PN-ABM-612

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: 4/19/88

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose VO

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. C5-107
PR

Attachment

1 cy

a

PN-ABM-612
79693

CDR Research Project C5-107, Grant PDC-5544-G-55-5082-00

Progress Report and Current Perspective

Title:

Development of a New Field Tool to Optimize Nitrogen Fertilization by the Aquatic Fern Azolla

Principal Investigators in Israel:

Professor Elisha Tel-Or, Department of Agricultural Botany, The Hebrew University of Jerusalem, Rehovot.

Professor Shmuel Malkin, Department of Biochemistry, The Weizmann Institute, Rehovot.

Principal Investigator in Sri Lanka:

Professor S.A. Kulasooriya, Department of Botany, University of Peradeniya, Peradeniya.

Objectives of the programme:

Our joint research programme was aimed to develop a sensitive, fast and useful tool to determine the yield of N-biofertilizer production, under field conditions, by the water fern Azolla. The main goal was to combine the analysis of photosynthesis by the novel photoacoustic device with the analysis of nitrogenase activity by acetylene reduction and to define the interrelation between these activities. Originally, we have planned to study the system in the lab, and transfer the technology to the

APR 19 1990

rice fields, where Azolla is employed as a biofertilizer. It is expected of the field tool to monitor changes in the productivity and N_2-fixation of the Azolla biofertilizer, in response to the various nutritional and environmental limitations, such as phosphate starvation, extreme temperatures, excess light intensity, and poor water quality (due to salinity and pollution), that may confront the Azolla crop.

Results

1. Correlating Photoacoustic to N_2-Fixation

The introductory phase of the programme commenced upon Professor Kulasooriya's visit to our laboratory in Dec. 1985 - Jan. 1996. During his visit we decided to analyse the distribution of photosynthetic activity along the stem of Azolla plant and relate it to nitrogen fixing activity distribution in the same segments. The results of this research led to the interesting conclusion that the major photosynthetic yield is produced by young leaves, while the major part of N_2- fixation takes place in mature leaves along the stem. This indicated that photosynthates may be translocated from young to mature leaves in order to support nitrogenase activity. This conclusion was confirmed in three species of Azolla: A. filiculoides, A. pinnata and A. caroliniana.

Further efforts were directed to analyse the effects of environemntal and nutritional stresses on the photosynthesis, productivity and nitrogenase activity of Azolla.

The temperature tolerance of Azolla was defined during the first year of the project, by the photoacoustic technique, and the heat tolerance of Azolla strains were compared. Apparently, A. pinnata strains, introduced from Sri

Lanka, were more tolerant to high temperature than the New World species: A. filiculoides and A. caroliniana.

The resolution of Azolla response to phosphate starvation, and heavy metal contamination exhibited greater sensitivity of the nitrogenase than the photosynthetic activity. It is evident from the results that by using these techniques environmental stresses and nutritional deficiencies could be easily monitored.

2. Potential Agronomic and Practical Implications

Scientific investigations directed towards the practical use of Azolla for rice production, received an impetus from the pioneering work carried out at the International Rice Research Institute, Philippines, in the mid-seventies. These studies provided useful information on the growth and N_2-fixation of this plant under rice field conditions, and its potential use in rice culture.However, critical information on the photosynthesis of this system was limited, primarily due to the lack of a field applicable method for rapid measurement. The ability of the photoacoustic technique to rapidly monitor photosynthesis, together with the acetylene reduction technique to measure N_2-fixation, enables one to simultaneously evaluate two major metabolic processes in this symbioses and examine the effect of environmental stresses on these processes.

Findings from laboratory studies conducted At the Department of Agricultural Botany, The Hebrew University, Rehovot, and The Weizmann Institute of Science, showed that the tolerance levels of different species of Azolla to temperature and light intensities, are different and that nitrogen fixation is generally more sensitive than photosynthesis to these factors. The practical implications of

these findings are: (1) the application of these techniques to screen species/strains/ecotypes of Azolla, suitable for use in particular localities whose environmental parameters are known or can be measured. (2) As photosynthesis is not inhibited to the same extent as N_2-fixation by high light and temperature, Azolla will continue to grow under such environmental condition, perhaps with little or no N_2-fixation. Such material may produce biomasses impressive to field personnel and farmers who would normally assess the biofertilizer value by the amount of material available for field in=corporation. However, Azolla biomasses produced under such conditions would be of low quality, with high C/N ratios, and will be of little fertilizer value.If the C/N ratios are very high, incorporation of such material could even result in adverse effects like immobilization of available soil nitrogen. Field application of photoacoustic and acetylene reduction techniques would enable the rapid in situ monitoring of the metabolic state of an Azolla growth in a rice field. Once such methodology is tested and standardized, it may be possible to use them to work out an "Azolla fertilizer application schedule" for rice cultivation. In the continuation of this project it is envisaged to verify the laboratory findings from Israel, under field conditions in Sri Lanka and examine to what extent these methods can be applied for practical purposes.

3. Setting Up of the Photoacoustic System in Sri Lanka

One of the innovative aspects of this programme was the adaptation of the photoacoustic system for field measurements, in a developing country like Sri Lanka. The primary objective of Prof. Shmuel Malkin's visit to Sri Lanka in Septemebr 1986, was to set up this apparatus, 1st in a laboratory at the department of Botany, University of Peradeniya and then to examine the feasibility of using it

at field stations located in predominantly rice growing areas of the country. Within a week of his arrival in Peradeniya, Prof. Malkin was successful in setting up the photoacoustic apparatus and measuring the photosynthesis of green house grown Azolla material. During the 2nd week,, he travelled more than 300 km to the deep down south of the island, and set up the apparatus at a field station at Ambalantota, in the low-country dry zone of Sri Lanka. The apparatus was also set up at another station in Bombumela, in the low country wet zone, about 170 km from Peradeniya. At both these stations,, the apparatus was set up in one day and measurements were done the next day. This clearly showed that the photoacoustic apparatus is a versatile piece of equipment which is simple to assemble and operate even in suburban areas, in a developing country situation. During his visit, Prof. Malkin was able to train a graduate student in Sri Lanka who is now competent to operate the apparatus by himself. It is noteworthy, that this collaborative project has opened up a programme of study for a graduate student in Sri Lanka, in an area quite novel to a developing country.

Wherever the photoacoustic apparatus was set up, plant physiologists and agronomists showed a special interest on the applicability of this technique to monitor photosynthesis of crop plants during field growth. Although such a venture appears to be outside the scope of this projject, it highlights the potential application of this apparatus that could have a tremendous impact on crop production.

4. The Control of N_2-Fixation by Photosynthates and Light

Prof. Kulasooriya has decided to spend his sabbatical leave in Rehovot, starting October 1987 to June 1988, and intensify the fundamental understanding of the relationship between photosynthates produced by the host, and nitrogenase

activity conducted by the symbiont - Anabaena. He works jointly with my Ph.D. Student - Mr. E. Bar, who has chosen to study this system. We have already observed some interesting, yet unknown, phenomena on the regulation of N_2-fixation in Azolla by light, and feel ~~most~~ confident that this information will be most valuable and novel for future optimization of N-biofertilizer in the field.

Future Objectives

Upon entering the 3rd year of the programme, we are satisfied by the progress and the knowledge that was gained until now. We also wish to declare that this cooperation involves active participation of all three principal investigators, and their teams. The close collaboration and personal relations presents a most productive atmosphere.

a. The PA technique, combined with ARA can, definitely, be used to monitor the effect of environmental stresses and to indicate improper nutrition or poor water quality of the Azolla. However, this approach has not yet been extended and monitored in the field.

b. Convincing evidences were shown, in laboratory studies, on the control of nitrogen fixation by light quality and photosynthates. During 1988 we will make an endeavour to accumulate as much information and insight as possible, in the hope that it will be applicable to Azolla productivity in the field. Nevertheless, this will depend on the extension of our joint research programme.

In view of the above report, we would greatly appreciate a positive consideration of our request for an extension of the support by the AID authorities.