Novel Invasive Plant Management for Restoration Using Commercial Textile Applications

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ABSTRACT

A global meta-analysis indicated one invasive species reduced richness 16.6% with adverse ecological effects. In Northeast deciduous forests, invasive plants outcompete natives, disrupt soil nutrient cycling and spread disease. Japanese barberry (*Berberis thunbergii*) stands increase black-legged tick (*Ixodes scapularis*) populations resulting in higher incidences of Lyme disease. Wineberry (*Rubus phoenicolasius*) hosts viruses of native herbaceous species and Oriental bittersweet (*Celastrus orbiculatus*) causes trunk failure. Novel approaches to invasive species control in restoration incentivizes commercial uses, large-scale removal and replacement. Natural dyes from invasives may serve as reliable, non-toxic, sustainable alternatives to synthetic dyes. Plant roots were harvested in Philadelphia, PA, USA. We treated 234 ea. of organic cotton and wool samples (10.16 cm x 12.7 cm, mean 6.4 g) with pairings of mordant and dye. Mordants (Red oak acorn (*Quercus rubrum*), acetate and alum) expedited dyeing and fixation. After 15 hrs of dye exposure, color intensity, color change from dry and wet crocking (performance measure of dye transfer) and antimicrobial properties were compared to control fabrics. Final fabric colors were coffee, latte, dusty rose and citron with wool morphology producing better coloration. Earth-tones and fabric weight are ideal for outdoor furniture or winter apparel. Crocking results need further evaluation of dye transfer. After incubating 48 hrs, Barberry revealed antimicrobial action against *Escherichia coli* and *Staphylococcus aureus* on all fabrics and mordants. Native replanting after complete plant removal is crucial for environmental restoration.

INTRODUCTION

Roots from three highly invasive plant species found in the Northeastern United States were processed into natural dyes for organic cotton and wool.

Barberry

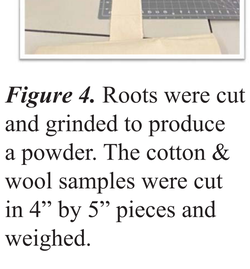


Figure 1. Bright red berries of *Berberis thunbergii.*

Oriental Bittersweet

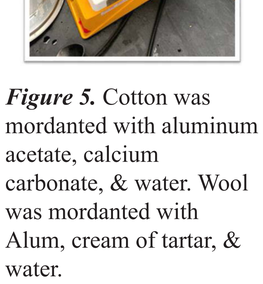


Figure 2. Bright red berries of *Celastrus orbiculatus.*

Wineberry

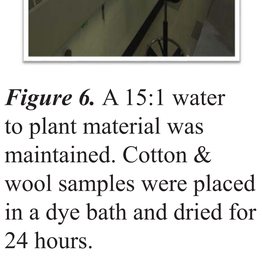


Figure 3. Bright red berries of *Rubus phoenicolasius.*

METHODS

Harvest & Grind

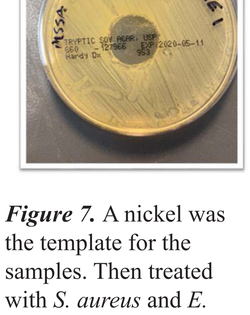


Figure 4. Roots were cut and grinded to produce a powder. The cotton & wool samples were cut in 4" by 5" pieces and weighed.

Mordant

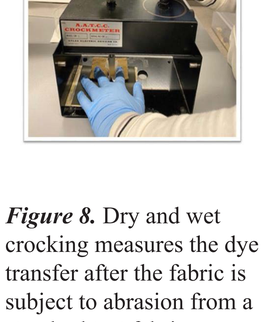


Figure 5. Cotton was mordanted with aluminum acetate, calcium carbonate, & water. Wool was mordanted with Alum, cream of tartar, & water.

Dye

Figure 6. A 15:1 water to plant material was maintained. Cotton & wool samples were placed in a dye bath and dried for 24 hours.

Antimicrobial

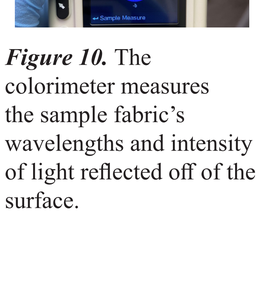


Figure 7. A nickel was the template for the samples. Then treated with *S. aureus* and *E. coli*. Zones of inhibition measured after 24 and 48 hours.

Crocking

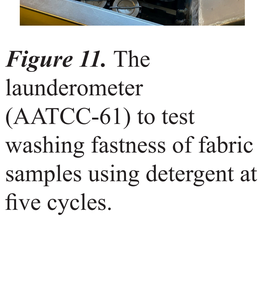


Figure 8. Dry and wet crocking measures the dye transfer after the fabric is subject to abrasion from a standard test fabric.

Perspiration

Figure 9. AATCC Method 15 - 2013 demonstrated the resistance of the dye to degradation from an acidic sweat-like treatment.

Colorimeter

Figure 10. The colorimeter measures the sample fabric's wavelengths and intensity of light reflected off of the surface.

Launderometer

Figure 11. The launderometer (AATCC-61) to test washing fastness of fabric samples using detergent at five cycles.

Colored Wool

Figure 12. Wool fabric colors after laundering included coffee, latte, dusty, rose and citron.

RESULTS

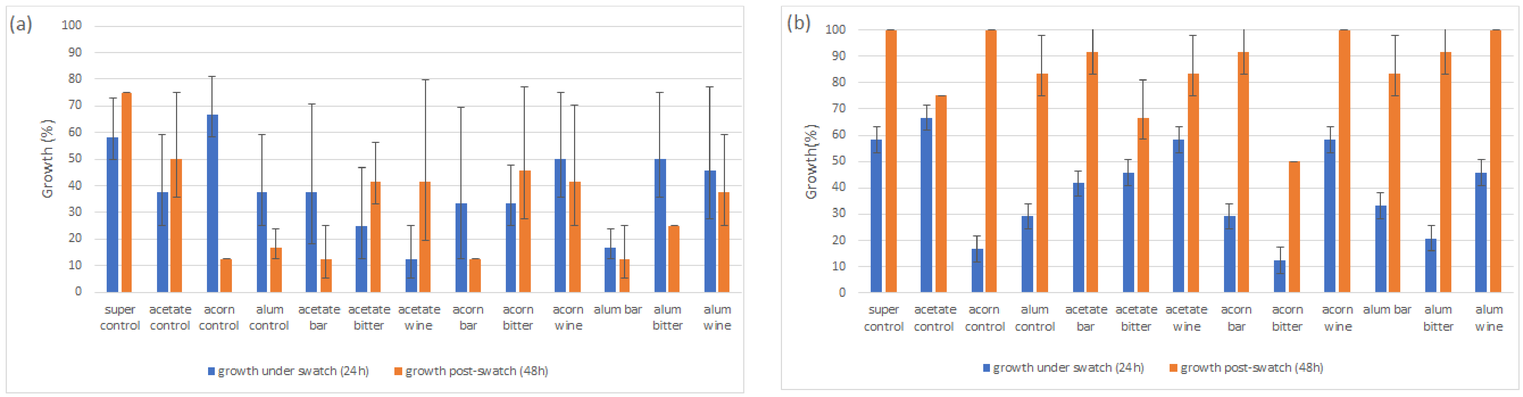


Figure 13. *E.coli* growth comparison of three mordants and dyes on (a) cotton where alum barberry displayed greatest inhibition, versus (b) wool where acorn bittersweet exhibited greatest growth reduction.

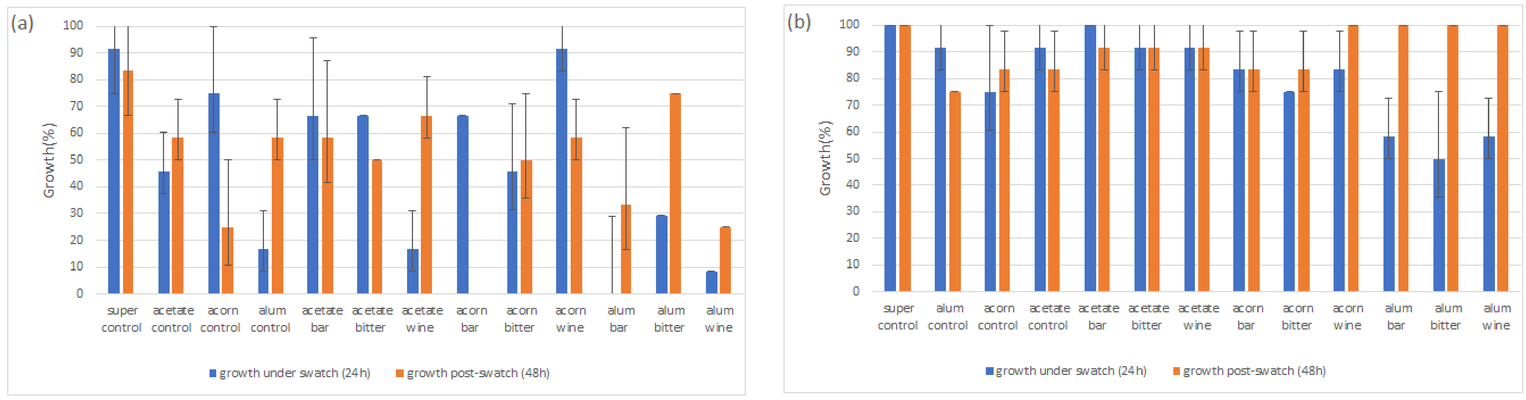


Figure 14. *S.aureus* growth comparison of three mordants and dyes on (a) cotton where alum displayed the greatest inhibition, showing no significant difference between dyes. Versus (b) wool where alum exhibited a slight inhibition of growth, but no significant difference between dyes.

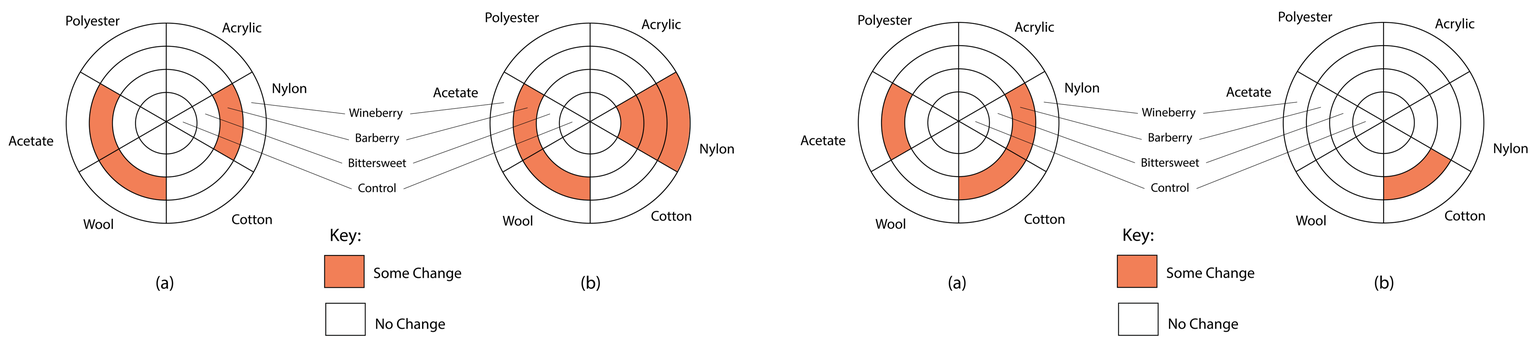
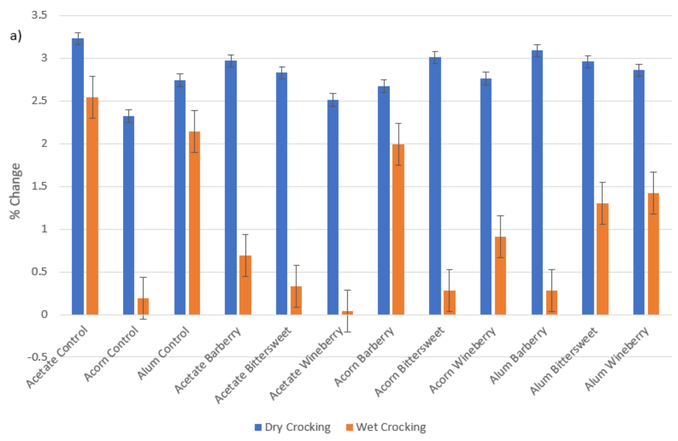


Figure 15. Color transfer of dye during laundering onto fabrics of various fiber types from (a) cotton and (b) wool, identifying barberry as the most prone to releasing dye, as well as identifying acetate, wool and nylon fabrics as the most receptive to waterborne dye



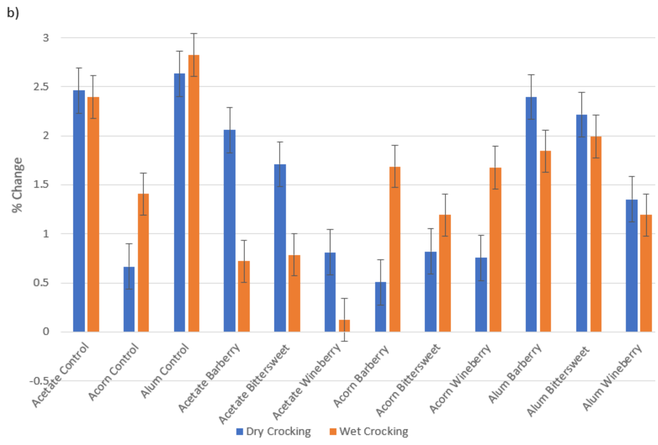


Figure 16. In all cases of dye migration, barberry dyed cotton and wool samples were responsible for the color change of multi-fiber strips, including the cotton strips for both (a) cotton and (b) wool samples, and additionally the acetate and nylon strips for the cotton samples

Figure 17. Crocking comparison of three mordants and dyes on (a) cotton where acorn control demonstrated the smallest percent change for dry crocking, and acetate wineberry displayed the smallest percent change for wet crocking and (b) wool where acetate wineberry had the smallest percent change for wet crocking while acorn barberry displayed the smallest percent change for dry crocking.

CONCLUSION

Barberry shows promise in outdoor uses for furniture or work apparel as it has antibacterial properties for both *E. coli* and *S. aureus* on wool and cotton despite dye migration during laundering, crocking, and perspiration testing. This may be mitigated if the fabric is washed with products of the same fiber type and of equal or darker depth of color. Wineberry and Bittersweet do not migrate with laundering and perspiration, however neither has significant microbial inhibition.

The mordants used had significant impacts. Due to the presence of polyphenols in tannins found in acorns and the dye-binding capability of acetate, both performed well with crocking for cotton and wool. The acetate mordants ability to open cellulose fibers lent itself to enhance the dyeing capability of the wineberry. Both mordants inhibited *E. coli* on cotton. The combination of acorn mordant with barberry dye has the greatest antimicrobial effects. None of the dyes or mordants were effective antimicrobial agents for *S. aureus* on wool.

The next step in this research is detailed experiments to explore the natural dye potential of these three invasive species' berries and other plant components.

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