STABLE ISOTOPES IN PLANT NUTRITION, SOIL FERTILITY AND ENVIRONMENTAL STUDIES

PROCEEDINGS OF A SYMPOSIUM
VIENNA, 1–5 OCTOBER 1990
JOINTLY ORGANIZED BY IAEA AND FAO

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1991

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PROCEEDINGS SERIES

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ON THE USE OF STABLE ISOTOPES IN PLANT NUTRITION,
SOIL FERTILITY AND ENVIRONMENTAL STUDIES
JOINTLY ORGANIZED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND THE
FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS
AND HELD IN VIENNA, 1-5 OCTOBER 1990

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The use of stable isotopes in plant nutrition, soil fertility, ecological and environmental studies has increased considerably over the past decade. Stable isotopes have advantages in that they occur naturally and changes in their distribution and natural abundance in soils and plants can give important information on the functioning of ecosystems, organic matter dynamics and important processes such as water use by plants. The experimental use of ^{15}N, ^{13}C and other isotopes has been valuable in various applications, including measurement (and management) of nitrogen fixation, exploration of biochemical pathways, assessment of fertilizer use efficiency and of the uptake of nutrients and their physiological function in plants, and investigation of the dynamics of nutrients in soil, including loss by leaching. In addition to mass spectrometry and emission spectrometry, techniques such as nuclear magnetic resonance, gas chromatography–mass spectrometry and automated nitrogen and carbon analysis–mass spectrometry (ANCA-MS) are playing an increasing role in soil fertility and plant nutrition research, being often the only direct methods available, as well as the most reliable. For example, ANCA-MS may be adapted to determine each of the 14 essential elements in plants which exist as stable isotopes.

The objective of this symposium, attended by about one hundred and fifty participants from over forty countries and six international organizations, was to evaluate progress in the use of stable isotopes to examine various aspects of soil fertility and plant nutrition and some environmental problems, the potential and limitations of existing methods, and possibilities for further development. The symposium focused on the site level rather than the landscape level and, more specifically, on soil–plant relations, although landscape environmental aspects were also examined to some extent.

Two important problems at present are: (a) how to increase or sustain productivity with minimum inputs, and (b) how to limit environmental damage due to inappropriate land management and to industry. Population growth has outstripped food production in many developing countries, including 35 of the 44 sub-Saharan countries, where the present per capita arable land will be halved by the year 2000. The fragile tropical soil systems become rapidly depleted on being farmed, and quickly become infertile. Adequate amounts of fertilizer are often beyond the means of farmers. Insufficient soil nitrogen and lack of soil water are two of the major constraints on sustained productivity and part of the solution is to sustain productivity by effective management of nitrogen fixing plants, by effective use of fertilizers (and water) with regard to appropriate timing and placement, and by selection of highly responsive plant genotypes. This last, major factor, genotype variation, has been largely neglected in developed countries.

The second main current concern, environmental pollution, is not unrelated, especially in view of the high rates of nitrogen fertilizer application to crops in many industrialized countries and the occurrence of nitrates in water supplies — another

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^{15}N LEVELS IN CURRENT GROWTH LEAVES IN A RESPROUTING MEDITERRANEAN SHRUB

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1. INTRODUCTION

Mediterranean type ecosystems have been subjected to recurrent disturbances since ancient times. Population persistence after disturbances depends on the resprouting capacity from basal protected buds [1].

The success of the resprouting mechanisms in reconstructing the above ground biomass of the genet depends critically on the physiological status of both the root system and anatomical structures such as the lignotuber or burl, and on nutrient availability.

We use ^{15}N labelled compounds to investigate the ability of plants to use both internal (storage within plant) and external (soil storage) sources of nitrogen. We investigated this in one species with burl (*Erica arborea* L.). This species is an important component of the Mediterranean maquis in the northeast of the Iberian Peninsula.

2. METHODS

2.1. Study site

The study was conducted in the Corredor mountains (41°40′ N, 2°29′ E), which are located about 30 km north-northeast of Barcelona (northeast Spain). The selected area was sited on a 5° south facing slope at 430 m a.s.l. Mean annual precipitation is 828 mm.

2.2. Experimental design

Three individuals of *E. arborea* were used in ten plots. The study, designed as a complete randomized block experiment, consisted of two blocks. Five treatments were applied:

(1) Unlabelled N fertilizer application (to be harvested after first growing season) (control),
(2) ^{15}N labelled fertilizer application (to be harvested after first growing season),
(3) ^{15}N labelled fertilizer application and removal of plant above ground biomass (to be harvested after second growing season),
(4) ^{15}N labelled fertilizer application (to be harvested after second growing season),
(5) Unlabelled N fertilizer application (to be harvested after second growing season) (control).

Fertilizer was applied at 16 g N/m² (4 at.% ^{15}N excess) in a radius of 40 cm around each individual, diluted in 2 L of distilled water.

3. RESULTS AND DISCUSSION

3.1. ^{15}N

3.1.1. *Comparison of treatments 1 and 2*

E. arborea has the capacity to take up immediately any extra N available. This can be deduced from the high amount of ^{15}N found in current foliage after one growing season (Table I). The difference between treatments 1 and 2 was statistically significant ($P = 0.0001$).

TABLE I. TOTAL N AND ^{15}N ANALYSIS FOR THE DIFFERENT TREATMENTS APPLIED

Treatment	Total N (%)		^{15}N (mg/kg)	
	Mean	SE	Mean	SE
1	1.060	0.049	0.045	0.025
2	1.125	0.025	60.683	13.457
3	1.657	0.076	21.465	5.262
4	1.091	0.039	24.108	4.121
5	1.095	0.047	0.220	0.169

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3.1.2. Comparison of treatments 3 and 4

The difference between treatments 3 and 4 was not statistically significant ($P > 0.05$). This indicates that N retranslocation to current growth from adjacent above ground parts is quantitatively of lesser importance than other sources of N (soil and root systems).

3.2. Total nitrogen

The total N concentration (%) in current foliage averaged 1.09 ± 0.03 (SE) for non-disturbed shrubs (treatments 1, 2, 4, 5), while the N concentration in disturbed ones (treatment 3) averaged 1.66 ± 0.08, the difference being statistically significant ($P = 0.0001$). High leaf N concentration in new resprouts is probably related to high organic matter production during the first months of the resprouting process.

REFERENCE

[1] KEELEY, J.E., "Resilience of Mediterranean shrubs communities to fire", Resilience in Mediterranean-type Ecosystems (DELL, B., HOPKINS, A.J.M., LAMONT, B.B., Eds), Dr. W. Junk Publishers, Dordrecht (1986) 95–112.