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AGRICULTURE AND BIOTECHNOLOGY CENTRES OF THE PAEC: A RESUME

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Pakistan recognized the role of nuclear techniques in agricultural and other biological research and started establishing goal-oriented, multi- disciplinary institutions to help agricultural research in the country. A core manpower was trained and centres established in the cities where most of the agricultural research was located; the objective was to supplement the research activity in areas where nuclear techniques would have a clear advantage.

The first centre was established at Tandojam, Sindh and others at Faisalabad, Mymensingh, Peshawar and again at Faisalabad. Apart from agricultural research, these centres utilized their facilities and ventured into other areas such as biotechnology and can now take some pride in contributing in the country's economy and in development of human resource and helping develop a science culture in the country. With better management systems, the inputs seem to have been better utilized. That the end users and the government have recognized the contributions of these centres is evident from the number of farmers visiting these institutions for advice and the number of medals awarded to their scientists by the government. These institutes could, perhaps, have done even better yet it seems their positive contributions outweigh their deficiencies.

In this piece of writing a brief history of these institutions is given and some information provided about the raison for their programmes and the environment under which the programmes were executed. A few of their salient achievements have also been mentioned.

Keywords: PAEC, Agricultural research, Biotechnology, Economic returns, Human resource

1. Introduction

The PAEC is one of the organizations in the country that has, at least to a considerable extent, succeeded in institutionalizing their working. Although the Pakistan Atomic Energy Commission (PAEC) was established in the nineteen-fifties, it became a vibrant organization in the 1960s under the dynamic leadership of its then Chairman, Dr. Ishrat Hussain Usmani. A huge training programme was initiated that was the first effort of that magnitude in human resource development in science and technology in the country. Quite a few areas, where nuclear techniques could help in their peaceful uses, were identified, people selected strictly on merit, and awarded scholarships for studies abroad. It was declared that at least 500 bright young men and women would be educated and trained at advanced levels of science and technology. It was one of those endeavours that was well executed and completed. One of the areas identified was agriculture and biology; young people selected strictly on merit were sent for studies and training in fields such as mutation breeding, soil science, food irradiation, horticulture, plant physiology, microbiology, biochemistry, etc.

The selected candidates, designated as Scientific Officers/Officers on Special Training (OSTs) were given a brief nuclear orientation course before they were sent abroad to selected institutions. Different scholarships through the IAEA, Colombo Plan etc., were made available to them and half of their salary also provided in foreign exchange. The best of the available talent was thus nurtured for the scientific effort to come. This was the vision that produced human resource for the future programmes of the Commission and even for other organizations; later came a time when the Chairmen of the Pakistan and Bangladesh Agricultural Research Councils, the Chairman Pakistan Council of Scientific and Industrial Research (PCSIR), and Chief Scientist, Defence Science Organization, all came from the PAEC !

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The Commission initially had a small "laboratory" in a warehouse building in Karachi. The first fully fledged centre was established at Lahore in October 1961, and was used as a training centre for all inductees including those in biosciences and agriculture. The Radiobiology Division at this Atomic Energy Centre (AEC), Lahore, became the forerunner for all the productive efforts in biosciences and agriculture that the Commission was to make in the future.

Scientific research is a creative activity and flourishes only in a conducive environment that is generally lacking in this country. A lack of a tradition, lack of desired human resource, isolation from the world's scientific community, sub-critical inputs, inflexible management systems, meager incentives, selections and rewards not necessarily on merit, the social milieu, poor material facilities, short-term planning, etc., were listed as some of the major reasons for the near- absence of quality research in the country in a report from NIAB in 1982- and still seem to be valid. To overcome the handicaps a researcher here needs greater perseverance, greater initiative and drive and nothing less than a missionary zeal for his or her work.

The Commission has shown an awareness of these problems and has endeavoured to address them in a variety of ways. It is luckily one of those semi-autonomous bodies of the government that has perhaps used its "autonomy" in a better way and evolved its own systems of administrative and financial management and decentralized authority to a great extent, making it a bit easier for its institutions to take decisions without reference to central authority. It has strictly followed selection on merit. With better management, the resources have been utilized better and adequate facilities provided to the research centres. By dint of its early efforts in development of human resource that lasted from 1960 to 1972, the Commission developed bilateral cooperation with several countries such as Germany, Italy, France. Through these arrangements joint projects were developed with institutions in these countries. The agriculture centres had about a dozen joint projects through which exchange of scientists was possible and our scientists got an exposure of working in good laboratories abroad. Some training and exposure to outside labs was also possible through the International Atomic Energy Agency (IAEA) and through other funding agencies.

The PAEC also signed Memoranda of Understanding (MOUs)with 19 public universities in Pakistan through which formal collaboration became possible. The agricultural research centres already had arrangements with several universities through which scientists working at these centres could register for Ph.D in those universities while conducting their thesis research at these centres; the MOU's formalized this cooperation.

Most of the larger centres of the Commission were provided with good workshops with trained technicians for all repair and maintenance and even fabrication of facilities and of some equipment. Unlike in the developed world, it is so difficult to keep sophisticated instruments fully operational here in this country; the workshop facilities thus ensured maximum availability of equipment.

1.1. Research centres

The Commission established its first fully fledged agricultural research centre, the Atomic Energy Agricultural Research Centre (AEARC) at Tandojam in Sindh, in 1963. Young agricultural scientists trained at AEC, Lahore, and those educated and trained abroad were transferred to this Centre and it was inaugurated by Mr. Zulfiqar Ali Bhutto in 1963. This Centre had Divisions of Plant Breeding and Genetics, Plant Physiology, Entomology and Soil Science. Apart from the well equipped centrally air-conditioned laboratories, it had a workshop as at AEC Lahore. The AEARC was renamed the Nuclear Institute for Agriculture (NIA) Tandojam in 1998. The AEC Lahore continued with its role in providing basic orientation in the use of nuclear techniques and the Radiobiology Division retained the scientists that were working on food irradiation and other relevant studies. It also was the place where the new inductees and those returning from their foreign training/studies in biological and agricultural sciences would be initially placed.

Considering the role of nuclear techniques in insect control, the next agriculture centres were planned as Insect Pest Control Research Institutes (IPCORI) at Lyallpur (later renamed Faisalabad) and Mymensingh (in the then East Pakistan). However, the Commission later decided to have these centres as multi-disciplinary institutions dealing with mutation breeding, soil science, entomology, food irradiation and other biological research. The planned IPCORI, Lyallpur, was christened as Radiation Genetics Institute

(RAGENI) and as its buildings became ready, all the scientists at the Radiobiology Division at AEC Lahore, and a few from the AEARC, Tandojam, were transferred there in 1969 and started researches in mutation breeding, soil science, molecular biology and food irradiation, and the Institute, was formally inaugurated on 12 April 1972. Considering the multi-disciplinary character of this Institute it was renamed the Nuclear Institute for Agriculture and Biology (NIAB) in October 1972. Since the name of the city of Lyallpur was changed to Faisalabad, the NIAB became known as NIAB, Faisalabad. NIAB developed as a multi-disciplinary institution having groups working on goal- oriented or demand- driven researches. (The Institute planned at Mymensingh also developed as a multidisciplinary institution and is thriving in Bangladesh). NIAB also became a training centre for scientists in different fields of agriculture and biology and as a result of human resource development at NIAB, it was possible to establish three other institutions in the country. Young scientists were recruited with the intent of training them for a new institution to be established at Peshawar. When the buildings at the Nuclear Institute for Food and Agriculture (NIFA) became ready, the scientists trained at NIAB and those that were working on food irradiation at NIAB, were all transferred to NIFA and it was formally inaugurated in 1982 with a major thrust of its programmes in food science, crop breeding, entomology and soil science.

NIFA has continued to develop its programmes and is now a major agricultural research centre in the NWFP with the thrust of its programmes towards the problems of the area. In crop breeding, wheat, chickpea and brassica improvement for both irrigated and rain-fed areas, is being persued with success. The soil scientists help find the nutritional requirements and management practices for different crops in different conditions, while the entomologists concentrate on biological control of insects. Food Science Division deals with post- harvest techniques including food irradiation, studies on oils and fats, mushroom culturing and human nutritional studies including iron fortification of wheat flour.

Another institution that got its core manpower from NIAB was the Centre of Excellence in Molecular Biology established at the Punjab University -initially within the buildings of its Department of Zoology later moving to its own buildings and developing into a premier institution. The Director of this centre and its four scientists that formed the initial core manpower of this centre went from NIAB.

NIAB had the distinction of organizing the first ever courses in Biotechnology (DNA Replication and Repair; Gene cloning) in Pakistan in 1981, at a time when biotechnology was not a household word as it is today. It is heartening to note that the seed that was sown in 1981, and the public awareness within the government and the public at large created through efforts from NIAB, resulted in recognition of the need for biotechnology research in the country. At the time of its 10th Anniversary in 1982, NIAB proposed to the President of Pakistan that a national institute be established for biotechnology research; he agreed and issued directives that such an institution be established. NIAB submitted a proposal (PC-I form) to the government and after a long process of deliberations, red tape and outright hostility from many quarters the project was approved in 1987 as a Development Project. It was to be established at Lahore on land promised by the Punjab University. However, right when the project was in the last stages of approval, the Punjab University showed its inability to give land for the Institute. The National Institute for Biotechnology and Genetic Engineering (NIBGE) was thus established within the campus of NIAB where land had become available after evacuation of illegal occupants of 220 acres of land allotted to it by the government. NIAB had already started developing manpower for this Institute since 1982. For the biomedical biotechnology a group was established within the Atomic Energy Medical Centre Lahore. When the buildings of NIBGE became ready, 25 senior and junior scientists from NIAB along with programmes and equipment were moved to NIBGE, and they started functioning there without any break. Similarly, the equipment from Lahore was also transferred to NIBGE. NIBGE was formally inaugurated by President Farooq Ahmad Leghari in 1994. The programmes at NIBGE have expanded and progressed and it can boast of, perhaps, being the largest and more successful biotechnology research institution in the country with a wide variety of research in agricultural, industrial, medical and environmental biotechnology.

The Commission has established a new agriculture- related institution during every successive decade since the establishment of its first centre at Tandojam in 1963. It seems that the

establishment of yet another such centre is now overdue. Since agriculture is a provincial subject, the Commission established three agricultural research institutions in Sindh, Punjab and the NWFP, located at cities where provincial agricultural research is concentrated. Tandojam has the Sindh Agricultural University and the provincial Agricultural Research Centre. Similarly, Faisalabad and Peshawar both have the Universities of agriculture and the main agricultural research activities of Punjab and the NWFP respectively. The fourth institution, the NIBGE is also located at Faisalabad. Balochistan still awaits its centre!

The agriculture centres are well integrated into the provincial agriculture systems and also have direct linkages with the farmers, in addition to links with the federal agricultural systems. The PAEC institutes receive their budget grants from the federal budget and their total annual expenditure has remained less than 5% of the total annual expenditure on agricultural research in the country. However, the output has far outweighed this meagre input. The human resource developed during the nineties sixties, seventies and eighties has made it possible to have more highly qualified staff at these institutions compared with the provincial centres, except the universities of agriculture that have far larger numbers of qualified people. Another reason for higher output is greater decentralization and multi-disciplinary team work at PAEC institutions. It needs to be recognized that in a goal-oriented research, multidisciplinary teams are essential and the group leader is the linchpin who needs to have particular qualities in addition to his/her research capabilities. It takes years for a young scientist to become such a group leader; only a few having the requisite qualities can be groomed for such leadership. The PAEC was lucky to have some who proved to be good leaders. Selection of staff on merit, continuous review of research work internally at each centre, jointly by four centres and externally through other mechanisms, conscious effort at human resource development, demand-driven goal-oriented research, better management of resources taking the available rupee farther have paid dividends.

At NIAB the human resource development became possible owing to three activities. First a Trainee Fellowship scheme; secondly the PAEC's bilateral cooperation with Germany, Italy and briefly with France and the US AID's help through the Pakistan Agriculture Research Council (PARC); and thirdly Memoranda of Understanding signed between the PAEC and 19 of the public sector universities in the country. After public notices in the press almost twice a year, Trainee Fellows having masters' degrees were selected purely on merit; about a hundred M Sc's with good academic career applied every time, 70 to 80 appeared for interview and only 4 or 5 were found up to the mark, and were selected. They were attached to different research groups and their performance constantly monitored and evaluated; those found good were absorbed in regular positions as Scientific Officers. Most of them were then registered for a Ph.D degree in one of the Universities, that had an MOU with PAEC and started work on problems that were part of the institutes research programmes. Since the institute also had joint projects with European institutions and exchange of scientists was a part of that programme, the young scientists often got an opportunity to work in the collaborating laboratories abroad for 6 months to a year. Work done in those labs also became a part of their Ph.D dissertation that was submitted to a Pakistani University where they were already registered. Several other staff members also got PhD degrees working at NIAB and submitting their PhD theses to the Universities. As a result of these efforts in the nineties eighties and nineties, a number of trained and qualified scientists (over 25 Ph.D and over 300 M.Sc theses were done at NIAB) were developed and new institutes such as NIBGE were, in part manned by these. NIBGE started its own training programmes in the late nineties and started conducting M.Phil courses and research as an affiliate of the Quaid-e-Azam University, Islamabad. At present it has 75 such students from all over Pakistan; the human resource development goes on.

Most of the agricultural research and education institutions in the country employ agriculture graduates exclusively. However, the Commission felt that bright young men and women with degrees in pure sciences also had a great role to play in agricultural research, as is the case worldwide. By inducting M.Sc’s with background in chemical or biological sciences, it was possible to enhance the quality of research and to introduce molecular techniques that made it possible to take new initiatives. This has resulted in establishing a first rate biotechnology institute, NIBGE, and the core manpower for Centre of Advanced Molecular Biology (CAMB), Lahore. It also resulted in making it possible to spare over half a dozen Ph.D's to the Pakistan Agricultural Research Council.

Scientists, like any other creative workers, are individualists. For improvement of agriculture demand-driven, goal-oriented research is necessary and requires team effort; making successful multi-disciplinary teams out of individualist scientists is a challenging managerial task.

1.2. Raison for research programmes

Pakistan, with an area of 80 million hectares stretching from the Arabian Sea to the Himalayan mountains in the north and the alluvial Indus plains in between, has a vast potential for agriculture. The wide variety of fruits produced in the country indicates its varied climatic zones: apple, pear, peach, plum, apricot, cherry, grape (temperate), mango, guava, citrus, date, melons, etc. (sub-tropical), banana, papaya, cheekoo, coconut, lychee (tropical) and various kinds of summer and winter vegetables and so many field crops indicate the vast potential in agriculture. The potential is achievable since the Indus river system carries 145 million acre feet (MAF) of rain and snowmelt water annually, of which 102 MAF is diverted for irrigation - but only 60% reaches the farmgate, the rest literally going down the drain; yet 22 million hectares (i.e. about a quarter of the country's total area) are cultivated.

However, the yields of all the crops are far below the potential, and large amounts of the produce are lost due to numerous factors.

The problems of agricultural development are many, of which a few are mentioned here to set out a perspective that should be taken into account while planning agricultural research. Some of the problems such as shortage of capital, difficulties of marketing, etc., may be beyond the purview of what the Commission's research centres could do yet there are others that can be looked into , for which some solutions could be evolved. Some of the latter are: energy shortage, wastage of water, poor land utilization, poor utilization of farm inputs, wastage of produce- and above all shortage of quality human resource, lesser use of technology and fewer possibilities of development of appropriate indigenous technology relevant to the specific problems.

The country has well over a hundred agricultural research institutes and stations, and a vast network of extension services. The Atomic Energy Commission trained scientists in the use of nuclear techniques in agriculture, and its research centres thus found a niche in the overall effort in agricultural research. The Institutes developed goal-oriented programmes (a) to make fuller use of the relevant nuclear techniques; (b) to develop indigenous technology in areas of comparative advantage; (c) to make efforts at increasing yields; (d) to find better methods of conservation; (e) to ensure dissemination of results; (f) to provide better input of scientific knowledge into development of agriculture; and (g) to develop human resource. For achievement of better results a multi-disciplinary approach was adopted. It was also realized that 'sub-critical' inputs cannot get the desired results. Therefore, programme selection was acute, and it was monitored and evaluated regularly through different methods. The rationale for the researches seems to have paid off, and these institutions have clearly shown that investment in research could pay high dividends. We will, later, give a few examples of the magnitude of returns from small investments.

Although there are four agricultural/ biological research institutions in the country, it was decided to avoid overlap in programmes and to concentrate on certain aspects at one institute and others at others. For example, in plant breeding, NIA Tandojam concentrated on wheat and non-aromatic rice, while NIAB at Faisalabad focused on aromatic rice, cotton and grain legumes, and NIFA at Peshawar on wheat and brassica. Similarly, NIA's thrust was on Plant Physiology and Entomology, NIAB's was on Soil Biology and Biological Chemistry, while NIFA's was on Food Science and Entomology. NIBGE concentrated on the use of molecular techniques in areas of need and of comparative advantage.

1.3. Salient achievements

NIA succeeded in evolving better, higher yielding varieties of wheat that still cover a majority of the area in Sindh. Sindh 81, Saughat, Sarsabz, Marvi, Bhittai, etc., have given up to 30% higher yields compared with prevalent varieties. The benefit amounted to a few billion rupees in additional productivity. Other varieties of rice, cotton, grain legumes and sugarcane have also gained increased productivity. A total of 16 new varieties of crops from NIA cover a large area in Sindh and five more have been approved for general cultivation. Another significant achievement is the bio-control of borer pest in sugarcane; in 2004-5 over 250,000 acres of sugarcane were covered with this method of control. Last year 1500 acres of cotton has also

been freed of borer attack by biocontrol technology.

NIAB's programme in mutation breeding has been extremely successful, and the Institute has so far developed over two dozen improved varieties of cotton, rice, chickpea, mungbean, lentil and blackgram. Cotton variety NIAB 78 truly helped revolutionize cotton production in the country and at one time covered almost 80% of the area in Punjab and Sindh and resulted in an increase in production from 4.7 million bales to 12.7 million bales per year. NIAB mung varieties still cover 90% area in Punjab, and disease- resistant mutants have stabilized chickpea production. A salt-tolerant wheat obtained through wide-hybridization with aegilops is being grown by farmers as a trial. Irradiation of kinnow buds gave a sparsely seeded (3-5 seed per fruit) mutant. Hundreds of plants grafted with this mutant have so far been sold to growers. The work on economic utilization of saline lands has made it possible for farmers to utilize such lands for forage production. NIAB also established two Biosaline Research Stations (60 ha and 400 ha) to demonstrate on a larger scale the feasibility of growing useful salt-tolerant plant species on such lands. On the basis of this work the International Atomic Energy Agency (IAEA) initiated a programme on "Sustainable Utilization of Saline Groundwater for Plant Production" in ten Member States. This project managed by the former DG of NIAB/NIBGE was considered to be one of the most successful projects. Studies on biological nitrogen fixation resulted in producing Biopower by NIBGE, which is now a commercial product as a source of nitrogen for rice and pulses. The group on conversion of biomass to energy products established pilot biogas plants using kallar grass as feedstock. The work on cellulases and other enzymes was continued at NIBGE and has been exceedingly productive. Isotope hydrology was used to study the movement of groundwater in the Faisalabad Division to understand how and why the areas in the middle of *doabs* (area between two rivers) is more saline. The model was also used for the above-mentioned IAEA project. Work was also initiated in Environmental and Hydrocarbon biotechnology, as were studies in microbial leaching of ores. Since its transfer to NIBGE, both the subject areas have developed further, and some techniques have been applied on a large scale in solving several problems, as and will be mentioned later.

An anti-fungal antibiotic produced by B. Subtilus that was active, among others, against Alternaria Citri in citrus was successfully used to treat kinnows meant for storage or export (it just sealed the cut end of the stalk and left no residue after 3 days). Two patents were obtained on post-harvest wax treatment of kinnow and the method demonstrated to a party exporting kinnow.

Apart from results of its researches that were disseminated to the end users, one of NIAB's major achievements was initiating and introducing biotechnology in the country and developing human resource that helped in the establishment of three other institutions.

NIFA has had more successful programmes in crop breeding and pest control. It has evolved four very successful higher yielding wheat varieties for irrigated as well as rainfed areas of the province. A chickpea variety and a variety of oilseed Brassica evolved by NIFA are widely grown in the province (NWFP).

NIBGE now is not only the premier biotechnology research centre in the country, it has also been nominated a Regional Centre for UNIDO (United National Industrial Development Organization) and is the focal point for FAO Biotechnology biosafety. It has received permission to start Ph.D degree courses in Biotechnology. It is providing analytical and consultancy services to various organizations. Its productivity can be gauged by the number of scientists receiving productivity allowances from the Pakistan Council for Science and Technology (PCST).

NIBGE has provided understanding of the Gemini virus disease complex in Pakistan and has successfully engineered virus and insect-resistant plants. Cotton varieties resistant to cotton-leaf curl virus (CLCV) have been tested extensively, and two resistant varieties released. Transgenic rice, resistant to bacterial blight, has been evolved. Salt and insect tolerance has also been introduced into sugarcane.

Some better varieties of cotton, rice, sugarcane, tomato and tobacco are also in the pipeline.

The studies initiated on biological nitrogen fixation have expanded to numerous other microbes. Some of the results have already been commercialized as Biopower, a biofertilizer for rice, maize, cotton and a number of leguminous crops.

Efforts in Health Biotechnology have provided useful information to the medical community.

Efforts in the production of ethanol from agro industrial wastes, and production of industrial enzymes and biochemicals, have been successful and some processes have been passed on to end-users. Microbial desulphurization of coal also seems to be successful. One of the major applications in environmental biotechnology has been bioremediation of oil-contaminated sea shore at Karachi.

There are numerous scientific achievements that have led to excellent international publications, and are at a stage where their applications will have great impact. NIBGE is now well known nationally and internationally and has cooperation with numerous international agencies. It is also helping human resource by producing M.Phils and Ph.Ds in biotechnology.

1.4. Dissemination of new technology

The agriculture centres have been conscious of the fact that any new technology evolved by them must reach the end-user. In every province the centres are well integrated with the agriculture system and are in direct contact with the extension service. They are also directly in contact with thousands of farmers. Each centre organizes "Farmers' Days" and exhibitions where farmers, students and people from agriculture departments are invited and informed about the work of the institutes and about the package of technology that goes with the new varieties or techniques evolved by these institutes. Field trials and model demonstration sites are also established on farmers' fields to show the comparative advantages of the new technology. Workshops and courses are also arranged for the same purpose. The Institutes also produce pure pre-basic seed of each variety every year and pass them on to seed producing companies and to farmers. The whole package of technology is also explained and provided in writing. Apart from every centre's experimental farms, NIAB has also established two Biosaline Research Stations (150 acres and 1000 acres) to demonstrate the evolved technologies.

Without the various methods used for the dissemination of the new technologies, their adoption by the end- user would not have been satisfactory and the economic benefits would have been marginal.

2. Concluding Remarks

The PAEC has been the business of agricultural research for 42 years. The results should now speak for themselves. Looking back overall these years and viewing the entire scenario up until this day, it appears that gone are the days when the PAEC's centres were seen as "outsiders": they have found an important niche for themselves and are in the mainstream and constantly helping agriculture with innovative technologies. Their contributions in the economy, contributions in developing human resource and in developing a science culture in the country have by no means been small. With a relatively small funding, the output has been very high. However, it does not mean that they could not do more; they have had their own problems, deficiencies and inefficiencies, yet the overall output is positive. This is attributable to the vision of the early management of the Commission. Dr. I. H. Usmani needs to be remembered on every occasion of success of the Commission.

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