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Effects of "lights out" turfgrass renovation on plants, soil arthropod and nematode communities

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ABSTRACT

"Lights out" turfgrass renovation approach is a pesticide-free method of weed and pest management that can reduce weed pressure when replanting turf, switching grass types, or completing a total renovation of a designated grassy area. In this study, we addressed the feasibility of using black, geo-textile weed mats made of woven polypropylene plastic in this alternative turfgrass renovation approach. The specific objectives were: 1) to determine the most effective weed mat density to suppress weeds; 2) to determine the most effective fertilizer treatment (fertilizer × rate) to stimulate weed seed germination and drain the weed seed bank; and 3) to document changes in the biotic communities in the soil including nematodes and insects. This research was conducted in 2016 at Magoon Research Facility on the island of Oahu, Hawai'i. Our results indicated that the "lights out" method was effective, with all cover types providing better weed suppression than control plots treated with glyphosate. There were no significant differences between fertilizer treatments for weed diversity or coverage percent one-month post-fertilization. However, all plots treated with fertilizer had significantly less weed diversity and coverage after the Bermudagrass was planted, indicating that fertilization plays a crucial role in draining the weed seed bank. Soil arthropod and nematode communities were generally altered after each renovation step, indicating that covering and fertilization play a role in shaping the diversity, abundance, and maturity of the soil food web.

1. Introduction

Seventy percent of the population of Hawai'i lives on Oahu and 62% of visitors spent part of their stay on Oahu. This makes Oahu the home to many recreational turfgrass sites (Kawate et al., 2015). Many of these warm-season turfgrass systems in Hawai'i including golf courses, athletic fields, recreational areas, and even home lawns are valuable economic resources. The golf economy alone has a size of $1.4 billion, indicating that turf is a significant part of Hawai'i's tourism-driven economy (PGA Aloha Sector, 2009). Recreational surfaces also play a crucial role in the landscapes that surround the native residents. The turfgrass system itself is unique because unlike temperate climates, it receives abundant solar radiation, rainfall, and maintains robust soils that support high rates of biodiversity year round. Among a variety of turfgrass pests, many annual weeds in temperate climates are able to compete for resources as perennials in tropical conditions. Some of these weeds grow uncontrollably with turfgrass, presenting a major obstacle for turf managers in Hawaii. In other situations, turfgrass mismanagement can encourage weed growth and cause severe infestations (Murphy, 2004). This sometimes requires a complete renovation to re-establish the desired turfgrass species (Cheng and DeFrank, 2014).

Bermudagrass (*Cynodon dactylon*) is a very common grass choice for turfgrass that receives a lot of annual "wear and tear". It is the most commonly used turfgrass on golf courses and athletic fields in Hawai'i. It establishes quickly, and has a moderate tolerance of drought stress, and thrives in the sun. However, it is somewhat prone to thatch buildup, which can compromise the integrity of the grass surface if not properly managed (Kawate et al., 2015). Bermudagrass is also somewhat vulnerable to certain lepidopteran larvae, including webworms (*Herpetogramma* spp.) and armyworms (*Spodoptera* spp.) Common Bermudagrass cultivars used in Hawaii include Sunturf, Tifway, and Tifgreen varieties. A Riviera Bermudagrass cultivar was used for this "lights out" project because of these lucrative properties.

Non-selective herbicides such as glyphosate have been used traditionally as the first step of turfgrass renovation (Stier, 2000). The dead weeds are then mechanically removed or incorporated into the soil using tillage. However, the use of non-selective herbicides to renovate turf is somewhat contentious in the turfgrass industry in modern days. There has been an elevated public concern of exposure to chemicals.

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There have also been some restrictions on the number and variety of pesticides that can be used on turfgrass nationally and in Hawaii (Cheng and DeFrank, 2014). These types of obstacles necessitate the flexibility and creativity of the turf community to develop alternative methods of control. It is commonly considered that soil biota support overall plant, including turfgrass, growth and health. However, findings from glyphosate impact studies often contrast each other; some have reported deleterious impacts to soil biodiversity, while others have reported no significant changes (Jackson and Pitre, 2004). The majority of these impact studies have been completed in agricultural systems, reinforcing the need to study glyphosate impacts on turfgrass systems.

One non-chemical alternative is light exclusion (McCarty and Murphy, 2004). "Lights out" approach uses light exclusion rather than chemical introduction as a method of weed control in turfgrass systems, and has some practical applications for turf and landscape management. "Weed mat" in this study refers to a sheet of black, woven, polypropylene plastic commonly used in agriculture setting to reduce weed pressure. Dark, geo-textile weed mats are placed over an affected area to exclude light over a prolonged period of time. This limits common problem weeds in Hawai'i from proliferating in turfgrass systems. The surface underneath the mat also reaches high temperatures (41–55 °C) (Chauhan, et al., 2015), which may kill many species of weeds, nematodes, and insects in the top layer of soil (Klein et al., 2012). The heat and darkness drastically reduce the ability of the weeds to survive, and may facilitate plant decomposition over time (Cheng and DeFrank, 2014). A fertilizer amendment is then applied in order to stimulate weed seed germination after covering and to flush the weed seed bank. Potassium nitrate and ammonium sulfate have been found to work well for this type of approach (IPNI, 2015a,b). Newly germinated weeds will also be covered, reducing weed pressure for when the new grass is planted. Mulching provides turf managers with an alternative to traditional control strategies in a variety of warm season turfgrass including Bermudagrass, Zoysiagrass (*Zoysia* spp.), and St. Augustinegrass (*Stenotaphrum secundatum*) (Kawate et al., 2015).

The overall goal of this study was to quantify the efficacy of "lights out" mulching as an alternative method of turfgrass renovation. We also aimed to evaluate the potential impact and benefits of "lights out" approach on soil biological diversity indicated by arthropods and nematode communities. We hypothesized that "lights out" approach could be an effective alternative method of turfgrass renovation, and with less chemical inputs, "lights out" approach would pose less disturbances to soil biological diversity compared to traditional turfgrass renovation practice relying heavily on non-selective herbicides.

2. Materials and methods

There are six steps to complete a "lights out" turfgrass renovation. The steps are listed here to provide a concise overview:

1. Cover existing weedy turf area for 6 weeks to eliminate all above ground portions (February 25–April 13, 2016).
2. Remove cover, and then remove dead weeds and turf (and re-establish the desired site grade if necessary).
3. Fertilize to stimulate weed seed germination.
4. 4Allow for maximum weed seed germination and growth with overhead irrigation (April 26–May 26, 2016).
5. Cover the site a second time to eliminate newly emerged young weeds (May 26–June 29, 2016).
6. Remove the cover for second time and re-plant new turfgrass.

2.1. Experimental design

A graphical scheme with details of the experimental design is provided in the Supplementary Material. A 9.14 m × 15.24 m mixed turfgrass study area at the Magoon Research Facility on University of Hawaii at Manoa campus was divided into sixteen 2.13 m × 3.05 m plots during the first two weeks of January 2016. The study area was comprised of mostly St. Augustinegrass, some Bermudagrass, and some common turfgrass weeds in Hawaii. Black, geo-textile fabric commonly referred to as 'weed mat' was cut at 91 cm width and secured using metal stakes around the study plots. It was also cut at 30 cm width and secured in between plots to serve as a treatment buffer. This created a walkable perimeter around each plot. The area was enclosed with orange construction fencing using large, metal rods. Irrigation was installed.

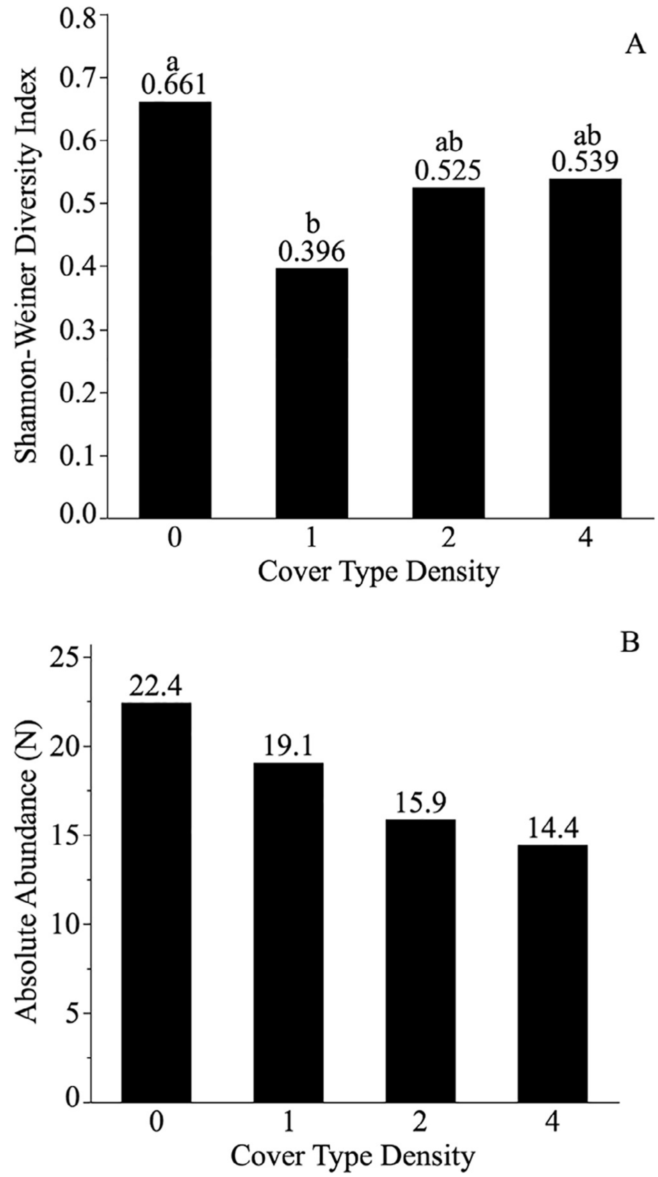

Fig. 1. Soil surface arthropod diversity (A) and abundance (B) after the first cover based on density. Low (1), medium (2), and high (4) density cover types. Bars with different letters on top indicate a significant difference based on Wilcoxon test ($P < 0.05$).

The lowest density fabric was an LP200 woven fabric (136 g/m^2) from Belton Industries (Exacta Sales, INC). The medium density fabric was an LP315 (203 g/m^2), and the high density fabric was an 876 style woven fabric (197 g/m^2). The 876 style has lower permittivity (0.04 s^1 compared to 0.05 of the other two fabric styles). This contributes to its efficacy as the 'high density' cover type. Each cover was cut to measure approximately 3.66 m × 4.57 m, accommodating for the extra length needed in order to reach the clip base. They were attached to the perimeter of the plots using the clip base and a piece of wiggle-wire on