25. Demonstration of geotropism and phototropism to show the region of perception and region of response

Tropic movement is a type of plant growth movement. It normally involves differential growth within the plant or one of its organs in response to some environmental stimuli such as gravity or light. In tropic movement the direction of response is related to the direction of the stimulus.

A tropic phenomenon comprises a sequence of events which may arbitrarily be divided into three stages, namely stimulus perception, physiological mediation and growth response. The first stage involves the perception by the receptor of an environmental stimulus. The final stage is the one when the tropic response is observed. The second stage is the ‘ black box’ that includes all the physiological or biochemical processes which take place between stimulus perception and the growth response. Often the region of perception is different from that of response and the following experiments attempt to demonstrate this.

A. Geotropism

Procedure

1. Prepare a tray of moist vermiculite. Use a pair of clean forceps to insert a number of maize grains, with the root end of the embryo pointing downwards, into the vermiculite.
   (To reduce microbial contamination, do not handle plant materials with bare hands.)
2. Allow the maize grains to germinate and grow for two or three days until the roots are about 2-3 cm long. Select 10 maize seedlings with straight primary roots of about equal length.

3. Use a pair of forceps to randomly pick out one seedling and place it in a petri dish containing some water. Viewing through a stereoscopic microscope, carefully remove the root cap (the opaque part of the root tip) with a scalpel.
4. Repeat step (3) with four other maize seedlings. Leave the roots of the other five seedlings intact as the control. Make sure that the 10 seedlings are kept moist all the time. (Young plant seedlings die of desiccation readily).
5. Fill one 500 ml beaker to a depth of 5 cm with moist vermiculite. Place the five seedlings which have roots decapped, horizontally adjacent to the glass surface so that each root is visible when viewing from the side of the beaker. Fill the beaker with a further 2 cm depth of moist vermiculite. Cover the beaker entirely with aluminium foil.
   (If available, a square or rectangular glass vessel would be more suitable than a beaker.)
6. Repeat step (5) with the five control seedlings.
7. Set the two beakers aside overnight. Remove the aluminium foil and observe the orientation of the roots in each beaker.

Note

1. Roots of the control seedlings should show positive geotropic response while those of the decapped seedlings fail to do so. This is because the geosensitive cells are present in the root cap. However, both the treatment and the control seedlings continue to elongate during the experiment as evidenced by the increase in root length in both cases. If the experiment is allowed to continue for a further few days, each treated seedling will resume geotropic response after the regeneration of a new root cap.

B. Phototropism

Procedure

1. Remove the glumes of about 30 oat grains and soak the oat grains in water for an hour.
2. Fill a plastic cup to the rim with moist vermiculite.
3. Transfer all the soaked oat grains to the cup and place it in a darkroom or a lightproof cabinet until the coleoptiles have reached a height of about 2 cm. This would take 3 to 5 days depending on the temperature. Water whenever necessary.
4. Prepare a cardboard box to be used for the unilateral light treatment experiment. The box should be large enough to house the cup with the coleoptiles in their final size.
5. Paint the inside of the box with matt black paint. On one side of the box, cut a horizontal slit about 10 cm long and 0.5 cm wide and at a height that will allow light to enter and strike the coleoptiles when the cup is in place inside the box.
6. Place the cup under dim red light (safety lamp) in a dark room. Select oat coleoptiles that are straight and remove any atypical ones by cutting them off with a razor blade at the vermiculite level.
7. Wrap a small piece of aluminium foil (about 8 mm^2) around the end of a matchstick to form a small hood.
8. Select two adjacent coleoptiles that are about the same height. Detach the hood and place it over the tip of one coleoptile thus shielding the apical 5 mm or so. Leave the other coleoptile unshielded, as the control.
9. Repeat step (7) & (8) four more times resulting in five apically shielded and five control coleoptiles.
10. Place the cup inside the cardboard box. Switch off the dim red light and allow light from a 25-watt fluorescent lamp at a distance of about 50 cm to enter through the

slit and strike on one side of the coleoptiles for three minutes.

11. Keep the whole set up in the dark for another 90 minutes.
12. Take the cup out of the cardboard box and observe the orientation of the coleoptiles with respect to the direction of the unilateral light.

Note

1. The photoreceptor pigment(s) is/are concentrated at the tip of the oat coleoptiles whereas the region of growth response is located further towards the base. The control coleoptiles should bend towards the direction of light but the apically shielded ones fail to respond.
2. Other treatments could be tried, such as decapitating the tip 3-4 mm of a coleoptile, or shielding the whole coleoptile, except the tip 2 mm, with a tube of aluminium foil before the unilateral light exposure.
3. For such short duration of low light dosage exposure, maximum curvature response would occur about 90 minutes after light stimulation. The bent coleoptiles would straighten up again soon afterwards.