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Use of Nuclear Techniques in Soil Fertility and Plant Nutrition

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SUMMARY

Radiation and Isotope methods have proved to be very useful in agricultural research and in increasing world food production to the level at which it is today. These methods are being used routinely in fields like plant nutrition and soil fertility, plant breeding, animal production and health, insect pest control, food preservation and pesticide residue studies. With continuous improvements of isotope and radiation methods there is the need to update at regular intervals information used for the training of agricultural scientists in these fields.

INTRODUCTION

Nuclear technology that involves the nuclear reactions of atomic nuclei. Among the notable nuclear technologies are nuclear reactors, nuclear medicine and nuclear weapons. It is also used, among other things, in smoke detectors and gun sights. Nuclear techniques are normally complementary to conventional or classical techniques in agricultural experimentation. Nuclear techniques, which include the usage of radioactive and stable isotopes, had been used in soil fertility, plant nutrition, plant breeding, plant protection and food preservation research works Radioisotopes and Isotopes are variants of a given chemical element that have nuclei with the same number of protons, but different numbers of neutrons. The attributes of naturally decaying atoms, known as radioisotopes. In general, it is possible to separate the nuclear techniques used in soil fertility and plant nutrition into to 2 groups. The first group is the use of radioactive and stable isotopes as a tracer in order to find out the optimum fertilization rate of plants precisely. Eg; 14N, 15N, 31P, 18O, 12C etc .The second group is the use of neutron probe in determining the soil moisture at different periods of the growing season and at various soil depths precisely without any difficulty.

Application In Agriculture

- Techniques that include the use of chemicals or compounds that are tagged with stable or radioisotopes.
- Techniques that include the use of irradiation of the plants, seeds or food with different type of radiation x-rays, a-alpha, p-beta and 8-gamma for obtaining improved varieties of plants, for preserving and increasing the shelf life of food.
- Techniques for improving soil water management practices using neutron probe. Soil fertility and Plant nutrition.
- Irrigation and Water management
- Insect pest control
- Livestock production and health
- Chemical residue and pollution

Application in Soil fertility and Plant nutrition

Genotypic difference in nutrient uptake and use
• Recovery of nutrient from crop residues.
• Nitrogen gaseous losses (volatilization and denitrification)
Degradation of nutrient among plant parts
• Tolerance of plant for salinity and drought
• Time and placement of fertilizer
• Per cent nutrient derived from fertilizer by crop
• Residual effect of fertilizer

Measurement of fertilizer use efficiency:

1) The classical or conventional method based on yield.

2) Methods based on nutrient uptake: Indirect method.
3) Isotopic method: Direct measurement of uptake from the applied fertilizer through the use of isotopes.
By labeling of fertilizer with isotope 15N and radioactive isotopes 32P or 33P.

Fertilizer Use Efficiency: Quantitative measure of the actual uptake of fertilizer nutrient by the plant in relation to the amount of nutrient added to soil.

Ways to detect the presence of labelling isotopes:
1. **Mass-** Mass spectroscopy
2. **Vibrational mode-** IR-spectroscopy
3. **Radioactivedecay-** Nuclear magnetic resonance (NMR),
Autoradiographs of gels- Gel electrophoresis
Liquid scintillation
Geiger-Muller (GM) counters

Stable Isotope Analysis (SIA) - 15N, 13C, 18O and 34S

The isotopes which are stable and do not undergo radioactive decay are measured by the property of their variable mass using mass spectroscopy. In stable isotope analysis, milligram amounts of samples are combusted or pyrolysed at high temperature in a helium carrier gas, the elements are converted into their gaseous form. After suitable preparation the measurable gases (N2, CO2, CO or SO2) are separated on a chromatography column based on the difference in the mass of the atoms. The gas species of different masses are subsequently deflected across a collector array where the individual masses are monitored and quantified against known references.

Radio isotope Analysis

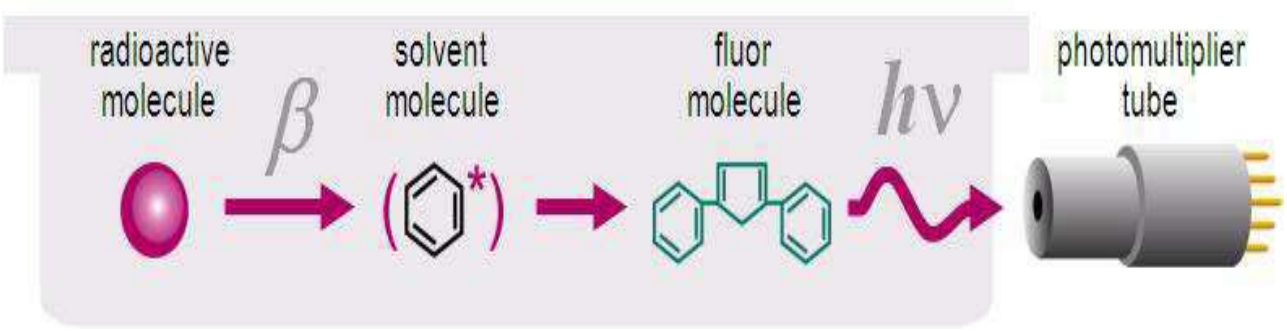
Radio isotopes are unstable and undergo decay. During the process of decay they emit various form of radiations, by measuring the amount of radiation emitted by the isotopes their concentration is measured. The various methods/ instruments used for the radio isotope analysis are: liquid scintillation and Geiger Muller counter (GM counter).

Liquid Scintillation-Counting:

Liquid scintillation counting (LSC) is the standard laboratory method to quantify the radioactivity of low energy radioisotopes, mostly beta-emitting and alpha-emitting isotopes. The sensitive LSC detection method requires specific cocktails to absorb the energy into detectable light pulses. In order to efficiently transfer the emitted energy into light, LSC cocktails must consist of two basic components: The aromatic, organic solvent and the scintillator(s) or fluors.

Principle of LSC:

After excitation of the aromatic solvent molecules through the energy released from a radioactive decay, the energy is next transferred to the scintillator (also sometimes referred to as the "phosphor" or "fluor"). The energy absorbed through the scintillators produces excited states of the electrons, which decay to the ground state and produce a light pulse characteristic for the scintillator. The light is detected by the photomultiplier tube (PMT) of the liquid scintillation counter.



Advantages:

- With the help of radioisotopes we can easily locate the presence of a molecule and their movement.
- Very small quantities of labeled nutrients can be accurately measured in presence of large quantities of other nutrients.
- Tracer technique enables one in tracing those elements taken by the plants accurately and precisely.
- It also helps to study accurately the interaction among the mineral nutrients.
- You can label specific atoms (say carbon goes).

Disadvantages:

- Radioisotopes are rather expensive.
- Radioisotopes are hazardous and must be handled with extreme care as they present a disposal hazard.
- Some radioisotopes (like P-32 and I-125) have short half-lives, so have to be used quickly.

CONCLUSION

Nuclear and isotopic techniques which are now available to determine soil fertility and water requirement of the crops. By using available data can be used to develop integrated and improved crop nutrition, soil and water management practices to ensure sustainable food security and to leave fertile soil for future generations. Radioisotope is a very powerful tool for measuring the nutrient uptake from various sources for studying the processes that influence the efficiency of the applied fertilizer and for assessing the fate of non-efficient fractions, for instance to minimize losses of nutrients and water from the agro-ecosystem.

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