The objectives of this experiment were to determine the effects of various grove drive middles management practices on soil moisture levels and changes in vegetation species composition over time.

There are about 850,000 acres of commercial citrus production in Florida, most of which is under some form of grove floor vegetation management program. Varying widths of herbicide bands in the tree rows are determined by tree size and are complemented by mechanical and chemical mowing, and to a lesser extent tillage practices in row middles. Overall weed management can account for 20 to 25% of the total production costs. Estimated annual costs per acre for all vegetation management range from $150 to 200/acre totaling $127.5 to 170 million for the total acreage. Tree row management accounts for $80 to 130/acre totaling $68 to 105 million. Management of drive middles costs per acre are estimated to be $50 to 70/acre, or $42.5 to 59.5 million for the total acreage. It is now estimated that about 50% of total grove middles acreage is under mechanical/chemical mowing programs, for a total cost of about $21 to 30 million. Costs of grove middles management programs can vary with power, machinery requirements, middles width, climate, soil conditions and vegetation species and density (Muraro and Hebb, 1997).

Middles management practices can influence vegetation species composition, soil moisture, nutrient status, erosion potential, grove climate and a host of biological interactions. Vegetative groundcover dries the soil by extracting moisture through roots and transpiring it from leaves to the atmosphere. Vegetation continues to dry the soil even when mowed regularly. When grass species predominate, mowing helps maintain vegetation vigor and water use causing drier soil than under unmown grass. Thus, grass can be very competitive with young trees for soil moisture. In contrast, mowed vegetation in which grasses are not predominant, will reduce competition for moisture with young trees (Davies, 1987). A series of experiments conducted in various deciduous tree fruit crops showed that orchard floor management systems should be based on soil type, vegetative species, water availability, and economic considerations. Where water supplies are limited, systems using residual herbicides, chemical mowing and certain less competitive cover crops should be used (Elmore, 1989; Klinsky and Elmore, 1989; Pritchard et al., 1989).

Abstract. Selection of grove middles management systems may be based upon several considerations including power and machinery and chemical requirements, erosion control, water usage, grove accessibility and freeze hazard. The effect of five middles management practices on soil moisture retention and composition of vegetation were evaluated in a bedded grove in St. Lucie County, Florida. The treatments included mechanical mowing, chopping and combinations of chemical and mechanical mowing at several frequencies. Soil moisture tension sensors were placed at 6 and 12 inches below the soil surface in row middles. Soil moisture depletion was greater for the mechanical mowing and chopping treatments. The chemical mowing treatments retained higher levels of soil moisture than all other treatments. A shift from a mix of grass species to annual weed by chemical mowing was observed.

Florida Agricultural Experiment Station Journal Series No. N-01487. We would like to acknowledge the technical assistance of Mr. Stephen Mayo of MGM Field Research Services. Without his routine gathering of soil moisture data over the period of the experiment, this publication would not have been realized.

Reprinted from

MIDDLES MANAGEMENT METHODS IN CITRUS AFFECT SOIL MOISTURE RETENTION AND VEGETATION SPECIES

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Additional index words. Chemical mowing, glyphosate.

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Materials and Methods

A mature, seepage irrigated, double bedded citrus grove in St. Lucie county on a Winder loamy sand was selected for this study. Five drive middles management treatments were established in spring and summer, 1995. These treatments were: 1) mowing 4× (M), 2) intensive mowing 6-8× (IM), 3) chopping 6-8× (C), 4) chemical mowing 2× and mechanical mowing 3× (CM), and 5) intensive chemical mowing 4× and mechanical mowing 1× (ICM) per year. Standard grove equipment was used for all treatments. Mower blades were operated at about 4 to 6 inches above the soil surface. The chopper was pulled at 5 mph with approximately 2.5 inches of the blades penetrating the soil surface. The chemical mowing treatments were applied using the isopropyl amine salt of glyphosate at the low rate of 0.28 lb ae/acre, with 20% wt/vol addition of ammonium sulfate and with 40 gpa carrier volume. Visual estimates were made of the vegetation by species for each treatment. Ten resistance soil moisture tension blocks (Watermark; Irrometer Co., Inc.) were installed at a depth of 6 inches in each treatment middle and read daily during dry periods or weekly during high soil moisture periods. Sensors were installed horizontally to eliminate disturbance of the soil directly above them. Watermark sensors are resistive type devices which measure soil water status or tension. The tension under which water in a soil is held increases as water is withdrawn from the soil by evaporation, gravity or root activity. The ability of a plant to take up water reduces as the soil water tension increases.

In April, 1996, 10 additional resistance blocks per treatment were installed at a 12-inch depth. Each sensor was installed horizontally in the row middle approximately 3 ft outside the herbicide strip. Readings were taken twice daily by means of a handheld device supplied by the manufacturer calibrated to generate soil moisture tension values. Centibar values for each sensor were recorded and plotted over time. Damaged or defective sensors were replaced as required.

Results and Discussion

Mechanical mowing or chopping treatments did not alter the species distribution of the sward. Swards were initially composed of an approximate equal mix of bermudagrass (Cynodon dactylon (L.) Pers.) and both narrowleaf and broadleaf guineagrass (Panicum maximum Jacq.). However, a shift in species was observed in the chemical mowing treatments during the second year of treatment, resulting in swards composed of a variety of annual weeds including spiny pigweed (Amaranthus spinosus), Virginia pepperweed (Lepidium virginicum L.), field sandbur (Cenchrus echinatus L.) and southern crabgrass (Digitaria ciliaris (Retz.) Koel.).

Three intervals of data are used to illustrate the effect of chemical mowing on soil moisture tension. Average soil moisture tension values for all treatments and depths were within 3 centibars of each other prior to the application of treatments on July 12, 1996 (Fig. 1). Soil moisture tension values increased overtime after chopping (C) and both mechanical mowing treatments (M and

![Figure 1. Effect of drive middle management methods on soil moisture tension at 6-inch depth after treatment application on July 12, 1996.](image-url)
IM). On August 3, 1996, M and IM soil moisture tension values were significantly (P = 0.05) higher at the 6 and 12 inch depths than values for ICM and CM treatments. On August 24, 1996, the ICM treatment was reapplied. Rainfall on September 13, 1996 reduced soil moisture tension below 5 centibars for all treatments. The ICM application maintained lower soil moisture tension values than all other treatments (Fig. 2). Soil moisture tension values for M, C, IM, and CM were not significantly different (P = 0.05) from each other, but were significantly higher (P = 0.05) than values for ICM at all depths on September 27, 1996. All treatments were applied on April 24, 1997. Little differences in soil moisture tension was apparent until the rainfall ceased in mid May. While soil moisture values were higher at the 6-inch depth than 12 inches, CM and ICM treatments tended to maintain lower soil moisture tension (Fig. 3). Mowing (M), C, and IM treatments exhibited significantly (P = 0.05) greater soil moisture tension than CM and ICM treatments at the 12-inch depth on May 24, 1997.

The chemical applications in 1997 were of higher concentration than in 1996 and provided enhanced suppression of the bermuda and guineagrass allowing the annual weeds and grasses to germinate and grow into the sward. This, as well as time of year, may account for the differences in soil moisture tension levels between treatment applications. The amount of water saved in chemical mowing treatments in this experiment was not determined due to the need to calibrate the soil moisture tension values registered by the sensors with the actual soil moisture content values. This relationship varies greatly from soil to soil. As soil moisture tension increase above 30-40 centibars in sand soils, values given by Watermark resistance sensors tend to be higher than those given by tensiometers and must be taken into account when using them to determine soil moisture content. However, this experiment illustrates reduction in evapotranspiration by effective control of vegetation in citrus grove row middles with CM or ICM treatments which may be translated into significantly lower soil moisture tension and thus greater available soil moisture for the trees. The contribution of soil water in the row middles to the total water used by citrus trees is not fully understood. However, any water that can be made available to the tree during times of high evapotranspiration will reduce stress on the tree. Research in these aspects of soil moisture conservation needs to continue in order to further define the impact of chemical mowing programs on soil moisture as these practices become more widely integrated into weed management programs.

**Literature Cited**


Figure 2. Effect of drive middle management methods on soil moisture tension at 6-inch depth after ICM treatment application on August 24, 1996.


Figure 3. Effect of drive middle management methods on soil moisture tension at 6-inch depth after treatment application on April 24, 1997.