2. The Logos doctrine lends itself to scripture, and the higher religions identify the Logos with God, or perhaps with an essential attribute of God. Thus in the *Bible* we have 'In the beginning, (i.e. in the foundation) was the Word, and the Word was with God, and the Word was God', John, 1.1.
3. What prevailed earlier leaned on imprecise notions such as the 'association of ideas'.
4. The deductive apparatus of Leibniz comprised the rules of logic together with his famous 'Principle of Sufficient Reason', which time does not allow us to describe. For an evaluation of the principle by a first-rate mathematician, see G. D. Birkhoff[29].
5. Note that these automata are machines in Ashby's sense rather than in Wiener's sense: after each communication (input–output cycle), the state of the automaton is changed. The communication is exclusively with God.
6. The omnipresence of the de Broglie wave of a particle, with respect to the frame of reference in which it is at rest, comes from setting $u = 0$ in the equation $V = c^2/u$ for the speed of the de Broglie wave, cf. Appendix, eq (3).

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Education for agriculture in India: Time for a change*

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The agriculture sector is important for food security, employment generation and economic growth. However, concern has now been expressed on the decline in agricultural growth. Modern agriculture is knowledge-based, in which education at all levels, particularly higher education has an important role. This paper traces the circumstances and history of developments of higher education in agricultural sciences which resulted in the creation of agricultural universities on the pattern of Land-grant System in the US, while there are no exclusive agricultural universities in USA. This has resulted in isolation of agriculture sciences from other multifaculty universities of science, arts and humanities. The present structure, function and objective of agricultural universities are not in conformity with the concept of rural universities of the Radhakrishnan University Education Commission. Consequently, the agricultural universities have not been able to make any significant impact on rural development. An excessive emphasis on variety in the early stages of 'green revolution' did help in improvement of food grain production, but also became the cause of unsustainable agriculture in the absence of adequate science and knowledge base. Since agriculture is a vital sector in India, the end of isolation of agriculture and agriculture universities is the need of the time to make it interactive with multifaculty universities. The process for this change is discussed.

HISTORY of agriculture is the history of evolution of mankind. Human beings selected plants and animals which met their requirements. Was this intentional or experience, or a combination of both? The important crops and livestock of today have a history of centuries recorded in scriptures, paintings and monuments. We must feel humble with the thought that the man (woman) has not added any new crop or animal in the last few centuries. There was no formal education of the kind we talk now, and yet through generations the people have learnt to grow, protect and preserve plants and even breed new races of animals and livestock. It is true that most of the civilizations came up around the river banks and basins, but this only shows that our ancestors realized the importance of water. People were aware of their surroundings and knew their friends and foes. In India awareness manifested itself through rituals and ceremonies, which integrated the country by bringing agricultural products or commodities from different parts of India. What is commonly used in these ceremonies and *havans* are wood, sticks of at least five fruit trees, coconut, betel leaf, clove, rice, barley, ghee (cow), a lamp with a cotton wig and fruits of the

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region. All these ingredients cannot be found or cultivated in one region. They are tropical, sub-temperate and temperate in origin. Do our children know the uniqueness of Indian agriculture in integrating the people of this country? The sculptures of the Moghul period show the fruits and flowers of Central and West Asia, thereby indicating the movement and exchange of bio-diversity. These are examples of the agriculture-related wisdom of our people which obviously cannot be found in textbooks of genetics or agronomy. Therefore, education in agriculture has to contribute to learning and wisdom and giving a scientific base to this wisdom and foresight.

Formal aspects of agriculture and agriculture education

All of us have time and again said that India is primarily an agrarian society. Even today almost 70% of the population depends on agriculture, but in the last century, the country's economic and social life revolved around agriculture and peasants. Therefore, organizing the peasantry was essential for getting freedom. However, there was really no serious concern about agriculture. It was only when there was failure of crops due to drought, floods, crop diseases, etc. resulting in famine conditions that the Government had to wake up. Therefore, management of famine was the responsibility or the job of the Home Department. There was no Department of Agriculture in British India until 1870 when a proposal was made to establish a Department of Agriculture and Commerce. This did not happen because there were droughts or famines which caused thousands of deaths, but because of civil war in America in 1863–64, the supply of cotton to textile mills in Manchester was affected. Therefore, the British Government was exploring the possibility of getting cotton. India had the potential to supply cotton to Britain. Therefore, Lord Mayo the Governor General requested creation of a Department of Agriculture and Commerce. He indeed wanted to help Indian agriculture besides growing cotton. But what was approved in 1871 was the Department of Revenue, Agriculture and Commerce[1]. Earlier, there was the need of veterinarians to look after the health and breeding of horses which were used by the army. Table 1 lists the stations/institutions related to veterinary, established since 1839.

Table 1. Year of establishment of veterinary institutions (stations) during pre-independence period

Year	Institution/station
1839	Horse breeding farm cum cattle farm
1882	Veterinary College at Ludhiana
1884	Recommendation for establishing a Veterinary College in Bengal (Bihar, Orissa and Assam)
1902	Indian Civil Veterinary Department

The recommendation for establishing a Veterinary College in Bengal stated: 'In this school the cow should constitute the main or sole subject of attention and the horse and other domestic animals will receive scant notice'. However, a quarterly journal of veterinary science and animal management was started in 1882, thereby clearly showing the need of animal science including breeding, but the main emphasis was the horse. We might now ask if there was any information, research and teaching about such important animals like buffalo, goat, camel and others. The answer is 'possibly not'. However, it is clear from this that there was no emphasis on agriculture in general, and crops in particular. Allan Octavian Hume, who became the first Chief of the Department of Revenue, Agriculture and Commerce in 1879 stated 'though originally designated the Department of Agriculture, etc. this Department has never, from the first, been so constituted as to permit of its dealings either directly or effectively with agricultural matters'. Thus the creation of the Department of Agriculture, etc. did not necessarily put any emphasis on agriculture and farmers in India. Hume founded the Indian National Congress in 1885, which eventually spearheaded the freedom movement.

Establishment of colleges of agriculture

There were droughts in the latter half of the nineteenth century which caused famine conditions frequently. Two political and socio-economic events, the 1857 uprising and freedom movement, and later the establishment of the Indian National Congress made the peasantry conscious of their plight and inability to meet even their food needs. This made the British Government to think about agriculture in the country. Jawaharlal Nehru in *Discovery of India* states, 'In 1933 Major General Sir John Megaw, the Director-General of the Indian Medical Service wrote in the course of a report on public health in India: "Taking India as a whole the dispensary-doctors regard 39% of the people as being well nourished, 41% as poorly nourished and 20% as very badly nourished. The most depressing picture is painted by the doctors of Bengal who regard only 22% of the people of the Province as being well nourished while 31% are considered to be very badly nourished" '. Thus we are forced to think that the problem of food was not only during the periods of droughts and famines, but even when such events did not occur enough food was not available to a large population. However, the famines in 1890s made the Government to consider the importance of agriculture, and to establish six agriculture colleges and a research institute. Interestingly the problems of agriculture were surmised to be of chemistry of soils, and were given priority. Colleges were established at Poona (Pune), Cawnpore (Kanpur), Sabour, Nagpur, Lyallpur and Coimbatore in 1907, having the positions of Agriculturist, Economist, Botanist, Agricul-

tural Chemist, Entomologist and Mycologist. The Imperial (now Indian) Agricultural Research Institute was established at Pusa-Bihar in 1905. Since the requirement in these institutions was chemistry, botany, entomology and mycology, the students studying these subjects in Universities were attracted to problems of agriculture, some of best examples being B. P. Pal, A. B. Joshi, K. C. Mehta, S. P. Raychaudhuri, Purthi and others who made fundamental and enormous contribution to agriculture. This interaction of science and agriculture continued until recently.

Establishment of the Indian Council of Agricultural Research

With the establishment of the Imperial (Indian) Agricultural Research Institute, there was emphasis on recording diversity in wheat, barley, gram (chickpea), Arhar (pigeon pea) linseed and maize, and on water use and nutrient use efficiency and plant pathology at Pusa-Bihar. The indigenous selection of wheat Pusa 4 (NP4) was released and was followed by many other varieties. This possibly encouraged research on crops in different provinces. A project on dry land farming, popularly known as Bombay method of dryland farming, was also taken up. However, there was almost none or negligible research on several commodities which had commercial importance particularly cotton and plantation crops. It was to meet the needs of agriculture at the national level, that the Indian Council of Agricultural Research (ICAR) was established in 1929. From the objectives of the establishment of ICAR it is clear that it was concerned with research, and publications, but not education. The Royal Commission on Agriculture recommended the constitution of the Imperial (Indian) Council of Agricultural Research, the primary function of which would be to promote, guide and coordinate agriculture research throughout India. It would not exercise any administration control over Imperial (Indian) or provincial (State) research institutions. These objectives were maintained till the ICAR was reorganized in 1965, and B. P. Pal became the first Director-General of the Council.

Realization of the need of agriculture education

Soon after independence the Education Commission (1948–49) known as Radhakrishnan Commission was constituted to consider the growth of university education in the country. This Commission realized that rural development would be necessary for the development of the country because most of its people lived in villages. They made the suggestion of establishing rural universities in the country with a view to providing practical education for development of rural India. The actual shape of these universities was not defined, but the objective was to spread education which could help agriculture and rural development. However, no progress was made until the Chief Minister of UP, Pandit Govind Ballabh Pant initiated steps for establishing a rural university. He had been impressed by the progress of agriculture in the US and hence deputed two persons, A. N. Jha, Chief Secretary of UP and Harpal Singh Sandhu, a farmer who had settled in the Tarai area of UP. This team recommended establishment of an Agricultural University on the pattern of Land-grant System of USA. This recommendation was followed by sending another team to USA in 1955, called the Indo-American Joint Team to suggest setting up rural (agriculture) universities in India. The five Indian members of the team included Agriculture Secretary, Directors of Agriculture and included no educationist or an agricultural scientist. This team recommended setting up of rural universities in UP (Tarai region), West Bengal, Bihar, Orissa, Travancore-Cochin and Bombay state (Anand). The recommendation did not include any university in Central India or the dryland regions of the country. Today it would be enlightening to know the analysis that went in identifying these locations. Nonetheless, the Land-grant System was to be the basis of agriculture education in India. M. S. Randhawa in *A History of Agriculture in India* states about the governance in British Raj (1866–81) as follows: 'Moreover, they believed in the theory that the experts should not be on the top. He should be down below so that his knowledge could be tapped'.

In the establishment of agricultural universities, the Government of India and State Governments followed the norms of governance of the British Raj, and ignored both educationists or agriculture-related scientists while setting up rural universities. In the mean time the Cummings Committee recommended setting up of post-graduate school at IARI and the Indian Veterinary Research Institute. IARI was recognized as a Deemed University under the UGC Act of 1956, and since then started awarding M Sc and Ph D degrees in various disciplines of agricultural sciences. However, IARI had developed a training programme of its own which included research and course work leading to the award of Associate IARI. There did exist a Central College of Agriculture affiliated to Delhi University giving a B Sc (Hons) Ag. degree. Thus IARI was the only research institution in the country at that time which imparted undergraduate education. Although the Central College of Agriculture admitted students from specified states where agriculture colleges did not exist, the continuation of the Central College of Agriculture could have helped the union territories, north-east and other regions; but for some reasons the college was closed in 1959, once IARI became a deemed university. It was a sad loss of our system in favour of a completely untested system of USA. We may today like to ask the following questions:

1. What is Land-grant System of education in USA?
2. How have the Land-grant Colleges/Universities changed since their inception?

Land-grant colleges

Justin Smith Morrill, a US Congressman presented a bill in 1862 which became an Act in the US. The objectives of the Land-grant Colleges and Universities were '. . . the endowment, support, and maintenance of at least one college where the object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as related to agriculture and mechanic arts, in such manner as the legislature of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life'.

The Morrill Act of 1862 was modified in 1890 at the initiative of Morrill who by that time was a Senator. Not going into the details, I should bring out the main circumstances, features and methods in the enactment of this Act.

1. There were few institutions of higher learning such as Harvard, which were considered elite, and did not concern themselves with education or research relevant to common persons, whether agriculture, industry or military studies.
2. The Federal Government had lands in every state which was an asset, and could be made available to meet the needs of the masses.
3. The system of governance provided a mechanism by which an Act could be passed by the Federal Government but autonomously implemented by the State Government.
4. The legislators could take initiative to introduce a legislation and if both the Congress and the Senate agreed it could become an Act or Law. An amendment could be introduced by the same Congressman/Senator or anyone else later on.
5. Thus all the wisdom of drafting, modifying or introducing any legislation did not remain with bureaucracy which normally is insensitive to social causes, and if some individual in bureaucracy be conscious, they by their training are averse to a change. Therefore, what a political leader having down-to-earth knowledge and contact could achieve in US is not able to do in our system of governance, and in any case is not motivated because every legislation is a government bill and not ever presented or passed in the name of a legislator.
6. The Federal Government through Morrill Act transferred 30,000 acres of land to each state for establishing a College/University. Thus the name Land-grant System came to be known because assets in the form of land were transferred and also there was a provision to provide financial assistance up to 50%. Thus the Federal Government made a significant contribution to the State in establishing institutions of higher learning. Some of these universities such as the Michigan State University, Washington State University, Texas State University, Kansas State University, etc. are now leading institutions of learning in science, agriculture, engineering, classics and arts. Thus the American Concept of Land-grant System did not restrict intellectual growth in any field of science or arts, and in any case it did not mean agriculture alone. The essence of this concept was development according to the needs of the time.

The Association of Land-grant Colleges and Universities in 1998 met and reviewed its role for the future. The following objectives for the year 1897, 1997 and 2027, bring out the farsightedness of the system.

University research in the changing environment

1897: One hundred years ago, the rapidly evolving enterprises were not on what universities do, but the political power was based around certain industries, e.g. machine tools, fire arms, clocks, sewing machines, agricultural implements, bicycles, steel, electrification, and telegraphy/telephony.

1997: In contrast, the fastest growing industries today are: biotechnology, telecommunications, new materials science industries, computer numerically controlled tools and robots, microelectronics and civil aircrafts manufacturing.

2027: Can we predict the future growth companies? This may look like this: biomimicry, bioelectronics, nanotechnology, planetary management, biomaterials, biocomputing, artificial intelligence, and green power technologies.

Thus the Land-grant Colleges/Universities in the US considered and adjusted their programmes according to the changing needs or environment, and also assumed the emerging scenarios and needs. Therefore the Land-grant System does not address education in agriculture alone. The Land-grant Colleges/Universities in 1997 considered biotechnology, microelectronics, telecommunication, civil aircraft manufacturing, new materials science, computers, robotics, etc. as areas worthy of teaching. This possibly indicates that agriculture *per se* is not a major issue in the US. Therefore, these institutions are giving education in such fields which enhance the capability of the US is global competition and have an impact on the quality of life. They have tried to predict and assess the future needs and technologies. These new technologies will form the basis of growth of new enterprises or companies. Accordingly, for the year 2027, the predicted technologies would be based on biomimicry, biomaterials, bioelectronics, biocomputing, nanotechnology, planetary management, green power technologies, etc.

What is the status of Land-grant System of education in India? We have always been concerned with agricultural

production, and almost never related the education in agricultural universities to that of major, medium or small-scale industries. It would be appropriate to say that the State Agricultural Universities are unique by themselves and cannot really be compared with the Land-grant System in the US which we apparently adopted. We in this country adopted a policy of isolation wherein our contacts with science, engineering and arts have become minimal. It is hard to find any university where political economy and literature are important subjects. There is no university which contributed to the understanding of phytochemicals and synthesis of unique compounds which could support the chemical industry. Even today we do not know pre-harvest and post-harvest physiology and biochemistry of different types of guavas, to develop technologies which could be used by small entrepreneurs. We really cannot find fault with agricultural universities, but indeed other universities (called in approximately conventional) stopped looking for all what is around them. Thus we have by and large adopted the policy of isolation. This eventually percolated to agricultural universities themselves. For example, it is rare to find a student having done M Sc in genetics and plant breeding, being admitted to horticulture, or a student of soil science getting admission to Ph D in agronomy or physiology. We do talk of interdisciplinary research by those who are committed to the discipline in which they obtained their degrees. These are therefore, laudable statements without conviction and commitment.

What we adopted from Land-grant System

From whatever has been adopted is possibly in part the administrative and financial system. The State Governments allotted or endowed 2000 or more acres of land which was to become a financial support to the university. In many instances more land was allotted to enable the university to produce seeds and distribute it. However, this mechanism did not succeed in most instances because this was not adopted as a commercial venture, including its work and management culture. Thus the products of the university which were mostly in the form of seed had to be propagated through either State or National Seed Corporations: The Universities and the Seed Corporations could really not establish any able commercial and research relationship, and consequently the financial dependence of the Universities on State Governments became an accepted norm. Therefore, both political interference in appointments and day-to-day management became inevitable. In many states the Agriculture Secretary (or Production Commissioner) and the Agriculture Minister became the ex-officio chief of the University without having an understanding of the education system, what to say of the agriculture science education.

The agricultural universities adopted the concept of colleges, and had the colleges of engineering and basic sciences for namesake. Though the concept of a Dean for every college was accepted, the concept and the supremacy of the Dean of Post-Graduate Education never got implemented. One of the reasons for this is the lack of decentralization of power, and the concept of power became demonstration of one's ability to interfere or stop proposals, instead of working for a common good. This is not surprising because it happens in agricultural research and education management organizations.

The success of agricultural universities depended mostly or exclusively on the field of agriculture through the integration of research, education and extension. Every State Government has a Department of Agriculture. Thus it leaves only the extension research with the university and hence a holistic approach to farmers is not adequately delivered. In any event, there are hardly many technologies for commercialization that have been developed and transferred to the people of the region. The carpenters, blacksmiths and other artisans continue to struggle with the out-dated implements and if at all they have made improvements it is by themselves. The thatched roofs of mud houses made of crop residues remain vulnerable to fire hazards even after the existence of agriculture universities for 40 years. The improved bullock-cart although a need of rural India did not come from any agriculture university or institution. The universities have to evaluate their contributions from the overall growth and development in the region. The impact of the universities must be felt beyond the farming community. If this had happened then migration from rural to urban regions would not have occurred. It is time that review teams include technologists, scientists, social scientists, economists, etc. to evaluate the performance of the Land-grant System. It would be appropriate to name them Punjab State University, Tamil Nadu State University, etc. on the same pattern as the Michigan State University, Washington State University, etc. The objectives of such a university do not remain only crops and resources but should also include all those technologies which are needed for economic empowerment of rural India, rural transport, rural energy, rural storage systems, etc.

Let the performance of agricultural universities be evaluated against the vision of the Radhakrishnan University Education Commission which initially proposed the establishment of rural universities. The vision was 'Picture the kind of village life which should be aimed. It must be economically prosperous. Its life must not be wasted in primitive habits of production. Full advantage should be taken of modern technical development. Small-scale farming by efficient methods will require only a small part of human labour needed at present and production may be greatly increased. Much in the village populations will be available for work other than agriculture. Each village and especially each group of villages, will have a wide range of economic activity. A large part of the industry of the country should be located in villages

and small towns. Every village should have a good year-round transportation and should be supplied with electric power. Each one should have a piped water supply under pressure, a sewer system and a telephone system.'

The Commission further envisaged 'among professions or branches of professions in the development of which rural universities may well participate are various phases of Water Control Engineering, Soil Improvement Engineering, Temperature Control Engineering, Food Processing Technology, Chemical Engineering, Ocean Products Technology, Mineral Processing, Rural Industrial Counselling, Rural Public Administration, Rural Social Welfare, Rural Land and Village Planning, Social Engineering, Rural Sociology and Anthropology, Rural Arts and Rural Medical Services'.

From the above it is obvious that present agricultural universities have a vast potential of changing rural India, if they followed the original concept of rural universities.

Mismatch of agriculture education, research and resource management

The original concept of rural universities encompassed the education which would be in the context of rural growth, culture and development, not confined to crop production alone. However, the circumstances during the post-independent period resulted in emphasis on crops or more specifically grain production for meeting the food grain demand in the country and to avoid import of food grains. Consequently, the emphasis on resource management of natural, human and monetary inputs was not adequately placed. This possibly also was the legacy of pre-independent India. The British had the need of maintaining an excellent horse-mounted army. Therefore, horse breeding, health, nutrition, physiology, etc. were necessary. Accordingly, the veterinary institutions and equine breeding institutions were established earlier than institutions related to water, soil, climate or genetic resources. The excellent examples are the lack of research and management on buffalos until a few decades ago, though this animal is unique and economically important in the Indian sub-continent. Tables 2 and 3 give the year of establishment of the various research institutions in India.

Reorganization of ICAR

The ICAR after reorganization became responsible for agriculture research in the country. The reorganization did not specifically make ICAR responsible for education for agriculture but creation of the position of the Deputy Director-General (Education) implicitly meant some role of ICAR in agriculture education. This was further formalized when a Department of Agriculture Research and Education (DARE) was created. However, the fact remains that agricultural universities are established under the UGC Act. Therefore, ICAR plays no role in establishment of agricultural universities, and yet a relationship between ICAR and agricultural universities has been established. This relationship is not entirely based on any major financial support to agricultural universities by ICAR. Strangely when the question such as the revision of grades or other benefits comes, the agricultural universities feel closer to other universities. The result is that the ICAR which is primarily a research organization functions like a university, particularly the Universities of Arts, Humanities and Science (UAHS) and abandons the norms of evaluation of scientists for their contribution in research. Instead the number of years of service becomes the basis for promotions. Consequently the motivation to excel in research is lost, and eventually leads to mediocrity. This has been further strengthened by a centralized system of recruitment where research is not necessary in favour of a course work-based examination. In the ultimate analysis the present policy of ICAR has neither helped excellence in research nor in education. Yes, it has helped in isolation of agriculture-related institutions from science institutions. We have established and supported agricultural universities on the presumption of following the Land-grant Sys-

Table 2. Establishment of crops-related research institutes

Institution	Year of establishment
Indian Agricultural Research Institute	1905
Sugarcane Breeding Institute	1912
Cotton Technological Research Laboratory	1924
Indian Lac Research Institute	1925
Jute Technological Research Institute	1938
Central Rice Research Institute	1946
Central Tobacco Research Institute	1947
Jute Agricultural Research Institute	1953
Central Institute for Cotton Research	1976

Except the Indian Agricultural Research Institute (after famine in the 1890s) and Central Rice Research Institute (after the Bengal famine), no institution addressing the problems for food crops or horticulture institutes were established.

Table 3. Establishment of institutions on soil, water and environmental sciences

Institution	Year of establishment
None before independence	
Central Arid Zone Research Institute (from a Station to Institute)	1959
Indian Grassland and Fodder Research Institute	1962
Central Soil Salinity Research Institute	1969
Central Soil and Water Conservation Research and Training Institute	1974
Central Bureau of Soil Survey and Land Use Planning	1976
Indian Institute of Soil Research Division of Environmental Sciences in IARI	1993

There were no research institutions on soil, water and environmental sciences before reorganization of ICAR.

tem of education of USA, where no exclusive agriculture university exists.

Agricultural universities and rural service sector

One of the major achievements of agriculture management systems was to recognize the need of integration of research, education and extension. All agricultural universities have separate Departments of Agriculture Extension, which not only teach the principles of extension but in fact practice it also. They have developed various techniques of demonstration and communication. However, in all the states, Departments of Agriculture exist and are responsible for the extension services in the concerned state. Therefore, we might ask the following:

1. What is the relationship and interaction between the university departments and the State Agriculture Department?
2. Could the success or failure in transfer of technology be attributed to the University Extension Department or the State Department?
3. How have the concepts and needs of extension been changing in the last three decades?

Let us recount the mechanism of transfer of technologies from the agricultural universities to farmers. We may also ask whether the spread of rice and wheat production technology was the result of scientists–extension nexus or considerably due to farmer-to-farmer communication. The agricultural technology is based on the following biophysical factors:

- Understanding of location-specific climate/weather.
- Soil characteristics, including its physical, chemical and biological properties.
- Appropriate soil treatment.
- Assessment of suitability of crops for a crop season.
- Knowledge and assessment of different diseases, insect pests, nematodes and weeds and their potential for competition with different crops.
- Availability and arrangement of the various inputs, crops varieties with alternative choices, water, fertilizers, pesticides, energy source and labour.
- Facility for availability of seed material and its testing or other plant material.
- Time management for different operations for the success of agricultural production.

All the above aspects must be integrated and implemented. This amounts to saying that an extension scientist, besides having the knowledge and means of communication, should be aware or be supported by specialist in the above areas. Let me identify a few common constraints:

- Appropriate knowledge of nutrients of the soil, though farmers often have a good idea about their soil.
- Non-availability of the right seed of a recommended variety and seed quality.
- Supply of poor or adulterated quality of fertilizer and chemicals.
- Lack of availability of water or the source of energy at appropriate time.
- Pest management operations in early stages to control epidemic.
- Repair of agricultural implements.

All the above timely operations are necessary for successful crop production. However, an extension worker can communicate the desirable operations but hardly has a mechanism at his/her disposal to implement the recommendation. Most extension workers in the State Departments of Agriculture are not adequately equipped with the desired knowledge. The result could be that an area of high production potential remains a low or poor production region. When we talk of transfer of technology it is not a few farmers or few hectares of land. We indeed have most of the desirable technologies but their dispersal would not occur except in those cases where it is seed-based, and that too of a self-pollinated crop such as wheat and rice. This can happen, and indeed does happen from farmer to farmer. But it requires understanding of seed production and storage.

Introduction and spread of technologies outside agriculture

We have seen several technologies spreading in India after independence. There was the introduction of radio and transistor in the fifties and sixties; then came television. There were refrigerators and air conditioners based on refrigeration, and now we see the spread of information technology. The fundamental difference between these technologies and agriculture is the emergence of a service sector for each of these technologies.

Despite having several technologies, no independent service sector has developed in agriculture. There could be several reasons for this situation. First, the managers at different levels believe that public sector institutions already provide the necessary services. Could an extension worker from a block help in choice of an appropriate variety of crop according to the time, source of seed material, testing the seed for its germination, vigour and uniformity? Often a farmer depends on a local shop dealer, this can and does have disastrous consequences.

Role of universities of arts, humanities and sciences

Several important colleges and universities existed in the pre-independence period in the country which imparted education in science and humanities. Some of them such as the Banaras Hindu University had an excellent school

of agriculture which was integrated in the university education. The departments of botany and zoology existed in all Universities of Arts, Humanities and Science (UAHS). There were departments of mathematics, chemistry and physics. Two streams – biology and physics were created for undergraduate studies. The biology department had some outstanding scientists who contributed in the areas of morphology, taxonomy and anatomy. Either because of lack of funds or some other reasons, these departments did not have an active experimental research programme on plants and animals. For some strange reason these departments lacked expertise in genetics, physiology, biochemistry and statistics which were to become important areas of applied science or technology. Many professors had studied abroad and worked on problems of temperate plants, animals and systems. Many of them continued to address similar problems and paid no serious attention to plants, animals and systems around them. Though important studies leading to theories and principles were evolved, they did not include food crops or important animals. There were, however, important contributions in the field of plant pathology and entomology. A few examples would suffice to strengthen this observation. There was very little work on the biology of pulses, most oilseeds, millets and horticulture crops such as mango, citrus, guava, cucurbits, etc. It may not be inappropriate to say that many departments remained attached to terms such as botany than to plant sciences. As a consequence, when the agricultural universities started developing, very few students and teachers felt interested in these institutions from UAHS, though disciplines such as economics flourished and contributed significantly to agricultural economics. Indian scientists did outstanding work in the field of reproductive biology of plants but were not enthusiastic to convert this knowledge to technology, thus developing interactions with agriculture research institutions.

In fact as the time passed, the departments of biology in UAHS also followed the policy of isolation. They refused to accept geneticists, physiologists, biochemists and molecular biologists in their teaching staff, particularly from agricultural institution. Thus the direction of research in UAHS could not get a focus. We have seen that molecular biology of fruit ripening in musk melon came from North America rather than India. How a sharing interaction and cooperation among UAHS and agricultural universities (UAS) is achieved is a major challenge in the coming period. This does not remain confined to biological sciences but also to chemistry, physics, mathematics as important disciplines to agriculture. We today expect good soil sciences research without the knowledge of thermodynamics. We expect output or concepts in agroecological developments without geography and humanities. We rarely consider international relations and laws important to agricultural institutions in an era of globalization. It is time that a serious thought is given to integration of education loosely defined as basic and applied.

What is needed now?

Agriculture in its broadest sense remains the most important sector of the society even though its contribution to economy might have declined. Agriculture remains and will remain the source of food supply in the world. But agriculture is a part of the rural society and culture. Therefore, improvement of agriculture means the improvement of rural society, environment and quality of life. This includes housing, sanitation, health care, energy, water supply, road and telecommunication, rural industry, literature and arts. If today in India we think of Panchayat Raj institution, there is also a need for the people to know about its management and legal systems. Thus when agriculture is talked in isolation we deprive students of the aspects of social development. Why cannot we think of enhanced agricultural production being taught along with health care and sanitation. The university has to be an institution which offers an opportunity to students to learn and also become capable of earning. Therefore, it is time that we make agriculture as an integral part of university education and broaden the outlook of teachers and students. A person having started as a student of biology should have the possibility of growing into a social scientist. The narrow loyalties of disciplines which restrict the vision must give way to broader perceptions but having a strong anchor of a discipline and related areas. C. Subramaniam said: 'The time has come to realize that agricultural sciences cannot function in isolation. It has to interact with other scientific disciplines. Mathematics has its own impact on agricultural sciences, physics has its own and of course so does biology. Therefore, in the fora in which I have been participating in the last few years, I have been suggesting that there is no question of isolating agricultural sciences and agricultural universities. There should be greater interaction with the general university and with research in other disciplines.'[2].

We have come a long way since the establishment of first University of Agricultural Science and Technology and have made a significant contribution towards crop improvement. However, in the process crop variety has been made so important that it became the central theme of crop production and also synonymous with agriculture and rural development. Then we talk and look for the basis of sustainable agriculture without holistic thinking.

It is time that education for those who eventually opt for agricultural sciences and agriculture have a broad base. This could be best done by supporting growth of multifaculty universities. The universities in Britain, US, Canada and Australia are examples for us to emulate. These universities have all faculties, including science, arts, medicine, engineering or agriculture. Students could take course credits from any department to complete their course requirements. A student doing B Sc or M Sc could do a course in history, whereas another student doing a Ph D in agriculture could attend a course on molecular

biology. A teacher in biochemistry could feel proud that students from different departments and faculties attend his/her course.

Thus the vistas of knowledge spread. Consequently one university could become famous in medicine, another in management and still another in agriculture (like Reading in UK). The emphasis is on generation of knowledge and sharing it with others. Such an approach expands boundaries and not limit to a discipline or sub-discipline. It does not lead to development of a mechanism of exclusion but of competition. Thus we should make the existing universities as multifaculty, by including agricultural sciences. It would also be necessary for the present-day agricultural universities become the State Universities by adding other faculties. Thus the Punjab Agricultural University becomes Punjab State University, University of Agricultural Sciences, Bangalore becomes Karnataka State University, etc. This would end the isolation of agricultural sciences and agricultural universities following the vision of C. Subramaniam, the father of Green Revolution in India.

1. Randhawa, M. S., *A History of Agriculture in India*, 1979.
2. Subramaniam, C., in *Wheat Revolution* (ed. Swaminathan, M. S.), 1993, p. 106.

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