Arundo donax physiology, shoot, and root growth under two nutrient regimes

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ABSTRACT

Arundo donax (giant reed) is a pervasive invader of riparian systems, and therefore a potentially good candidate for bio-control. As a part of an on-going study of *A. donax* herbivory response, we investigated growth of 12 individuals grown from 4 x 3 cm rhizomes over a 5 month period (2/02-7/02). These plants were grown in 125cm x 125cm x 125cm containers with mini-rhizotrons at 30 cm intervals, filled with felt sand. Plants received either de-ionized or well (high N) water via drip irrigation daily. For two months, (5-6/02) plants also received weak solutions (2x for high nutrient treatment) of a micro and macro nutrient fertilizer on a weekly basis. We measured growth weekly; above ground growth was measured with a 3-D digitizer, and below ground growth was measured by analyzing root pictures taken with a mini-rhizotron camera. Photosynthetic measurements were made using a LI-6400. Above and below ground growth, photosynthetic rate, and water use efficiency rates varied widely among individuals and did not consistently differ between treatments. However, all 12 plants had roots >1m deep within 4.5 months. *A. donax* in the field and in our pots reached photosynthetic saturation around 1000 PAR, but it closed stomata and stopped photosynthesizing between 29-31^{0} C. However, they are not CO_2 limited, typical of a C-3 grass. These preliminary results suggest that *A. donax* has been successful because it has high enough photosynthetic rates to compensate for its heat sensitivity, and deep root systems to access water during the dry season.

Figure 1: Photograph of large pots, with mini-rhizotrons.

Figure 2: Photograph of Polhemus 3-D digitizer.

Figure 5: A photograph of the mini-rhizotron camera.

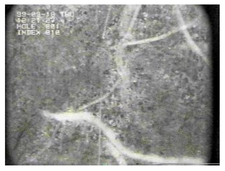


Figure 6: A photograph of *Arundo* roots, taken by the mini-rhizotron camera.

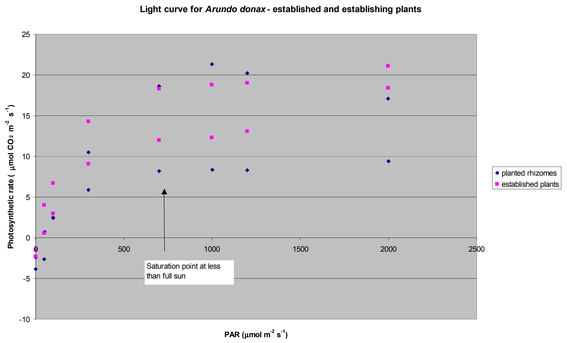


Figure 8: Graph showing light saturation point for *Arundo* in pots and in the field.

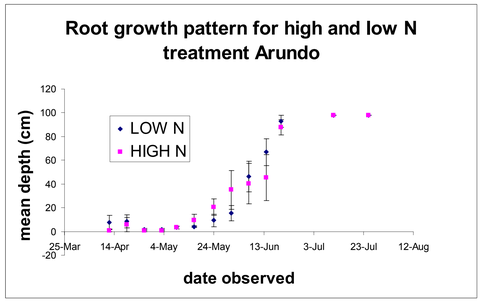


Figure 7: Graph showing mean depth of root growth over time in our pots. Depth was determined by the observation of new roots in a mini-rhizotron at that depth. The measurement is dependent on the random occurrence of a root intersecting a mini-rhizotron tube, and therefore may even be an underestimation of root growth.

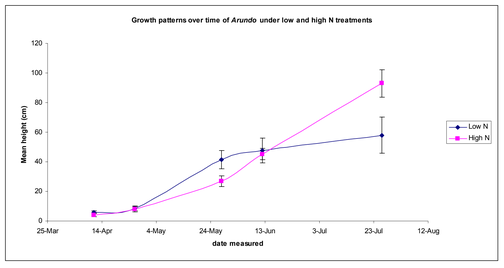


Figure 4: Graph showing growth trajectories of *Arundo* plants grown under low versus high nitrogen (N). Low N plants were watered twice a day with de-ionized water, and given a dilute solution of micro and macro-nutrient fertilizer once a week, whereas high N plants were watered twice a day with high-N well-water, and received twice the concentration of fertilizer as the low N plants, also once a week.

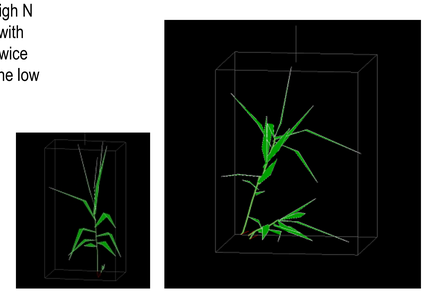


Figure 3: Images from Floradig software, created using the 3-D digitizer to measure growing *Arundo* plants. These are images generated from a single plant, over the course of three months. Measurements between points (for leaf length/width, internode distance, etc.) are also recorded in a separate data file.

Introduction and Methods

As a part of an on-going study of *A. donax* herbivory response, we investigated growth of 12 individuals grown from 4 x 3 cm rhizomes over a 5-month period (2/02-7/02). These plants were grown in 125cm x 125cm x 125cm containers, mini-rhizotrons tubes at 30 cm intervals, filled with felt sand (Fig 1). Plants received either de-ionized or well (high N) water via drip irrigation daily. For two months, (5-6/02) plants also received weak solutions (2x for high nutrient treatment) of a micro- and macro-nutrient fertilizer on a weekly basis. We measured growth weekly; above ground growth was measured with a 3-D digitizer, and below ground growth was measured by analyzing root pictures taken with a mini-rhizotron camera. Photosynthetic rate was measured using a LI-6400.

Results- Morphological measurements

Above ground growth: Polhemus 3-D digitizer and Floradig software

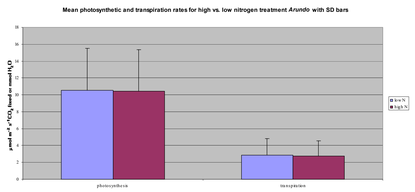
This equipment allowed us to map any level of detail of a growing plant by recording the location of points on the plant marked by the hand-held emitter and triangulated by a receiver (Fig 2). These locations in three-dimensional space were recorded and interpreted by software (Floradig) that also was programmed to make a 3-D image of the plant as it was being traced. Floradig can be customized to interpret distances between points as measurements such as leaf length, internode length, leaf area, etc. The images below were from measurements taken from a single plant at weekly intervals, and reflect the speed at which *Arundo* grows, and the pattern of new shoot growth (Fig 3). Advantages to this method are the level of detail possible, but it is not recommended for large sample sizes.

Preliminary data analysis reflects greater growth rate of *Arundo* plants growing under high nitrogen treatments (Fig 4).

Root growth: Mini-rhizotron camera

Clear acrylic tubes were inserted horizontally in the pots to act as mini-rhizotrons. This allowed us to track root growth over time. A camera designed for the purpose (Fig 5) was inserted into the tubes and pictures taken of the roots (Fig 6) at approximately one-centimeter intervals. These images are converted to digital and saved such that comparisons of the same location in the tube could be tracked over time. Data of interest included root surface area, depth of rooting, longevity of roots, and ratio of small to large diameter roots. All plants reached a rooting depth of 1m within three months of growth (Fig 7).

Figure 9: Graph showing photosynthetic measurements of high and low N treatment *Arundo* plants.



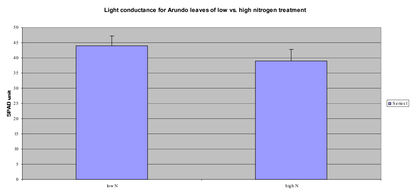
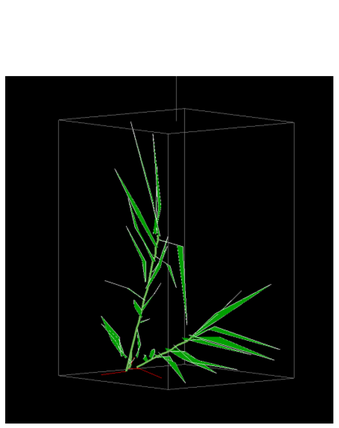
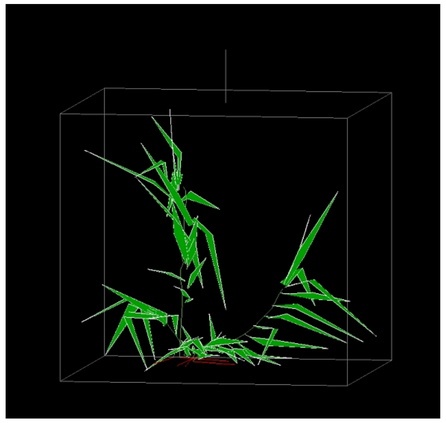


Figure 10: Graph showing difference in SPAD readings of high versus low nitrogen treatment plants.





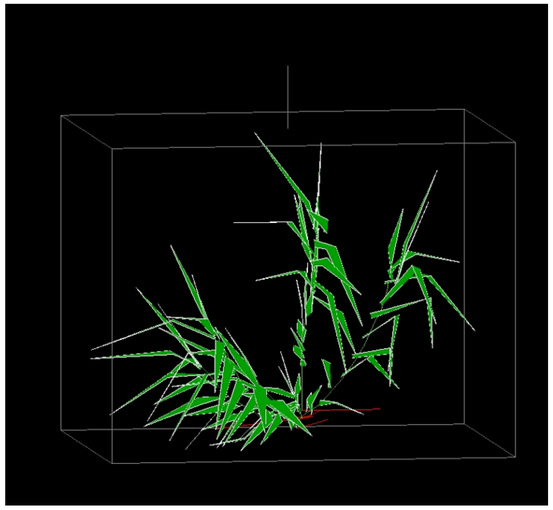


Figure 11: Photograph of re-growth from a cut stem of *Arundo*.

Results- Physiological measurements: IRGA Li-6400 and SPAD

The Licor infrared gas analyzer was used to measure photosynthetic rates, transpiration rates, and other physiological measurements. As has been shown previously, *Arundo* plants grown either in pots or in the field reached photosynthetic saturation around 1000 µmol m^{-2} s^{-1}PAR, but it closed stomata and stopped photosynthesizing between 29-31^{O} C (Fig 8). However, they were not CO_2 limited, typical of a C-3 grass (data not shown here). Preliminary data also suggest that there is no difference between photosynthetic rates of high versus low N treatment plants (Fig 9).

The Minolta SPAD measures light conductance of the leaf, thereby indicating chlorophyll concentration per unit area of the leaf. We found a significant, linear relationship between SPAD measurements and nitrogen concentration of *Arundo* leaves; therefore, the SPAD may be a useful tool in the field for measuring condition of *Arundo* plants. In this study, preliminary data suggests that nitrogen-stressed plants may actually have higher concentrations of nitrogen per unit area in their leaves (Fig 10).

Conclusions

1. Changes in height of potted plants suggest that *Arundo* responds positively to nitrogen addition over time.
2. All plants had very rapid root growth, reaching 1 m within 3 months.
3. No differences in photosynthetic or transpiration rates were detected between high and low N plants, and chlorophyll concentrations appeared to be higher in low nitrogen plants.
4. Results suggest that stressed plants produce less biomass, but may concentrate chlorophyll in their tissues. However, this concentration was not reflected in higher photosynthetic rates per unit area, thus total plant photosynthetic output was probably lower, and therefore growth was slower in low N treatment plants.

Future/current work

These techniques for measuring *Arundo* are currently being employed to identify response to herbivory-simulation treatments of potted and field plants. In the potted plants, initial observations indicate that meristomatic tissue is not damaged by some types of stem-cuttings, and therefore re-growth can occur directly from the top of the cut, and immediately after cutting (Fig 11). Future data analysis will quantify physiological and morphological responses of cut versus uncut plants, seeking to identify energetic cost and therefore limits of compensatory growth.