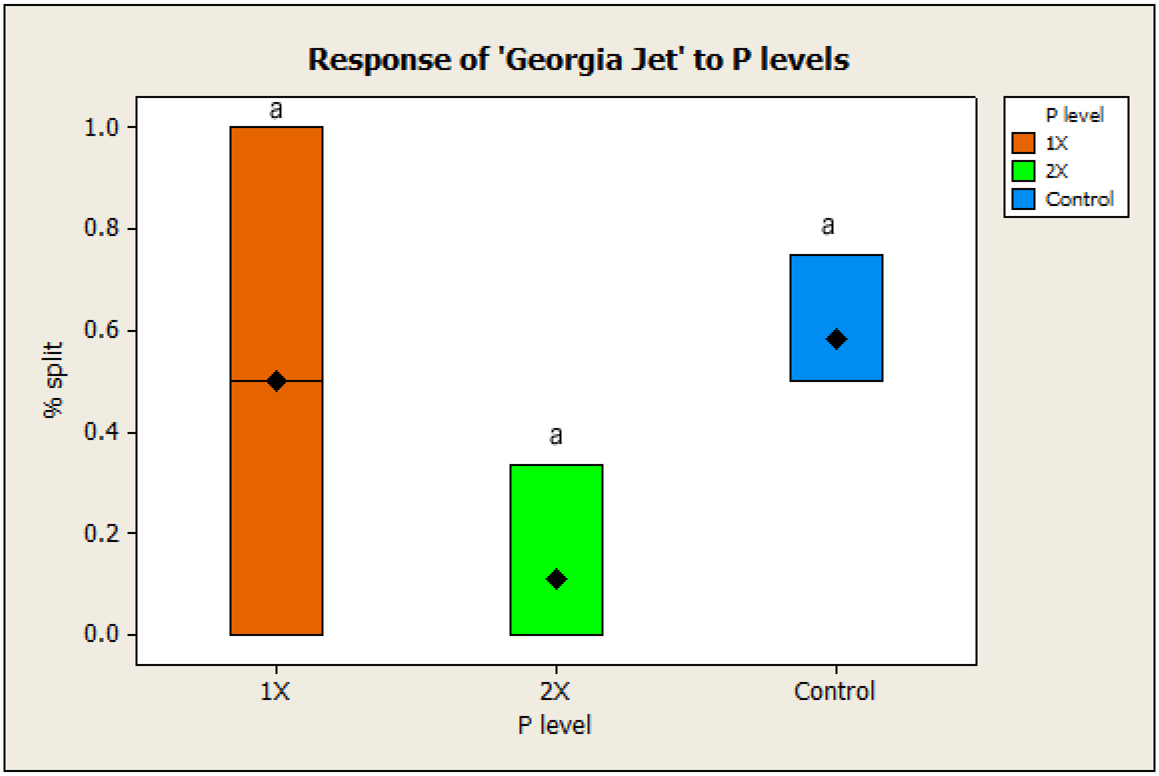

Figure 8. Box plots of ‘Georgia Jet’ storage root percent splitting response to phosphorus treatments. Bold horizontal lines indicate median values. Boxes represent the interquartile range (IQR, or middle 50%) of values for each feature. Upper box plot whiskers represent the last data point within the range of 75% quantile + 1.5 IQR, lower box plot whiskers represent the last data point within the range of 25% quantile–1.5 IQR. Dots represent outliers (values smaller or larger than the median ± 1.5 times the interquartile range). Control = 0 P; 1X = 16 ppm P; 2X=32 ppm P. Substrate P analysis: control = 1 ppm.

Results

- Splitting was observed in ‘Georgia Jet’ storage roots sampled from plants grown with nitrate relative to plants supplied with ammonium
- No splitting was observed in ‘Evangeline’ and ‘Beauregard’

Study 4. Phosphorus and storage root splitting follow-up work (May to June 2020)

Figure 9. Follow-up studies were conducted to investigate if increasing P availability reduced splitting in 'Georgia Jet' provided with nitrate as a source of N. 'Beauregard' and 'Murasaki' cultivars were also included.

Results

- We failed to observe splitting in the controls ('Georgia Jet" plants grown with nitrate as source of N).

Figure 10. 'Georgia Jet' storage roots from plants grown with 0, 16 and 32 ppm P and sampled at 50 days (A). Storage root samples from plants provided with 0 P (B).

Follow-up studies: Possible role of B in periderm thickness/splitting

Rationale

Experimental results from the Bundaberg trials support the hypothesis of a possible boron mediated genotype effects in periderm thickness determination. At the Sweet Potato Research Station, current research focuses on the role of nutrients in determining root architecture, storage root formation, shape and quality, hence these follow-up trials can be conducted past the life of the project. The DAF QLD partners will be regularly updated on findings from these follow-up studies, as well as possible subsequent work.

General Conclusions:

- The experimental evidence supports the hypothesis of that nitrogen form (nitrate vs ammonium) plays a role in genotype-specific splitting in sweetpotato
- Preliminary data do not currently support the role of P in reducing splitting in 'Georgia Jet'.
- The lack of splitting from experiments conducted during the summer phase (higher greenhouse temperatures) suggest that environmental conditions, i.e., temperature, mitigates the role of nitrate in genotype-specific splitting in 'Georgia Jet'