PERIODICITIES IN THE INFLUENCES OF AIR IONS ON THE GROWTH OF GARDEN CRESS, *LEPIDIUM SATIVUM* L.

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ABSTRACT

When garden cress was exposed to either positive or negative air ions there was a net increase in the rate of growth, and an apparent periodicity, coincident with lunar phases, in the growth differences between the ion-treated and the control plants. A mechanism is suggested whereby lunar and other geophysical factors influence plant growth and other biotic phenomena.

INTRODUCTION

For over 200 years there has been speculation and support for the idea that electricity, both current and atmospheric, affects plant growth. The early literature on this subject was reviewed by Blackman (1), Dorchester (7), and Krueger *et al.* (8).

Krueger and his associates (8) showed that air ions of either positive or negative polarity significantly stimulate plant growth and recently (9, 10, 11) they studied the mechanics of these phenomena.

Most previous experiments establishing that air ions stimulate plant growth were done over relatively short periods and without comparisons of growth differences during lunar or annual periods.

This paper records the effect of air ions on the growth of garden cress, *Lepidium sativum* L. in experiments covering a three-year period.

METHODS

In all, 130 tests were made and in each separate test 25 seeds of common garden cress, *Lepidium sativum* L., were placed approximately 2 cm apart on each of two growth pads. One pad was treated with air ions, the other served as the control. The pads were 17 × 15-cm wooden frames to which was stapled 32-mesh nylon screening. They floated on 1,500 ml of distilled water contained in 17 × 17 × 8-cm lucite boxes. Surface tension held the screen in contact with the water. Constant light was provided by four, 117-cm long, 40-watt, cool white, rapid-start, fluorescent tubes suspended 40 cm above the growth pads. The growth pads were placed at either end of a revolving (1 rpm) turntable so as to overcome position effects such as variations in light intensity and chance magnetic influence. Air ions of selected polarity, produced by a small tritium ion generator, arrived at the center of the test growth pad at a rate to produce an ion current of 1.8×10^{-9} amps. The growth period was 5 days at 22 ± 1°C and a new test was begun each week from September, 1963 to April, 1966. Growth in each test was measured in terms of the mean length in millimeters between the apex of the longest terminal leaf and the junction between stem and root of the 25 plants in each pad. Fresh distilled water without nutrients was used in each test.

RESULTS

No ion-produced effects on germination were observed, and most seeds germinated and showed good growth within 24 hr. Growth continued over the 5-day experimental periods, with both positive and negative ion-treated plants showing a mean increase in growth over that of the controls.

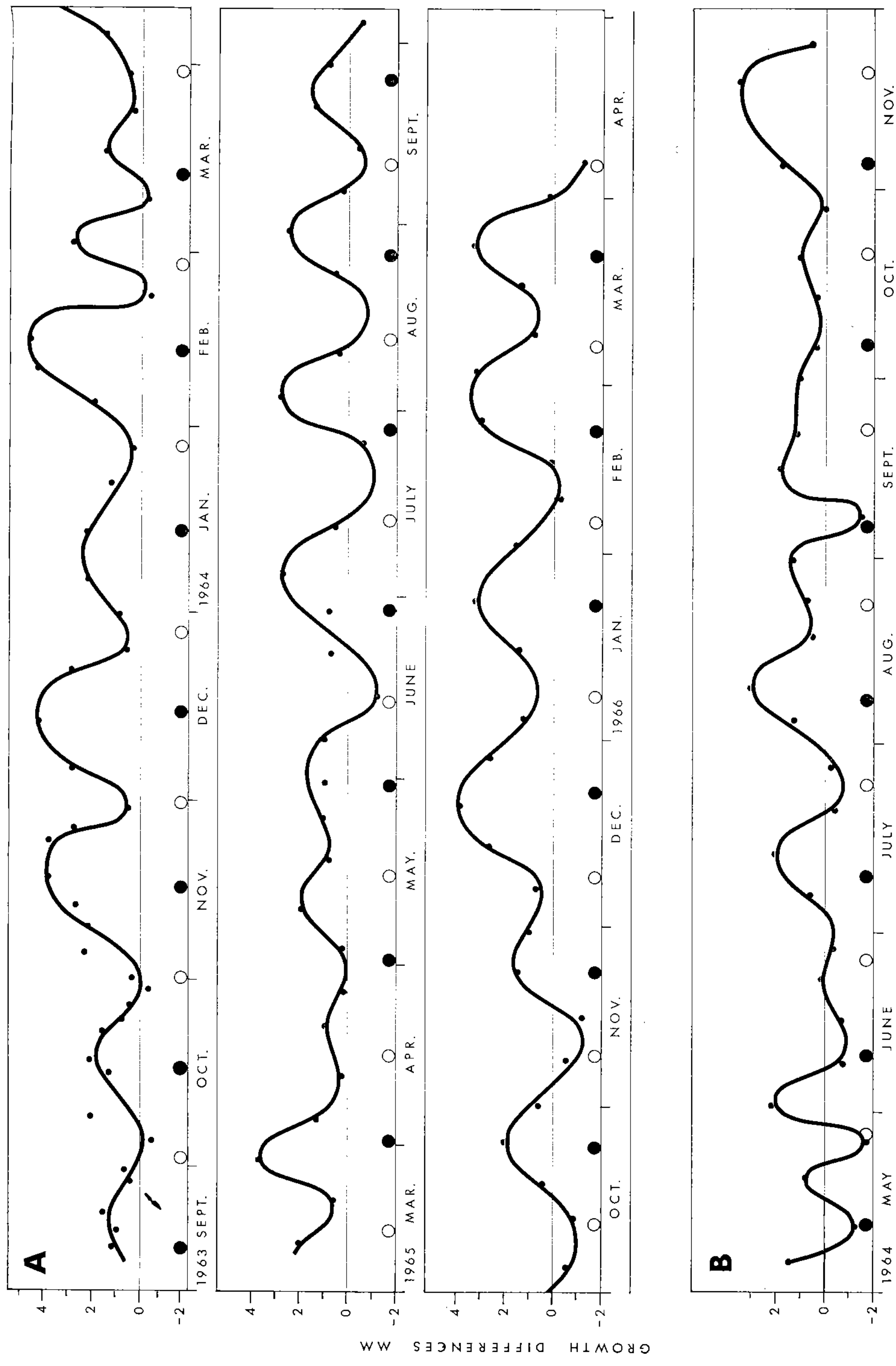

Fig. 1,A. Variations in the differences in growth of *Lepidium sativum* between negative ion-treated plants and controls in relation to lunar phases for a period of twenty months.
Fig. 1,B. Variations in the differences in growth of *Lepidium sativum* between positive ion-treated plants and controls in relation to lunar phases for a period of seven months.

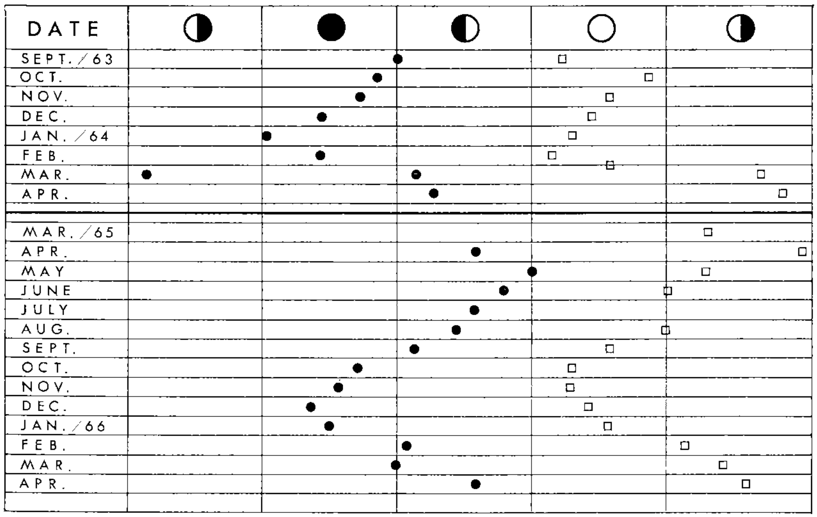

FIG. 2. Maximum growth periods for *Lepidium sativum* exposed to negative ions (dots) and controls (squares) in relation to lunar phases.

The mean length of cress which had been subjected to negative ions in 108 tests was 20.1 mm (standard deviation 2.84), while the mean length of the controls was 18.5 mm (standard deviation 2.92). This was significantly different, with $P < 0.01$ (t-test). The plants that were subjected to positive ions showed a mean growth slightly but not significantly ($P > 0.05$) greater than their paired controls (19.7 vs. 19.0 mm).

The stimulating effect upon plant growth of an atmosphere enriched with positive or negative ions is not in itself unique, but an intriguing facet revealed in this work is a cycling of maximum and minimum effects of the ions upon plant growth.

The differences between the means of negative ion-treated plants and those of the controls for each test were plotted against the day of the year and the phase of the moon, and showed a monthly cycle. In this cycle the maximum difference in growth was on or near the day of the new moon and the minimum difference occurred about the time of the full moon, from October to March (Fig. 1,A). Between March and September there was a tendency for maximum growth differences to occur near the period of the first-quarter moon, and for the minimum differences to shift from the period of the full moon to that of

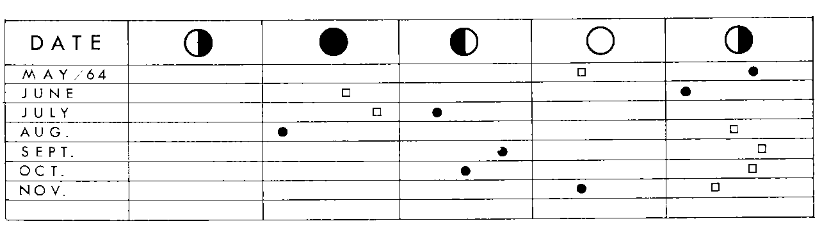

FIG. 3. Maximum growth periods for *Lepidium sativum* exposed to positive ions (dots) and controls (squares) in relation to lunar phases.

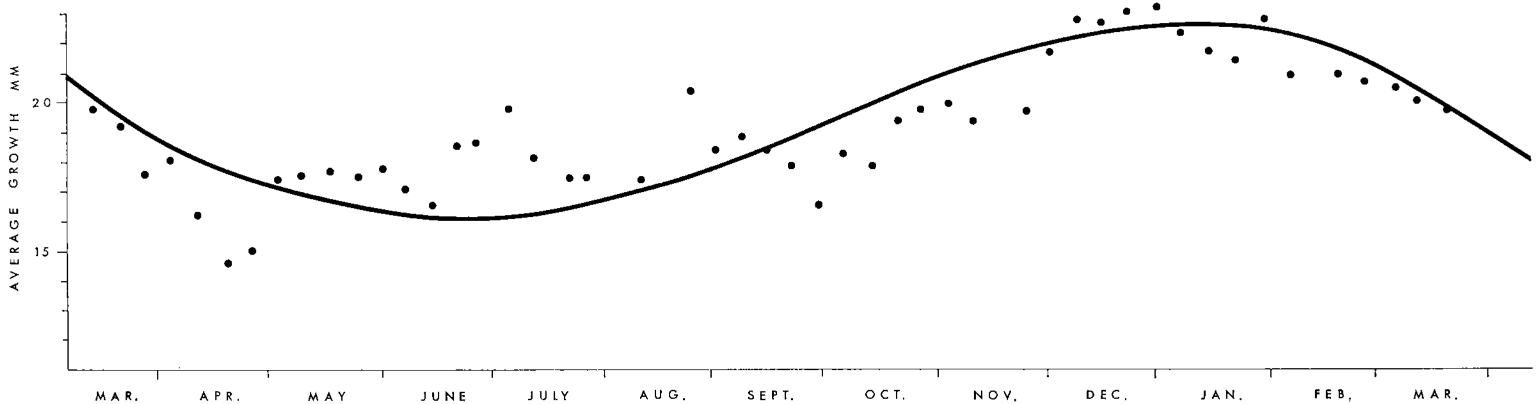

FIG. 4. Average growth of *Lepidium sativum* for all plants (treated and control) in tests extending over one year. Each point represents the mean for fifty plants.

the last-quarter phase. This shift occurs not as an abrupt change between summer and winter positions relative to lunar phases, but as gradual advancements or recessions (Fig. 2). Positive ion influences, though not as regular as those of the negative ions, showed some lunar coincidences (Fig. 1,B) but these are not clearly defined in the maximum growth periods, and the minimum growth periods present a very confused picture (Fig. 3).

The raw data indicated that there was, in addition to the lunar cycles, an annual cycle with maximum growth periods for both ion-treated and control plants occurring from about October to March. Subsequently, the mean growth for all plants in each test year was plotted on a theoretical sine curve based on the actual data (Fig. 4). This showed a somewhat plausible trend, though it left much to be desired.

DISCUSSION

The theory that plant growth is stimulated by air ions has in the past few years become an established fact. It is also becoming increasingly evident that all living organisms are rhythmic systems that respond to rhythmic environmental factors. In the laboratory under controlled light and temperature conditions, average periodicities of the natural geophysical frequencies are demonstrable. In addition to these frequencies, other rhythmic changes with regular periods deviating slightly from those of the natural solar-day or lunar-day often occur (3) such as, for example, the rhythmic responses of living systems to very weak magnetostatic and electrostatic fields and to weak gamma radiation (4, 5, 6).

Sea and littoral organisms have the expected periodicity of behavior and metabolism synchronous with tidal rhythms, and consequently with those of lunar phases. The lunar phase relationship of terrestrial organisms is more difficult to explain. Perhaps, as postulated by Terracini and Brown (14), such lunar-phased periodicity is an inescapable consequence of dwelling in the geophysically varying environment.

Whatever the reason for the periodicities in living organisms, the growth responses of cress to ionized particles follows much the same frequencies as those described by Brown (4, 5, 6). In fact, differences in the growth of cress exposed to negative ions (Fig. 1,A) is almost identical to the frequencies of orientation responses of the planarian, *Dugesia*, in weak magnetic fields (4). This coincidence warrants some speculation.

The earth's atmosphere, magnetosphere, and ionosphere protect living organisms from lethal cosmic radiations, mostly from outer space, and electromagnetic radiations from the sun. The stronger the terrestrial magnetism, the more effective the barrier, and vice versa (2). Terrestrial magnetism varies continuously and includes all the natural periods.

Suppose the moon in its orbit around the earth should act as an interference to incoming cosmic or solar radiations; the maximum interference would occur during the period of the new moon when the moon is between the earth and the sun, and the minimum would occur during the period of the full moon when the moon is farthest from the sun. An additional bonus is a thicker atmosphere caused by the atmospheric tide at the time of new moon. If deleterious radiation retards plant growth, the plants should respond to the protection by growing faster at about the time of the new moon. Further, should plants be subjected to additional applied physical factors such as magnetic, electrical, or radiation fields that act as shields from cosmic-ray influence (12, 13), the differences in responses between treated and untreated organisms should be more apparent near the time of the new moon. Moreover, from October to March further protection from incoming radiation could be afforded by the earth's angle of inclination away from the sun. Greater growth was indeed obtained in the plants during the winter months.

Why then the apparent advancement and recession of the times of maximum plant growth (Fig. 2)? In its orbit about the earth the moon appears to be relatively higher or lower in the sky. This is due to both the movement of the moon and the inclination of the earth's axis, and if the points directly beneath the moon are plotted on a flat map of the earth, the resulting moon track appears as a sine wave. As the orbit of the moon requires 27.3 solar days and the synodical month (period from new moon to new moon) is 29.5 days, the point on the sine wave at time of new moon is repositioned each month out of phase with the previous month by 2.2 days. This is approximately the shift shown in Fig. 2 for the succeeding months.

Because of this shift, the moon does not exert the same relative degree of interference to the incoming radiation each month, at any one particular geographic location. This would permit greater growth of the cress at a specific location at different time periods near the new moon. Also, in Fig. 2 each point shown is for the end of growth period rather than for growth period per se, so that the points should in reality be shifted to the left and would correspond more closely to time of the new moon. The greater growth during the winter months (Fig. 4) may be due to the relatively greater protection afforded by the earth's angle of inclination.

None of the foregoing has explained the erratic results obtained from the tests with the positive ions. It is possible that when there is a limited number of negative electrical particles from the atmosphere, these combine with the positive ions. However, when there is a sudden burst of negative particles, more arrive than can be neutralized. These undeflected and unneutralized particles may retard the plant growth. This possibility was noted in the tests with the negative ions; those plants under the greatest ion concentration often showed a decrease in growth relative to others in the test. The negative ions, though shielding the plants from other radiation and thereby promoting an increase in growth, may have themselves been retarding growth to some extent.

Testing the hypothesis that the moon may aid directly in affecting plant growth or other biotic activity will not be easy. However, circumstantial evidence of a link between lunar and other geophysical periods, and biotic and physical phenomena is accumulating.

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