BANGLADESH AGRICULTURE

Volume 4 Number 1 January 2011

BAAG 1993

JOURNAL OF BANGLADESH ACADEMY OF AGRICULTURE

BANGLADESH AGRICULTURE

Volume 4 Number 1 January 2011

BAAG
1993

JOURNAL OF BANGLADESH ACADEMY OF AGRICULTURE

Published by : Bangladesh Academy of Agriculture, 3-C, Centre Point Concord (3rd Floor),
14 A & 31 A Tejkunipara, Airport Road, Farmgate, Dhaka-1215
Tel : 8115204, E-mail : bkazi@dhaka.agni.com

ISBN : 984 - 31 - 1511 - 6

Subscription Rate :

	Individual		Institution	
Annual	Tk. 200	US $ 30	Tk. 300	US $ 40
Single Copy	Tk. 100	US $ 15	Tk. 150	US $ 20

All communications should be addressed to :

The Editor
Bangladesh Academy of Agriculture
C/O: Dr. Kazi M. Badruddoza
Scientist Emeritus, NARS-B
BARC, Airport Road, Farmgate, Dhaka-1215
Tel : 8115204, E-mail : bkazi@dhaka.agni.com

Printed by :
Bangladesh Academy of Agriculture

BANGLADESH AGRICULTURE

Volume 4 **Number: 1** **January 2011**

Table of Contents

Articles dealing with the past activities, present status and future guidelines in one or more disciplines of agriculture will get priority for publication in this journal. Original research work, both fundamental and applied, will also receive priority. The articles, in addition to being on research results, should preferably be on policy, management, advancement and frontier issues of research, extension and economic aspects on different disciplines/ subjects related to agriculture. The disciplines/ subjects would encompass all sub-sectors of broad-sense agriculture i.e, crops, fisheries, livestock, forestry, environment, economics etc.

The topics may also entail current and future scenarios for improvement of sustainability of the fragile eco-system, food security, natural resource management, input distribution & management, nutrition, agribusiness, climatic risk management, human resource development and economic implications of rapid globalization obtaining since the recent past. The retrospects and prospects of agricultural improvement vis-à-vis the constraints hindering progress of agricultural development are burning topics needing elaborate analysis and synthesis for the policy markers, teachers, researches, extensonists, service providers, marketing agents, NGOs and private sector entrepreneurs, will also get preference.

The authors are to note the following instructions.

1. Typing the manuscript: Manuscript should be typed in double spacing on A4 size papers leaving at least 2.5 cm in all sides. The text and tables may be typed in 10 points and 4 or 6 point type, respectively on one side of the page only. The full-length articles ordinarily may not exceed 10 typed pages including Tables, Figurers and References.

2. Title of the article: The title should be short, specific and informative. There may not be any scientific name in the title unless it is absolutely necessary, a running (short) title with maximum of 40 characters should be typed at the top of each page.

3. Name of the author(s) and of the institution (s) should be written as under:

a) in case of one or more authors working in the same institution as

M. Ziaul Karim, Department of Agronomy, Bangladesh Agricultural University Mymensigh

b) In case of more than one author working in different places as Bangladesh Agricultural University, Mymensigh and Ahmed U. Sarker, Bangladesh Jute Research Institute, Dhaka.

4. Abstract: The abstract should be completely self-explanatory in a single paragraph summarizing the objective, method(s), contents and conclusion of the topic. It should be typed in italic font.

5. Original research based full-length article may have the following main headings: Introduction, Materials and Methods, Results and Discussion followed by a Conclusion. If possible, Review- based articles should be described under necessary headings and sub-headings with comments on each and every important item of discussion.

6) Tables: Each table with a descriptive title should be typed in a separate page. The tables are to be numbered as they are placed in the body of the text.

7) Figures and Photographs: Drawing diagrams, graphs etc. should be made in India ink on tracing paper in a form ready for plating. Photographs should be printed in black and white on glossy papers. On the back of each illustration write in soft pencil the number of figure, name(s) of the author(s) and short title of the articles. Magnified drawings and photographs may either show bar scale or numerical magnification. Grouped photographs and drawing should comprise a symmetrical rectangle or square.

8) Literature citation: In the text citation should be made consistently following the " Name and Year Systems" as Shaikh (1998) or (Shaikh,1998) in case of single author, Alam and Miah (1997)in case of two authors or Rahman et al., (1996) in case of three or more authors.

List literature citations, references or bibliography at the end of the paper in alphabetical order. Examples:

- Ahmed S.S. 1997, Cytogenetics of the jute, Bangladesh Jute Fibre Res.10(2): 107-110.
- Ali, M.S., S.A. Khan and A.R. Chowdhury, 1998. Production of rice in the changing climatic condition of Bangladesh. Bangladesh Agriculture: 1(1): 9-13.
- BARC, 1995. Fibre Crops of Bangladesh, Bangladesh Agric. Res. Council, Dhaka.
- Khan A.A.1958, Production of rice without irrigation. In: M.A Ali, Bangladesh Agric. Res Council, Dhaka. Pp 217-241.
- Rahman, S.1987. Water stress in potato. In: Annual Report, Bangladesh Agric, Res. Institute, Gazipur, Pp. 170-190.

Editor

- **Two hard copies and a soft copy should be submitted.**

Genetic Conservation : Microbes to Man[1]

M. S. Swaminathan[2]

When N.I. Vavilov* was born, Mendel's laws of heredity were yet to be rediscovered. Leading botanists were, however, fascinated by the enormous variability occurring in nature. Attempts were made to collect and conserve some of this variability in botanical gardens and national parks. It was, however, only after the rediscovery in 1900 of the laws of inheritance propounded by Gregor Mendel in 1865 that planned research on the effective utilization of genetic diversity in plants and animals began. We own it to Vavilov for showing the importance of genetic diversity in crop improvement.

Vavilov's great contribution was not only that he demonstrated the value of genetic diversity in breeding research but that he also developed a systematic plan of action for collecting genetic material from the primary centers of origin of crop lands. He explained the relationships between genetic diversity and centers of origin of crop plants. Addressing the 6th International Congress of Genetics held at Ithaca, USA in 1932, Vavilov pointed out that "the growing needs of civilized man and the development of industry make the introduction of new plants necessary. The vast resources of wild species, especially in the tropics, have been practically untouched by investigation."

Even when Vavilov was explaining the importance of plant exploration and conservation, concern was expressed by several geneticists over the loss of genetic stocks due to the process of modernization of agriculture.

It was pointed out that without coordinated efforts around the world, valuable genes could be lost through neglect. The need for a clear national policy on genetic stocks and genetic diversity has been stressed at numerous symposia on genetic conservation.

We salute Vavilov for his farsighted vision. Today, tissue culture and genetic engineering techniques have opened up possibilities for the transfer of genes across sexual barriers. This possibility has enhanced the value of wild relatives of crop plants. Interest in genetic conservation has therefore grown enormously in recent years.

In this lecture dedicated to Vavilov's

---

[1] Paper presented at the 100th Anniversary of Academician N.I. Vavilov (the great Rassian Geneticist), Moscow, 24-25 November 1987.

[1] Director General : Indian Agricultural Research Council, New Delhi and International Rice Research Institute, Los Banos, The Philippines.

memory, I would like to briefly refer to a few key issues in genetic conservation ranging from microbes to man. I shall confine myself to problems of particular interest in the field of crop improvement. In my Presidential Address at the XV International Congress of Genetics, I had dealt with the current status of our efforts in the conservation of biological diversity in considerable detail (Swaminathan 1983). I shall hence confine myself to a few of the recent developments.

I. Nitrogen Fixing Organisms

There is a growing interest in the conservation and utilization of biological nitrogen fixing organisms. The reason for this interest is the rapid growth in the energy needed to produce a ton of grain using essentially mineral fertilizer produced from fossil fuel based feedstocks (Table 1).

At the International Rice Research Institute (IRRI), an extensive program of research on azolla, bluegreen algae and green manure crops is, therefore, in progress. Recently, it has become possible to produce hybrids among azolla species as well as between azolla and anabaena. Therefore, the conservation of azolla species, many of which have distinct characteristics, has become important. The IRRI collection now consists of 353 accessions from different parts of the world (Table 2).

Legume-Rhizobium germplasm collection and conservation

There are about 650 genera and 18.000 species in the family Leguminosae mostly found in the tropics (National Academy of Sciences, 1979). Many species yield seeds that are rich in protein and constitute valuable sources of food and fodder; others are important either as components of pasture or used as green manures or timber. Legumes are valued for their nitrogen-fixing ability. The nitrogen contribution of legumes can be vital for maintaining the sustainability of intensive production systems.

Although thousands of species of legumes are known, only a few are economically exploited and still fewer are available in the form of germplasm. The work on collection of genetic resources of tropical non-grain legumes started only a few decades ago. The major collections are held by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia: the Centro International de Agriculture Tropical (CIAT), Colombia, International Livestock Centre for Africa (ILCA) in Ethiopia, International Council for Research in Agroforestry (ICRAF) in Nairobi and the University of Hawaii. Among all the collection centers, the largest and the most comprehensive collections are with CSIRO, CIAT, and ILCA (Table 3).

At IRRI, a Biofertilizer Germplasm center has been established to

preserve the genetic resources of leguminous green manures like Azolla, bluegreen algae, and bacteria including rhizobia. Collections of biofertilizer germplasm will be expanded, and characterization and evaluation will be made. The collection is being made available to researchers, extension workers, and farmers all over the world. The importance of germplasm collection and conservation is manifested by the recent exploration by French scientists of hitherto unknown aquatic legumes, e.g *Sesbania rostrata*, and species of *Aeschynomene* (*A. nilotica* and *A. afraspera*) that grow wild in the waterlogged soils of Senegal, Africa (Rinaudo et al., 1983 and Alazard and Becker, 1987). These legumes are fast growing, produce nodules on both roots and stems, and can grow under flooded conditions. They have opened up new possibilities for integrating a green manure crop into rice farming system without disturbing current cropping systems very much. It has been found that growing and incorporating a 40 to 50-day old *S. rostrata* crop before wet season rice can add up to 100 kg N/ha (Ladha et al., 1987).

Research on legume-Rhizobium symbiosis has led to the establishment of collections of rhizobia in many places throughout the world. In 1974 the UNEP /UNESCO /ICRO Panel of Microbiology started the concept of Mocrobiological Resources Centers (MIRCENs) and the major goal was the conservation of Rhizobium gene pools in developing countries. Since then several MIRCEN centers are operating (Table 4). The World Data Center (WDC) for microorganisms supported by UNESCO /UNEP published the World Catalogue of Rhizobium Collections in 1983.

Sexual hybridization

Wei et al. (1986) reported the success of sexual hybridization between two species of Azolla (*A. filiculoides* and *A. microphylla*). The hybrid was confirmed by esterase isozyme pattern. In some crosses, new sporophytes happened to be albino and could not grow in N-free medium. One hybrid, which was tested in the field in Fujian in China, showed hybrid vigor and exhibited cold temperature tolerance that was apparently inherited from one parent. The F_1, however, did not form megasporocarps.

At IRRI and the University of the Philippines at Los Banos, "hybrids" have been obtained between *A. microphylla* and *A. filiculoides*. But hybridization has not yet been tested by biochemical means (Watanabe et al., 1987).

A combination of interspecific hybridization and change of algal partner would be useful to change Azolla's characters for better agricultural use and wider applications.

Blue-green algae

During the last thirty years, blue-green algae (BGA) have become recognized as a major group of prokaryotes. As pointed by Stanier (1980), one hundred fifty years ago, BGA were left without much question to the botanists, in view of the classical definition of the term algae as encompassingall oxygenic phototrophs of simple general structure. As a result, research on BGA was basically concerned with two descriptive elements: taxonomy and ecology. The recognition of the prokaryotic nature of BGA has opened up new fields of microbiological research on cyanobacteria, the name coined by Stanier(1980) to emphasize the prokaryotic nature of BGA.

Interest in BGA arises from:

1) The ability of a number of genera to fix atmospheric nitrogen, which has implications in the maintenance of fertility of the natural and cultivated ecosystems. In particular, BGA are of importance in rice fields where their growth and N_2 – fixing activity can be enhanced by inoculation and various cultural practices, thus providing a cheap source of nitrogen for the crop (Roger and Kulasooriya, 1980).
2) The high nitrogen content of some genera, especially Spirulina, and the possible usage of certain strains as food or feed (Venkataraman, 1983).
3) The possible usage of BGA as a source of useful biochemicals.
4) Academic curiosity for organisms that constitute the largest number of most diverse and most widely distributed group of photosynthetic prokayotes.

For most eukaryotic organisms, and especially for cultivated plants, gene erosion is the major reason for establishing germplasm banks. For prokaryotic organisms, in the contrary, there is certainly very little risk of gene erosion. In particular, BGA are the most ancient living organisms on earth. They are ubiquitous, able to grow or survive in almost any environment including extreme ones and exhibit a very large morphological, ecological, and genetic diversity. The major reason for establishing a collection of BGA comes from the difficulties to isolate and characterize strains. Once a strain has been isolated, there is very little chance to reisolate it from another ecosystem (or even from the same ecosystem) and to be sure of the identity of the material.
Because facilities are not yet available for a large culture collection at IRRI, only a restricted number of N_2 – fixing strains (Table 5) is being maintained. the major purpose is to have available range of strains for producing inocula for

field inoculation experiments. Therefore, no special trials are made to purify the strains which are maintained as unialgal material. However, a fex axenic strains obtained from other laboratories (mainly the Pasteur Institute) are maintained, for basic studies, in liquid medium and on agar slants. Unialgal strains are maintained in liquid medium and as dry powdered inocula.

II. Crop Plants

Until recently issues relating to the collection, conservation and utilization of crop genetic resources were primarily of interest to plant breeders and conservationists. After World War II, fears of large scale genetic erosion caused by the destruction of the habitats where genetic variability exists in nature led to a stepping up of efforts in both *in situ* (biosphere reserves) and *ex situ* (gene banks) conservation. The Consultative Group on International Agricultural Research (CGIAR) established an International Board for Plant Genetic Resources (IBPGR) in 1974 for promoting coordinated efforts in the collection, conservation, and utilization of crop genetic resources. of late, political interest and concern, particularly with reference to the question of ownership of gene banks has grown. The reasons for this development stem from the realization that access to genetic variability is essential not only for avoiding genetic vulnerability to pests and diseases but also to take full advantage of recent progress in molecular biology and genetic engineering. Developing countries which constitute the most important centers of origin and diversity of economic plants have to produce more and more food from less and less land in the decades and centuries ahead. This can be done only by increasing crop yield per day on a sustainable basis, thereby harvesting solar energy to the maximum possible extent. Increasing productivity and intensity of cropping are the twin pathways of achieving higher yield per day, which is the only meaningful way of measuring yield in the tropics and subtropics.
This will call for the efficient utilization of genetic variability for tailoring new strains of crop plants characterized by higher yield potential and greater resistance to a broad spectrum of climatic and soil stresses in addition to pests. Developing countries, therefore, are concerned with the implications of the future of total privatization of plant breeding research in developed countries with regard to the easy and non-commercial access to the genetic resources collected from their countries and conserved in gene banks in developed countries. This concern resulted in the adoption in November 1983 by member nations of FAO, with reservations by some countries, of a resolution on an

International Undertaking on Plant Genetic Resources (IUPGR). The undertaking aims to achieve the following purposes:

1. to promote greater efforts in the exploration of plant genetic resources;
2. to facilitate the adoption of appropriate legislative and other measures for the preservation, evaluation, and documentation of genetic material;
3. to allow access to samples of genetic resources and to permit their export where the resources have been requested for the purpose of scientific research, plant breeding, or genetic resource conservation;
4. to strengthen international cooperation and to improve the capabilities of developing countries;
5. to foster a coordinated network of national, regional, and international network of base collections in gene banks under the auspices of FAO;
6. to develop a global information system on available crop genetic resources; and
7. to promote greater financial support and security to conservation work.

To promote the implementation of the provisions of the international undertaking on plant genetic resources, FAO has also established a Commission on Plant Genetic Resources. This commission whose membership is open to all member nations and associate members of FAO will monitor the operation and arrangements for the implementation of the international undertaking and take or recommend measures that are necessary or desirable to ensure the comprehensiveness of the global system of conservation.

As mentioned earlier, these initiatives on the part of FAO had their genesis in the growing apprehension among several developing countries that the introduction of plant breeders' rights and crop variety patenting may hinder the availability of useful genetic material to developing countries (Mooney 1983 and Barton 1982). Under a convention signed by several countries in Europe, the breeders of a new plant variety will be eligible for royalty for at least 18 years in the case of trees and vines, and at least 15 years for all other plants. This convention is administered by the International Union for the Protection of New Varieties of Plants (UPOV) which is an inter-governmental organization. The UPOV Convention of Plants was signed in Paris on December 2, 1961, and amended by an additional Act signed in Geneva on November 10, 1978. The objective of the convention is the protection of plant patent rights (Swaminathan, 1983).

A new plant variety for the purpose of patent rights must be clearly distinguishable by one or more

important characteristics from any other variety whose existence is known at the time protection is applied for. Distinctions from existing varieties, homogeneity, and stability are important for recognition.

The major aim of legislation relating to Plant Breeders Rights (PBR) is to provide stimulus to private sector breeding and investment. Various views have been expressed on the positive and negative implications of PBR legislation (Brown 1983, and IBPGR 1983). According to IBPGR, the issue of PBR in relation to genetic resources is of no great significance. What is urgently needed is greater effort in the collection and conservation of the basic sources of variation in wild and weedy species and primitive cultivars to prevent genetic erosion. However, IBPGR has also warned that "consent for the transfer of material under development may be more difficult to obtain than hitherto."

The importance of access to wild species and strains of rice for introducing genes for resistance to pest of commercial importance will be clear from the following recent experiments in rice:

1. Novel sources of resistance / tolerance to insect pests and viral diseases as a result of screening wild rices in the Entomology and Plant Pathology departments of the International Rice Research Institute (IRRI) are listed in Table 6. The only sources of resistance to date to whorl maggot, Hydrella philippina, has been found in a wild species (Heinrichs et al., 1985).
2. Resistance to biotype 2 of the grassy stunt virus has only been found in a perennial rice accession, Guan-ken A/0. rufipogon / /0. longistaminata (Agwero et al.,1984).
3. Hill rice Mijingem from Bangladesh has more xylem vessels in its roots and is thus better able to withstand short drought periods than the lowland cultivars with fewer xylem vessels (IRRI, 1986).
4. An incect pest of increasing significance in South and Southeast Asia is the leaffolder, Cnaphalocrosis medinalis. The primary sources of resistance to this pest are found in traditiobnal varieties. The resistant traditional varieties, Muthumanikam and Yakadayan from Sri Lanka and Gora and Kalachikon from Cox's Bazaar district, Bangladesh were collected by IRRI field collectors.

It is therefore obvious that we have to take steps to preserve for current and future use a full spectrum of germplasm in all economic plants. Also, today's needs may be very different from those of the plant breeders in the 21st century, because of changing food habits and processing methods on the one hand, and projected climatic changes on the other.

In situ conservation through biosphere reserves and national parks is important not only for conserving biological diversity but also for preserving the ecological conditions under which variability is generated and maintained. However, *ex situ* methods of conservation are becoming even more urgent because of the widespread destruction of natural ecosystems. In a recent book, Plucknett, Smith, Williams, and Anishetty (1987) have described the steps taken in recent years to establish gene banks for *ex situ* conservation. Such gene banks aim to maintain a representative sample of gene pools originating from the different sources indicated in Figure 1.

The existing gene banks fall under the following 3 major categories:

1. Nationally organized, supported and controlled gene banks in developed and developing countries. Some of the largest collections under this category are at Leningrad in the USSR and in Fort Collins (National Seed Storage Laboratory) in the USA. In recent years, IBPGR and bilateral donors have supported the establishment of long term seed storage facilities in developing countries. A Gene Bank where over 400.000 seed samples can be preserved for long term conservation has recently been established at Beijing with support from the Rockefeller Foundation and IRRI.
2. Regional gene banks like the Nordic gene bank at Lund in Sweden and the Mediterranean gene bank at Bari in Italy.
3. Gene banks maintained by international agricultural research centers (IARCs). These have become very important sources of availability of genetic variability because IARCs not only conserve germplasm but more importantly screen and describe the important genes contained in the collection. Nigel Smith (1987) has given information on the existing collections in IARCs (Table 7).

The need for extensive use of land races in breeding new varieties will be clear from a comparison of the pedigrees of IR8 and IR66 rices (Figures 2 and 3).
Figure 4 shows how modern varieties involve pyramiding of genes from a large number of primitive cultivars. The International Rice Germplasm Center at IRRI now has over 80.000 accessions consisting of the following material:

0. sativa accessions
72,550
0. glaberrima strains
2,983
Genetic testers and mutants
695
Populations of wild species
2,268

Twenty-three wild species are conserved from 61 countries while 4,465 samples have been newly received.
IRRI also maintains all the wild species of *Oryza*, several of which have very useful traits which are now being transferred to the cultivated rice with the help of tissue culture and genetic engineering technology (Table 8).

III. Implications of the Transition from Mendelian to Molecular Techniques

Following the development of recombinant DNA technology, existing genetic resources could be used to a greater extent than is presently possible. Firstly, it will become possible to introduce specific genes into a target plant without causing large-scale disruptions in the existing selected and adapted genome. Secondly, it will greatly extend the horizons of sources of genes for transfer into any particular target species, extending this horizon beyond the current perimeter defined by the barriers of sexual hybridization procedures. In this respect, existing genetic resources may be stored as seeds or tissues for subsequent DNA extraction, or as DNA libraries.
A number of gene transfer systems are being developed in plants with varying degrees of success. The first proven DNA method for introducing genes into plants involves the Crown Gall tumor-inducing bacterium, *Agrobacterium tumefascins,* which provides a natural vector system for 'foreign'DNA, inserted into the T-DNA segment of the bacterium's plasmid. Recently alien genes have been introduced into cells of both monocotyledonous and dicotyledonous plants and stable transformation has occurred in many dicotyledonous species (Uchimiya et al, 1986., Spielmann and Simpson, 1986 respectively). Other established methods of DNA transfer include microinjection and electroporation.

The biggest limitation to the efficifent exploitation of genetic resources through recombinant DNA techniques will be our ability to identify the appropriate gene to meet a particular challenge. Maintenance of a complete DNA library would allow gene transfer by a shotgun approach, followed by the selection of transformants possessing the required phenotype. This system would avoid the need for precise molecular identification of the gene and would be comparable to what a plant breeder does in his normal hybridization-based plant breeding. Peacock (1984) considers that DNA libraries have no particular advantage over a seed "gene library" because in a seed is a collection of genes which is coordinated to a high degree. A DNA gene library, on the other hand, would present us with the total genetic information but not with coordinated information. However, he considers that an *in vitro*-based storage system for vegetatively propagated plants of those with recalcitrant seeds is an extremely risky and expensive form of storage. Therefore, gene library may safely perpetuate a range of genetic variation which will become increasingly available for incorporation into genes as our recombinant DNA methodologies become progressively more sophisticated.

Such transformation studies have also been successful with animals, an example being the transformation of mice with rat growth hormone genes using microinjection techniques (Parmiter et al, 1982). The insertion of donor DNA into one of the transposable sequences which are present in many *Drosophila* species has proved successful in achieving high levels of gene function in the right tissue.

The methods of DNA-mediated gene transfer will increasingly permit the introduction into cells of normally functioning genes to replace defective single genes. A DNA library of human genes can be envisaged for therapeutic purposes. In fact, over 200 human genes have already been cloned, of which over 100 are associated with clinical diseases (Robinson, 1987).

Two types of gene therapy can be defined. Somatic therapy entails the production of defined genes *in vitro* and their introduction into the cells that require them, in functional and normally regulated fashion. This is a form of replacement therapy that is in principle no different from all medical therapy. Germ-line therapy, on the other hand, requires the introduction of functional genes into gametes or fertilized eggs. When this approach is practical, it will produce genetic "cures" which will be passed on to the offspring. This type of therapy may have to be closely regulated to prevent abuses (Robinson, 1987).

Such types of DNA transfer are not just limited to transfer of genetic resources between related species or genera. Fischoff et al, (1987) were able to determine structure of the insect control protein gene from the bacterium *Bacillus thuringiensis* var. *kurstaki* HD-1. Truncated forms of the gene that express a functional insecticide protein were generated and successfully incorporated into tomato plants, using a plant expression vector for *Agrobacterium*-mediated trans-formation. Transgenic tomato plants were produced which expressed the insect control protein gene and were tolerant to the insect pest.

New opportunities for introducing *in vitro* methods of collecting germ plasm in the field are also now becoming available (Withers, 1987).

IV. Looking Ahead: Need for a Global Germplasm Ethic

We can now develop an integrated conservation strategy ranging from the *in situ* conservation of populations to conservation at the molecular level.

Biosphere reserves and national parks are becoming important instruments for the *in situ* conservation of biodiversity. The establishment of such biosphere reserves is particularly important in the main Vavilov centers of origin of crop plants. In November 1972, a Convention for the Protection of the World Cultural and Natural Heritage was adopted by the UNESCO General Conference. This convention provides the framework for international cooperation in conserving the world's outstanding natural properties. IUCN (1982) has published an indicative inventory of natural sites of world heritage quality.

Plant genetic conservation is, unfortunately, becoming an area of considerable controversy on the basis of ownership and patenting issues. What is urgently needed is a *global germ plasm ethic.* While professionals and political leaders may quarrel, it is not surprising that in some of the world's less disturbed habitats indigenous tribal people as well as traditional farmers are practicing a holistic germ plasm ethic. Aldo Leopold (1966) whose birth centenary also falls this year proposed a land ethic for the protection of our land resources. What we need now is a similar global germ plasm ethic for the conservation, evaluation, and utilization of genetic resources of economic plants and animals for the purpose of increasing human happiness and welfare everywhere.

Nicolai Ivanovich Vavilov triggered the present day scientific efforts in germ plasm exploration, collection, and conservation. On the occasion of the birth centenary of this great scientist, may I propose that we develop and foster a Global Germ Plasm Ethic which will provide a framework for coordinated action by scientists, farmers, and development administrators in the conservation of biodiversity so essential for the maintenance and enhancement of quality of life. Diversity is the essence of life. Such a Global Germ Plasm Ethic can, therefore, become an important instrument of promoting sustainable food and nutrition security.

References

Alazard, D. and M. Becker. 1987. *Aeschynomene* as green manure for rice. Plant Soil 101:141-143.

Agwero, V.M.,P.Q. Cabauatan and H. Hibino. 1984. A possible source of resistance to rice reassy stunt virus (GSV). IRRN. 9(3):11-12.

Aldo, L. 1986. The land ethic. In : A Sand County Almanac. Ballantine Books, New York. 237-264 pp.

Barton, J.H. 1982. The international breeder's rights system and crop plant innovation. Science 216:1071-1075.

Brown, W.L. 1983. Genetic diversity and genetic vulnerability – an appraisal. Econ. Bot. 7(1):4-12.

Fischhoff, D.A., K.S. Bowdish, F.J. Perlak, P.G. Marrone, S.M. McCormick, J.G.

Niedermeyer, D.A. Dean, K. Kusano-Kretzmer, E.J. Mayer, D.E. Rochester, S.G. Rogers, and R.T. Fraley. 1987. Insect tolaerant transgenic tomato plants. Bio/Technology 5, 807-813.

Heinrichs, E.H., F.G. Medrano and H.R. Rapusas. 1985. Genetic evaluation for insect resistance in rice. IRRI, Los Banos, Philippines. 356 pp.

International Board for Plant Genetic Resources. 1983. Plant varieties rights and genetics resources. 8 pp. IBPGR, Rome.

International Rice Research Institute. 1986. IRRI Research Highlights 1985. IRRI, Los Banos, Philippines.

International Union for Conservation of Nature and Natural Resources. 1982. The World's Greatest Natural Areas: An Indicative Inventory of Natural Sites of World Heritage Quality. IUCN, Gland, Switzerland. 69 pp.

Ladha, J.K., I. Watanabe, and S. Saono. 1987. N_2 fixation by leguminous green manure and practices for its enhancement in tropical lowland rice. In: Proceedings of the Symposium on Sustainable Agriculture – the Role of Green Manure Crops in Farming Systems. International Rice Research Institute, Los Banos, Philippines.

Mooney, P.R. 1983. The Law of the Seed. Development Dialogue, Dag Hammarskjold Foundation, Uppsala. 172 pp.

National Academy of Sciences. 1979. Tropical legumes: Resources for the Future. Washington, D.C. 3318.

Parmiter, R.D. R. L. Brinster, R.Ej. Hammer, M. Ej. Trumbauer, M.G. Rosenfeld, N.C. Birnberg, and R.M. Evans. 1982. Dramatic growth of mice that develop from eggs microinjected with metallothionein-growth hormone fusion genes. Nature 300: 611-615.

Peacock, W.J. 1984. The impact of molecular biology on genetic resources. In "Genetics: New

Frontiers" Volume IV, Applied Genetics, Proceedings of the XV International Congress of Genetics, New Delhi, 1984 . Eds. V.L. Chopra, B.C. Joshi, R.P. Sharma, and H.C. Bansal.

Plucknett, D.L., N.J. H. Smith, J.T. Williams and N. Murthi Anishetty. 1987. Gene banks and the world's food. Princeton University Press, Princeton, New Jersey. 247 pp.

Rinaudo, G., B. Dreyfys, and Y. Dommergues. 1983. *Sesbania rostrata* a green manure and the nitrogen content of rice crop and soil. Soil Biol. Biochem. 15:111-113.

Robinson, A. 1987. Genetics and the futurje of medicine. Somatic Cell and Molecular Genetics 13 (4): 485-489.

Roger, P.A. and S.A. Kulasooriya. 1980. Blue-green algae and Rice. The International Rice Research Institute, Los Banos, Philippines. 112 pp.

Schultze-Kraft, R. 1987. Germplasm collection and evaluation of tropical legumes. Paper presented in Symposium on Sustainable Agriculture – the role of green manure crops in rice farming systems 25-29 May 1987. IRRI, Los Banos, Philippines.

Smith, N.J.H. 1987. Genebanks: a global pay-off. The Professional Geographer, 39 (1), 1987. pp. 1-8.

Spielman, A. and R.B. Simpson. 1986. T-DNA structure in transgenic tobacco plants with multiple independent integration sites. Molecular and General Genetics 205:34-41.

Swaminathan, M.S. 1983. Genetic conservation: microbes to man. Presidential address delivered at XV International Congress of Genetics. In: Genetics: New Frontiers. Vol. I. Oxford and IBH Publishing Co., New Delhi.

Uchimiya, H., T. Fushimi, H. Hashimoto, H. Harada, K. Syono, and Y. Sugawara. 1986. Expression of a foreign gene in callus derived from DNA-treated protoplasts of rice (*Oryza sativa* L.) Molecular and General Genetics 204: 204-207.

Venkataraman, L.V. 1983. Blue-green alga spirulina. Department of Science and Technology, India. 100 pp.

Watanabe, I., C. Lin, C. Ramirez, M. T. Lapis, and C.C. Liu. 1987. Physiology and agronomy of Azolla-Anabaena symbiosis. Plant and Soil (In press).

Wei, W.X., G.Y. Jin, and N. Zhang. 1986. Preliminary report of Azolla hybridization studies. Bull. Fujian Agric. Sci. 1:73-79 (in Chinese).

Withers, L.A. 1987. In Vitro methods for collecting germplasm in the field. In: Plant Genetic Resources Newsletter Bull. 69. 56 pp.

Worldwatch Institute. 1987. State of the World 1987. W.W. Norton & Company, New York. 268 pp.

Table 1.World Agricultural Energy Use and Grain Production, 1950-85

Year	Energy Use in Agriculture	Grain Production	Energy Use to Produce a Ton of Grain
	(million barrels of oil equivalent)	(million metric tons)	(barrels of oil equivalent)
1950	276	624	0.44
1960	545	841	0.65
1970	970	1,093	0.89
1980	1,609	1,423	1.13
1985	1,903	1,667	1.14

Source: Worldwatch Institute estimates based on U.S. Department of Agriculture data; David Pimentel, Energy Utilization in Agriculture; Gordon Slogget, Energy in U.S. Agriculture; W.R. Rangeley, "Irrigation and Drainage in the World" and "Irrigation – Current Trends and A Future Perspective."

Table 2 : *Azolla* collection at IRRI.

Specie	Number of total collection	Origin
A. pinnata var. *imbricata*	117	Australia, Bangladesh, China, India, Indonesia, Japan, Malaysia, Nigeria, Pakistan, Philippines, Sri Lanka, Thailand, Taiwan, USA, Vietnam.
A. filiculoides	81	Brazil, China, Colombia, Germany, Japan, Peru, Philippines, UK. USA.
A. mexicana	5	USA, Guyana
A. caroliniana	44	Brazil, China, Philippines, UK, USA
A. microphylla	48	China, Galapagos, Paraguay, Philippines
A. nilotica	1	Sudan
A. Rubra	9	Japan
A. pinnata var. *pinnata*	46	Australia, Ivory Coast, Malagasy, Senegal, Mexico.
Unclassified	1	Mexico
Hybrid*	7	Philippines, China
Total	353	

- Hybrids between *A. filiculoides* x *A. filiculoides*, *A. filiculoides* x *A. microphylla*, *A. microphylla* x *A. microphylla*, *A. microphylla* x *A. filiculoides*, *A. microphylla* x *A. mexicana*.

Table 3. Germplasm collections of forage legumes.

Genus	CSIRO	CIAT	ILCA
Acacia	50	*)	100
Aeschynomene	450	850	100
Alysicarpus	250	250	150
Cajanus	300	50	100
Calopogoinum	150	500	50
Canavalia	100	200	*)
Cassia	250	300	100
Centrosema	1200	1900	300
Clitoria	100	150	50
Crotalaria	300	250	150
Desmanthus	200	150	50
Desmodium	1500	2550	150
Dioclea	*)	200	*)
Dolichos	50	*)	*)
Eriosema	*)	100	*)
Erythrina	*)	*)	50
Flemingia	*)	50	*)
Galactia	100	550	*)
Glycine	100	*)	*)
Indigofera	450	200	150
Lablab	150	*)	150
Leucaena	600	150	100
Lotonomis	100	*)	*)
Lotus	200	*)	*)
Macoptilium/Vigna/Phaseolus	1300	1250	750
Macrotyloma	150	50	50
Mucuna	*)	50	*)
Neonotinia	250	100	200
Phyllodium	*)	50	*)
Pseudarthria	50	50	*)
Pueraria	100	200	*)
Rhynchosia	300	400	150
Sesbania	150	50	*)
Stylosanthes	2000	3250	900
Tephrosia	250	150	100
Teramnus	100	300	50
Trifolium	1200	50	1050
Uraria	100	150	*)
Vicia	100	*)	*)
Zornia	100	950	250
Total	**12750**	**15500**	**5250**

- = Fewer than 50 accessions

Source: R. Schultze-Kraft (1987) Germplasm collection and evaluation tropical legumes. Paper presented in the Symposium on Sustainable Agriculture – the Role of Green Manure Crops in Rice Farming Systems, 25-29 May, 1987. IRRI, Los Banos, The Philippines.

Table 4. Rhizobia Culture Collections*

Institutions	Country	No. of strains
MIRCENs		
Porto Alegre	Brasil	650
Nairobi	Kenya	208
Hawaii	USA	2000
Beltsville	USA	938
		3796
Others Centers*	Argentina, Brasil, Chile, Colombia** Peru, Uruguay	5410

* No a available for large collections of Australia

** CIAT, Colombia – 3000 strains, mainly of pasture tropical legumes

Source: R. Schultze-Kraft (1987) Germplasm collection and evaluation of tropical legumes. Paper presented in the Symposium on Sustainable Agriculture – the Role of Green Manure Crops in Rice Farming Systems 25-29 May 1987. IRRI, Los Banos, The Philippines.

Table 5: Number and origin of collection of blue-green algae. IRRI, 1987.

Genera	Africa		Asia		Europe	Other	Total
	Senegal	Other	Philipp.	Other		Regions	
Anabaena	20	2	5	11	9	3	50
Aphanothece	0	1	1	0	0	0	2
Aulosira	1	1	0	1	0	1	4
Calothrix	14	2	5	3	0	1	25
Cylindrospermum	4	1	1	0	0	0	6
Gloeotrichia	1	0	3	0	0	0	4
Fischerella	0	3	7	0	0	0	10
Nodularia	2	0	1	1	0	0	4
Nostoc	20	6	13	13	2	5	59
Scytonema	6	0	1	1	0	0	8
Tolypothrix	0	0	0	4	0	0	4
Wollea	0	0	1	0	0	0	1
Westiellopsis	0	1	0	0	0	0	1
N_2 -fixing	68	16	38	34	11	10	177
Nonfixing	16	0	0	1	1	0	18
Total	84	16	38	35	12	10	195

Table 6. Sources of resistance found in wild *Oryza* spp.

Source	Nature
0. eichingeri, 0. minuta, 0. officinalis	Resistance to BPH biotypes 1, 2,3, GLH, ZZLH, WBPH, YSB and thrips
0. alta, 0. australiensis, 0. brachyantha, 0. grandiglums, 0. punctata, 0. ridleyi 0. rufipogon	Resistant to RRSV
Guang-keng A/*0. rufipogon*// *0. longistaminata*	Resistant to RGSV 1 & 2
0. branchyantha	Resistant to RWM

BPH = Brown planthopper

WBPH = White backed planthopper

GLH= Green leafhopper

YSB = Yellow stemborer

RGSV1 = Rice grassy stunt virus

ZZLH = Zigzag leafhopper

RRSV = Rice ragged stunt virus

RWM = Rice whor 1 maggot

Table 7. International Agricultural Research Centers with Major Crop Germplasm Collections within the Consultative Group on International Agricultural Research.

Center	Crop Genebank	Samples
International Rice Research Institute (BRRI)	Rice*	78,800
Central Internacional de Mejoramiento de MaIZ Y Trigo (CIMMYT)	Wheat	31,144
	Maize	11,100
	Barley	5,569
Centro Internacional de Agricultura Tropi-cal (CIAT)	Common bean* (Phaseolus vulgaris)	30,790
		2,527
	Lima bean* (P. lunatus)	1,179
	Runner bean* (P. coccineus)	3,700
	Cassava*	
Centro Internacional de la Papa (CIP)	Potato*	6,500
International Institute of Tropical Agriculture (IITA)	Rice*	6,500
	African rice (Oryza glaberrima)	2,000
	Cowpea*	12,000
	Soybean	1,359
	Bambara groundnut (Vigna subtenanea)	1,200
		1,829
	Cassava	1,000
	Sweet potato	
International Center for Agricultural Research in the Dry Areas (ICARDA)	Wheat	16,596
	Barley	14,215
	Lentil	5,906
	Chickpea	5,585
	Faba bean	3,293
	Pea	3,058
International Crops Research Institute for	Sorghum*	24,600
The Semi-Arid Tropics (IGRISAT)	Pearl millet*	16,985
	Finger millet*	1,863
	Foxtail millet*	1,260
	Chickpea*	13,819
	Peanut*	11,448
	Pigeonpea*	10,104

- Base collection designated by the International Board for Plant Genetic Resources, Rome. Base collections, of which there may be more than one per crop, are major genebanks containing a large proportion of the genetic variability of the crop.

Table 8. Useful traits of wild species of *Oryza*.

Wild species	Chromosome number	Genome	Useful traits
0. eremmos	24	AA	Tolerance to stagnant flooding and acid sulphate soil
0. Nivara	24	AA	Resistance to grassy stunt virous and blast
0. sativa var fatua	24	AA	Tolerance to cold temperature and acid sulphate soil
0. longistaminata	24	AA	Floral characters for out pollination. Resistance to stemborer
0. barthii	24	AA	Resistance to bac terial leaf blight
0. officinalis	24	CC	Resistance to BPH, WBPH, and GLH
0. eichingeri	24,48	CC BBCC	Resistance to BPH, WBPH, and GLH
0. minuta	48	BBCC	Resistance to BPH, WBPH, and GLH
0. latifolia	48	CCDD	Resistance to GLH, Sturdy stem
0. australiensis	24	EE	Resistance to BPH and drought
0. brachyantha	24	FF	Resistanceto stemborer
Porteresia coarctatum	48	-	Tolerance to salinity

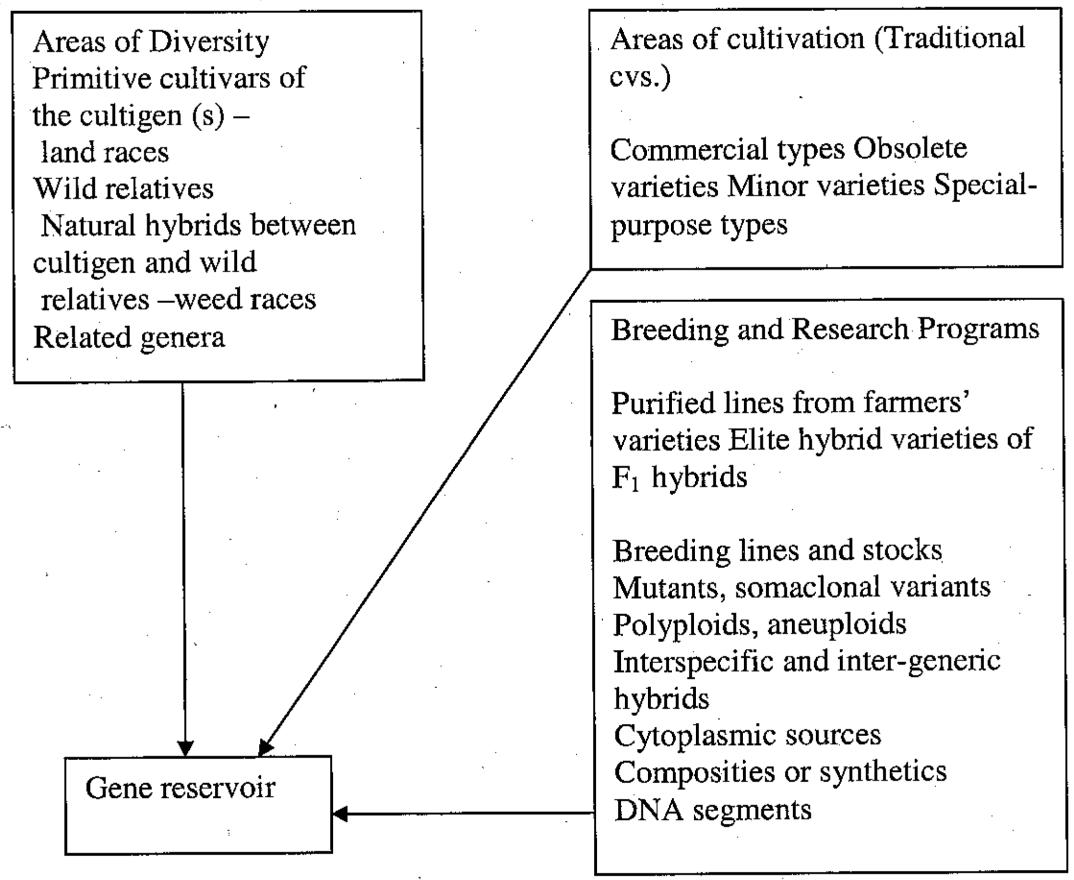


Fig. 1. The full spectrum of germplasm in a crop species (cultigen) and its sources.

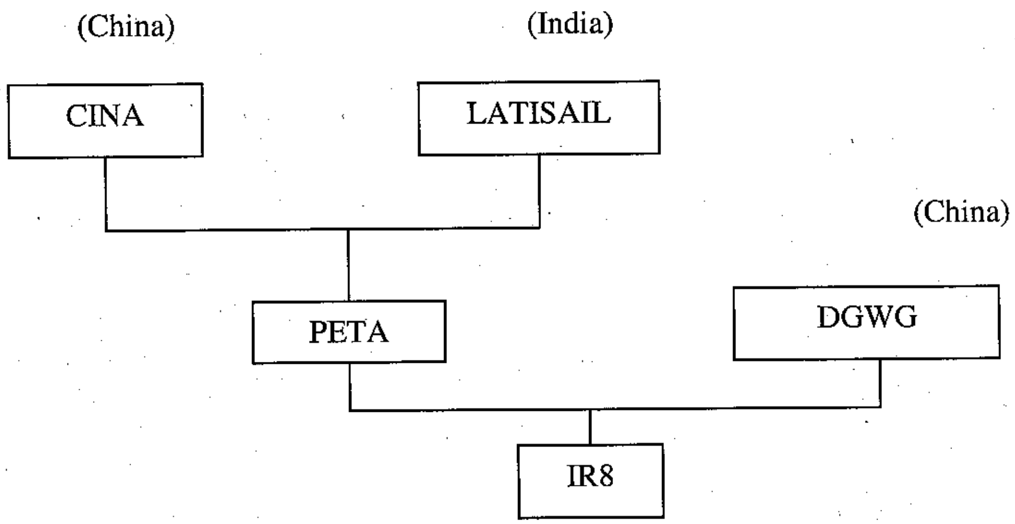
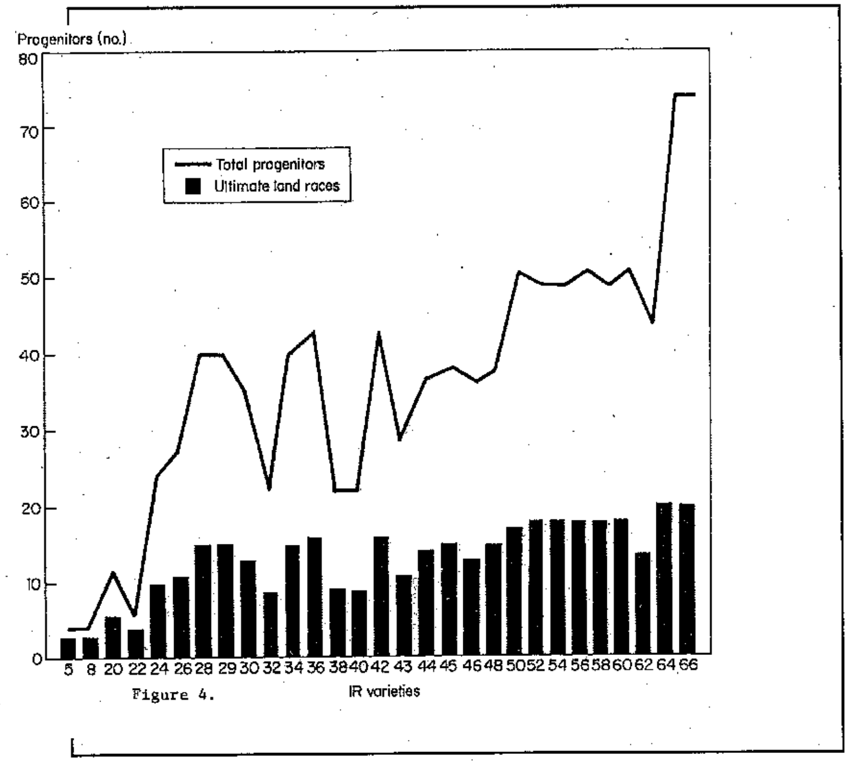


Figure 2. Pedigree of IR 8



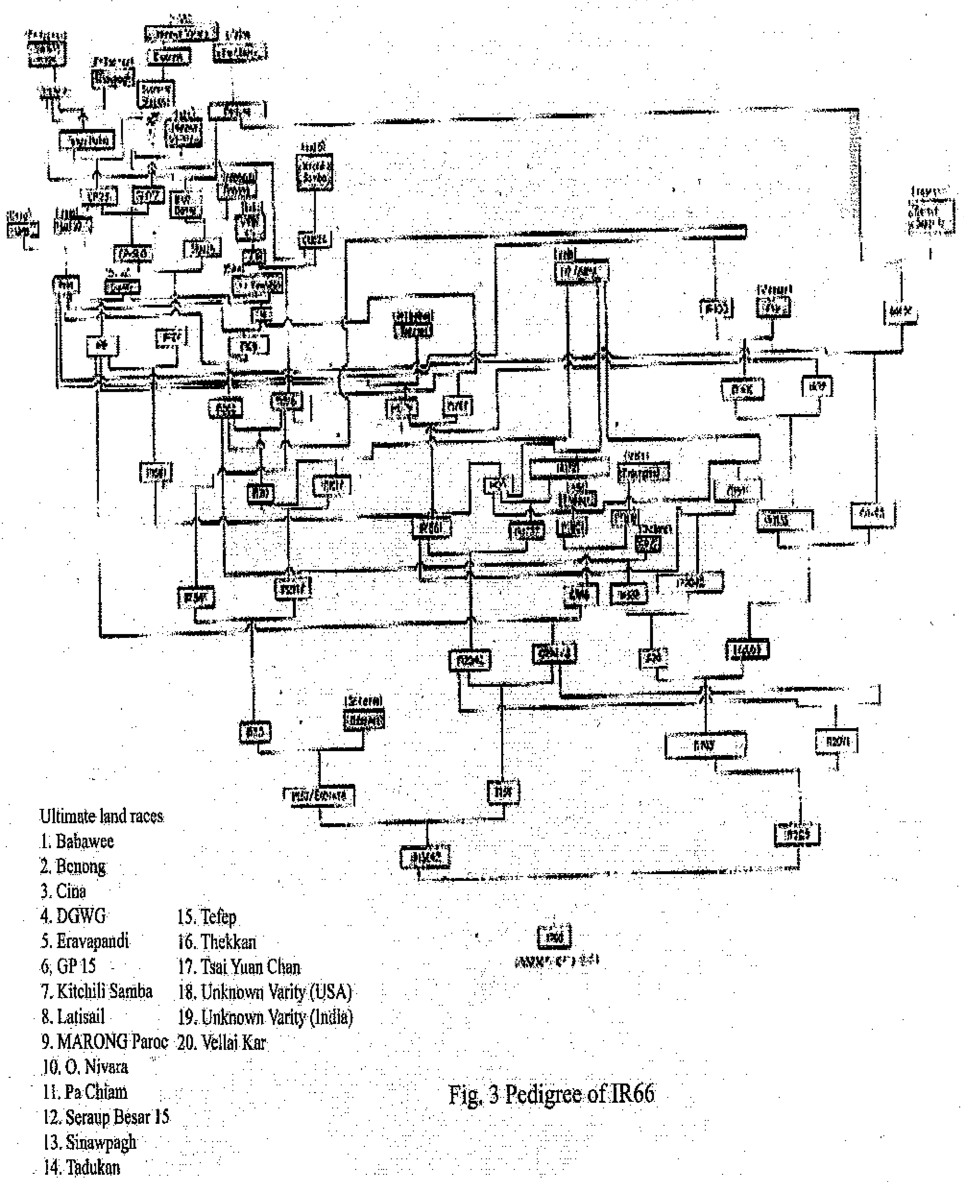


Fig. 3 Pedigree of IR66

Existing Weather Forecast Systems of Bangladesh and their Potential to manage different risks to minimize crop productivity losses

Mohammad H. Mondal[1]

Abstract

In Bangladesh, weather forecasting on cyclones, storms, tornadoes, etc. is mainly provided by Storm Warning Center (SWC) and on temperature, flood, drought, rainfall, etc. by Agro-met division of Bangladesh Meteorological Department (BMD) located at Agargoan, Dhaka. The BMD operates 35 synoptic stations throughout the country. The SWC issues meteorological information based on synoptic chart analysis, pilot chart analysis, radio sonde analysis, etc. The weather data collected are disseminated through print and electronic media, fax, internet, etc. The Agro-met division, on the other hand, operates its activities through a network of 12 agro-met stations. Weather data on flood, drought, rainfall, etc. are collected twice a day by the stations for submission to the head office of BMD in Dhaka. The information thus generated are disseminated by e-mail, website, fax, etc. to users such as DAE, NARS institutes, Ministry of Agriculture, FAO (Bangladesh), etc. The mechanism of information dissemination is often handicapped due to weak linkage between BMD and DAE & research institutes. Besides, there are at present no agricultural experts at BMD to analyze the weather forecast data specially for location-specific technologies. Forecast information to manage different risks like drought, flood and pest incidence to minimize crop productivity losses have as well been discussed in this paper. The paper also highlights the limitations of the existing weather forecasting system and recommends actions to improve the latter.

Introduction

Agriculture and climate are very much interrelated processes. Pre-harvest (seeding, weeding, application of fertilizers, irrigation, pesticides, etc.) and post-harvest (drying, processing, preservation, etc) operations are highly influenced by climatic changes. In recent years, agriculture in the developing countries including Bangladesh has become seriously vulnerable to climatic stresses like drought, flood, cyclones, salinity, etc. Both flood and drought cause considerable losses to crops every year. In 2008-2009, potato production declined to about 65 lakh tons from more than 80 lakh tons due to the attack of late blight disease which was aggravated

[1] Former Director General, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

as a result to foggy weather and temperature higher than **18^0 C** during December-January, 2008-2009. Besides, about 1 million ha land in coastal region are constant by vulnerable to different degree of salinity forcing farmers to go for monocrop agriculture during the rainy season only. Timely weather forecasts may reduce the losses of crops to a considerable extent.

The paper highlights the limitations of the a) existing weather forecasting systems of the Bangladesh Meteorological Department (BMD), specially with respect to dissemination of such information to Department of Agricultural Extension (DAE) and farmers and feedback from farmers to BMD and b) how forecast could minimize the productivity losses of crops. Necessary recommendations have been offered to take policy actions for improving the current weather forecasting systems.

Existing Weather Forecasting Systems in Bangladesh

In Bangladesh, weather forecasting on cyclones, storms, tornadoes, etc. are mainly provided by the Storm Warning Center (SWC) and on temperature, flood, drought, rainfall, sunshine hour, etc. by the Agro-met Division of the BMD. The BMD is a government organization under the administrative control of the Ministry of Defense. The BMD operates 35 Synoptic Stations (Fig.1) throughout the country of which 12 provide agro-met information, reporting daily to the central office in Dhaka.

Storm Warning Center

The Centre is responsible for monitoring, issuing daily forecasts and warning on meteorological events such as cyclones, storms, tornadoes, heavy rainfall, etc. based on (a) Synoptic chart analysis, (b) Pilot chart analysis, (c) Radio Sonde analysis and (d) Satellite (MT SAT, Japan). BMD is now operating experimentally a Weather Research Forecast (WRF) model of Numerical Weather Prediction System (NWPS). First phase of NWP project has already been completed.

The weather data are disseminated mainly through print and electronic media, fax, telephone and internet. The Centre maintains linkage with the Disaster Management Bureau and Flood Forecasting & Warning Centre of the Bangladesh Water Development Board to provide information on storm, disaster, cyclone, tornado, etc. for public in general.

Bangladesh Agriculture, 4 (1): January, 2011: Weather Forecast & Minimization of Crop Loss

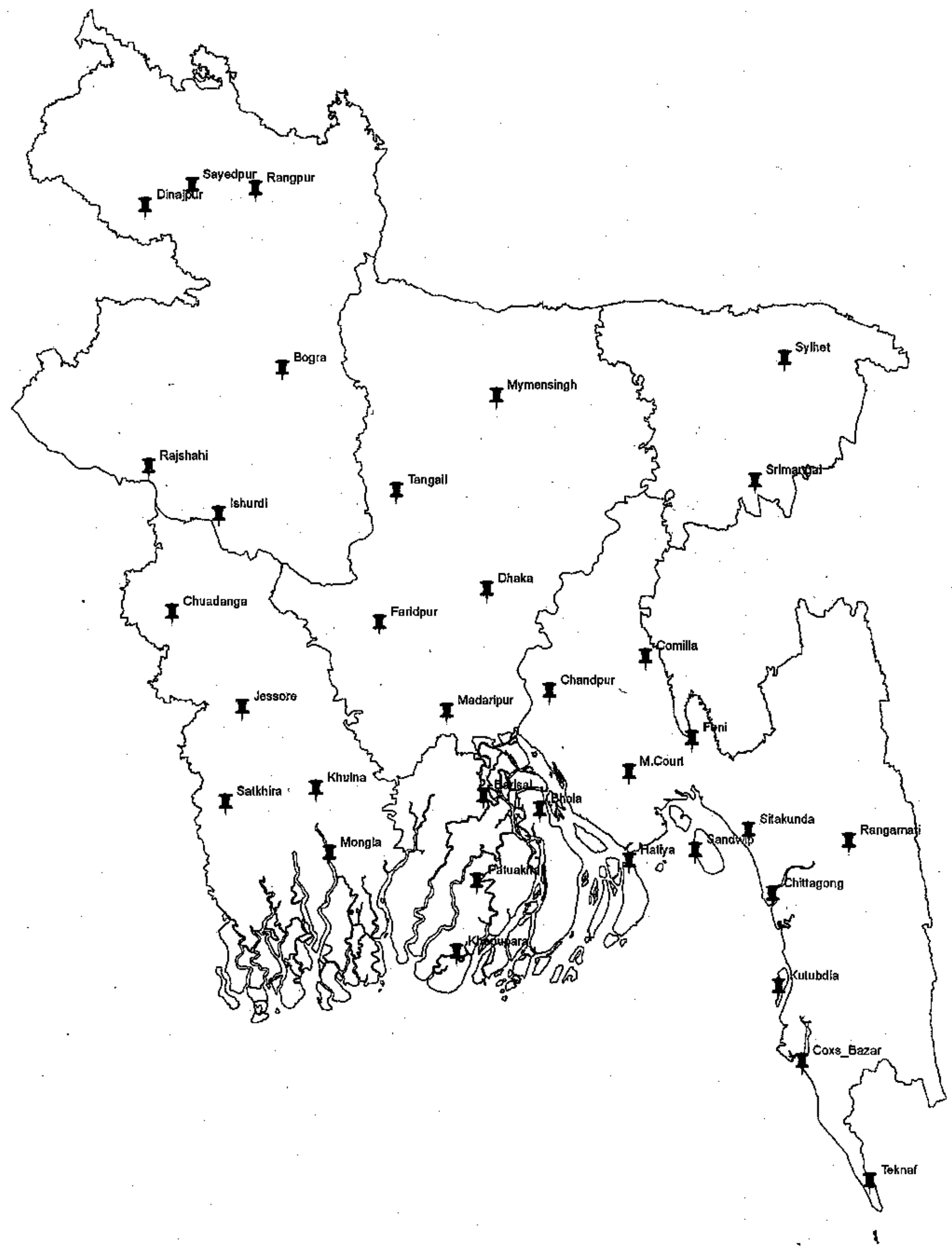


Fig. 1

Agro-met Division

The agro-met unit was established as a division of BMD. The Agro-met Division of BMD at present operates its activities through a network of 12 agro-met stations. The stations record forecasting information mainly on rainfall, average max/min humidity, average max/min temperature, flood and drought around the area. The stations are responsible to collect weather data as inputs for the preparation of agro-met bulletin/advisories for different end users. The data are collected twice a day at 0000 GMT and 1200 GMT from all agro-met stations and submitted to the head office of BMD in Dhaka.

The agro-met bulletin is issued every 7 days of each month using the data collected from 12 agro-met stations. The information thus generated are disseminated by e-mail, website, fax and postal service to different users, namely DAE, AIS, Ministry of Agriculture, Ministry of Food and Disaster Management, BARI, BRRI, BSRI, IRRI (Dhaka Office), SPARRSO and FAO, Bangladesh.

The Agro-met Bulletin is prepared based on the following weather information:

• 07 days actual rainfall in mm • 07 days climatic normal rainfall in mm • Departure % of actual rainfall from normal. • No. of rainy days • Max. temperature • Normal max. temperature • Min. temperature Normal min. temperature	• Average evaporation • Average max. humidity • Average min. humidity • Average sunshine hours • Weather forecast for next 07 days (rainfall, temperature, sunshine hours, evaporation, fog, hail, storm) • Advisories for the farmers 7 days location-specific deterministic forecast (rainfall and temperature)

The information allows farmers to take necessary action in the event of unusual weather pattern and thereby contributes to minimize losses of crops and their income. To improve the quality of agro-met bulletin and advisory services, model outputs of different international meteorological centers, namely ECMWF (EU), NCEP (USA), JMA (Japan), MRWFC (India), etc. are used for making deterministic forecasting.

Limitations of current weather forecasting systems of BMD

a. The Agro-met Division of BMD does not have aerospace Remote Sensing (RS) and Geographic Information System (GIS) facilities to obtain more accurate

data on yield, moisture stress, incidence of diseases and pests, etc.

b. Model outputs of international meteorological centres such as ECMWF, NCEP, JMA, etc. are still being used for forecasting. The WRF model of BMD is still at the experimental stage.

c. At present, the BMD does not have a facility to offer training courses for DAE officials and researchers of the research institutes the National Agricultural Research System (NARS) on the quality and relevance of weather forecasting information and to obtain their feedback for improving the existing forecasting system.

d. At the moment BMD has a network of only 12 agro-met stations that are quite insufficient to obtain representative weather data. The stations are also staffed/equipped with inadequate number of manpower and instrument.

e. No formal mechanism has yet been established at BMD to obtain feedback from farmers, DAE officials and concerned agricultural scientists on the quality of weather forecasting system. Besides, dissemination mechanism of information from agro-met division to farmers is weak.

f. At present, there are no krishibeeds (agricultural scientists) at BMD to correctly analyze the weather forecast data for location-specific technologies.

Linkage with DAE and NARS institutes

DAE is the main user of agro-met advisory service of BMD on natural hazards like flood, drought, pest incidence, etc. Advisories are received by DAE at almost regular intervals. The forecast messages are then disseminated to its District Offices that in turn transmit the same to Upzila Offices through telephone, fax or postal services. The mechanism of advisory dissemination is often handicapped due to weak linkage between DAE and BMD. Such messages from BMD are also passed on to NARS institutes to facilitate the latter to develop location-specific technology. However, linkage between the research institutes and BMD is very weak as well.

Application of forecast information to manage different risks to minimize crop losses

a) Drought and its impacts on crop productions

Droughts in Bangladesh are associated with late arrival or early withdrawal of monsoon rains and sometimes complete failure of monsoon. Bangladesh had experienced droughts of major magnitude in 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994 and 1995.

Droughts of different intensity affect about 2.32 million ha land in *Kharif* season (April-October) and 1.2 million ha in *Rabi* (November-March) season almost every year. *Kharif* drought affects Transplanted (T) amon rice whereas *Rabi* affects drought wheat, potato, mustard and pulses and Aus rice mainly. Yield reduction of T.amon rice ranged from 20 to 60% due to *Kharif* drought. Yield reduction of *Rabi* crops (wheat, potato, mustard) varied from 20 to 70% due to *Rabi* drought (Karim et al, 1990). Management plan of drought risk to reduce losses of crops is shown in Table 1:

Table 1. Management plan of drought risk in *Kharif* and *Rabi* crops

Crop	Kind of risk	Management plan to reduce risk
Aus rice	Dry spell in March/April	Timely/delayed sowing
T. Aman rice	Dry spell in July/August	Delayed transplanting
Boro rice	Inadequate soil moisture at sowing	Early/delayed transplanting coinciding rainfall
Wheat	Inadequate soil moisture at sowing	Sowing under minimum tillage to exploit residual soil moisture
Rabi crops	Inadequate soil moisture at sowing	Timely sowing under minimum tillage to exploit residual soil moisture

b) Flood and its impacts on crop production

Between 1953 and 2007, there had been 42 occurrences of flood in Bangladesh. The floods of 1974, 1988, 1998, 2004 and 2007 are worth mentioning. The flood of 1988 inundated 89,000 sq. km. land of 52 districts and that of 1998 inundated 100,000 sq. km. area of 53 districts causing considerable losses of crops, livestock, fisheries and humans. Flood normally affects 2.6 million ha of land every year (Karim et.al.1990). Flood mainly affects aus/T. amon/ boro rice, jute and summer vegetables. Management of flood risk to reduce crop losses is listed below (Table 2):

Table 2. Management plan of flood risk in different crops

Crop	Kind of risk	Management plan to reduce risk
Aus rice	Flood at harvest	Advanced harvest at physiological maturity
T. Aman rice	Chance of late flood	Early transplanting/ late transplanting of LIV of rice
Boro rice	Flash flood at harvest	Early harvest/transplanting short duration varieties
Jute	Early flood	Early harvest
Summer vegetables	Early flood	Sowing short duration vegetables/cultivation of vegetables at homesteads

c) Late blight disease and its impacts on potato production

In 2008-2009, area under potato in Bangladesh was 4.64 lakh ha of which 16087 ha was affected by the late blight disease. As a result, production of potato was reduced to about 67 lakh tons against the target production of more than 80 lakh tons. Foggy weather and temperature of 18^0C or more in December - January, 2008-2009 favoured the incidence of the disease causing production loss of potato throughout the country. On the other hand, cooler temperature (less than 18^0C) and bright sunshine in following year (2009-2010) was unfavourable for the appearance of the disease that resulted in higher production of approximately 88 lakh tons of potato (TCRC, 2010).

Farmers could be advised to go for delayed planting of potato to minimize losses due to the disease. Alternative options to reduce the losses could be to select varieties of potato tolerant to the disease or arrange timely availability of appropriate pesticides to control the disease.

Conclusion

The current linkage of DAE and NARS institutes with BMD to obtain weather information and apply such messages to manage different risks like flood, drought, pest attack, etc. is very week. The linkage needs to be strengthened without delay specially with respect to dissemination of forecast data by BMD to DAE and research institutes. Appropriate and timely weather forecasts are essential to manage the risks of flood, drought, etc.

Recommendations

* The current linkage between DAE/NARS institutes and BMD needs to be strengthened for effective interactions in respect of weather forecast related to crop agriculture. The Technology Transfer and Monitoring Unit

(TTMU). BARC may take a lead in improving the linkage.

- An MOU should be signed involving BMD, DAE and BARC without delay to strengthen the present mechanism of dissemination of farmer's advisories from BMD and feedback on such advisories from farmers, DAE and NARS institutes. Ministry of Agriculture may take an initiative in signing the MOU.
- Remote Sensing (RS) and Geographic Information System (GIS) facilities should immediately be installed at the Agro-met Division of BMD to collect more accurate data on crop yields, soil moisture stress, incidence of pests and diseases, etc.
- It is also recommended that at least two krishibeeds (agricultural scientists) with strong background in integrated crop management and skill in GIS and RS be immediately placed at BMD on deputation mainly to correctly analyze and interpret the farmer's advisories based on location-specific weather forecast. DAE may take steps to implement the proposal. Alternatively, BMD may take steps to create two such posts in its Agro-met Division to Address the issue.
- Introduction of training programs with required training aids at the Agro-met Division of BMD is essential to offer training courses to farmers, DAE officials and scientists of NARS institutes on weather forecast and agro-met advisory systems.
- The Agro-met Division is recommended to prepare and publish Agro-met Advisory Bulletin based on major crop seasons for the farmers of different agro-climatic zones of the country, The proposed RS and GIS technologies could be used to publish such season-based agro-met bulletins.
- It is essential that increased number of Agro-met Stations is established at different locations of the country to obtain location-specific information on climate changes. The stations must be simultaneously equipped with adequate number of professionals, supporting staff and Automatic Weather Observation Systems (AWOS) with telemetry.

References

Abedin, M. Z. 2009. Achieving food security at times of crisis: Bangladesh perspective. A paper presented at the World Food Day, 16 October, 2009, MOA and FAO, Dhaka.

BMD. 2009, Brochure. Bangladesh Meteorological Department, Abhawa Bhaban, Agargaon, Dhaka. 2009.

FAO and ADPC, 2005. Training manual for climate and flood forecast applications in agriculture. FAO and ADPC.

FAO and ADPC, 2007. Climate Variability and Change. Adaptation to Drought in Bangladesh. A Resource Book and Training Guideline FAO and Asian Disaster Preparedness Centre Rome, Italy.

Karim, Z. et.al. 1990. Soils publication no. 34, Bangladesh Agricultural Research Council (BARC), Dhaka.

Mondal, M. H. 1997. Drought management technologies for sustainable crop production in Bangladesh. A paper presented in the symposium of Bangladesh Society of Agronomy.

Mondal, M. H. 2010. Country document (Bangladesh) on "Impact of climate parameters on agricultural production and minimizing crop productivity losses through weather forecast and advisory service", 2010. A consultancy paper submitted to SAARC Agriculture Center, BARC, Farmgate, Dhaka.

T.C.R.C, 2010. Personal communication with Tuber Crops Research Centre (TCRC), BARI on area and production of potato affected by late blight disease in 2008-2009

Crop Biotechnology: An Emerging Science In Bangladesh

Nilufar Yasmin Shaikh[1]

Abstract

Biotechnological methods have been employed as the latest weapons by Bangladeshi scientists in their long struggle for developing new crop varieties with desirable characters. However, although the use of modern biotechnology for varietal improvement started during the 1970s in some countries of the world, Bangladesh could not enter into the arena due to lack of trained manpower, fund and infrastructures.

Biotechnology has significantly strengthened programs to develop new crop varieties with higher yield and nutritional quality. Success in the culture of somatic cells; pollen, protoplasts and plant regeneration; availability of marker genes; cloned DNA fragments; direct DNA transfer methods; nuclear probe; gene mapping and gene tagging etc have made improvement of better crop varieties possible. Micropropagation through somatic cell culture is being commercially practiced in Thailand, India, Japan and USA. The most important transgenic crops in terms of planted area are soybean followed by maize, cotton and canola. Field testing of transgenic tobacco, potato, brinjal, rice and tomato in India, release of papaya and import of GM soybean in Malaysia and GM tomato, cotton, rice and papaya in Thailand are some of the important achievements.

At present, in Bangladesh, biotechnological research is being carried out in seven universities, six research institutes and a few NGOs. Biotechnology research topics cover the areas like : (a) Tissue culture (b) Transformation (c) Molecular biology.

Perceived risks of biotechnology: Like any new technology, Biotechnology can bring in both benefits and risks. The situation can be described as technology inherent others are related more to value systems or cultural practices and hence can be described as technology transcending. The scientists, however, have been designing ways in minimizing potential risks associated with Biotechnology before recommending their release to the farmers. Biosafety rules are being enacted in the country.

Future thrusts and strategic programs needed to utilize the great potential of this novel technology in Bangladesh are listed at the end of the paper.

[1] Senior Scientific Officer, Biotechnology Division, Bangladesh Rice Research Institute, Gazipur, Dhaka.

I. Historical Background of Crop Biotechnology in Bangladesh

Biotechnology may be defined as any technological application that uses living organism and biological systems to make or modify products or processes for specific use and human benefit. The use of biotechnology as a tool for varietal improvement of crops in Bangladesh is comparatively recent compared to other classical breeding techniques. Techniques like plant introduction and hybridization started in Bangladesh as early as in the first decade of the last century with the establishment of the nucleus Agricultural Research Laboratory (ARL) at Dhaka in 1908. By the end of 1939, the research system had successfully introduced as well as developed some improved varieties of rice, sugarcane and jute (Badruddoza, 2001).

The first high yielding varieties (HYV) of rice were introduced into the country from the International Rice Research Institute (IRRI) in 1965 (Kabir and Bagchi, 2008). By this time HYV wheat, improved sugarcane varieties and Virginia tobacco were imported for testing locally. With the Dhaka farm being taken over in early 1960s to build what is now Sher-e-Banglanagar to accommodate the parliament house. The ARL scientists shifted crop breeding work in rice on the lands of the Savar Dairy Farm. In 1970, the then East Pakistan Rice Research Institute was established in Joydebpur which was re-designated as the Bangladesh Rice Research Institute (BRRI), after the liberation of Bangladesh in 1971. Induction of mutation by using nuclear technique started in 1961 and induction of mutations in crops using atomic energy was re-organized in 1972 with the establishment of the Institute of Nuclear Agriculture (INA), which was made autonomous and renamed as Bangladesh Institute of Nuclear Agriculture (BINA) in 1982 (Shaikh, 2009). By late 1970s, the institutes such as Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Jute Research Institute (BJRI) became autonomous and started functioning independently (Badruddoza, 2001). These research institutes continued varietal improvement of their mandated crops using various techniques. Multidisciplinary studies were also organized for many crops.

Biotechnological methods are the latest weapons in the long race of scientists of Bangladesh for developing new crop varieties with desirable characters. Already several of the universities, research institutes and even NGOs started programmes on biotechnology and eventually a National Institute of Biotechnology (NIB) was established at Savar near safety rules. Enforcement of related laws and safety procedures will minimize the risk of biotechnology products to human and environmental health.

III. Global Status of Genetically Modified Crops

Genetically modified crops and foods are a major issue of debate worldwide. Currently, approved genetically modified plants have been developed to express one or more basic phenotypic character such as delayed ripening, fatty acid composition, fertility restoration, herbicide tolerance, insect resistance, male sterility, modified color, virus resistance etc. Since 1986 about 1500 field trials of more than 50 genetically modified crops (Alfalfa, Cotton, Tobacco, Soybean, Sugar beet, Tomato, Potato, Oilseed and Maize) have been conducted. Most of them were conducted in the western developed countries. The list is becoming longer day by day with the involvement of more countries and also the inclusion of new species in these programmes (Miah, 2001).

According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA) report, the estimated global area of GM crops for 2003 was 67.7 million hectares; the 67.7 million hectares equivalent to 167 million acres was grown by 7 million farmers in 18 countries, an increase from 6 million farmers in 16 countries in 2002 (James 2003). The increase in area between 2002 and 2003 of 15% was equivalent to 9 million hectares or about 22 million acres (James 2003). About 75% of this area is in industrialized countries. The most important transgenic (biotechnologically modified) crops in terms of planted area are soybean followed by corn, cotton and canola (James, 2003). In China more than 50 GM crops varieties are approved and transgenic cotton is grown in an area of 500,000 ha. (James 2003). GM cotton and soybean released for commercial cultivation, field testing of transgenic tobacco, potato, brinjal, rice and tomato are in progress in several institutions under Indian Council of Agricultural Research (ICAR) (James 2003). Malaysia approved field release of papaya and import of GM soybean (Herbicide tolerant). In Thailand field testing is in progress on GM tomato, cotton, rice and papaya etc. (James 2003).

IV. Initial Approach to Crop Biotechnology in Bangladesh

The program on plant biotechnology in Bangladesh was initiated in late 1970s in the Department of Botany, Dhaka University with tissue culture of jute. Thereafter, within a span of 10-12 years tissue culture research laboratories have been developed in different universities and R&D organizations. A few scientists and a handful of university students started playing with plant organs in the name of tissue culture in the early

eighties with bare minimum facilities. Generally, biotechnology in the form of tissue culture has been incorporated in the course curricula of 4 universities including BAU. Meanwhile, Bangladesh Association for Plant Tissue Culture came into existence in October 1989 through the untiring efforts of a group of plant scientists with the active support of the then Executive Vice Chairman of BARC. This association has, however, pursued the concerned organizations and ministries including the Ministry of Science and Technology to develop infrastructures, physical facilities and training of manpower in biotechnology. Although some improvement took place in the universities, the research organizations are still lagging behind. Establishment of the National Institute of Biotechnology at Savar near Dhaka city facilitated the way for a higher level biotech research.

V. Present Status of Biotechnology in Bangladesh

Biotechnology research is being conducted in Dhaka University, Rajshahi University, Chittagong University, Jahangirnagar University, Khulna University, Bangladesh Agricultural University, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh Agricultural Research Institute, Bangladesh Rice Research Institute, Bangladesh Jute Research Institute, Bangladesh Institute of Nuclear Agriculture, Bangladesh Sugercane Research Institute and Bangladesh Forest Research Institute. A few NGOs like BRAC, DEBTECH and PROSHIKA are also working on plant tissue culture. Biotechnology research topics cover the following areas:

(a) Protocol development for plant regeneration, micropropagation for large scale plantlet regeneration, in vitro culture
(b) Somaclonal variation
(c) Anther culture
(d) Embryo rescue and embryo culture
(e) Wide hybridizations
(f) Potato tuberisation
(g) Stress tolerance (disease and salt)
(h) Germplasm conservation
(i) Secondary metabolite production (that is production of chemicals and alkaloids)
(j) Protoplast isolation, culture for organogenesis and for transformation programme
(k) Transformation of jute, brassica, rice, papaya and peanut.

Micropropagation of Banana, Orchids, Papaya, Jackfruit, Carnation and some other species are worth mentioning for their economic value. Tissue culture derived banana suckers are disease free and uniform, which are being evaluated in the farmer's field (Miah, 2001). Success in virus free potato plantlet production from infected stock and *in vitro* potato tuberisation is a breakthrough in potato seed production programme in the country. This technology is mature for adoption by the private entrepreneurs. Variants generated by way of tissue culture cycles are referred to as somaclones and creation of somaclonal variation was attempted in peanut, rice and sugarcane. In all cases, regenerants showed variation in morphological traits except rice where variation in yield was also observed in the homozygous clones, but most of the somaclones showed wide segregation generations after generations (Miah, 2001).

In the early nineties BRRI took the approach of transferring gene(s) of economic importance from wild rice to cultivated ones. Crosses were accomplished using *Oryza latifolia* (4n), *O. nivara*, *O. barthii* and *Porterasia coactata* to transfer genes of high biomass, tolerance to Rice Tungro Virus, cold and drought. Embryo rescue technique through tissue culture was employed in appropriate cases (Miah, 2001).

Anther culture is virtually pollen or microspore culture to produce haploid plants, which eventually become auto diploids or made diploids by doubling the chromosome set (double haploids). This technique provides scope to produce homozygous plant in one generation cycle and was tried in papaya and rice (Miah, 2001). Papaya mosaic virus resistant doubled haploids were obtained from a potato mosaic virus resistant variety development program (wide cross) (Miah, 2001). Rice anther culture was initiated by BRRI to breed short duration and stress (cold and salt) tolerant rice varieties. Many double haploid (DH) lines were produced through anther culture. Two short duration lines so developed were used as parents to utilize their gene for earliness. Nine DH lines were high yielding and quite early (138-145 days) in Boro season. Fifteen DH lines were found salt tolerant at the level of 8-10 ds/m. These lines were confirmed by IRRI as good as Pokkali which is the standard check for salt tolerance (Miah, 2001).

In modern biotechnology, now it is possible to regulate nucleotide sequence for modification and recombination, to take them out from one organism and insert them into another. The application potential of this capacity is enormous. Research on such transgenic crops, in Bangladesh, is at the rudimentary stage. It will continue to remain as such until adequate physical facilities (equipments and chemicals) are provided and sufficient technically qualified manpower is developed. Recombinant DNA technology (taking out nucleotide sequence from one organism and inserting them into another) although sounds to be simple but in practice, it is quite complex, tenacious, costly and challenging. At present only a limited number of laboratories are

working to introduce and utilize such gene transfer technology for the improvement of crops like rice, jute and also for obtaining better strains of industrial microbes (Miah, 2001). Successful transformation was done in jute by insertion of two gene constructs, *BSF 16* (carrying GUS gene and Basta resistant gene) and *Tab 7* (carrying GUS gene and Kanamycine resistant gene) into jute tissues through *Agrobacterium tumefaciens* infection (Miah, 2001). This is a milestone for jute improvement. Genetic transformation in peanut was attempted by infecting leaf explants with *Agrobacterium* strain (Miah, 2001). Other technologies such as Gene Mapping, Direct Gene Transfer through Bombardment, Plasmid Construction, Recombinant DNA Technology, Polymerase Chain Reaction, Restriction Fragment Length Polymorphism, Rapid Amplified Polymorphic DNA etc., are highly sophisticated ones but have to be mastered by our scientists. There is lack of sophisticated instruments as well as proper training of the scientists to take up research in these lines. A disease resistant papaya-breeding programme was undertaken in BAU. Gene for disease resistance was transferred from a wild source *Carica cauliflora*. *Agrobacterium tumefaciens* mediated genetic transformation approach was employed to achieve the resistant variety (Miah, 2001).

The list given below shows some of the important research programs which are being carried out at present in different universities and research institutes in the country.

1. *Agrobacterium* mediated genetic transformation of jute: being carried out at the Institute of Food and Radiation Biology, Atomic Energy Research Establishment (AERE), Dhaka and BJRI.
2. Genetic transformation of pulses for fungus resistance: initiated at the Department of Botany, Dhaka University (DU).
3. Genetic transformation of rice and jute for salinity tolerance and fungus resistance: being carried out at the Department of Biochemistry, DU.
4. Use of DNA probes for the diagnosis of diseases: being initiated at the Institute of Nuclear Medicine, BAEC, Dhaka.
5. Development of food, fibre and energy through recombinant DNA technology: being carried out at the Department of Zoology, Rajshahi University.
6. DNA fingerprinting of rice and jute at the Department of Biochemistry, DU.
7. Development of micropropagation and regeneration protocols of potato, banana, jackfruits, eggplants, orange, mango etc; cell and

organ culture and plant genetic engineering, at the Bangladesh Agricultural Research Institute (BARI).

8. Rice anther culture for genetic improvement, molecular characterization of rice, fingerprinting of rice varieties of the Bangladesh Rice Research Institute (BRRI), identification of markers for marker aided selection and genetic transformation for drought and salinity tolerant rice, at BRRI.
9. Development of saline and submergence tolerance rice varieties through tissue culture at the Bangladesh Institute of Nuclear Agriculture, Mymensingh.

VI. Progress of Biotechnology Research in Rice

Vitamin A deficiency affects some 400 million people worldwide, leaving them vulnerable to infections and blindness. Iron deficiency affects 3.7 billion people, particularly women, leading to high maternal deaths and infant mortality. Developing micronutrient dense rice with higher amounts of iron, zinc and vitamin A, can have tremendous impact on the health of low income people. Conventional breeding when combined with biotechnology can provide very powerful tools to achieve this goal. Weeds, brown plant hopper (BPH), yellow stem borer, sheath blight, and bacterial blight are common pests causing substantial yield loss of rice. Biotechnologists have been able to develop methods to transfer *Bacillus thuringiensis* (Bt) and Chitinase genes to enhance resistance of rice against these insects and pathogens. Research is going on in the private sector on developing herbicide resistance seeds to reduce yield loss from weeds (Hussain et al., 2004).

In the initial years, rice biotechnology research was located in the laboratories of developed countries outside Asia. The big multinational companies who invested heavily in upstream research on biotechnology have back tracked in recent years. They assess that rice biotechnology research for Asia is no longer economically profitable because of the predominance of small and marginal farmers, and the high transaction costs of enforcing intellectual property rights under weak judicial systems makes it less attractive.

Within Asia, most of the biotechnology research is now confined in the public sector laboratories in Japan, South Korea, India, China, Philippines and in the International Rice Research Institute (IRRI). Progress has been made in herbicide tolerance and insect and disease resistance using biotechnological tools. This will benefit farmers in irrigated ecosystems by stabilizing yields at high levels and increasing profits due to reduced yield losses and lower

application of pesticides. Some progress has also been made in developing submergence tolerance and in incorporating iron and vitamin A in rice (Hussain et al., 2004). These traits have been transformed mostly in *Japonica* varieties, which are grown in temperate zones in East Asia. Scientists from IRRI and those of NARS of some selected countries are now working for transferring these genes in popularly grown *indica* varieties of rice. Major products which are available but undergoing tests on bio-safety and health effects are Bt rice for stem borer and sheath blight resistance and iron- and vitamin A enriched rice (Hussain et al., 2004).

VII. Potential Benefits: The Bangladesh Context

Policy makers in Bangladesh must not be complacent with the past achievement in meeting the food needs of the people. Food security will remain a major concern so long as population continues to increase. Indeed, Bangladesh must increase production of rice by 300,000 tons every year to meet the needs of the growing population. Bangladesh must exploit all scientific opportunity for shifting the yield frontier and reducing the yield gaps for sustaining the growth in rice production. Application of modern biotechnology tools provides Bangladesh with such an opportunity. Use of molecular biology tools, e. g. molecular markers have made it possible to map and tag quantitative trait loci (QTL) that affect characters such as yield, quality and tolerance to submergence and drought stresses and tolerance to problem soils. The gene for submergence tolerance (*SUB1*) has already been identified (Hussain et al., 2004), which if incorporated into the popularly grown modern varieties such as BR11 and Swarna (Indian variety grown widely in the border belt) can help reduce the yield losses and the cost of repeated transplanting of rice in the wet season in the low lying areas.

IRRI scientists have been collaborating with the scientists of Dhaka University and BRRI for developing high yielding salt tolerant varieties applying biotechnology tools which, if successful, can help expand area under modern varieties in the coastal region of Bangladesh. The Bt rice has been proved effective in controlling stem borers and chitinase genes for sheath blight disease and is now being considered for release in China and being field tested in India (Hussain et al., 2004). Resistance against these pests has been found difficult to incorporate in high yielding varieties through conventional breeding. If the Bt rice is widely adopted, farmers will be able to save the yield losses from stem borers and at the same time reduce pesticide use that will have a positive effect on human health and the environment.

Even more important for Bangladesh is the potential benefit of genetically engineered rice in addressing major health issues. The level of micro-nutrient induced malnutrition in Bangladesh remains to be one of the highest in the world. Nearly 60% of the children under age five are underweight and more than half are stunted. Almost half of the children suffer from chronic energy deficit and more than 70% of pregnant women suffer from anemia due to iron deficiency (Hussain et al., 2004). In rural areas where three-fourths of the population lives, malnutrition is high due to lack of knowledge regarding balanced diet (or financial capacity to afford) or economic capacity to purchase supplemental iron and vitamin A. Since the poor consume nearly 150 kg of rice per year, incorporation of a small amount of iron and vitamin A in rice can go a long way in meeting the deficiency of these critical micro-nutrients. IRRI scientists have already incorporated iron gene in rice varieties using genetic engineering (Hussain et al., 2004), which are currently being evaluated for bioavailability and food safety concerns. Genes controlling Beta-carotene have already been incorporated into IR64, the most widely grown rice variety in the world and also in BRRIdhan 29, the most widely grown boro rice variety in Bangladesh (Hussain et al., 2004). Adoption of these varieties in Bangladesh after proper evaluation of the food safety and environmental effects and economic viability, may contribute substantially to improved nutrition and human health.

VIII. Perceptions and Attitude of Bangladesh Civil Society

It is useful to study the debate as well as the attitude and perceptions of the Bangladesh civil society groups regarding rice biotechnology research in the Bangladesh context. The study is important because the civil society groups mould the public opinion and any negative opinion may stand in the way of releasing the products however beneficial they might be to rice producers and consumers.

IX. Future Thrust in Biotechnology Research for Bangladesh

In order to augment crop biotechnology research, the foremost consideration would be:

i. The level of research standard must be improved to address problems that require high technology.
ii. Both basic and applied research have to be conducted to satisfy both the long and short term needs of the country.

iii. The existing facilities for biotechnology research must be upgraded and strengthened according to need of the individual research organization.
iv. Biotechnology research programmes of the research institutions under the National Agricultural Research System (NARS) and the agricultural universities must be coordinated by the BARC to avoid wasteful duplication of research.
v. Manpower training programmes at postgraduate and post doctoral levels in various aspects of plant biotechnology is imperative to carry out useful and successful research. Research on advanced plant molecular biology should be promoted on an urgent basis.
vi. Private NGOs should be encouraged to establish biotech industries of medium technology level to sustain the innovative research. (Miah, 2001).

The NARS institutes of Bangladesh need to embark upon suitable research programmes involving application of biotechnology to solve various problems of agriculture. Some of these programmes and needed strategic actions are described below:

a) Research work on priority problems related to crop varieties, fisheries, livestock and forestry.
b) Development of plant cultivars tolerant to stress from factors such as pests and diseases, salinity and submergence.
c) Since agriculture in Bangladesh is very much prone to environmental hazards and 70% of all disasters originate from weather-climate extremes (Karim, 2009), and since the country is one of the most vulnerable ones to potential climate changes (SAIC, 2005), the most important challenge for the country is to develop crop varieties to avoid the on-slaught of the natural hazards like cyclones, tidal surges, floods and climatic changes like global warming and sea level rise (Shaikh, 2010). Biotechnological intervention has great potential for developing such varieties of crops, fishes, animals and forests.
d) Biotechnological research has immense potential of mitigating another most important challenge facing the country i. e. to develop crop varieties suitable for the agro – ecologically disadvantaged areas like the Coastal Saline Zone, Haor Areas, Hilly Areas, Peat Basins, Piedmont Plains (Foothill Areas) and Active Flood Plains. Each of these areas has special ecological niches needing crop varieties

with special genetic improvements (Shaikh, 2009).

e) Holding of regular seminars and symposia in order to disseminate the up to date knowledge on crop biotechnology.

f) Priorities in R&D work should include programmes on development of high yielding and stress tolerant varieties of food crops through modern genetic engineering techniques.

g) According to the National Strategy for Accelerated Poverty Reduction -II, FY 2009-2011 (Planning Commission, 2009), the GoB's vision for the agriculture sector is to enhance growth through development and dissemination of technologies which are sustainable, ecologically adaptable, economically profitable, and capable of creating productive job opportunities, diversification of both crop and non-crop agriculture, agribusiness development and human resource development thereby making Bangladesh self sufficient in food by 2013 through adoption of all possible measures. The ultimate goal of all these efforts is to ensure food security for all. Obviously, biotechnological research has a significant role to play in developing such technologies.

h) The country can benefit from advances in biotechnology, but much needs to be done to make the bio-engineered products available in the appropriate forms for the farmers to use. Use of biotechnology for agricultural improvement in the country is in the rudimentary stage. The government has established the National Institute of Biotechnology(NIB) but the Biotechnology Institute is still in the development budget and does not possess the required facilities and manpower to deal with Important agricultural projects. Bangladesh Agriculture Research Institute, Bangladesh Rice Research Institute, Bangladesh Jute Research Institute, Bangladesh Institute of Nuclear Agriculture, Bangladesh Sugarcane Research Institute, Bangabandhu Sheikh Mujibur Rahman Agriculture University, Dhaka University, Rajshahi University, Jahangirnagar University and BRAC (NGO) have biotechnological programmes but not much worthwhile result is in hand to solve farmer's problems yet. An integrated and well coordinated research program utilizing the biotechnological methods has to be embarked upon immediately involving all those institutes, universities and NGOs.

i) A National Human Resource Development Scheme for higher education and training for the scientists of the NARS, especially in biotechnology is to

be developed and implemented without delay. The NARS has a general scientific community with only 24% Ph. D. degree holders (Siddique, 2009). Proportion of Ph. D. holders among the biotechnologists may be even smaller than 24%. This figure is grossly inadequate indeed.

j) The system of sabbatical leave has to be re-introduced by BARC to encourage and enable scientists to avail such leaves for scientists to learn new techniques from other laboratories of the NARS as and when necessary.

k) Importance of quality staff and quality technicians to generate knowledge and technology through quality research needs no emphasizing. The sooner the GoB realizes this, the better will it be for the country. Under the circumstances, the foremost strategy should dictate the necessity of conducting a thorough assessment of capacity needs for higher education and training in biotechnology in each institute of the NARS. This should be followed by formulation and phase-wise implementation of a National Human Resource Development Programme commensurate with formulating and implementing prioritized biotechnological research programs having time bound and result-oriented endeavors.

References

1. **Badruddoza, K. M.** 2001. Agricultural Research in Bangladesh in the 20th Century, published jointly by BARC, Airport Road, Farmgate, Dhaka-1215, and BAAG, 11/8, Iqbal Road, Mohammadpur, Dhaka-1207, p. 3.
2. **Choudhury N. and M. S. Islam** 2002. Biotechnology in Bangladesh, National Institute of Biotechnology, Bangladesh Atomic Energy Commission, Ramna, Dhaka-1000, (from internet).
3. **Hossain M., A. M. M. Husain and S. K. Datta** 2004. Biotechnology for rice improvement, CPD – IRRI Policy Brief 5, Editor: Uttam Kumar Deb, Research fellow, Center for Policy Dialogue, Dhaka.
4. **James, C.** 2003. Preview: Global Status of Commercialized Transgenic Criops: 2003. ISAAA (International Service for the Acquisition of Agri-biotech Applications) Briefs No. 30. ISAAA: Ithaca, NY, (http://www.isaaa.org).
5. **Kabir, K. M. E. and T. Bagchi** 2008. "Dhan Gobeshonar Pothikrit, Agricultural Scientist Dr. Shah Md. Hasanuzzaman" (Book in Bangla), Publisher: Kazi Daud, 491 Baro Mogbazar, Dhaka 1217.

6. **Karim, Z., 2009**. Climate change impacts on Bangladesh agriculture and food security: Policy, Strategy and Management Interventions. Keynote Paper. Consultative Workshop on Climate Change Impacts on Agriculture and Food security. MoA/ FAO, Dhaka.
7. **Miah M. A. A.** 2001. "Hybrid Research and Biotechnology": In Agricultural Research in Bangladesh in the 20th Century, published jointly by BARC, Airport Road, Farmgate, Dhaka-1215, and Bangladesh Academy of Agriculture, Dhaka, p. 43.
8. **Planning Commission,** 2009. Steps towards Change, National Strategy for Accelerated Poverty Reduction ii FY 2009-II, General Economics Division, Planning Commission, GoB, Dhaka.
9. **SAIC, 2005**, Risks in Agriculture and Their Coping Strategies in SAARC Countries, SAARC Agricultural Information Center, BARC Complex, Dhaka.
10. **Shaikh, M. A. Q.** 2009. National Consultant for Consulting Report on "Country Study on National Agricultural Research System (NARS) in Bangladesh – An Analysis of System Diversity", SAARC Agriculture Centre, BARC Complex, Dhaka.
11. **Shaikh, M. A. Q.** 2010. National Consultant for Consulting Report on "Sector Report on Knowledge Generation and Management in Agriculture, National Medium-Term Priority Framework (2010-2015) for Bangladesh", FAO Representation in Bangladesh, Dhaka.
12. **Siddique, M. A.** 2009. Consulting Report on "Enhancement of Research Institutional Efficiency: Human Resource Development Plan 2009-2025," Project implementation Unit, National Agricultural Technology Project, BARC, Dhaka.

Salvaging Our Soils – Promotion of Vermicomposting in Bangladesh Agriculture

M. Gul Hossain[1]

Abstract

The paper describes the poor status of soil fertility of Bangladesh that covers more than 60% of the cultivable land. Soil salinity covers 62% of the coastal area. Also soil acidity and toxicity covers wide areas in different parts of the country. It gives a brief history of vermiculture, articulates the harmful impacts of chemical agriculture and the need for introducing vermicomposting in Bangladesh agriculture. It highlights the properties of vermicomposting in view of restoring soil fertility in a sustainable manner. Based on the facts collected from literature and the author's own experience in farmers fields, the paper demonstrates the role that vermicomposting can play in ameliorating the impoverished soils of Bangladesh and thereby improving crop productivity. It also recommends scientific research on vercomposting which the Bangladesh National Agricultural Research System (NARS) is yet to take up seriously.

Introduction

Bangladesh soils have become alarmingly impoverished. Most soils have organic matter less than 1.7%, some even less than 1%, against a good soil which should have organic matter content more than 3.5% (Miah et al, 1993). The net removal of nitrogen, phosphorus, potassium and sulphur (NPKS) in areas of intensive cultivation is estimated at 180 to 250 kg per ha per year (Karim et al. 1994.). Most soils under high and medium high land are low in fertility level where NPKS are deficient. Deficiencies in magnesium (Mg), zinc (Z), boron (B) and molybdenum (Mo) have also been detected in increasing areas. These areas of low soil fertility comprise about 60% of the total cultivable land of Bangladesh (BARC, 1999).

According to a recent report of the Soil Resources Development Institute (SRDI), about 10.56 lakh ha, out of the 16.89 lakh ha of the coastal area, are affected by soil salinity at various degrees (The Daily Star, Dhaka, July 11, 2011). Some 62% out of the total cultivated land in the coastal area have already been affected by salinity. The salinity areas increased to 10.56 lakh ha in 2010 from 8.33 lakh ha over the last four decades.

Severe forms of acidification of 62,000 ha of acid sulphate soils of coastal region with acidity ranging from p^H 2 to 4, along with aluminium

[1]Fellow, Bangladesh Academy of Agriculture

toxicity, have been reported (BARC, 1999). In addition, ferrolyzation, a process of degradation of silicate mineral under alternate oxidation and reduction in Madhupur and Barind tracts, making soils toxic, and plough-pan formation in 2.3 million ha in the basins of Tista, Ganges, Brahmaputra and Meghna rivers as well as in the Barind tracts have been detected (BARC, 1999).

Soil toxicity occurs from indiscriminate uses of agrochemicals and industrial wastes, pesticides, nitrate and nitride wastes (from nitrogenous fertilizers), discharges from liquid effluents and solid wastes (from urea fertilizer factories leading to ammonia concentration), chromium, cadmium and lead and other heavy metals (from fertilizer plants, tanneries, pharmaceutical and paint factories) (Zaman, undated, mimeo.). Substandard phosphate and zinc fertilizers applied to crop fields add heavy metals like lead and cadmium to the soil. Surface run-off, leaching of fertilizers and pesticides contaminate water bodies. With such degradation of soils, one can only guess what has been the adverse impact on our crop production and what lies ahead, if measures are not taken to ameliorate the soils.

Fortunately, the means of restoring the fertility of most of these soils is available in nature. Unfortunately these means are less known and studied in Bangladesh, even though the technology is old and simple. The present paper focuses on **vermicomposting** - production and use of earthworm casts, to restore soil fertility - the process that mother-nature used in building up the fertile layer of soils on the surface of the earth through hundreds of millions of years. But unlike the natural process which is slow, with modern knowledge and technology we can ameliorate our soils with rapidity. It appears that there is no other technology to restore and improve soil fertility as efficient as vermicomposting which would be discussed in the paper.

Vermicomposting, as noted above, is the process of production and use of earthworm casts in fertilizing crop fields. It results from culture of earthworms, known as **vermiculture** and the use of its end product, the earthworm casts, called **vermicompost**.

In the modern high-tech society in which so much is either chemically or genetically engineered, the earthworm has been dubbed the "missing link" by agriculturists around the world (The History of Vermiculture eHOW_com.htm). For example, Kangmin (2005) states, *"We have to say that earthworms seem to be a missing link in ecological agriculture in China. Earthworms can treat organic wastes, livestock manure, and poultry droppings, and turn them into quality organic manure and*

greatly improve the ecological environment in rural areas. ... Earthworms are the missing link that makes sustainable agriculture a reality". Bangladesh, however, has lagged behind not only in studies on earthworm but also in genetically engineered crop production.

The paper gives a brief overview of the history of vermiculture *vis-à-vis* vermicomposting, articulates the harmful impacts of chemical agriculture and the need for introducing vermicomposting in Bangladesh agriculture. It highlights the properties of vermicomposting for restoring soil fertility in a sustainable manner. Based on the facts collected from literature and also the author's own experience in farmers fields, the paper demonstrates the role that vermicomposting can play in ameliorating the impoverished soils of Bangladesh and thereby improving crop productivity. It also recommends scientific research on vercomposting which the Bangladesh NARS is yet to take up seriously.

A Brief History Of Vermiculture

If we were to start at the very beginning of the history of vermiculture, we would have to go back more than 400 million years to the time when earthworm first appeared on the planet. Yet, until just 30 years ago, no one knew the value of these little creatures (The History of Vermiculture eHOW_com.htm). In Bangladesh, vermiculture and vermicomposting are practically absent in scientific studies.

Aristotle (384 – 322 BC) called earthworms *"the intestines of the Earth"* because of the realization of the important role that earthworm played in maintaining the soil (The History of Vermiculture eHOW_com.htm). However, until the end of 19th Century, most people believed that earthworms would eat the roots of plants. It was not until 1881, when Darwin (1881) published ***"The Formation of Vegetable Mold through the Action of Worms with Observations on Their Habits"*** that people began to take notice of the *"lowly little earthworm"*.

In the 1950s, red worms were brought to California, USA by Asian immigrants as they migrated (The History of Vermiculture eHOW_com.htm). The California red worm was originally thought to be a hybrid but later proved to be wrong as studies revealed that there is hardly any interspecific hybridization in earthworms. This red earthworm, however, is still one of the choicest worms for vermicomposting because it can easily be adapted to different types of soils and climate.

In the late 1970s, scam artists started telling people that they could make

$14,000 a year just by raising worms and selling them as baits, fertilizer or even food. The red worm developed a bad reputation. By the end of 1970s, the California red worm traffic came to a complete halt (The History of Vermiculture eHOW_com.htm).

By early 1990s, people were becoming more conscious of the environment, and composting became the preferred method for fertilizing farms and gardens. Meanwhile in 1972, a Canadian biology teacher in Michigan, Mary Appelhop (1936 – 2005), wanted to rear earthworm during the frosty winter months in Canada and put a pound of worms in a bin in the basement (The History of Vermiculture eHOW_com.htm).. She fed the worms with kitchen wastes and other wastes. By the end of the winter months the worms consumed 65 pounds of garbage and excreted compost. She used the compost in her kitchen garden and it gave excellent results. This eventually led to the development of controlled, simulated methods of vermiculture. Prior to this, all studies of vermiculture were conducted in the open in gardens or orchards (Darwin, 1881; Beddard, 1895.; Barret, 1947; Bahl, 1947; Evans,1948; Cohen & Lewis, 1949;. Barley,1959; Edwards &. Lofty. 1972; Gis & Christensen 1973). By now vermiculture has become a major business in America. In 1997, International Worm Growers Association was formed with 300 charter members (The History of Vermiculture eHOW_com.htm).

In the Indian sub-continent vermiculture practices, under controlled conditions, cannot be traced up to the 1970s. But it started spreading in the 1980s.In India, a network of 2 lakh Indian farmers have been producing 50,000 tons of vermicompost per month. (The History of Vermiculture eHOW_com.htm). It is worth mentioning that after the collapse of the Soviet Union, fertilizer supply from Soviet Russia to Cuba came to a halt. As an alternative, the Cubans started vermicomposting in a big way. By 2003, the Island produced 10 lakh tons of vermicompost to fertilize crops fields (The History of Vermiculture eHOW_com.htm).. Besides, Argentina, Australia, Canada, China, Italy, Israel, Philippines, South Africa and Thailand are producing increasing quantities of vermicompost (Vermicompost – Wikipedia, the free encyclopedia. htm), while the history of the studies on earthworms in the United Kingdom is pretty old.

In Bangladesh, few NGOs (ASA, CMES, GKSS, Practical Action, Surid etc.) have started vermicomposting. The author himself started vermiculture and vermicomposting in 2001 with the villagers of Maheswar Chanda in Jhenaidah district. The initial

progress was slow but after sometime, it has now gathered a momentum. Farmers of the village and surrounding villages have by now established scores of vermiculture units and are producing vermicompost. They are using the compost in their vegetable and rice fields with great success - better yields of crops and improved soil fertility. They are also selling earthworms to farmers coming from far away villages. During 2009-2010, the UNDP Bangladesh took up a small project on vermiculture under its Rural Employment Opportunities for Public Assets (REOPA) Project and trained assetless rural women in Sirajganj, Satkhira, Borguna, Narsingdi, Habiganj and Lakhsmipur districts on vermicomposting. The author had the opportunity to work as the consultant to the project. The technology is spreading, in some areas, rather fast (Jhenaidah and Chuadanga).

Under the National Agricultural Research System (NARS) of Bangladesh there is hardly any research in vermiculture, if anything, apathy about the technology appears to prevail. This appears to be due mainly to lack of knowledge on the technology. However, recently the Soil Science Division of the Bangladesh Agricultural Research Institute (BARI) has undertaken a research project on vermiculture supported by the Bangladesh Academy of Sciences (BAS). Apparently this is the first ever formal project on vermiculture in the NARS of Bangladesh.

Why Vermicomposting?

Green revolution started in the late 1960s. This led to cultivation of high yielding varieties (HYVs) of rice and wheat. This in turn increased cropping intensity. With HYV cultivation, the use of chemical fertilizers, irrigation and pesticides increased rather fast. Crop yields increased two to three folds. For a long time we did not give attention to the loss of soil fertility that accompanied HYV cultivation and with increased cropping intensity. We also ignored the pollution it was causing to the environment, including the soil, the water and the environment.

The deterioration of soil fertility that followed the introduction of HYV cultivation with chemical fertilizers was highlighted earlier in the paper. In addition, there are also socio-economic costs involved in chemical agriculture. For example, more than 80% of the Bangladeshi farmers are small and marginal. They are economically fragile, and hence fail to apply fertilizers in adequate quantity and in time. Because of this, the present government is subsidizing fertilizer prices amounting to thousands of crores of taka. We have seen the good impact of the subsidy in terms of increased crop production in the country in recent years. But these measures are not contributing to sustainable improvement of the soil health and crop production. Deficiency of organic matter content remains, leaching down of nutrients continues, pollution of the environment continues, more and more fertilizers have to be applied to the crop fields, making crop production increasingly expensive. We are looking for a sustainable solution to all these problems. Fortunately, the solution lies in the nature itself. Vermicomposting can solve most of these problems as will be revealed from the discussion that follows.

It is pertinent here to mention that the current demand for chemical fertilizers in the country is estimated at about 32 lakh tons. Domestic urea production is about 15 lakh tons. We have to import about 40% of the amount of demand. This costs the country Tk.3,000 to Tk.4,000 crores every year (Fertilizer – A Big Bother for Bangladesh. http://www.ebangladesh.com/2009/01/27/fertilizer-a-big-bother-for-bangladesh/). The more we can produce and use vermicompost, the more we would be able to reduce the import quantum of fertilizers and save the import cost. At the same time we would be able to improve the soil in a sustainable manner. More importantly, the technology can be managed locally, by the farming community itself, without establishing big industries or involvement of foreign currency spending.

Properties Of Vermicompost

1. Humus production

Earthworms ingest decomposed organic wastes of the soil and excrete amorphous colloidal material, **vermicompost**. This contains **humus** (Kangmin, 2005). What the soil needs is not only manure, but more importantly humates. Compared with other manures, only earthworm casts contain humic acids. Humic acids (humic, ulmic and fulvic) are found in humus and are essential to plants in three basic ways: humic acid enables plants to extract nutrients from the soil, ulmic acid stimulates and increases root growth; and fulvic acid helps plants to overcome stress and dissolve unsolved minerals to make organic matter ready for plant use (Kangmin, 2005).

Unlike the slow natural process, humus production by using earthworms is much faster. In order to stress the rapidity with which earthworms produce humus, Barret (1947) postulates a hypothetiical scenario, *"When a requisition is put in for a few million tons of humus, to be prepared overnight for emergency plant food for tomorrow, nature marshals her vast earthworm army to a feast; and behold, the miracle is accomplished – the order is filled*

and the crying children of plant world are fed – the night-soil of earthworms, the castings, is deposited on and near the surface of the earth, ready for immediate use – for ***earthworm excrete humus****. No waiting, no worry, no confusion – just the ordinary routine, daily transaction of business in the humus factories of nature. ... In the body of the earthworm we find a complete, high speed humus factory, combining all processes – both mechanical and chemical – for turning the finished product, topsoil, properly conditioned for best root growth and containing in the rich proportion and in water-soluble form all the elements required of the earth for plant nutrition"*

Bangladesh needs to master the science and technology of vermicpomosting, not only for salvaging its impoverished soils but also for food security.

2. Improvement of the physical structure of the soil

There are three ecological types of earthworms (Ismail, 1997): **Epigics** - the surface dwellers serving as efficient agents of comminution and fragmentation of leaf litter. They are phytophagous. They generally have no direct effect on soil structure as they cannot dig into the soil. They are, however, efficient producers of vermicompost to be used in crop fields. **Anecics** that feed on the leaf litter mixed with soil of the upper layers and are called geophytophagous. They also produce surface casts depending on the bulk of the organically rich sod they ingest. Finally, the **Endogics,** that live deep within the soil deriving nutrition from the organically rich soil they ingest. They are geophagous. They drill holes underground parallel to the soil surface and excrete underground.

All of these, however, help improve the soil structure by improving their physical properties either by loosening the soil or by adding organic matter content through deposit of casts or when the casts are added to the soil. All of them improve the soil fertility too, as will be discussed in the following paragraphs. It needs to be made clear that it is the Epigics and Anecics that are suitable for vermicompost production Edogics are useful in increasing soil porosity, soil aeration and water penetration in the soil. The changes in the physical strructure of the soil promotes microbial activities in the soil. Vermicompost turns clay soils loose and makes the soil more congenial for crop production. As vermicompost is colloidal, it helps improve not only the water holding capacity of the sandy soil but also reduces waterlogging in clay soils.

3. Chemical changes in the soil

From our discussion on humus above, it becomes obvious that chemical changes do occur due to vermicompost application to the soil.

Earthworms process the transport of organic material to the sub-surface layers and during this process much of the materials is ingested, macerated in the gut of the earthworm and eventually excreted as casts. They contribute nutrients in the form of nitrogenous wastes, ammonia, which forms a large proportion of the nitrogenous matter of the soil. This can lead to a temporary rise in the soil pH (Cohen & Lewis. 1949).

Researchers have shown that casts produced by earthworms have a higher base-exchange capacity and are generally richer in total organic matter, total exchangeable bases, phosphorus, exchangeable potassium, manganese and total exchangeble calcium (Ismail, 1997). Earthworms favour nitrification since they increase bacterial population in the soil (Parle, 1963 a & b). as well as soil aeraion. As the protein content of earthworm tissue is high, on decomposition it also yields nitrate nitrogen to the soil (Alaweedin, & Ismail. 1986; Russell, 1910).

The organic material that the earthworm ingests is macerated, mixed with inorganic soil material, passed through the gut and excreted as casts, with most of the organic matter changed very little chemically, but finely ground physically. This increases the surface area and, therefore, microbial activities (Nowak, 1975) that enhances the transformation of soluble nitrogen into microbial protein, peventing their leaching to lower horizons of the soil. There is earthworm mobilisable nitrogen pool in the soil which is linked to earthworm mobilisable carbon resources and that physically protected nitrogen and carbon contribute to the earthworm mobilisable nitrogen and carbon pool (Scheu, 1994).

4. Increased soil nutrients

Vermicompost application increases the organic matter content of the soil. As a result, it not only increases the carbon content but also the nitrogen content of the soil. It also increases the phosphorus, potassium, manganese content of the soil. Compared to the ordinary soil, vermicompost contains 5 times more nitrogen, 7 times more phosphorus and 11 times more potassium. In addition, the compost is rich in most of the micronutrients (Vermicomposting: Journey to Forever to Organic Garden. (http://journeytoforever.org/compost_worm.html; Lunt & Jacobson cilted by Kangmin, 2005.).

The Table 1 below shows a comparison of nutrient contents of vermicompost with those of ordinary compost.

Table 1. The comparative nutrient contents of vermicompost and ordinary compost

Nutrients	Vermicompost	Ordinary Compost
Nitrogen (%)	1.6	0.5
Phosphate (%)	0.7	0.2
Potassium (%)	0.8	0.5
Calcium (%)	0.5	0.9
Magnesium (%)	0.2	0.2
Iron (ppm)	175.0	146.5
Manganese (ppm)	96.5	69.0
Zinc (ppm)	24.5	14.5
Copper (ppm)	5.0	2.8
C:N Ratio	15.5	31.3

These values are subject to variation depending upon the type of organic waste

Source: Punjab State Council for Science and Technology, Chandigarh, India (VERMICULTURE.htm)

It is obvious from Table 1 that all the nutrient contents in vermicompost is higher than in ordinary compost. It is further noted that the C:N ratio is less in vermicompost than that in ordinary compost suggesting that the nitrogen content is higher in vermicompost which is more beneficial to plants..

Apart from these, vermicompost contains vitamins (Kale & Daniel, 2009.), hormones (auxins and gibberellins) (Vermicompost – Wikipedia, the free encyclopedia.htm) and enzymes (protease, lipase, amylase, cellulase, lichenase, chitanase) (NIIR. undated). These enzymes act on organic matter resulting in biodegradation of macromolecules (NIIR,undated) that helps increase the activities and the number of microorganisms in the soil. In addition, the milky fluid excreted from the body of earthworms, the coelomic acid, works as an antibiotic (NIIR,undated). For this reason the vermicompost is free of pathogens. In effect, vermicompost is not only a better substitute for chemical fertilizers, but it may also be called the *ideal fertilizer* for all crops.

5. Pathogen free soil environment

During preparation of ordinary compost, high temperature generates in the compost heap. But no such high temperature is generated in vermicompost. This led to the belief that there might be a lot of pathogens present in vermicompost. But research has shown that pathogens are present only in the initial parts of the earthworm guts, but are not found in the rest of the intestine. It is assumed that some changes occur in the intestine that makes the vermicompost free of pathogens (Appelhop, 2003).

Researchers have shown that the use of vermicompost in crop fields would not contaminate surface or underground water and regular culture of earthworm *(Eisenia foetida)* in pasture land would help prevent pollution due to pathogens (Monroe, 2005). This is because colonies of earthworm in pasture land produce vermicompost which helps to free the environment of pathogens. Based on such reasons researchers recommend the production and use of vermicompost in order to free the environment of pathogens (Eastman, 1999; Eastman et al. 2000).

6. Reduction in greenhouse gas emission

Emission of carbon dioxide and methane gas from decomposition of organic matter contributes to greenhouse gases in the atmosphere. The increase of greenhouse gases in the atmosphere leads to the increase in atmospheric temperature which in turn melts the ice in polar region of the earth. This increases the water level of the sea. A 1989 estimate forecasted that with the sea level rise of 1.5 meter, 22,000 square kilometer of southern Bangladesh will be affected (http://maps.grida.no-Potential impact of sea level rise on Bangladesh-Maps and Graphics at Microsoft Internet Explorer). Vermicomposting traps the carbon gases, generated from organic matter decomposition, in microorganisms and humus formed and helps reduce their emission to the atmosphere (carbon sequestration) (Monroe, 2005).. The use of chemical fertilizers is leading to the reduction of carbon content in the soil. Use of compost and vermicompost on a regular basis would lead to the increase in carbon content of soil and to the reduction of carbon gases in the atmosphere (Monroe, 2005).

It may be noted that vermicompost is 5-7 times more effective in plant growth and yield compared to ordinary compost (Monroe, 2005). As we have mentioned above, the nitrogen content in vermicompost is more than that of ordinary compost, the emission of nitrous oxide is reduced as a result of vermicomposting. And as a greenhouse gas, the effect of nitrous oxide is 310 times more harmful compared to that of carbon dioxide

((Monroe, 2005). Research along these lines is in progress (http:/www.wormresearchcentre.co.uk). Since a continuous increase of greengouse gas has been posing a serious threat to the overall atmospheric balance of the planet, a global campaign about the beneficial role of vermicompost in reducing the scale of greenhouse gas is the need of the time. Also the NARS, especially of Bangladesh, should take up programmes on research and technology transfer involving vermicomposting as its wider application will have several benefits:

(i) farmers will be spared from buying chemical fertilizers;
(ii) cost of crop production will be reduced;
(iii) farm income will increase;
(iv) import cost of fertilizers will reduce; and
(v) atmospheric pollution will be reduced /avoided through the reduction / avoidance of chemical agriculture and reduced nitrous oxide release in the atmosphere.

7. Protection of biodiversity

Biodiversity is declining rapidly worldwide. Earthworms have an important role to play in counteracting the loss of biodiversity. They increase the types and numbers of microbes in the soil by creating conditions under which they survive and thrive. The earthworm spews out many times more microbes in the casts than they ingest. For this reason the earthworm gut has been described as a little "bacteria factory". By adding vermicompost and cocoons to the soil, one is increasing the soil's microbial community enormously (Monroe, 2005). The below-ground biodiversity is the basis for increased biodiversity above-ground, as the soil creatures and the plants that they help to grow are the basis for the entire food chain. The United Nations Environment Programme (UNEP) has acknowledged the importance of below-ground biodiversity as a key to sustainable agriculture, above-ground biodiversity and the overall economy (http:/www.ciat.cgiar.org/tsbf institute/csm bgbd/htm)

8. Re-establishment of organic agriculture

The harmful effects of chemical agriculture are now a common knowledge. Soil erosion, environmental pollution, human health hazards, deterioration of crop quality, increase in the incidences of pests and diseases, destruction of soil microorganisms are well known effects.

An important component of traditional agriculture was livestock. The use of livestock dung in crop fields helped maintain soil fertility. Under traditional agriculture, cultivation of different crops (especially the legumes like lentil, grasspea, blackgram, chickpea, mungbean, crotolaria as well as jute, mustard, etc. along with rice) used to create crop diversity that helped maintain balanced soil fertility. The chemical agriculture of the green revolution promoted monoculture, mainly of rice and wheat. Monoculture has been identified as one of the main causes of deterioration of soil health and increased incidence of pests and diseases in crop fields. At the same time, mass destruction of soil microorganisms has taken place. The traditional agriculture was basically organic and was sustainable. The need for organic agriculture and organic food has never been felt more than at the present time. One cannot overemphasize the role vermicompost can play in re-establishing organic agriculture.

Conclusion

I would like to conclude with a quotation from the well known Russian Professor Anatoly M. Igonin, ***"Nobody and nothing can be compared with earthworms in their positive influence on the whole living Nature. They create soil and everything that lives in it. They are the most numerous animals in Earth and the main creatures converting all organic matter into soil humus providing soil fertility and biosphere's functions: disinfecting, neutralizing, protective and productive."*** **If Professor Igonin is right and if the discourse in the paper is on the right track, we have no reasons for not promoting vermicomposting in Bangladesh agriculture as a nationally coordinated programme. Patronization for development and transfer of the technology by both the public and private sector is overdue indeed.**

References

1. Alaweedin, S.S. & S.A. Ismail. 1986. Stage of growth as a factor in harvesting the earthworm, *Lampito mauriti* Kinberg. Proc. Nat. Sem. Org. Waste. Utiliz. Vermicomp. Part B:Verms and Vermicomposting (Dash, M.C., B.K. Senapati & P.C. Mishra Eds.), Sambalpur University, Orissa. Pp 122-127.
2. Appelhop, M. 2003. Notable Bits. Vol 2(5), May 2003. http://www.wormwoman.com
3. Bahl, K.N. 1947. Excretion of the Oligochaeta. Biol. Rev. 22: 109-147.
4. BARC. 1999. Land Degradation Situations in Bangladesh. Soils Division, Bangladesh Agricultural Research Council, Dhaka.
5. Barley, K.P. 1959. Earthworm and soil fertility. IV. The influence of the earthworms on the physical properties of a red brown earth. Aust. J. Agric. Res., 10: 371-376.
6. Barret, T.J. 1947. Harnessing the Earthworm. Bruce Humphries Inc., Boston, Mass., USA.

7. Beddard, F.E. 1895. A Monograph of the Order Ologochaeta. Oxford. 769pp.
8. Cohen, S. and H.B. Lewis. 1949. Nitrogenous metabolism of the earthworm (*Lumbricus terrestris*) Fed Proc. 8:181.
9. Darwin, C. 1881. The formation of vegetable mould through the action of worms, with observations on their habits. Murray, London. 126p.
10. Eastman, B,R., N.K. Philip, C.A. Edwards, L. Trytek, B. Gundadi, A.L. Stermer and J.R. Mobley. 2000. The Effectiveness Of Vermiculture in Human Pathogen Reduction for USERPA Biosolids Stabilization. Orange County, Florida: Environmental Protection Division.
11. Eastman, B.R. 1999. Achieving pathogen stabilization using vermicomposting. Biocyle. November. Page 62.
12. Edwards, C.A. and J.R. Lofty. 1972. Biology of Earthworms. Chapman and Hall Ltd., London. 283pp.
13. Evans, A.C. 1948. Studies on the relationships between earthworms and soil fertility. II. Some effects of earthworm on soil structure. Ann. Appl. Biol. 35: 1-13.
14. Fertilizer – A Big Bother for Bangladesh. http://www.ebangladesh.com/2009/01/27/fertilizer-a-big-bother-for-bangladesh/
15. Gish, C.D. and R.E. Christensen 1973. Cadmium, nickel, lead and zinc in earthworm from roadside soil.Environ. Sci, & Technol.:1060-1062.
16. http://journeytoforever.org/compost_worm.html
17. http:/www.wormresearchcentre.co.uk
18. Igonin, Anatoly M. as cited by Monroe, G. 2005. Manual of On-Farm Vercomposting and Vermiculture. Organic Agriculture Centre of Canada. http://www.vermiculturemanual.com/en/manual/history.htm
19. Ismail, S.A. 1997. Vermicology – The Biology of Earthworms. Orient Longman, Himayatnagar, Hyderabad, India.
20. Kale, R.D. and T. Daniel. 2009. The role of earthworms in Tropics with emphasis on Indian Ecosystems. Applied and Environmental Soil Science. Volume 2010 (2010), Article ID 414356., 16 pages
21. Kangmin, Li.. 2005. Vermiculture Industry in Circular Economy. Chinese Academy of Fisheries Sciences, Freshwater Fisheries Research Centre, Asian Pacific Regional Research & Training Centre for Integrated Fish Farming. Wuxi 214081, China. E-mail: li_kangmin@yahoo.com.cn (Worm Digest – Vermiculture Industry in Circular Economy. http://www.wormdigest.org/content/view/135/2/)

22. Karim, Z., M.M.U. Miah and S. Razia. 1994. Fertilizer in national economy and sustainable environmental development. Asia Pacific Jour. Env. Dev. Vol 9. pp. 48-67.
23. Koont, 2004. Quoted by Glenn Monroe (2005). Manual for On-Farm Vermicomposting and Vermiculture. Organic Agriculture Centre of Canada (OACC).
24. Lunt and Jacobson (undated) of Connecticut Experimental Station, USA. Quoted by Kangmin, Li.. 2005. Vermiculture Industry in Circular Economy. Chinese Academy of Fisheries Sciences, Freshwater Fisheries Research Centre, Asian Pacific Regional Research & Training Centre for Integrated Fish Farming. Wuxi 214081, China. E-mail: Li_kangmin@yahoo.com.cn
25. Miah, M.M.U., A.K.M. Habibullah and S.D. Gupta. 1993. Depletion trend of potassium in Bangladesh soil and its management for maximizing crop production. Bangladesh Journal of Scientific Research. 14(1): 35-42.
26. Monroe, G. 2005. Manual of On-Farm Vercomposting and Vermiculture. Organic Agriculture Centre of Canada. http://www.vermiculturemanual.com/en/manual/history.htm
27. NIIR. (undated). The Complete Technology Book on Vermiculture and Vermicompost. National Institute of Industrial Research (NIIR), Delhi, India p. 37-38.
28. Nowak, E. 1975. Population density of earthworms and some elements of their production in several grassland environments. Ekol. Pol. 23: 459-491.
29. Parle, J.N. 1963 a. Microorganisms in the intestines of earthworms. J. Gen. Microbiol. 31: 1-11.
30. Parle, J.N. 1963 b. A microbial study of earthworm casts. J. Gen. Microbiol. 31: 13-22.
31. Russell, E.J. 1910. The effect of earthworms on soil productiveness. J. Agric. Sc. 2:246-257.
32. Scheu, S. 1994. There is an earthworm mobilisable nitrogen in soil. Pedobiologia. 38: 243-249.
33. The Daily Star, Dhaka. July 11, 2011. Salinity hits 62pc coastal land.
34. The History of Vermiculture eHOW_com.htm
35. Vermicompost – Wikipedia, the free encyclopedia. htm
36. Vermicomposting: Journey to Forever Organic Garden (Page 2).
37. Zaman, S.M.H. (undated). Conservation Cropping under Rain Forest Conditions. Mimeo.

BANGLADESH ACADEMY OF AGRICULTURE (BAAG)

ANNUAL REPORT 2011

Since the 16th Annual General Meeting held on April 10, 2010, the activities of the Executive Council were as summarized below:

1. Meetings of the Executive Council

The Executive Council met 4 (four) times during the period (May 12, 2010; September 26, 2010; November 01, 2010; and February 28, 2011).

2. Fund Raising for BAAG

The President of BAAG, Dr. Kazi M. Badruddoza, had written to USDA, Washington DC, for an endowment fund for BAAG to undertake studies in the field of agriculture. To this the USDA responded positively and asked for detailed information about the objectives and activities of BAAG. These details were sent to USDA.

The President entrusted two distinguished Fellows / Members of the Executive Council, Professor Dr. Lutfur Rahman and Dr. A. Q. Shaikh to follow up the matter. The two distinguished Fellows had meetings with the Chairman UGC who is responsible for recommending to the External Resources Division of the Planning Commission for the fund. Professor Lutfur Rahman also met separately the Director Planning, UGC and the Governor of the Bangladesh Bank in this connection. (The reports submitted on the activities undertaken in this respect are available with BAAG Secretariat). The matter needs further follow up.

3. Model Format for MOU with Other Institutes

At the suggestion of the President, two distinguished Fellows / Members of the Executive Council, Dr. Ameerul Islam and Dr, Golam Ali Fakir, were requested to draft a model MOU, using the copy of the MOU which Dr. Motlubor Rahman, the former President, developed and used for the MOU already signed with BARC, as a basis.

Dr. Ameerul Islam took the initiative to draft the MOU and submitted the draft to the Executive Council. This was further reviewed by Dr. Motlubor Rahman and the finalized version was prepared.

4. Publication of the Revised Edition of the Book "Agricultural Research in Bangladesh in the 20th Century"

Dr. M. H. Mondal and Professor Dr. A. M. M Tareque, distinguished Fellows / Members of the Executive Council, were requested to coordinate the work with sectoral reviewers to work on the revised edition of the book. The matter awaits follow up action.

5. **Guidelines for BAAG Gold Medal Award 2010**

In view of past experiences where all BAAG Gold Medals went to personnel in research, the Executive Council decided that the 2010 Gold Medal would be focused exclusively on extension personnel covering crops, livestock, fisheries and forestry. In this context, as per decision of the Executive Council, a fresh set of guidelines was developed and discussed in Council Meetings. The finalized version has now been prepared.

6. **Donation from Alhaj Mohammad Masum, a distinguished Fellow of the Academy and Chairman, Supreme Seed Company**

The Academy received this year's donation of Tk.1,00,000 (Taka one lac) from Supreme Seed Company on October 18, 2010. A letter of acknowledgement and thanks on behalf of the Academy was sent to Alhaj Mohammad Masum, Chairman, Supreme Seed Company on October 25, 2010.

7. **Donation from Dr. M. Motlubor Rahman, a distinguished Fellow of the Academy for award of BAAG's Special Gold Medal last year (2010)**

It may be recalled that a sum of Tk.33.000 (Thirty Three Thousand Taka) was received by the Academy from Dr. M. M. Rahman, a distinguished Fellow of the Academy, as donation towards BAAG's Special Gold Medal Award to Dr. Kazi M. Badruddoza last year (2010). The Academy thankfully acknowledges the generous donation which has been reflected in the current (2010).Audit Report.

8. **Date of Award of Gold Medal, 2010**

As the optimum time of the Annual General Meeting was passing by and the President of the Academy, Dr. Kazi M. Badruddoza, was away (now expected to return to Bangladesh around mid-May 2011), the Executive Council decided (in its Meeting February 28, 2011) that the 17^{th} Annual General Meeting would be held as scheduled (on May 23, 2011) while the date of the Gold Medal Award would be decided "after holding the Annual General Meeting".

9. **Publication BAAG Journal "Bangladesh Agriculture", Vol. 3, Number 1, January 2010**

The journal has been published recently and copies are being distributed.

Dr. M. Gul Hossain
General Secretary

BANGLADESH AGRICULTURE

Volume 4 Number 1 January 2011

Table of Contents