

FUTURE TRENDS AND POLICIES IN SOIL-PLANT STUDIES

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Root Growth

The root system supplies the plant with water and mineral nutrients and anchors it in the soil. The supply of soil resources to the above-ground part of the plant is dependent upon the length of root available for absorption at particular times in relation to demand, modified by root distribution with depth, soil condition, etc. New root production varied from year to year; periodicity of root growth can also vary greatly between species. With increasing age, suberized and woody roots make up a higher proportion of the available root length, and roots of this type have been shown to function in the uptake of water and mineral nutrients.

Root growth is important within the soil ecosystem not only to plants, but also to the flora and fauna, which depend upon roots as a food source. In this respect spatial and temporal aspects of root distribution and the transfer of root system production to herbivores, detritivores and decomposers will be vital.

Understanding of the growth, development and physiology of the above ground portion of the plant has reached a relatively sophisticated level and it is possible for plant breeders to use this information in producing cultivars with specific morphological or physiological characteristics. Many complex physiological properties are now routinely measured in field experiments or during the selection phase of a breeding programme. Studies on the underground portion of the plant are much less advanced; some studies still estimate the root system as a fixed fraction of the shoot. Although many studies have considered root systems, often these have been purely descriptive, rather than mechanistic, and have pictured the root system at a single point in time rather than as a dynamic entity showing rapid change. Of studies with mechanistic or dynamic elements many have only used young plants, of a restricted range of species, and growing them in solution culture. Recent changes in the demands on agriculture require a reappraisal of our knowledge of plant root systems and new research targets. Where crops were grown in monoculture, with large fertilizer applications and with maximum production as the sole objective, then the form and efficiency of the root system appeared to be unimportant. With emphasis on lower inputs and greater environmental sensitivity, links between root system characters and the efficiency of functioning become critical. Advances in the available

technology for assessments, such as mini and micro-rhizotron methods, now make it practical to record routinely properties which previously could not easily be measured.

Rhizotrons are designed to measure changes in size and activity of root systems. Qualitative determinations of such characteristics as root colour and root branching can be made along with quantitative measurements of root development, e.g. root length, rooting density, root diameters, root dynamics, and lateral root spread. Root length can be measured on plants growing in a rhizotron, either directly or indirectly, using methods for estimating length such as those developed recently. Often it is desirable to obtain some estimate of the rooting density or the total length or mass of roots per unit volume of soil. These densities can be utilized as appropriate parameters to describe the morphological changes in a root system important to water or ion uptake.

Rhizotrons have been used to study (i) the leaching of chemicals through the soil, (ii) the influence of soil temperature changes on root and plant growth (iii) the influence of changes in soil oxygen content on root growth (iv) the effects of water tables imposed at different growth stages. Other investigations have evaluated the influence of soil compaction. Changes in the depth that plant roots reach over specific time periods can be observed with the minirhizotron system.

The procedures for observing root growth and development known collectively as glass wall methods provide a unique opportunity to study plant root systems continuously *in situ*. One of the more recent advances, the video minirhizotron system, is not only capable of providing information on rooting depth and density in field situations, but also can provide estimates of changes in root orientation and morphological characteristics. The minirhizotron system also provides more flexibility than the rhizotron in terms of the number of crops and replicated treatments that can be investigated during a particular season. However, if the research involves applications such as the study of water or nutrient extraction or the influence of leaching nutrients through the soil as related to root activity, rhizotrons are more advantageous because the soil volume occupied by roots can be controlled.

The development of the modern minirhizotron system has taken place over a relatively short period of time. It is presumed that as future needs induce technological advances, the minirhizotron system will retain an important place in providing a 'window' into the root zone.

Organic Recycling

The rising cost of fertilizers and the need to conserve plant nutrients by recycling them focus attention on organic materials as sources of fertilizer elements. Moreover, organic farming, which eschews the use of soluble fertilizers and pesticides, offers the promise of an improved environment and may also influence soil biology,

including microbial and invertebrate populations. Research on soil nutrient dynamics, should therefore be given priority as this concentrates on the release of both nitrogen and phosphorus from soil organic matter and decomposition of leaf litter. Work on nitrogen should investigate the processes of mineralization and immobilization in relation to both soil water states and microbial activity. Determination of the forms of organically complexed phosphorus in soil solutions and the availability of different forms of phosphorus for plant uptake can be done using a variety of techniques, including NMR spectroscopy and ion-exchange resins.

Inductively Coupled Plasma Spectrometry

Soil is a complex matrix from which it is necessary to extract and determine a variety of biologically important elements. There is, however, currently no single internationally accepted standard method. A wide range of analytical procedures and chemical extractants are currently used to determine plant available nutrients in soil samples. The choice of extraction procedure depends upon the elements to be determined, together with the chemical characteristics of the soil to be analysed. Sometimes the reagents used exert a destructive influence on soil, by dissolving the chemical constituents that might not normally be readily available to plants. The multi-element analysis of soil samples is further complicated by the potentially wide range of concentrations and compositions likely to be encountered.

The development of inductively coupled plasma atomic emission spectrometry (ICP-AES) has arisen in response to the need for a solution analysis technique combining the sensitivity and precision of atomic and precision of atomic absorption spectrometry with a capability for simultaneous multielement determinations. Although high temperature and spark plasmas had been used for the multielement analysis of solid materials many years before the advent of the ICP, their rod like structure made them unsuitable for the injection of liquid samples, even when these were finely dispersed as aerosole.

The merits of the technique may be summarized as follows:-

01. High sensitivity for most elements in the periodic table covering the range 0.001 ng ml^{-1} (e.g. for Bi, Co) to 10 ng ml^{-1} (e.g., for Ca, K, S)
02. The ability to carry out isotopic and isotope ration determinations and to use isotope dilution internal standardization for high-accuracy determinations.
03. Greatly simplified spectra compared with the optical techniques, with the entire periodic table being covered by 211 isotopic lines.

04. The ability to carry out rapid semiquantitative analyses for the majority of elements in the periodic table.

The applications of ICP-AES for the analysis of soils/plant samples varied, and it is gradually replacing atomic absorption as the preferred technique for the multielement analysis of solution samples.

Research Management

Any agricultural research system should be concerned with determining a research programme, implementing it, and communicating appropriately interpreted conclusions to users, of the research outcome *i.e.* information and material. People, facilities and funds are needed to carry out all parts, with their attendant management requirements. Many complex factors enter into deciding what to do, and groups of people are needed at different management levels to make these decisions. The basic elements in any agricultural research system are illustrated in Figure 1.

It should be emphasised that the most critical resource for research is trained manpower. Allocation of resources based on priority assessment should be in terms of person-months of trained manpower, which therefore constitutes the key parameter in any agricultural research system.

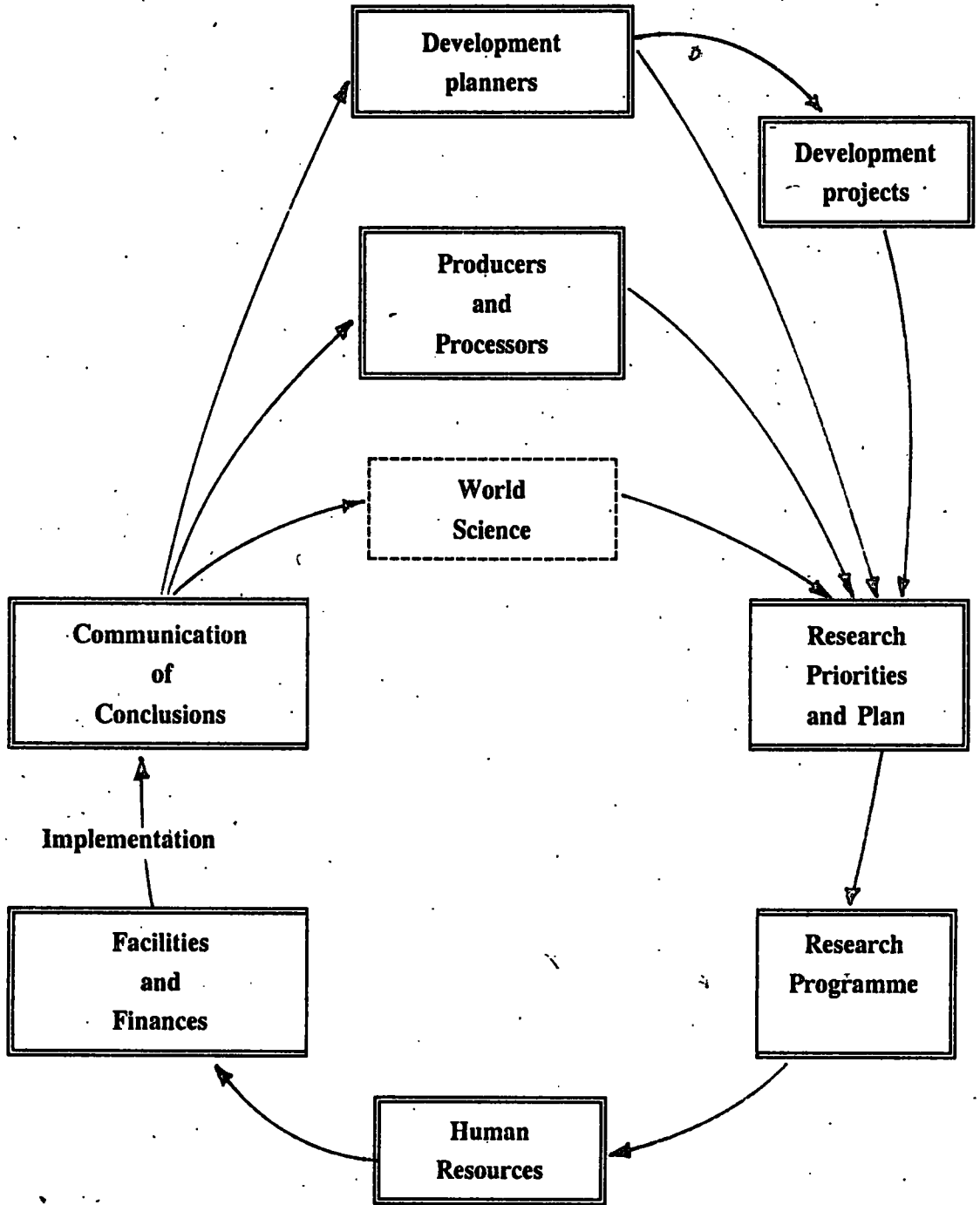


Figure 1. Elements of Agricultural Research System