SHORT COMMUNICATION

A simple technique to determine axial root growth force

Summary

The axial root-growth force developed by gram (Cicer arietinum) and maize (Zea mays L.) seedlings was measured with an A.C. operated direct reading top-pan balance. A radicle was passed through a hole in the bottom of a can and allowed to protrude about 1–2 mm and anchored on the inside of can with dental plaster of paris. Can was filled with soil, moistened and held firmly in a stand. The root tip was guided to a hole in the gypsum block placed on the pan. As the root grew vertically down, it pushed the balance; force was read as a function of time.

Maximum root growth force in gram averaged 14.2 ± 3.6 g and the root growth pressure 4.5 ± 3.8 bars. Similarly in maize, the root growth force was 28.6 ± 7.7 g and the root growth pressure was 10.9 ± 5.9 bars. This study experimentally verified the cyclic behaviour of the development of root growth force postulated by Abdalla et al. 1.

In the absence of a void larger than the diameter of the root tip 13, the root penetrates the soil by forcing and displacing the soil particles in various directions 2. Root penetration into the soil would, thus, be determined by two factors viz (i) displacibility of soil particles or mechanical resistance of soil, and (ii) displacing ability of the root.

Barley and Greacen 3 pointed out that by comparing the forces that can be exerted by plant organs with those that are needed to deform the soil, one can see whether the mechanical properties of the soil are likely to influence root growth. Penetrometers have been extensively employed to obtain this information 3 9 11. But Eavis 8 found that the force required for penetration of a rigid root-shaped penetrometer was four to eight fold greater than that required for root penetration. In view of these discrepancies, direct methods of measuring root growth force are often preferred to the indirect estimates.

Several workers have attempted to measure the root growth force/pressure by direct methods. Growth pressures developed by radicles of germinating seeds were first measured by Pfeffer 7. He found axial growth pressures of several species to range from 12 to 25 bars. More recently, root growth force has been measured by dead load technique and modification of Pfeffer’s method 8 10. But these techniques do not permit the measurement of the rate of development of the force and have a low sensitivity. This paper reports a
rather simple and sensitive technique for the measurement of root growth force.

Method and materials

Ten seeds of gram (*Cicer arietinum*), soaked in water, were germinated in moist soil. After about 2 days a seedling with approximately 2 cm long radicle was selected. The radicle was passed through a 2 mm hole at the base of the container such that about 1 mm tip protruded through the bottom. Dental plaster of paris of a suitable consistency was placed on the inside of the container around the radicle to anchor it. The container was filled with dry soil and water was added to bring the soil to 0.15 g g⁻¹ water content. The container was covered and fixed on a travelling microscope stand that could be moved to a precision of 0.01 mm in the vertical and horizontal directions. The root tip was guided to enter a small hole in a gypsum block placed on the top-pan of a direct-reading electric balance (Fig. 1). The gypsum block was kept moist with a filter paper by wick action. Since the container was firmly supported in place, the root growth force was exerted vertically down on the balance. This force was read from the balance at short time intervals.

Root growth force exerted by maize (*Zea mays* L.) seedlings was also studied using the same procedure except that the soil was used in place of plaster of paris for the anchorage. The studies were conducted in a constant temperature (25 ± 2°C) room.

To compute the root growth pressure, it was necessary to know the cross

![Fig. 1. Schematic diagram of the assembly for measuring root-growth force.](image-url)