Effect of Water Temperature on 2,4-D Ester and Carfentrazone-ethyl Applications for Control of Variable-leaf Milfoil

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INTRODUCTION

Variable-leaf milfoil (Myriophyllum heterophyllum Michx.) is a submersed plant native to southwestern Quebec and Ontario, to North Dakota and southward to New Mexico and Florida (Goldfrey and Wooten 1981). In the Northeastern U.S., variable-leaf milfoil is not native and is considered an invasive and weedy species. As an invasive species, it causes many of the same problems as Eurasian watermilfoil (Myriophyllum spicatum L.), including shading out native submersed vegetation and interfering with recreational activities and water supplies (Halstead et al. 2003, NH-DES 2002). Variable-leaf milfoil is an aggressive invader that can grow up to one inch per day under optimal nutrient, temperature, and light conditions and spreads mainly via fragmentation (NH-DES 2002).

Two herbicides that have been shown to effectively control variable-leaf milfoil include 2,4-D ester ([2,4-dichlorophenoxy]acetic acid) and carfentrazone-ethyl (a,2-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]-4-fluorobenzene propanoic acid, ethyl ester). In greenhouse studies, 2,4-D ester at 500 and 1500 µg ai L\(^{-1}\) exposed for 3, 8, and 24 hours provided 98 to 100% control of variable-leaf milfoil (Netherland and Glomski 2007). Bugbee et al. (2003) also reported that 227 kg ha\(^{-1}\) 2,4-D ester as Navigate controlled nearly all the variable-leaf milfoil in treated field sites. Carfentrazone at 100 µg ai L\(^{-1}\) for 4 to 30 hours was reported to provide 61 to 81% control of variable-leaf milfoil. Doubling the rate of carfentrazone did not improve efficacy (Glomski and Netherland 2007). While there is no published literature regarding field applications of carfentrazone to control variable-leaf milfoil, recent field trials in North Carolina have demonstrated good control (Rob Richardson, pers. comm.).

The effect of water temperature on efficacy of aquatic herbicide applications is not well documented in the literature. Westerdahl and Getsinger (1988) suggest that aquatic plants have low metabolic activity in cooler waters, and this can inhibit herbicide uptake. Studies done by Netherland et al. (2000) and Poovey et al. (2002) demonstrated that as water temperature decreases, plant uptake and metabolism of 2,4-D ester decreases, and therefore efficacy decreases. However, no research has been completed on the effect of water temperature on carfentrazone.

temperature decreased, diquat and endothall efficacy against curly-leaf pondweed was inhibited; however, biomass and tu-
rition formation was significantly reduced with all treatments. Information on the Aquakleen™ (2,4-D ester) and Sting-
ray™ (carfentrazone-ethyl) labels indicate that treatment should take place when weeds are actively growing, yet tem-
peratures are not specified. Many resource agencies have questions regarding the potential efficacy of herbicides if
products are applied early in the growing season when plants are actively growing but water temperatures are quite cool.
Our objective was to determine the effect of water temperature on efficacy of carfentrazone-ethyl and 2,4-D ester appli-
cations for control of variable-leaf milfoil.

MATERIALS AND METHODS

This study was conducted in a greenhouse at the U.S. Ar-
my Engineer Research and Development Center, Lewisville
Aquatic Ecosystem Research Facility (LAERF) in Lewisville,
Texas. Two apical tips of variable-leaf milfoil (15 cm) were
planted in each plastic pot (750 mL), filled with LAERF
pond sediment amended with 3 g L\(^{-1}\) osmocote (16-8-12).
Pots were topped with a 1-cm layer of play sand, and four
pots were placed in each aquarium (66 L). Aquariums were
filled with alum-treated Lake Lewisville water and were situat-
ed in 1000-L fiberglass tanks filled with water. Water tempera-
tures in the aquariums were maintained at 18 to 20 °C by
circulating water in the fiberglass tanks through a Pacific
Coast Imports C-1000 1 HP chiller. Carbon dioxide was bub-
bled into each aquarium once a day to lower the pH to 6.5 to
simulate conditions characteristic to the Northeast where
variable-leaf milfoil is problematic.

Forty-one days after planting, water temperatures were
slowly adjusted to 13, 16, 19, and 22 °C in the aquariums.
Once temperatures stabilized, tanks were treated at 100 µg ai
L\(^{-1}\) carfentrazone (Stingray, FMC Corporation, Philadelphia,
PA), 250 µg ai L\(^{-1}\) 2,4-D ester (Aquakleen, Cerexagri, Phila-
derphia, PA), or 500 µg ai L\(^{-1}\) 2,4-D ester. Treatments were
replicated 4 times and included an untreated control.
Carfentrazone treatments were static exposures due to the
relatively short half-live of carfentrazone, whereas 2,4-D ester
applications were 3-h exposures. Rates and exposures chosen
for this study were based on previous studies (Glomski and
Netherland 2007, Netherland and Glomski 2007). Two days
after the herbicide exposure, temperatures were gradually
adjusted back to 21 °C to stimulate active growth and recovery
of the plants.

At 28 d after treatment (DAT) all viable shoot biomass was
harvested and dried at 65 °C. Data was subjected to a two-way
analysis of variance (ANOVA). Where treatment differences
were detected, a post hoc test was conducted using the Tukey
honestly significant different test (p < 0.05).

RESULTS AND DISCUSSION

All plants treated with 2,4-D ester and carfentrazone at 19
and 22 °C were beginning to exhibit injury symptoms by 2
DAT. Carfentrazone treated plants had bleached tips and
dark red-to-brown stems, while 2,4-D ester treated plants
were exhibiting curling stems. In contrast, no injury symp-
toms were present for plants at 13 and 16 °C. At 10 DAT,
carfentrazone treated plants at all temperatures were necrot-
ic and starting to collapse. Symptoms of 2,4-D exposure were
also now present on plants exposed to 16 °C. By 21 DAT, all
treated plants at 22 °C were dead. At 13, 16, and 19 °C only the
250 ppb 2,4-D and the carfentrazone treated plants still had
a small amount of viable tissue present.

Biomass data indicated no interaction between herbicide
treatment and water temperature and no differences in her-
bicide treatments among the temperatures tested (Figure 1).
All treatments were different compared to the untreated
control. All three herbicide treatments reduced variable-leaf
biomass by 96 to 100%.

Lack of a temperature effect on 2,4-D applications has al-
so been seen in the field. Bugbee et al. (2003) reported good
control of variable-leaf milfoil regardless of the month of ap-
lication (May, Jun, Jul, and Sep). Results from this study in-
dicate that temperature may cause an initial delay in injury
symptoms but overall is not a key factor in carfentrazone or
2,4-D ester efficacy against variable-leaf milfoil. These data
disagree that applications to control variable-leaf milfoil could
take place in early spring when water temperatures are cooler.
Treating the variable-leaf milfoil before it reaches the wa-
ter surface and before native species begin to actively grow
are two advantages to early spring applications.

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INTRODUCTION

Currently melaleuca (Melaleuca quinquenervia [Cav.] Blake [Myrtaceae]) is a long-lived evergreen tree introduced into Florida from its native Australia by horticulturalists during the late 1800s (Dray et al. 2006). The broad-leaved paperbark tree, or melaleuca (Melaleuca quinquenervia), is highly invasive in the forested, grassy fluctuating areas of south Florida (Turner et al. 2004). In contrast, the morphological development of vegetative and reproductive structures in most plants progresses in a stepwise fashion, beginning with a dormant bud and terminating in mature foliage or a propagule. In agricultural and forestry systems, this progression is well studied with regard to the influence of various environmental factors on plant development; however, this understanding of vegetative shoot development and demographics for melaleuca is also necessary to create predictive models of weevil population dynamics and their concomitant effects on melaleuca populations. Such models are valuable when planning weevil redistribution efforts to maximize impacts on melaleuca infestations. Consequently, availability of suitable foliage appears to be the primary factor affecting weevil population dynamics that led to the introduction of the Australian melaleuca snout weevil (Oxyops vitiosa Pascoe [Coleoptera: Curculionidae]) into south Florida (Center et al. 2000). The larvae of this insect feed exclusively on young, tender melaleuca foliage and herbaceous wetlands of south Florida (Turner et al. 2004). In contrast, the morphological development of vegetative and reproductive structures is rarely subjected to detailed characterization of developmental patterns of invasive plants that cause ecological damage can enhance management efforts. Detailed knowledge of plants in natural areas is rarely subjected to detailed characterization of developmental patterns of invasive plants that cause ecological damage. Characterization of developmental patterns of invasive plants that cause ecological damage can enhance management efforts. Characterization of developmental patterns of invasive plants that cause ecological damage can enhance management efforts.

LITERATURE CITED


