Research Achievements in Bangladesh Agriculture using Nuclear Techniques

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SUMMARY. Nuclear techniques have been successfully used in Bangladesh agriculture in the development of many technologies that are environment-friendly and contributing to the national economy. Low input - and stress tolerant - crop varieties of rice, jute, mustard, chickpea, mungbean, blackgram and tomato, high BNF potential (Ndfa) rhizobial biofertilizers, many soil-water management practices including uptake efficiencies of fertilizer nutrients for various crops, irrigation scheduling, water requirements, residual effect of legumes to succeeding cereal, development of suitable tillage practices, food preservation techniques, means of livestock improvement, etc. are the important achievements that imparted a tremendous impact on agricultural development with less pressure on the environment. The paper also discusses the constraints related to nuclear research and highlights the prospects for its further development in Bangladesh.

1. INTRODUCTION

The beginning of the application of atomic energy for peaceful uses dates back to 1923 and the work of G.V. Hevesy, which signified the start of isotope application in soil and crop research (I). With the establishment of International Atomic Energy Agency on July 29, 1957 the work on this arena of science got momentum worldwide. In Bangladesh, application of isotopes and ionizing radiations in agricultural research has been initiated in 1961 at the Atomic Energy Agricultural Research Centre (AEARC), Dhaka under the then Pakistan Atomic Energy Commission (2). In July 1972, an institute was established as Institute of Nuclear Agriculture (INA) as a constituent institute of Bangladesh Atomic Energy Commission(BAEC) and was shifted from Dhaka to its present site in Mymensingh in 1975. Later the institute's activity was strengthened, separated from BAEC and made an autonomous research organization as Bangladesh Institute of Nuclear Agriculture (BINA) under Ministry of Agriculture on July 1, 1982. Since then the institute has been working on different disciplines of agricultural science viz. Plant Breeding, Soil Science, Crop Physiology, Plant Pathology, Entomology, Irrigation and Water Management, Agronomy, Training, Communication and Publication, etc. The other major institutes that are involved in nuclear agriculture research are Institute of Food & Radiation Biology and Bangladesh Agricultural University.

A good amount of work has been done with nuclear technique in Bangladesh agriculture. It is not possible to review all the works done, but some important research achievements made in the field of mutation breeding, soil fertility, food preservation and animal husbandry are briefly reviewed in this article.

2. DEVELOPMENT OF CROP VARIETIES

Sixteen crop varieties have been developed (2,3,4) using ionizing radiations either directly or by crossing with the irradiated mutant line that included three varieties of rice (Iratom 24, Iratom 38 and Binasail), two varieties of jute (Atompat-38 and Binadeshipat-2), one variety each of chickpea (Hyprosola), mungbean (Binamoog-2) and blackgram (Binamash-1) and four varieties each of mustard (Safal, Agrani, Binasarisa-3 and Binasarisa-4) and tomato (Anobik, Bahar, Binatomato-3 and Binatomato-4). The varieties are high yielder (10-20%) than their respective mother varieties, most of them (all the three rice varieties, chickpea variety Hyprosola, mungbean variety Binamoog-2 and mustard varieties Agrani, Binasarisa - 3 and

Binasarisa-4) mature 2-4 weeks earlier and resistant to diseases common to mother and/or popular variety.

The rice variety Binasail has got late planting potential and hence useful in flood rehabilitation programme. It is also tolerant to brown plant hopper. The jute variety Atompat - 38 has stiff stem and therefore has lesser possibility of lodging or breaking during stormy weather. It is tolerant to stem rot disease (*Macrophomina phaseolina*) and gives improved quality of fibre. The chickpea variety, Hyprosola contains 4% higher protein in the seed than mother variety Faridpur -1. It has shown field tolerance to root rot and *Alternaria* leaf spot disease and pod borer insect *Heliothis helicoverpa*. The mustard varieties Agrani and Safal do not lodge under high input condition and have tolerance to aphid and *Alternaria* blight. The Binamoog-2 is a bold seeded summer mungbean tolerant to weather damage caused by excessive rain and splitting of the pod. All pods of this variety mature at a time. It is also tolerant to yellow mosaic virus and *Cercospora* leaf spot. The blackgram variety Binamash-1 is tolerant to yellow mosaic virus and *Cercospora* leaf spot. The tomato variety Anobik is a dwarf variety, does not lodge, and contains more vitamin c. Bahar variety is characterized by its larger fruit size, fleshy, tasty and contains less number of seeds. The mutagenic agent (radiation or chemical mutagen) used to develop the mutant varieties with their mother variety/line and the year of release by the National Seed Board are given in Table 1.

3. SOIL FERTILITY AND PLANT NUTRITION TECHNOLOGIES

It has been observed through tracer studies that nitrogen is deficient in all soils of Bangladesh, phosphorus and sulphur status is below critical level in many areas and potassium is deficient in terrace and piedmont areas. Calcareous and HYV rice soils are deficient in zinc. Gray brown terrace soils of Madhupur and grey floodplain soils of Mymensingh and Jamalpur are deficient in molybdenum. Copper deficiency has also been observed in some soil series.Results from these studies are being utilized in formulating, updating and refining fertilizer recommendation guide for use by the farmers (5, 6, 7, 8).

Studies with ^{15}N isotope showed that nearly 70% of applied N is lost if applied in the soil surface and only 35-40% of it is utilized by rice crop. Nitrogen use efficiency can be enhanced considerably if applied at 8-10 cm depth. About 25-50% nitrogen fertilizer can be saved if applied by this method. Two split application of urea, one-half before planting and the other half at 45-50 days after planting have been found useful for increased yield of rice and jute. Ammonium sulphate and urea behaved similarly as a source of N in rice fields with respect to timing and placement while sodium nitrate was found inefficient as a source of N (9,10).

Use of ^{32}P indicated that phosphorus use efficiency of crops is enhanced if applied in the soil surface and hoed in before planting of seeds. Sodium bicarbonate extractable phosphorus has shown highest correlation with 'A' values. Direct application of rock phosphate is not suitable in the calcareous and saline soils while in acid soils, it is more effective as compared to triple super phosphate (TSP). It was found that 1270 kg sugar mill waste (press-mud) and 180 kg TSP were equally effective as sources of phosphorus. Thus a considerable amount of TSP can be saved if press-mud is applied in the soils of sugar mill area.. Surface placement of phosphatic fertilizer was superior to shallow or deep placement. Mixing ammonium sulphate with super phosphate stimulated P uptake by rice crop from applied fertilizer. Rubidium-86 tracer studies indicated that the annually flooded floodplain soils do not need immediate application of potash fertilizer. But the terrace soils of Madhupur and Barind area would require supplemental potash for increased crop production. It has been proved that phosphate, sulphur and zinc fertilizers applied in the first crop of a cropping sequence remains unutilized in a considerable amount and become available to succeeding crops. Thus the fertilizer need of

the next crops of a cropping pattern may be reduced. Nitrogen utilization in the first, second and third crops were found to be 36, 9 and 2%, respectively (7, 8, 11).

Irrigation scheduling and water requirement of HYV rice, wheat, chickpea, lentil and mustard have been made for the soils of Ishurdi, Bogra,, Madhupur and Satkhira area based on monitoring the changes in water content of the soil profile using neutron moisture meter (12,13). Minimum tillage for wheat cultivation by planting seeds in furrows made by country plough in between the lines of preceding rice crop has been recommended for the floodplain soils having water table at a shallow depth and where transplanted *aman* rice is harvested late (early to mid December). Deep tillage beyond 15 cm depth coupled with one or two irrigation has been found to increase wheat yield by about 20% in the heavy textured soils of Madhupur and Bogra area (14,15,16).

Using ^{15}N-isotope dilution technique seven high biological nitrogen fixation potential (Ndfa) rhizobial inoculants have been developed for seven leguminous crops that are being used in the demonstration trials by Department of Agricultural Extension since 1989. The yield increase due to use of these

Table 1. Crop varieties developed with the help of induced mutation and released by National Seed Board for commercial cultivation.

Crop	Variety Name	Physical/chemical mutagen	Mother variety	Year of release
Rice	Iratom-24	300 Gy	IR 8	1975
	Iratom-38	300 Gy	IR 8	1975
	Binasail	250 Gy	Nizersail	1987
Jute	Atompat-38	900 Gy	D - 154	1988
	Binadeshipat-2	NaN_3	CVL-1(BJRI line)	1997
Chickpea	Hyprosola	200 Gy	Faridpur-1	1981
Mungbean	Binamoog-2	Hybridization	Mutant MB-55 (4) x V-2773 (AVRDC line)	1994
Blackgram	Binamash-1	600 Gy	Local cultivar (BINA Acc. B-10)	1996
Mustard				
B. campestris	Safal	700 Gy	Advanced line YS-52	1991
	Agrani	700 Gy	Advanced line YS-52	1991
B. napus	Binasarisa-3	700 Gy	Nap-3	1997
	Binasarisa-4	700 Gy	Nap-3	1997
Tomato				
(winter)	Anobik	200 Gy	Local variety	1975
	Bahar	Hybridization	Anobik x Oxheart	1992
(summer)	Binatomato-2	Hybridization	Advanced line S_1 x Bahar	1997
	Binatomato-3	Hybridization	Advanced line S_1 x Bahar	1997

inoculants ranged from 15-40% in lentil, 20-45% in chickpea, 18-35% in mungbean, 25-45% in cowpea, 40-80% in *Sesbania*, 20-40% in groundnut and 75-200% in soybean (17). It was also observed that these local inoculants are better than the exotic strains and that the mixed culture inoculants are superior to single cultures (18,19). The success of the biofertilizer technology has led to the development of a Pilot Project by the Government and a model project by IAEA to creat awareness among the farmers and generate interest among industrialists for mass scale use of biofertilizer in the country.

4. FOOD PRESERVATION TECHNIQUES

Significant advances have been made in applying the radiation techniques to reduce post-harvest food losses and ensure microbiological safety for consumption of food materials. A gamma radiation dose of 0.50 kGy was found suitable for disinfestation of commercial quantities of pulses, oil seeds and tobacco leaves irrespective of varietal differences (20). Laminated gunny bags with additional 0.5 mm thick polyethylene pouches containing the pulses inside were observed to be adequate for irradiation and storage at ambient condition (20 - 35°C, 60-90% relative humidity). Significant reduction of losses was observed on 7-8 months storage of the irradiated samples. A dose of 0.04-0.08 kGy could inhibit sprouting in onions. Sprouting in potatoes could be inhibited at 0.10 kGy. Dried and cured fishery products could be infested of insects at a dose of 0.30 kGy (21). Sun-dried fish (moisture content 18% or below) packaged in high density polyethylene pouches and placed in ply-wood cartoon boxes was irradiated to 1 kGy with effective disinfestation and reduction of microbial load in both 100g laboratory samples and 20 kg commercial bags. The irradiated samples were also found to be of superior quality in physical appearance and organoleptic evaluations (22). Consumers preferred irradiated potatoes although some remarks on colour were received. An industrial enterprise has successfully marketed good quality chips made from irradiated potatoes. The success of food irradiation technology in this country has generated lot of interest among industrial entrepreneurs. A large multipurpose commercial radiation plant has already started its operation for processing foods and medical supplies since 1993.

DDT is a banned item in the country. But while monitoring of pesticide residues in food and environment indicated rampant misuse and overuse of agrochemicals in agriculture and post harvest food storage. Contamination of dried fish with alarming concentrations of DDT (upto 96 ppm) were observed following usage of this persistant organochlorine insecticide during sun-drying and storage. In a marine microcosm experiment conducted in aquaria, it was found that ^{14}C-DDT metabolized to DDE and DDD, and the reduction in ^{14}C-DDT in one component (water) resulted in an increase in other components. (sediment, algae and mussel) (23,24).

Using sterile insect technique Huda et al (25) were successful in the control of a blowfly (*Lucilia cuprina*), a serious pest that infest fishes while sun drying in 3 off- shore islands of Cox's bazar. They reported that male flies could be sterilized at 3 krad and female flies at 2.5 krad without any adverse effect on the adult emergence and longevity.

5. LIVESTOCK IMPROVEMENT

The improved feeding strategies and utilization of locally available low quality feed stuff were suggested by several workers on the basis of experiments conducted with nuclear technique (^{51}Cr-EDTA). Chaudhury (26) reported that water hyacinth in combination with rice straw and concentrated mixture (70% wheat bran + 30% oil cake) showed better results in respect of dry matter consumption, body weight gain, digestibility of dry matter, organic matter, nitrogen free extract, ether extract and total digestible nutrient in cattle. Addition of salt further increased the above parameter. Addition of *dhaincha (Sesbania)* significantly improved the digestibility of crude fibre. The efficiency of rice straw utilization was found improved due to inclusion of banana plant, azolla, sweet potato leaves, legumes and other grasses (27, 28).

Improvement of rice straw digestibility due to feeding of urea-molasses mineral block (UMB) together with rice straw which in turn also improved reproductive performance (29, 30).

Using ^{125}I-labelled progesterone Alam et al. (31) and Ghosh and co-workers (29) reported that supplementation of UMB increased body weight of Zebu cows by 4.8% during 3-month period after calving. Analysis of milk progesterone also showed that the block (UMB) alters body weight loss, resulting in an earlier resumption of ovarian cyclicity in postpartum Zebu cows. Alam et al (31) reported highly significant positive correlation between the changes of plasma and milk progesterone concentrations. Shamsuddin et al. (32) found radio-immunoassay of hormones as an effective tool to monitor the reproductivity in cattle. The technique can be reproducibly used to control the success of artificial insemination for the development of cattle by improving the breeds.

6. CONSTRAINTS TO NUCLEAR RESEARCH

Research work using nuclear techniques needs specialized equipment, supply of stable and radio-isotopes and skilled manpower to work with. Since nucleonic equipments or their accessories and the isotopes are not produced in the country, the long procedure to procure such items hamper the work seriously. It takes long time to clear equipment and chemicals from the custom authority which affects durability of the items specially short-lived radio-isotopes and temperature sensitive chemicals. Shortage of manpower on these specialized technical activity and for maintenance of the equipment, unavailability of foreign currency to the institutes involved in nuclear research, fear among the general mass on the development of nuclear establishments in the country and hence little allocation of fund in this sector, etc., are the main bottlenecks to foster the activity. A pragmatic plan is yet to develop to extract the benefit from this technology.

7. FUTURE PROSPECTS

Bangladesh is dominantly an agricultural country with more than 120 million population over an area of about 148,000 square kilometer. Like most other developing countries it is a resource-poor country burdened with over-population, food shortage, poverty, malnutrition, mass illiteracy and energy crisis. Hence, the development of appropriate technology using techniques with greater efficiency is more needed here than anywhere else to cope with the increasing demand of food in years to come .

Nuclear techniques now a days are being widely used in both developing and developed countries to solve many serious problems hampering health, agriculture and industrial development. The techniques are proved to be highly effective, do certain jobs better, easier, quicker, quantitatively accurate and direct. Some measurements could not be done at all without the use of isotopes as there are no alternative methods available. The successful application of these techniques can contribute significantly to the sound development of technologies that are economically feasible, environment-friendly and sustainable.

8. RECOMMENDATION

Bangladesh is basically a food deficit country and the gap between the need and the production (which is around 2-5 million tons per annum) is usually met up by imports. The demand for food due to increasing population will be more than double by 2025 and then rise at least another 50% by 2050. To cope with the increasing demand of food, nuclear techniques must be widely used to develop suitable technology. Research capabilities need to be strengthened substantially to address the issue. Strong Government commitment is essential to foster the activity. Increased international cooperation are of utmost importance to establish nuclear facilities and their effective utilzation.

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