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Nitrogen Level Affects Greenhouse Growth and Quality of Ornamental White Clover (*Trifolium repens* L.)

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ABSTRACT

Several new ornamental varieties of white clover (*Trifolium repens* L.) have been released in recent years. Unfortunately, greenhouse production information is currently only anecdotal in nature, and recommendations range from no fertilizer to 200 ppm N. This study was conducted to analyze performance at various fertilizer levels. Two ornamental varieties of white clover, 'Salsa Dancer' and 'Dark Dancer' were grown at four fertilizer levels, 0, 100, 200, and 300 ppm N during spring, 2007. Plants were grown in 15.24 cm (6") azalea pots using a commercially available mix, Berger BM-7 35. Plants were fertilized twice weekly. Additional water was given as needed. Plant size and shoot dry weight increased ($P < 0.05$) with increasing N level. However, N level negatively impacted root growth, with root dry weights being significantly lower at higher N levels. Additionally, plant quality decreased with increasing N level ($P < 0.05$), as leaf color became more green and ornamental characters became more poorly defined. While it is unclear what role plant growth regulators could play, N fertilization levels above 100 ppm should be discouraged.

Additional Index Words: 'Salsa Dancer', 'Dark Dancer', fertility, bedding plant

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White clover (*Trifolium repens* L.) is a species native to Europe that has naturalized throughout most of the continental U.S (Liberty Hyde Bailey Hortorium, 1976). It is used primarily as a forage crop and is a common weed in many landscapes and turf areas (Sperry, 1991; Duke, 1981). However, plant breeders have identified and released many new varieties with ornamental traits (Parrott, 2007).

The species form of white clover has a trifoliate leaf on a long slender petiole with a white, globose inflorescence. This along with the forma *lodigense*, form the basis of most forage clover planted in North America. These have a green leaf with a white, v-shaped watermark at the base of each leaflet. The forma *minus* and the variety *atropurpureum* have smaller foliage, that may be red in color, and a smaller inflorescence that can be pink or red in color. Mutants have been identified that have 4 and 5 leaflets, red watermarks, red midribs, and red foliage in various combinations. Several of these mutants have been identified as having ornamental characters worthy of release, including 'Dark Dancer', 'Salsa Dancer', 'Dragon's Blood', 'Good Luck', and 'Purpurescens'.

While these plants have become commercially available, virtually no information exists for efficient greenhouse production, though several growth requirements can be elucidated from agronomic research. White clover performs best under cool, moist conditions and is susceptible to drought injury (Carlson et al., 1985; Miller et al., 1951). Soil pH generally does not affect white clover, as it tolerates pH of 4.5 to 8.2, though ideal range in native soils is between 6.0 and 6.5 (McLeod, 1982; Duke, 1981). White clover does best in high fertility soils, and is an especially heavy user of phosphorus and potassium (Mackay et al., 1990; Duke, 1981). These can provide guidelines, though greenhouse producers, in the absence of other information, will generally treat white clover as a typical bedding plant and use the same fertilizer program (J. Green, Nortex Nurseries, personal communication).

Determining applicable greenhouse fertility data is further complicated by the fact that most plant N needs are met via a symbiotic relationship with *Rhizobium* bacteria. These bacteria fix atmospheric N and supply it to the plant as NH_4^+. White clover seeds should be inoculated prior to planting (Duke, 1981), but most ornamental varieties are propagated vegetatively and grown in sterile media lacking inoculant. Data collection from the field relies primarily on nitrogen fixation to provide adequate N, though studies have been conducted that demonstrate the benefit of NO_3^- additions at low levels (Kanyama-Phiri et al., 1990).

The objective of this study was to determine the effect of various N fertilizer levels on 1) plant growth and 2) plant quality.

MATERIALS AND METHODS

Dark Dancer and Salsa Dancer white clover plugs were obtained from EuroAmerican Propagators (Bonsall, CA) in 84 count trays in March 2007. Plugs were immediately planted into 15.24 cm (6") azalea pots containing BM-7 35% bark growing media (Berger Horticulture, St. Modeste, QC, Can.). Plants were watered in and each variety randomly arranged in the greenhouse. To prevent the occurrence of whitefly, all plants were treated with Imidicloprid (Marathon 1% G, Olympic Horticultural Products, Mainland, PA) at the rate of 2 g (1/2 tsp) per pot.

At the beginning of the 2nd week, pots were randomly assigned to 1 of 4 fertilizer treatments: 1) Control, No fertilizer, 2) 100 ppm N, 3) 200 ppm N, and 4) 300 ppm N. Fertilizer evaluation levels were based on a recommendation of 200 ppm N used by a local producer for this crop (Jennifer Green, Nortex Wholesale Nursery, Wylie, TX, pers. comm.). Lower and higher fertilizer values were included for comparative purposes, including the 0 ppm N control. Fertilizer was mixed in a 7.5 l (2 gal.) watering can using Peters' 20-10-20 GP water soluble fertilizer (The Scotts Company, Marysville, OH), and applied twice weekly at the rate of 750 ml (25.4 oz.) per pot. Plants received additional water as needed.

Weekly measurements were made of plant height and width. Average plant width was determined by averaging and doubling 3 radius measurements of each individual. At study end, 5 plants from each treatment were used to determine root and shoot fresh and dry weights. Also, root nodules were counted on every specimen. Linear regression models were developed for each physical attribute measured and analyzed using Proc Reg of SAS 9.1 (SAS Institute, Cary, NC).

Visual quality measurements were made by ranking the plants on a scale of 1 to 10 with 1 being poor quality and 10 the highest quality. Evaluators were students, faculty, and staff of Texas A&M-Commerce, and their horticultural expertise ranged from degreed professionals to no horticulture background at all. They were instructed to evaluate the plants as if they were selecting plants at a local nursery. Data were analyzed using Kruskal-Wallis one-way ANOVA by ranks (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Both varieties had similar responses to the fertilizer treatments (Figures 1- 4). In both Salsa Dancer and Dark Dancer, higher N levels were associated with increased shoot growth (Figures 1 and 3) with average dry shoot weights increasing from 6.02 g at 0 ppm N to 10.94 g at 200 ppm N in Dark Dancer and from 10.73 g at 0 ppm N to 16.13 g at 300 ppm N in Salsa Dancer (Figures 2 and 4). However, regression values (R^2) were very low, suggesting that size differences were not strongly related to N level and that other factors may have affected plant size in this study. This may be related to greenhouse temperatures exceeding cardinal temperatures for this species (Murray et al., 2000). Though no log was made of greenhouse temperatures, the researchers noted greenhouse temperatures exceeding 35 °C (95 ° F) on several occasions. Corresponding increases were found in plant height, but no differences were found in plant width, a factor possibly limited by pot size. Troublingly, increased fertility resulted in decreased root mass. Salsa dancer dry root weights decreased from 9.13 g at 0 ppm to 6.23 g at 300 ppm (Figure 3). Dark dancer dry roots weights also decreased from 5.43 g at 0 ppm to 3.5 g at 300 ppm (Figure 1). These responses are seen in other plants as increases in N levels cause a shift towards shoot biomass production and away from roots, similar to results found by Cardoso et al. (2007), Kim et al. (2002), and Hamlin et al. (1999).

While plant sizes increased with fertilizer level, increases in fertilizer level were generally associated with lower visual quality scores in Dark Dancer (Table 1). Plants grown at 0 ppm N were the highest quality, with average quality scores of 8.0. These plants were more compact and had the darkest foliage. Plants grown at 200 and 300 ppm N were the lowest quality with average scores of 4.3 and 4.8, respectively. The foliage color lightened from a dark purple to a pale green. As no information is available concerning the use of plant growth regulators for ornamental clover, it is unclear how their use may have affected these

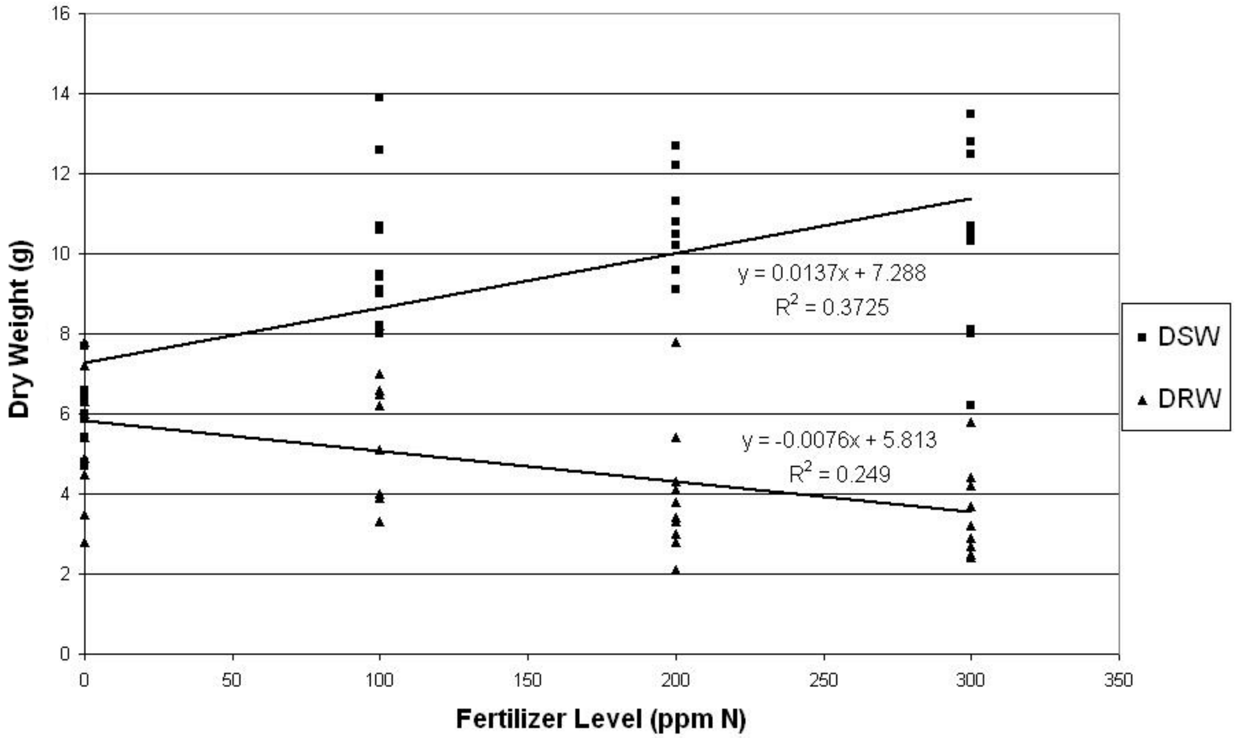

Fig. 1. Comparison of *Trifolium repens* 'Dark Dancer' dry root (DRW) and shoot weights (DSW) at 0, 100, 200, and 300 ppm N.

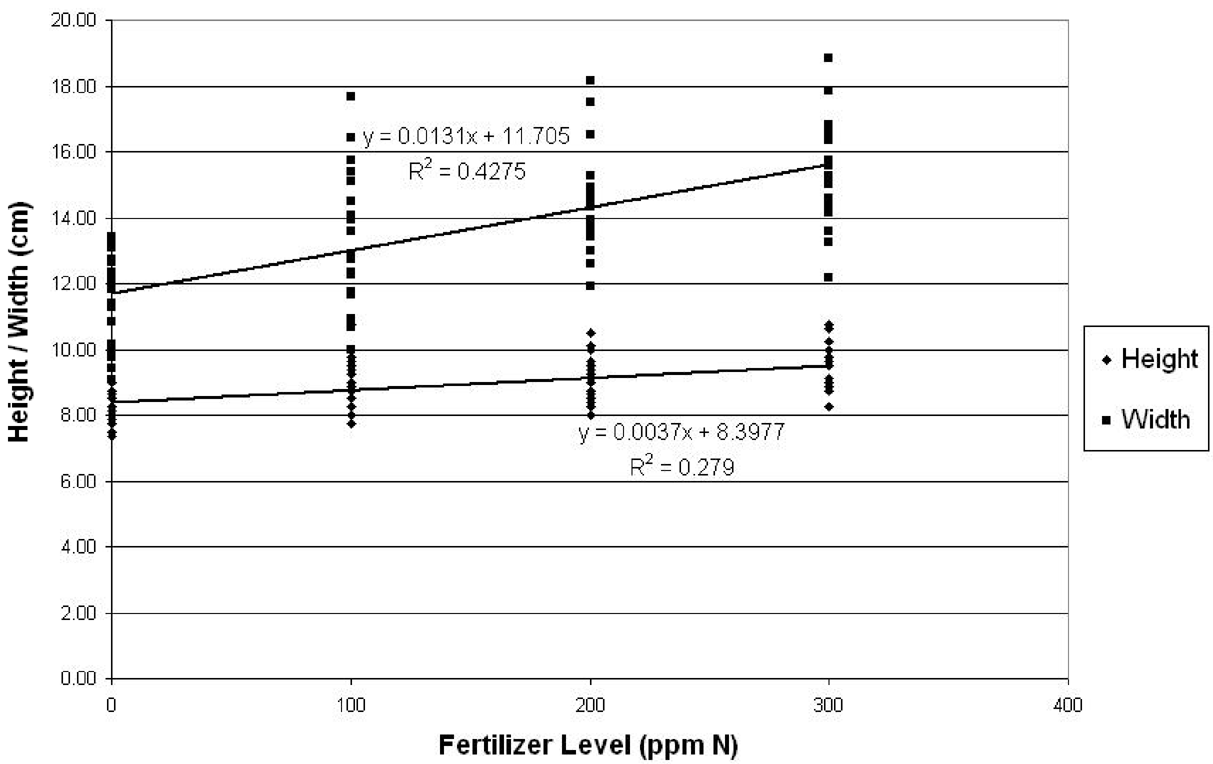

Fig. 2. Comparison of *Trifolium repens* 'Dark Dancer' plant height and width at 0, 100, 200, and 300 ppm N.

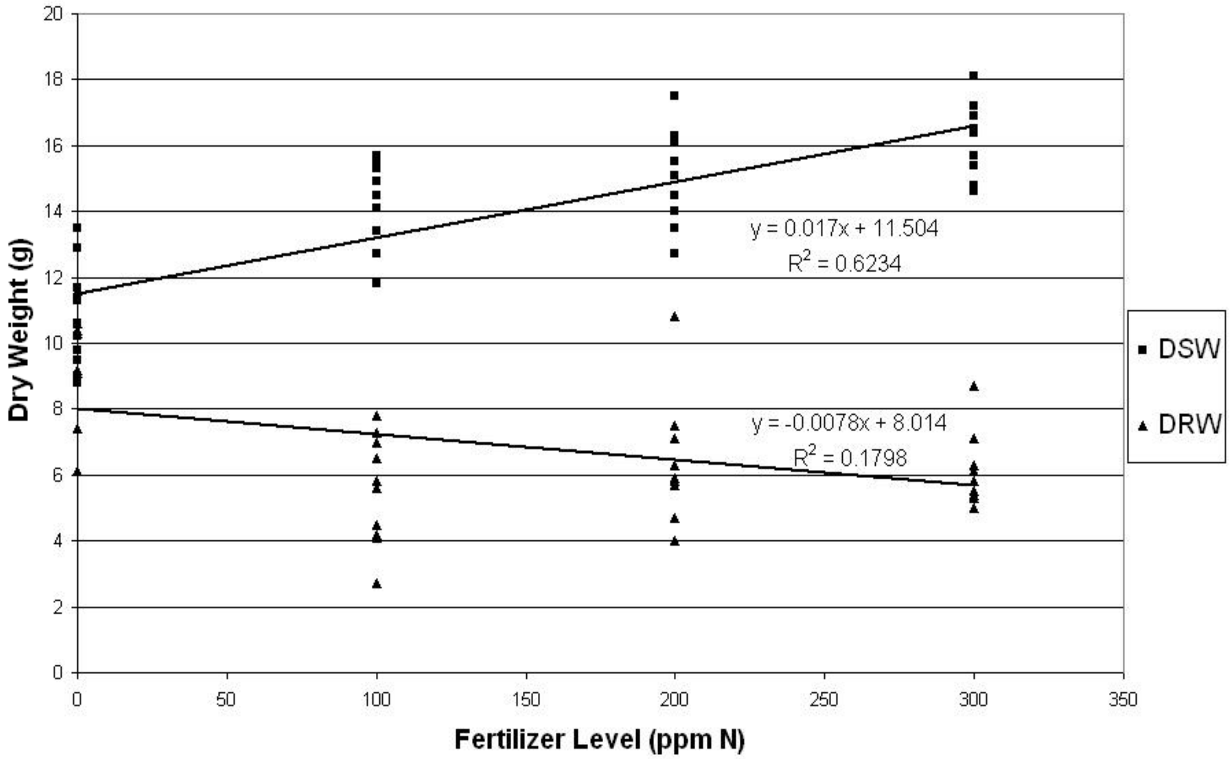

Fig. 3. Comparison of *Trifolium repens* 'Salsa Dancer' dry root (DRW) and shoot weights (DSW) at 0, 100, 200, and 300 ppm N.

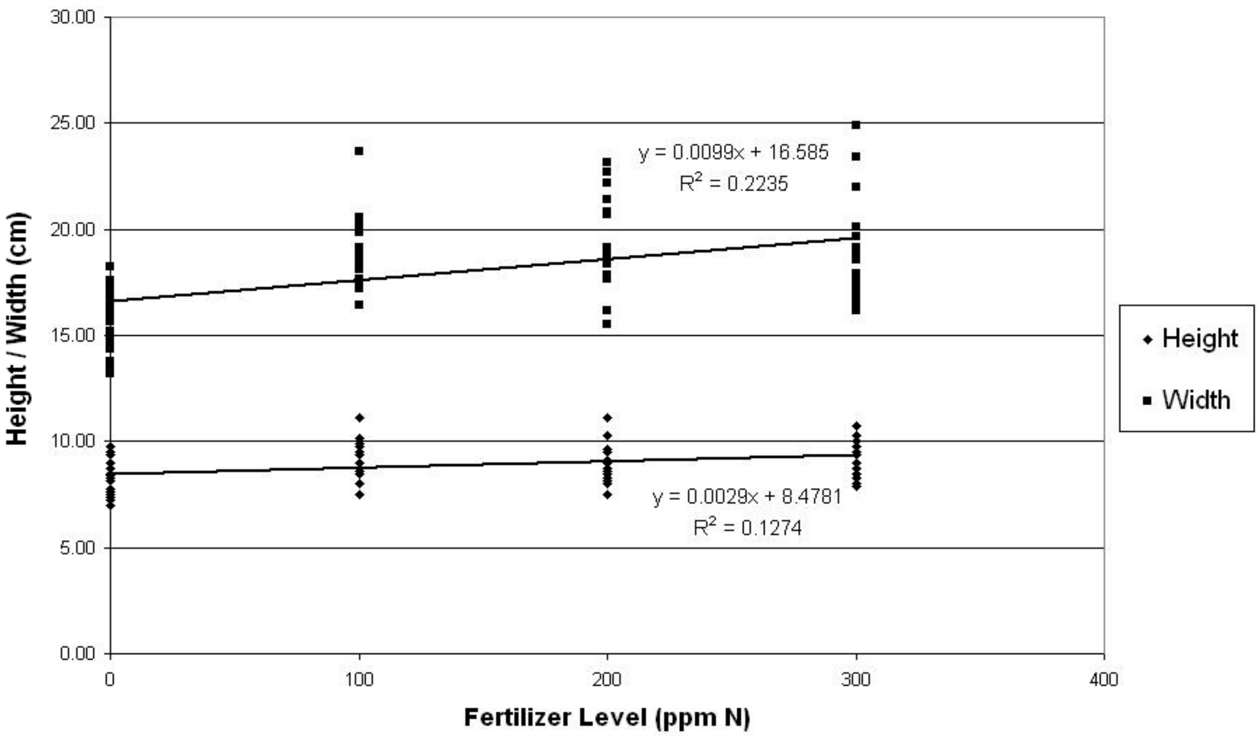

Fig. 4. Comparison of *Trifolium repens* 'Salsa Dancer' plant height and width at 0, 100, 200, and 300 ppm N.

Table 1. Visual quality assessment of Trifolium repens 'Dark Dancer'.Scale ranges from 1 to 10 with 1 representing poor quality and 10 excellent quality.

Fertilizer Level (ppm N)	Average Score
0	8.00
100	6.50
200	4.33
300	4.83

scores.

The increased shoot mass and decreased root mass of plants fertilized at 200 and 300 ppm N resulted in poor drought tolerance in both varieties. Unfortunately, the effect was pronounced enough in Salsa Dancer to cause a near complete crop loss in the absence of daily irrigation. It is likely this was exacerbated by greenhouse temperatures that frequently exceeded 35^{o}C (95°F) during the study, when white clover cardinal temperatures are between 8 and 27^{o}C (45 and 80°F) (Murray et al., 2000; Castle et al., 2006).

Though more research is needed, we recommend against fertilizer levels above 100 ppm N and found that a quality crop can be produced in the absence of additional fertilizer. While plant growth is minimized, the increases in plant quality result in a much more marketable crop. Further testing is warranted and planned concerning issues such as greenhouse temperatures, alternate fertilizer sources, and the use of plant growth regulators.

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