The effect of gravity and centrifugal force on plants

(Item No.: P4050200)

Curricular Relevance

Area of Expertise: Biology

Education Level: University

Topic: Plant Physiology / Botany

Subtopic: Growth and Development

Experiment: The effect of gravity and centrifugal force on plants

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	20 Minutes	1 Hour	2 Students

Additional Requirements:

- Sunflower seedlings

Experiment Variations:

Keywords:

Positive geotropism of roots, Negative geotropism of shoots, Centrifugal force, Rotational speed, Statoliths

Overview

Principle

Related topics

Positive geotropism of roots, negative geotropism of shoots, centrifugal force, rotational speed, statoliths

Principle

To measure the alignment of shoots and roots under the effect of centrifugal forces which are less than, equal to or greater than gravity. To raise sunflower seedlings in small beakers in a rotating drum. To set different centrifugal forces by changing the speed of rotation of the drum motor.

Fig. 1: Experimental set-up

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Equipment

Position No.	Material	Order No.	Quantity
1	Strobe drum	65976-00	1
2	Insertion piece for centrifuge	65976-10	1
3	Motor with disk holder	11614-00	1
4	PHYWE power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
5	Connecting cord, 32 A, 750 mm, red	07362-01	1
6	Connecting cord, 32 A, 750 mm, blue	07362-04	1
7	Support base, variable	02001-00	1
8	Boss head	02043-00	1
9	Support rod, stainless steel, 500 mm	02032-00	2
10	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
11	Glass beaker DURAN®, tall, 50 ml	36001-00	10

Tasks

1. Measure the alignment of shoots and roots under the effect of centrifugal forces which are less than, equal to or greater than gravity.
2. Raise sunflower seedlings in small beakers in a rotating drum.
3. Set different centrifugal forces by changing the speed of rotation of the drum motor.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Set-up and procedure

Set-up

- The strobe drum is secured in one hole of the support base and the 500 mm support rods are inserted into the side of the base (Fig. 1).
- The 250 mm support rod is secured in the other hole of the support base. The motor is then fixed to this support rod with a right-angle clamp in such a way that the pulley wheel of the motor and the base of the strobe drum are located at the same level.
- The drive belt is fitted and tensed. In order to keep the distance between the motor and the drum constant, the support rods inserted into the side of the support base are securely fastened with the yellow levers.
- The motor is connected to the DC output of the power supply unit by means of connecting leads. The power supply unit is set to 0 V / 2 A and switched on.

Procedure

- One sunflower seed is planted in each of 8 beakers filled to the brim with potting mould. The beakers are placed in the holes of the centrifugal insert in such a way that the lip is facing exactly towards the centre of the disc. After removal of the support rod which projects from the drum, the centrifugal insert together with the beakers is placed into the drum. It is important to ensure that the centrifugal inset is positioned exactly in the horizontal plane.
- The power supply voltage is adjusted so that the drum rotates at about 60 rpm. The centrifugal acceleration a at this rotatonal speed corresponds to half the acceleration due to gravity g. The easiest method of determining the rotational speed is to attach a piece of string at a point on the edge of the drum so that it comes into contact with the experimenter`s hand at each rotation of the drum.
- The sunflower seeds resp. seedlings are exposed to acceleration in the centrifuge for a few days. Since the soil will dry out quickly during centrifugation, the beakers must be thoroughly watered at least once daily.
- When the seedlings have reached a length of about 3 cm, the experiment is stopped and the beakers are removed from the centrifugal insert. The inclination of the shoot in each beaker is immediately measured with a goniometer and recorded. The position of the tip of the root is also determined and used for determination of the direction of growth of the roots.
- The experiment is repeated at a drum speed of 85 rpm (= 1 g), 120 rpm (= 2 g) and 150 rpm (= 3 g), using fresh seedlings in each case.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Result and evaluation

Results and evaluation

- The main shoot of a plant generally follows a perpendicular direction away from the centre of gravity of the earth (negative geotropism), whereas the main root grows towards the centre of gravity (positive geotropism). If however the plant is placed on a rotating horizontal disk, this will alter the direction of growth of the shoot and of the root. The force of gravity and the centrifugal force arising as a result of rotation are obviously perceived by the plant as identical. Both forces exert a compressive force on the starch granules present in the cell plasma. These granules probably act as statoliths (in the same way as in animals) for detecting the stimulus of gravity. Only those zones of the shoot and of the root which are still capable of growth can respond to this stimulus, since geotropic behaviour is based on growth movements.
- The anticipated orientation of the shoot and root is calculated for each of the four rotational speeds examined by means of a parallelogram of forces based on gravity and the centrifugal force (Fig. 2). The measured shoot and root orientation (the mean value in each case of 8 angular measurements per rpm) is found to be in good agreement with the calculated value. As is evident from Fig. 2, with the increase in centrifugal acceleration the embryo plants become progressively more inclined in the direction of the rotating disk, with the shoot toward the centre and the root away from the centre.

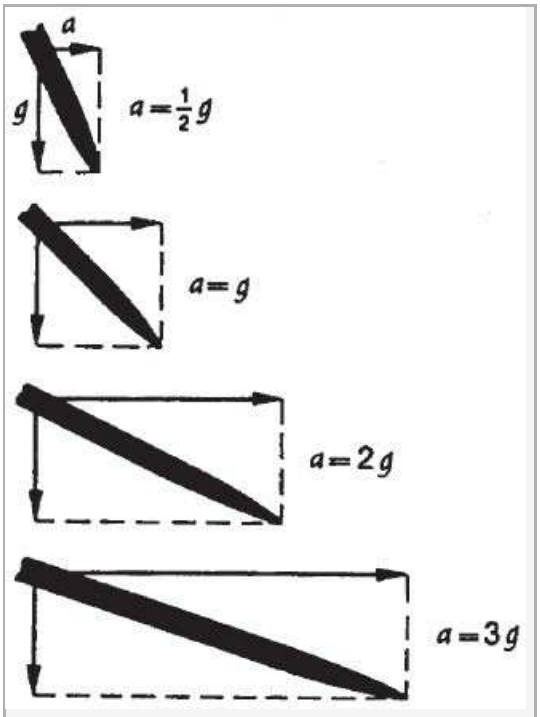

Fig. 2: Root orientation