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Influence of Plant Position on Growth of Duckweed[1]

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INTRODUCTION

The morphological distinction of root, stem, and leaf for a number of flowering aquatic macrophytes is often not as visible as it is in most terrestrial plants (6). As an example, a duckweed plant (*Lemna* spp. or *Spirodela* spp.) consists only of a frond (a leaf-like structure consisting of a fusion of stem and leaf) or connected fronds with a single or multiple root system on each frond (2).

A considerable amount of information is available on the nutritional requirements of duckweed plants floating in liquid nutrient medium (3); however, the manner in which the various plant parts, especially the roots, function in the uptake of nutrients is not known (6). Recently, Muhonen et al. (5) showed that roots of the giant duckweed [*Spirodela polyrhiza* (L.) Schleid.] contribute very little to the accumulation of the total amount of nutrients taken up by the plant, and they presumed that the major path for nutrient uptake is through the lower surface of the frond.

Uptake of nutrients by the upper surface of the duckweed frond has not been studied. The upper surface of duckweed fronds are nonetheless often exposed to conditions that could result in mineral accumulation. For example, uptake of nutrients could occur when wave action washes water over the surfaces of the fronds or when the plants are stranded on moist sediments in their normal upright position or inverted.

An experiment was conducted to study growth of duckweed plants which were positioned so that nutrients could be absorbed only by the upper or lower plant surfaces. We hypothesized that nutrient uptake may occur via the upper surface since plants that are stranded on the shore may be upside down. Uptake of nutrients during this abnormal state could enable the plants to survive until conditions become more favorable for growth in the normal upright, floating position.

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MATERIALS AND METHODS

Duckweed source. This study used duckweed (*Lemna paucicostata* Hegelm.) plants from a culture that has been maintained since 1978 at the Fort Lauderdale Research and Education Center using axenic culture techniques with periodic transfers of new plants to liquid nutrient media. Culture of plants and experiments were conducted with 1/3-strength Hutner's nutrient medium with 1% sucrose (here in after referred to as HNMS) (3,4).

Duckweed plants were transferred from stock cultures to fresh HNMS media. These fronds were allowed to grow for several days after which they were then placed in several plates each with 24 small wells filled with 1.0 ml of HNMS solution. A single frond was placed in each well. The fronds were inspected after 4 days and only fronds in the L4 stage of development (1) were selected for use in the study.

Axenic culture techniques were used for both maintenance of duckweed plants and for experimental culture conditions. Controlled conditions consisted of an incubator held at 28 C with a photoperiod of 14 hours of light at 28 microE/m^2 x s^{-1}.

Treatments were conducted in petri dishes with dimensions of 100 mm in diameter by 15 mm in height. Treatment 1 consisted of 25 ml of HNMS per petri dish. Treatments 2 and 3 used the same volume of liquid per petri dish except agar was added to the medium at a rate of 1.5% of the solution's weight to provide a solid surface for the plants. In Treatment 2 the duckweed plants were placed in an upright position on the surface of the agar medium while in Treatment 3 the plants were placed upside down.

Each petri dish was inoculated with three plants. The dishes were placed in the controlled environment chamber and the plants allowed to grow for 10 days after which the number of plants were counted. For this study, a single duckweed plant consisted of all fronds attached to each other. Dishes contaminated with bacteria, fungi, etc. were discarded. The experiment consisted of eight petri dishes per treatment and the experiment was repeated twice.

The Statistical Analyses System (SAS) software located at the Northeast Regional Data Center (NERDC) in Gainesville was used to analyze number of plants and multiplication rate using randomized block design procedures. The two repeats of the experiment were considered blocks. The Waller-Duncan Bayesian LSD method was applied to the harvested plant numbers to test if the mean values were significantly different at the 5% level. Prior to analyses, the number of plants were converted to logarithmic values because of the wide range of values found (7); however, the nontransformed values are presented. The Multiplication Rate (MR) proposed by Hillman (3) was used to estimate the daily growth rate.

RESULTS AND DISCUSSION

The number of duckweed plants counted after 10 days of growth on the liquid nutrient medium (Treatment 1) was 7.4 times greater than for Treatment 2 where the plants were cultured in the upright position on the agar (Table 1). Furthermore, the duckweed plants cultured upside down on the agar (Treatment 3) produced 55% more plants than those cultured in the normal, upright position on the agar (Treatment 2).

TABLE 1. GROWTH OF DUCKWEED IN AXENIC CULTURE UNDER CONTROLLED CONDITIONS FOR A 10-DAY GROWTH PERIOD. AT THE BEGINNING OF THE GROWTH PERIOD EACH CULTURE CONTAINER WAS INOCULATED WITH THREE DUCKWEED PLANTS.[a]

Treatment number	Plant position and nutrient medium base	Number of plants after 10 days	Multiplication rate (plants/day)
1	Upright, liquid	214 a	21.1 a
2	Upright, agar	29 c	2.6 c
3	Upside down, agar	45 b	4.2 b

[a]Values within a column followed by the same letter are not significantly different at the 5% level according to the Waller-Duncan Bayesian LSD procedure. Each value is the mean of 16 culture containers.

A multiplication rate of 21 plants per day was calculated for the duckweed plants cultured on the liquid medium. When the plants were placed on a solid nutrient medium the rate was reduced to 2.6 plants per day. However, when the plants were placed upside down on the agar, they grew at a rate of 4.2 plants per day.

Roots of upright plants did not readily penetrate the agar and tended to hold the lower surface of the plant away from the nutrient medium. This perhaps explains why these plants in Treatment 2 did not grow as well as those in Treatment 1.

Gravity did not appear to have any influence on growth of the duckweed plants in Treatment 3. Roots of these plants extended upwards in the air and did not turn toward the agar surface. Nor did any of the new fronds in the inverted position attempt to right themselves to return to their normal growth state as many other plants do. Rather, the inverted fronds continued to multiply and spread over the surface of the agar.

This study provides evidence for nutrient uptake through the upper surface of duckweed fronds although growth rates were found to be considerably less than for upright plants floating in liquid media. Also, these results show nutrient uptake may occur when plants become stranded, either in an inverted or upright position on moist solid surfaces as they were able to continue to grow for a period of time on the agar. Uptake of nutrients in this manner may be one of the mechanisms by which duckweed plants survive during periods of stress until conditions became favorable for growth.

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