makes it an excellent subject for the study of in vitro growth parameters of woody plants. Shoot cultures were initiated from shoot tips on Anderson's rhododendron medium with MS vitamins, 3% sucrose, 1 μM BA, pH 5.6, and solidified with 0.6% Phytagar. Shoot cultures stabilized rapidly. Two-node microcuttings were placed on modified MS medium (200.1 μM Na2 EDTA and 200.5 μM $FeSO_4$ $7H_2O$), MS vitamins, 3% sucrose, pH 5.6, 0.6% Phytagar and supplemented with NAA (0, 0.5, 1.5, or 3 μM) in combination with BA (0, 1, 5. 10, 15, 20, 30, or 40 μM). Cultures grown on media supplemented with 1 mM BA produced the longest shoots and the most nodes per shoot. Cultures grown on media supplemented with 10 ppm BA produced the most shoots. Microshoots readily rooted on plant-growth-regulator-free MS medium and were easily acclimated.

Use of Chlorophyll Fluorescence in Propagation

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INTRODUCTION

Chlorophyll fluorescence is the small portion of light that is re-emitted from chlorophyll during the processes of photosynthesis. It is an estimation of photosynthetic efficiency and in turn provides an indirect measure of plant stress which is important because stress levels detrimental to the plant are usually present before they are visible to the naked eye. Current applications include the detection/evaluation of environmental stresses such as: cold tolerance (Westin et al, 1995), heat stress (Ranney and Peet, 1994), water stress (Eastman and Camm, 1995), nutrient deficiencies (Strand and Lundmark, 1995), irradiance levels (Layne and Flore, 1993), and air pollution (ozone) (Patterson and Rundel, 1995). It has been used in micropropagation of transvaal daisy (van Huylenbroeck and Debergh, 1992) but until now there have been no experiments involving conventional propagation by stem cuttings.

If a quick, reliable method of determining potential rooting of cuttings based on the condition of a specific stock plant was available for propagators, then rooting success could be predicted prior to an investment in time, labor, and resources. Thus, a reduction in production costs could be realized. Therefore, the objective of this study was to examine chlorophyll fluorescence readings of ten cultivars of *Taxus* over the course of propagation and compare initial fluorescence measurements with subsequent rooting percentages.

MATERIALS AND METHODS

Ten cultivars of *Taxus* were selected for the study: Bobbink, Brownii, Dark Green Pyramidal, Dark Green Spreader, Densiformis, Densiformis Gem, Hicksii, Runyanii, Tauntonii, and Wardii. Cuttings were taken in mid October from field grown plants at Zelenka Nursery, Grand Haven, Michigan, and were placed in cold storage at 2.5C (36F) for 5 weeks. At this time they were recut to a uniform length of 4.5 inches, treated with Woods Rooting Hormone (IAA 1.03%; NAA 0.66%) at 2800 ppm (5 : 1 ratio), and placed into a medium of 100% perlite. The experiment followed a

Table 1. Rooting percentage of ten cultivars of *Taxus* ×*media*.

Cultivar	Rooting %
Densiformis	96.7 abc*
Wardii	88.3 abcd
Densiformis Gem	85 abcde
Dark Green Pyramidalis	76.3 bcdef
Runyan	70 cdef
Hicksii	65 def
Dark Green Spreader	61.7 defg
Taunton	56.7 efg
Brownii	46.7 fg
Bobbink	31.7 g

* Means with the same letter are not significantly different. Mean separation among cultivars by LSD, P 0.05.

Table 2. Initial chlorophyll fluorescence measurements of ten cultivars of *Taxus* ×*media*.

Cultivar	Fv / Fm*
Dark Green Pyramidalis	0.8728 a**
Taunton	0.8511 ab
Densiformis	0.8261 bc
Hicksii	0.8194 bc
Runyan	0.8173 bc
Dark Green Spreader	0.815 bc
Densiformis Gem	0.7909 cd
Brownii	0.772 d
Bobbink	0.7601 de
Wardii	0.7305 e

* Ratio of variable fluorescence to maximum fluorescence

** Means with the same letter are not significantly different. Mean separation among cultivars by LSD, P 0.05.

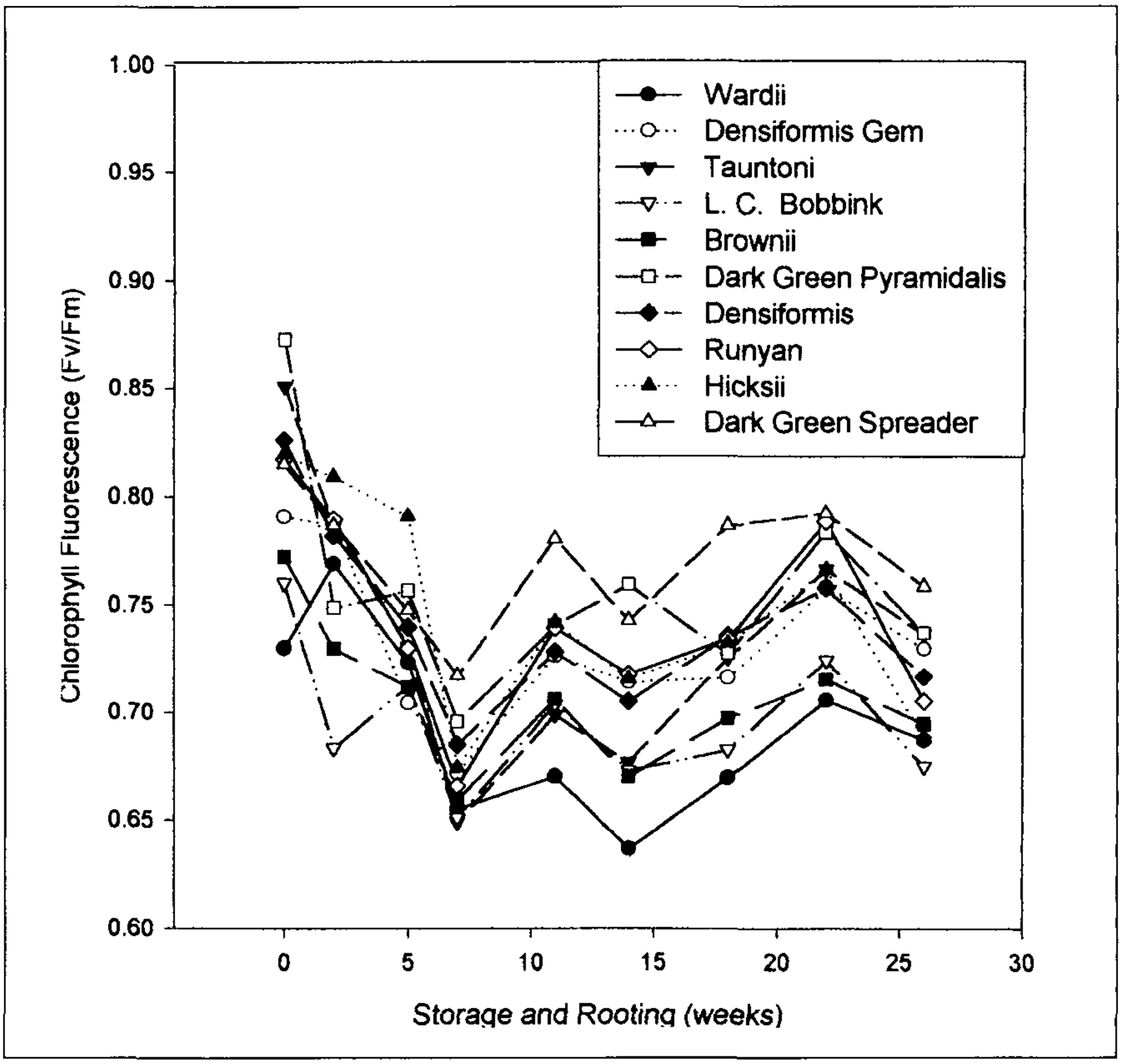

Figure 1. Chlorphyll fluorescence of Taxus during propagation.

randomized complete block design consisting of six blocks and 10 cultivars. There were 10 cuttings within each block/cultivar combination for a total of 600 cuttings. Periodic chlorophyll fluorescence measurements were taken with a Morgan CF-1000 Chlorophyll Fluorescence Measurement System throughout storage and rooting. Readings consisted of the ratio of variable fluorescence to maximum fluorescence (F_v/F_m). Following 20 weeks in the rooting beds, cuttings were evaluated and rooting percentages were determined. Means for each group of ten cuttings were subjected to analysis of variance (ANOVA) procedures to determine significant effects and means were separated by an LSD test.

RESULTS AND DISCUSSION

Fluorescence measurements exhibited a sharp decrease following severance from the stock plant which continued through storage and into the first 2 weeks in the propagation bed (Fig. 1). This decline in fluorescence measurements quantifies the increase in stress that the cuttings are enduring during the propagation period. Differences in the way chlorophyll fluorescence changes over time were found to exist among cultivars.

Differences among cultivars were also found in initial field chlorophyll fluorescence levels and final rooting percentages (Tables 1 and 2). An overall correlation between the two was not found, indicating that chlorophyll fluorescence values need to be examined at the individual cultivar level.

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LITERATURE CITED

Eastman, P.A.K. and **E.L. Camm.** 1995. Regulation of photosynthesis in interior spruce during water stress: Changes in gas exchange and chlorophyll fluorescence. Tree Physiol. 15:229-235.

Layne, D.R. and **J.A. Flore.** 1993. Physiological responses of *Prunus cerasus* to whole-plant source manipulation: Leaf gas exchange, chlorophyll fluorescence, water relations, and carbohydrate concentrations. Physiol. Plant. 88:44-51.

Patterson, M.T. and **P.W. Rundel.** 1995. Stand characteristics of ozone-stressed populations of *Pinus jeffreyi*. Amer. J. Bot. 82:150-158.

Ranney, T.G. and **M.M. Peet.** 1994. Heat tolerance of five taxa of birch (*Betula*): Physiological responses to supraoptimal leaf temperatures. J. Amer. Soc. Hort. Sci. 119:243-248.

Strand, M. and **T. Lundmark.** 1995. Recovery of photosynthesis in 1-year-old needles of unfertilized and fertilized trees of Norway spruce (*Picea abies* (L.) Karst.) during spring. Tree Physiol. 15:151-158.

Van-Huylenbroeck, J. and **P. Degergh.** 1992. Acclimatization of micropropagated *Gerbera jamesonii*. Use of chlorophyll-a fluorescence. Forum for Applied Biotechnology. Brugge (Belgium). 24-25 Sept. Mededelingen-van-de-Faculteit-Landbouwwetenschappen-Rijksuniversiteit-Gent (Belgium) 57(4a):1575-1579.

Westin, J., L.G. Sundblad, and **J.E. Hallgren.** 1995. Seasonal variation in photochemical activity and hardiness in clones of Norway spruce (*Picea abies*). Tree Physiol. 15:685-689.