GROWTH RESPONSES OF BARLEY SEEDLING TO SIMULATED WEIGHTLESSNESS INDUCED BY TWO-AXIS ROTATION*

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Summary. A device used for simulated weightless studies is described and is called the Nogravatron. The Nogravatron apparatus produces simulated weightlessness by rotating seedlings simultaneously at the rate of 0.25 rpm and 1.0 rpm in two axes perpendicular to each other. Atlas barley seedlings grown on the apparatus grew at rates different from that of stationary controls. Coleoptile elongation in rotated barley was not inhibited by light during the first 55 hours of rotation treatment whereas stationary controls were photoinhibited. After 55 hours the growth of rotated coleoptiles was inhibited by light. The coleoptiles did not show movements and were oriented along the longitudinal axis of the seed. Roots also did not show geotropic movements but the growth direction was affected by the proximity of other roots. Coleoptiles rotated in dark were significantly longer than stationary controls on the third and fourth day but not so on the fifth day and later. Coleoptiles rotated in light were about 35 percent longer than the stationary coleoptiles by the third day and maintained this significant difference to the end of the experiment.

Introduction

In recent years the interest in gravitational effects on organisms has increased greatly, particularly in the realm of the gravity-free or weightless state. At present there is very little information on the effects of long term weightlessness on organisms. Many devices have been built to simulate or create weightlessness but none of these has adequately tested long term reactions [3]. The free-fall devices so far used create true weightlessness but are inadequate because they operate only for a short duration. Water submersion devices used to create weightless sensations in men do not create true weightlessness. Clinostats have been used for many years to study the effect of gravity on plants. The environment on a clinostat can be said to simulate weightlessness for plants, at least in regards to geotropic responses. By slowly rotating the plant the clinostat equally distributes the gravitational force around the horizontal axis. Theoretically the rotated plant should not respond geotropically and thus can be said to be subjected to a simulated weightless environment. However, root and stem bending

responses reported [4, 5, 9, II] for plants grown on clinostats indicate that rotation around a horizontal axis may not always result in a geotropie-free environment. It occurred to us that it might be possible to cancel the bending response with a second rotational movement. Any

stimulus from a rotational movement which induces the bending might hopefully be counteracted by a similar stimulus created by a second rotational movement or the second rotational movement might distribute the bending stimulus equally around the plant and result in little or no bending. We have developed in the Space Biology Laboratory at U.C.L.A. a rotation device that distributes the gravitational force simultaneously along two axes perpendicular to each other. There are two possible orientations for the primary axis: a vertical or a horizontal