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University of Hawai'i at Manoa

Evaluation of Physical Barriers to Suppress Purple Nutsedge (*Cyperus rotundus*) in Landscape Beds in Maui, Hawai'i

Abstract

Purple nutsedge (*Cyperus rotundus*) is a noxious weed in landscapes and agricultural fields locally and globally. Physical barriers can be used as an alternative to herbicides or tillage for weed suppression. This study evaluated weed growth in irrigated bare ground control (C); irrigated plot covered with a 3" layer of mulch, woven black polypropylene geotextile fabric in the middle, and a thin layer (2") of mulch on top (MWCM); and irrigated plot covered with woven black polypropylene geotextile fabric (WC). Percent canopy ratings (assessed visually and using the Canopeo app), number of nutsedge per square foot, and weed biomass per square foot indicate that MWCM and WC were effective in suppressing weeds compared to C. Percent canopy ratings between MWCM and WC were similar. While MWCM exhibited slightly higher numbers of nutsedge per square foot and weed biomass per square foot compared to WC, weed control in MWCM was acceptable up to 116 days after covering the plots.

Introduction

Purple nutsedge (*Cyperus rotundus*) is considered as one of the world's worst weeds (Holm et al. 1977). It reproduces and spreads primarily through tubers and rhizomes—one tuber can potentially produce approximately 100 shoots in 100 days under optimum conditions (Brosnan and DeFrank 2008). Nutsedge tubers can be located 2–18 inches deep in the soil and can persist for 1–4 years (Stoller and Sweet 1987). Soil moisture and temperature are the primary environmental factors that induce purple nutsedge tuber sprouting (Miles et al. 1996).

Purple nutsedge can be suppressed by manual or mechanical removal of tubers and rhizomes, applications of systemic herbicides with precision timing to a specific growth stage of the plant, and physical barriers coupled with irrigation to induce germination and kill tubers through light exclusion (Brosnan and DeFrank 2008; Theodore 2005; Chen et al. 2013).

Physical barriers are a less toxic, low cost and sustainable option for suppressing purple nutsedge. While organic mulches are typically used as a physical barrier to control weeds in the landscape (Marble et al. 2015), they are not effective in controlling purple nutsedge (Saha et al. 2019). Thin and thick plastic sheet mulches are also ineffective since the sharp pointed shoot tip of purple nutsedge can readily penetrate through these materials (Brosnan and DeFrank 2008). Woven black polypropylene geotextile fabric (PGF) laid loose on the soil surface can be effectively used to suppress purple nutsedge by snagging the shoot tips under the weave, preventing photosynthesis. When used in combination with frequent watering, PGF increases soil temperature and promotes the sprouting of purple nutsedge in a wider range of the soil profile than surface irrigation alone (DeFrank, personal communication). Repeated cycles of weed growth and die-back under these conditions for 2–4 months exhaust the tubers resulting in effective suppression (Brosnan & DeFrank 2008). While this practice is effective in suppressing purple nutsedge, bare PGF can be unsightly when installed on landscaping beds. Typically, a layer of mulch could be applied on top to improve aesthetic appearance. However, if this is left over time, the mulch degrades and provides an ideal environment for other weeds to grow (Saha et al. 2019). Using a thin layer of organic mulch to temporarily cover bare PGF can improve the appearance of the area without the risk of providing new habitat for weeds.

The objective of this study was to determine the weed response to irrigated bare ground, ground covered with

September 2024
Subject Category: Weed Control, WC-13

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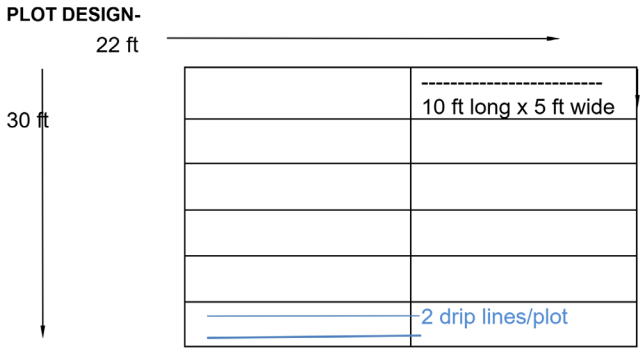
PGF alone, and ground covered with a layer of organic mulch on the soil surface and a layer of PGF topped with a thin masking layer of organic mulch. The PGF used in this study has the following specifications: trade name (Geotex 2300), distributor in Hawai'i (Rudy's Shade Inc.), manufacturer (Polyproductos), thickness (6.35 oz/sq yard), formulation (93.458% prime polypropylene, 4.85% black masterbach, 1.70% calcium carbonate) (Figure 4).

Materials & Methods

The experiment was conducted at Maui Nui Botanical Garden in Kahului, Hawai'i. Landscape beds previously planted with ornamental bananas and sweet potato were fallow for 3 months. A 30 ft long by 22 ft wide bed was hand-tilled and divided into 12 treatment plots, each 10 ft long by 5 ft long, with two lateral drip irrigation lines (emitters spaced every 12 inches) placed horizontally on the ground below each treatment (Fig. 1). The experimental design (Fig. 2) was a randomized complete block consisting of three treatments: irrigated bare ground control (C), irrigated woven black polypropylene geotextile fabric-PGF (weed cloth, WC), and irrigated woven black polypropylene geotextile fabric-PGF with 3" mulch below and a thin layer (2") of mulch on top (mulch–weed cloth–mulch, MWCM). Each plot was replicated four times. Each treatment plot received 30 minutes of water daily.

Counts of nutsedge plants, percent green cover, and visual percent ground cover were sampled twice a month for four consecutive months starting in April 2020 and ending in August 2020. Sampling was done by placing a 1 × 1 ft PVC square in an area that best represented the 50 square foot plot (Fig. 5). The total number of nutsedge plants was counted manually for each sample area. The percent green cover for the sample area was recorded using the Canopeo phone application. The percent ground cover for the sample area was also visually estimated. Air-dried weed biomass per square foot was also recorded two weeks after termination. Data were analyzed using Statistical Analysis Software (version 9.4). The Waller-Duncan *k*-ratio (*k* = 100) *t*-test was used to separate the means.

Figure 2. Site photo showing the layout of the three treatments: irrigated bare ground control (C), irrigated woven black polypropylene geotextile fabric-PGF (WC), and irrigated woven black polypropylene geotextile fabric-PGF with 3" mulch below and a thin layer (2") of mulch on top (MWCM), with four replications. Located at Maui Nui Botanical Garden, Kahului, Hawai'i.



Treatment Map

Plot 6-Mulch, Weed Cloth, Mulch (P6-MWCM)	Plot 9-Weed Cloth (P9-WC)
Plot 4-Control (P4-C)	Plot 5- Mulch, Weed Cloth, Mulch (P5-MWCM)
Plot 8-Mulch, Weed Cloth, Mulch (P8-MWCM)	Plot 2-Control (P2-C)
Plot 11-Weed Cloth (P11-WC)	Plot 10-Weed Cloth (P10-WC)
Plot 12-Weed Cloth (P12-WC)	Plot 3-Contol (P3-C)
Plot 1-Control (Pl-C)	Plot 7-Mulch, Weed Cloth, Mulch (P7-MWCM)

Figure 1. Experimental design and treatment map.

Results

The mean number of purple nutsedge shoots that penetrated through physical barriers was significantly reduced to 0.52 shoots/1 sq foot in the mulch–weed cloth–mulch treatment (MWCM) and 0.03 shoots/1 sq foot in weed cloth-only treatment (WC), respectively compared to the 29.4 shoots/1 sq ft in the control (C) (Fig. 6; $P<0.05$).

No significant differences in percent weed canopy cover (in Canopeo) were observed between the WC (0.03%) and MWCM (0.08%) treatments. The C treatment exhibited significantly higher percent weed canopy cover (64.9%) than the WC and MWCM treatments (Fig. 7).

The C treatment generated significantly more total average dry biomass of 42.9 g/1 sq ft consisting of purple nutsedge, broadleaves, and grasses compared to MWCW and WC (Fig. 9). WC generated the lowest biomass or weed weight of 0.006 g/1 sq ft (Fig. 9).

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Figure 3. Three treatments at the beginning, middle, and end of the trial. Top row: irrigated bare ground control (C) treatment, plot 4. Middle row: irrigated weed cloth with mulch above and below (MWCM) treatment, plot 8. Bottom row: irrigated weed cloth-only (WC) treatment, plot 12.
Photographs taken 4/28/2020 (left column), 6/24/2020 (center column), and 7/28/2020 (right column).

Figure 4. Polypropylene geotextile fabric-PGF used in the WC and MWCM plots. The PGF used in this study has the following specifications: trade name (Geotex 2300) distributor in Hawai'i (Rudy's Shade Inc.) manufacturer (Polyproductos), thickness (6.35 oz/sq yard), formulation (93.458% prime polypropylene, 4.85% black masterbach, 1.70% calcium carbonate).

Figure 5. Sampling was done by placing a 1 × 1 ft PVC square in an area that best represented the 50 square foot plot. The total number of nutsedge plants was counted manually for each sample area. The percent green cover for the sample area was recorded using the Canopeo phone application. The percent ground cover for the sample area was also estimated visually.

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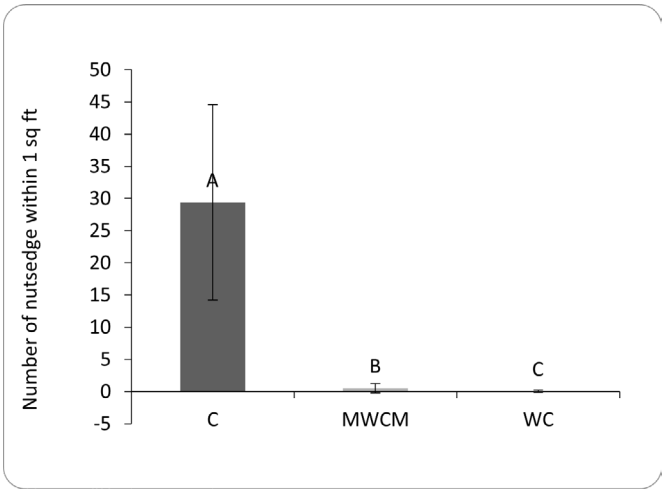

Figure 6. Mean number of purple nutsedge shoots sprouting above the irrigated bare ground control (C), irrigated plot covered with a 3" layer of mulch, woven black polypropylene geotextile fabric in the middle and a thin layer (2") of mulch on top (MWCM), and irrigated plot covered with woven black polypropylene geotextile fabric (WC). Values with the same letters are not significantly different at $P \leq 0.05$, according to Waller-Duncan *k*-ratio ($k = 100$) *t*-test.

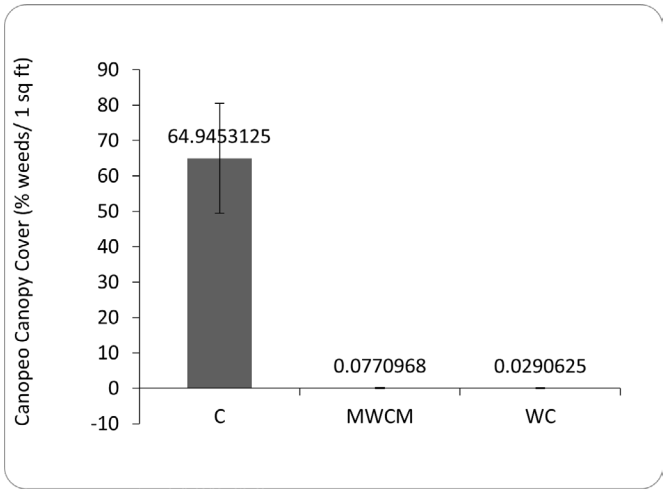

Figure 7. Mean percent canopy cover of all weeds in the irrigated bare ground control (C); irrigated plot covered with a 3" layer of mulch, woven black polypropylene geotextile fabric in the middle and a thin layer (2") of mulch on top (MWCM); and irrigated plot covered with woven black polypropylene geotextile fabric (WC). Measurements were taken by using the Canopeo application.

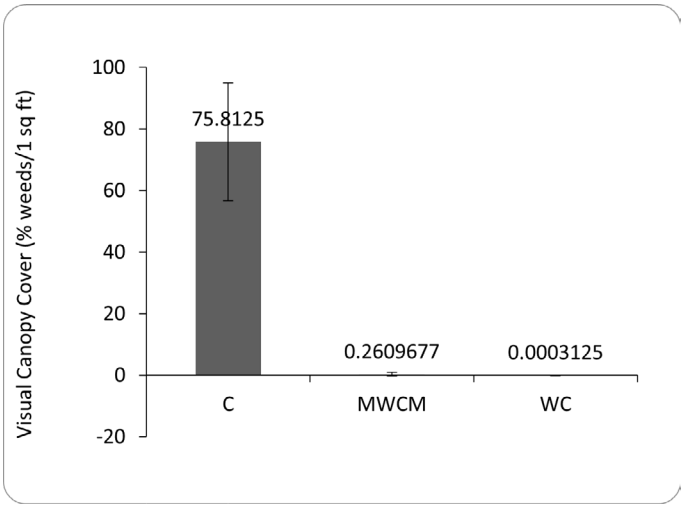

Figure 8. Mean percent canopy cover of all weeds in the irrigated bare ground control (C); irrigated plot covered with a 3" layer of mulch, woven black polypropylene geotextile fabric in the middle, and a thin layer (2") of mulch on top (MWCM); and irrigated plot covered with woven black polypropylene geotextile fabric (WC). Measurements were taken by using visual ratings.

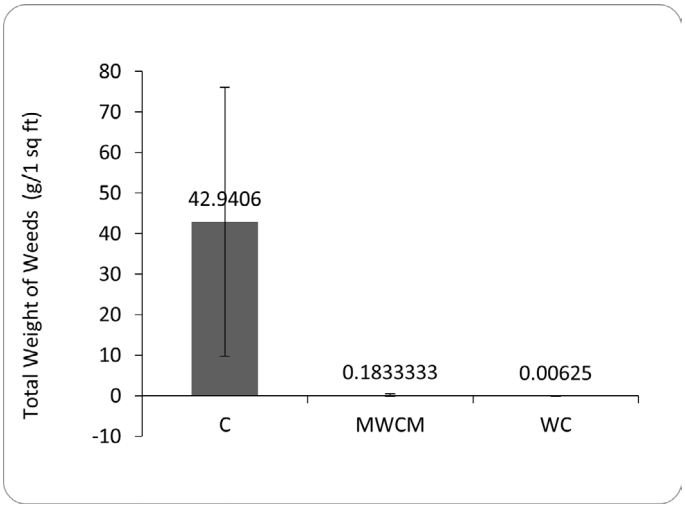

Figure 9. Total weight of all weeds collected above the irrigated bare ground control (C); irrigated plot covered with a 3" layer of mulch, woven black polypropylene geotextile fabric in the middle, and a thin layer (2") of mulch on top (MWCM); and irrigated plot covered with woven black polypropylene geotextile fabric (WC).

Figure 10. Nutsedge germination and suppression under the weed cloth-only (WC) treatment after 14 days.

Figure 11. Nutsedge suppression under the weed cloth and occasional nutsedge penetration through the weed cloth in the MWCM treatment.

Figure 12. Nutsedge suppression under weed cloth-only (WC) treatment after 116 days.

	Number of Shoots (# shoots/1 sq ft)			Canopy Cover (% of weeds/1 sq ft via Canopeo)			Weed Biomass-total weight of weeds (g/1 sq ft)		
Treatment	Mean	Std Dev	MS	Mean	Std Dev	MS	Mean	Std Dev	MS
C	29.375	15.2035	A	64.9453	15.5735	A	42.9406	33.1487	A
MWCM	0.51613	0.72438	B	0.0771	0.23513	B	0.18333	0.30747	B
WC	0.03125	0.17678	C	0.02906	0.1644	B	0.00625	0.03536	C

Table 1. The mean, standard deviation (Std Dev), and mean separation (MS) values for number of nutsedge shoots, canopy cover, and weed biomass ratings of the three treatments: irrigated bare ground control (C), irrigated plot covered with a 3" layer of mulch, woven black polypropylene geotextile fabric in the middle and a thin layer (2") of mulch on top (MWCM), and irrigated plot covered with woven black polypropylene geotextile fabric (WC). Values with the same letters are not significantly different at $P \leq 0.05$, according to Waller-Duncan k-ratio (k = 100) t-test. C=control; MWCM=mulch, weed cloth, mulch treatment; WC=weed cloth treatment.

WC and MWCM exhibited a greatly reduced number of purple nutsedge shoots that penetrated compared to C (Table 1). WC exhibited the lowest purple nutsedge counts at 0.03 plants per square foot. This was followed by MWCM at 0.52 plants per square foot. Bare ground plots exhibited the highest counts at 29.4 plants per square foot.

Percent cover measured visually and with the Canopeo app exhibited similar results. In the Canopeo app, the bare ground control treatment (C) exhibited the highest canopy cover composed of purple nutsedge and other broadleaf weeds and grasses (64.9%) while the WC (0.03%) and MWCM (0.08%) treatments exhibited the lowest canopy cover (Fig. 7 and Table 1). Percent canopy cover between WC and MWCM were similar. Visual percent canopy rating for the bare ground treatment (C) also exhibited the highest value (75.8%) while the WC and MWCM treatments exhibited the lowest canopy cover (0.0003% and 0.26% respectively) (Fig. 8).

The bare ground treatment (C) exhibited the highest weed biomass (42.9 g per square foot) followed by the MWCM treatment (0.18 g per square foot). The WC treatment exhibited the lowest weed biomass at 0.006 g per square foot (Fig. 9 and Table 1).

Discussion and Conclusion

Results of the trial indicate that both WC and MWCM can effectively suppress weed growth in comparison with bare ground soil (Fig. 3, 10, 11). Although the margin is small, WC (weed cloth-only treatment) significantly controlled the total purple nutsedge shoot count better than MWCM. The WC treatment generated the lowest biomass or weed weight, indicating that this treatment had the highest rate of weed suppression. WC exhibited the lowest number of nutsedge plants and weed biomass but did not differ with MWCM in terms of canopy cover. Adding a thin layer of mulch to conceal the weed cloth can increase the number of nutsedge plants penetrating, however, weed suppression up to 116 days after application is acceptable (Fig. 3, 12).

In conclusion, loosely secured weed cloth is the most effective in controlling weeds. The addition of a thin layer of mulch on top of the weed cloth can significantly control weeds up to 116 days after application.

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