THE EFFECT OF LIGHT, GRAVITY AND CENTRIFUGAL FORCE ON BUCKWHEAT SEEDLINGS

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It is well known that the shoots of plants will grow toward the light when unilaterally illuminated and that they are negatively geotropic, growing away from the force of gravity, provided all other factors are controlled. Likewise, shoots of plants will grow away from the direction of centrifugal force when they are revolved on a wheel, that is, they will grow toward the center of the wheel if no other elements interfere. But, what will be the direction of growth if two or more of these forces are exerted at once? Will one force completely overshadow the other or can a balance between the forces be found so that the direction of growth will be a median one between them?

In an attempt to answer these questions six points were chosen toward which to work:

(1) To find the dark response time. This response time is defined here as the time required for plants placed in a horizontal position to reach a vertical position, thus forming an angle of ninety degrees; (2) to find the sensitivity point of the seedlings on a revolving wheel; (3) to find the point of balance between gravity and centrifugal force in the absence of light; (4) to determine the distance at which light neutralizes gravity in the response time; (5) to balance gravity plus light against centrifugal force; (6) to find the response time of seedlings to gravity plus light at the distance at which light neutralizes gravity in the response time; (6a) difference in response time due to light. Since light will aid gravity in this case the response time will be shorter than the dark response time.

The plants were grown in ten ounce paper cups and planted in a straight row across the center of the cup. When these attained sufficient height to give good reactions, that is, when the shoots had completely straightened up, all but three or four of the best plants were removed. Plants measuring 3½ cm. to 4½ cm. were found to give the best reactions.

The dark response time, which was also used as the reaction time, was first found by placing plants in a horizontal position and noting the period of time required for them to assume a vertical position, thus forming an angle of ninety degrees. This time was three hours.

To find the sensitivity point the plants were placed on the wheel at a distance of 35 cm. from the axis and revolved in a vertical plane. The plants were at right angles to the plane of the wheel. The lowest speed at which the plants reacted was considered the sensitivity point. This point was found when the wheel made eight revolutions per minute exerting a force of one fortieth of the force exerted by gravity. The angles averaged seven degrees varying individually from zero to fourteen degrees.

In working out the balance point between gravity and centrifugal force in the absence of light the same procedure was used with the exception that the wheel was revolved in a horizontal plane. The plants were in a vertical position so that gravity and centrifugal force worked at right angles. Since a wheel with a radius of 35 cm. will exert one earth

pull when it makes 50.5 R. P. M. (revolutions per minute) this speed and speeds of one R. P. M. more, approximately 1 1/25 gravity, and one R. P. M. less, approximately 24/25 gravity, were used.

In measuring these angles it was found that a margin of seven degrees on either side of the theoretical point of balance must be allowed for natural variation in sensitivity of the plants. Although these plants actually varied seven degrees on either side of 45° when the force of the wheel was one earth pull the combined angles averaged 46°.

At first all the plants were placed in an upright position but later were placed at angles of 65° and 35° from the vertical position and toward the center of the wheel, but in every case they assumed angles which brought them to an approximate point of balance between the two forces. For instance, at a speed of 50.5 R. P. M. or one earth pull, those placed at 35 degrees assumed an average angle of twelve degrees downwards, which brought their tips to a point 47° from the vertical position. In a like manner the shoots at an angle of 65° from the vertical made an angle of 21° upward placing the tips 44° from the vertical. Those placed in a vertical position assumed an average angle of 46°.

The same methods and conditions were used when the wheel was turned at 51.5 R. P. M. or 1 1/25 earth pull, at which speed the plants assumed an average of 50° when placed in a vertical position. At 49.5 R. P. M. or 24/25 earth pulls the angles averaged 37°.

To determine the distance at which light neutralizes gravity in the response time, pots of plants were fastened at different distances above a one hundred watt bulb placed in a dark box with the open end up thus preventing light from going in any but an upward direction. The walls and ceiling of the room were also black preventing any reflections of light. The pots were fastened on a frame work of ring stands with large metal clamps so that they were illuminated on the under side. The experiment continued for three hours, the response time. The balance point was found to be at the end of this time at 120 cm. above the light. The plants varied not more than six degrees from their original horizontal position and this variation might be in either direction.

When the combined factors of light and gravity were balanced against centrifugal force the lights were placed above the plants at the distance at which light balanced gravity. They were arranged in such a manner that only the light from one 100-watt bulb illuminated the plants at a single given moment. The wheel was turned first at 72 R. P. M. which is approximately two earth pulls and later at 70 R. P. M. and 74 R. P. M. which is 1.9 and 2.1 earth pulls respectively. At two earth pulls the plants in a horizontal position averaged angles of 46° upward while those in a vertical position averaged angles of 45° downward. At 1.9 earth pulls the plants in a horizontal position averaged angles of 51° upward and those in a vertical position averaged angles of 41° downward. At 2.1 earth pulls the plants in a horizontal position averaged angles of 38° upward while those in a vertical position averaged 53° downward.

To find the response time of seedlings to gravity plus light at the distance at which light neutralizes gravity in the response time a one hundred watt light bulb was placed 120 cm. above the plants whose shoots were in a horizontal position and the period of time noted for the shoots to assume a vertical position. This time was one hour and fifty minutes.

This was one hour and ten minutes less than the response time in the absence of light.

In conclusion it may be said that in view of this work plants are found to respond to the physical forces light, gravity and centrifugal force with a considerable degree of accuracy.

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