M. S. Swaminathan

Few have contributed as much to shaping the destiny of post-independence Indian agriculture as Monkombu Sambasivan Swaminathan (see Box 1). Popularly known as the Father of Green Revolution in India, the missionary of ever-green revolution[1,2] continues to work for a hunger-free society in his 86th year. A conversation with this awe-inspiring, yet affectionate and simple scientist gives a glimpse into his life and work, and his vision that is based on six decades of experience witnessing first-hand the most important developments in global agriculture.

Prof. M. S. Swaminathan.
(Courtesy: Dr N. Parasuraman)

The dedication of a life to agriculture

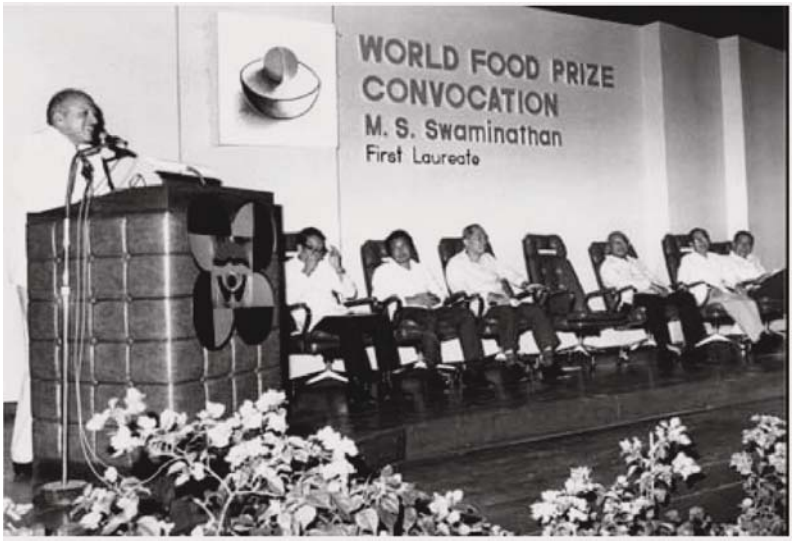
Transition from zoology to agriculture

My father, Dr M. K. Sambasivan, was a famous medical doctor. Unfortunately, he died in 1936 when I was very young. He had built a big hospital in Kumbakonam. My mother and others felt that I should do medicine, so that I could run the hospital. But when I was doing my B Sc in zoology, I started getting interested in genetics. Then in 1942–1943, there was the great Bengal famine. All of us in those days were very patriotic, and I was from a Gandhian family; my father was a freedom fighter. I thought the best thing to do would be to take up plant genetics, development of new varieties of crops and breeding. It was not very well received in the family, but I applied to the agricultural college at Coimbatore because I thought if I want to do plant genetics, I must have a rooting in agriculture. Then in 1947, I applied for post-graduate work at the Indian Agricultural Research Institute (IARI), Pusa. At that time, IARI was not a university. In fact, the first two deemed universities in the country, in 1958, were the Indian Institute of Science and IARI. Dr C. D. Deshmukh, who was then the chairman of the UGC, said these two institutions are the benchmark for future recognition of universities.

When I was at IARI, one of the joint secretaries in the Ministry who knew my family advised me, 'Why do you want to do agricultural research; there's not much future in it. Join the civil services'. He gave me the form in his room and

Box 1. A brief biographical sketch[3–5].

M. S. Swaminathan was born on 7 August 1925 in Kumbakonam, Tamil Nadu. After preliminary education in Tamil Nadu, Swaminathan obtained his Ph D from Cambridge University, UK, in 1952. After a two-year postdoctoral stint at the University of Wisconsin, USA, he returned to India and joined the Indian Agricultural Research Institute (IARI), New Delhi. It was from IARI that the 'wheat revolution' was choreographed during the 1960s. He is known for his contributions in wheat, rice and potato genetics and conservation of plant genetic resources (see Ramanujam *et al.*[5] for a detailed account). Swaminathan has been at the helm of several national and international institutions and commissions, including IARI (1966–1972), the Indian Council of Agricultural Research (1972–1979), International Rice Research Institute (1982–1988) and Pugwash Conferences on Science and World Affairs (2002–2007). He was the President of the Current Science Association from 2001 to 2006. Swaminathan has been recognized with a number of national and international awards, including Padma Shri (1967), Padma Bhushan (1972), Padma Vibhushan (1989), the Ramon Magsaysay Award for Community Leadership (1971), and the Albert Einstein World Award on Science (1986). He was the first laureate of the World Food Prize (1987) that is regarded as the Nobel Prize in Agriculture. Currently Swaminathan holds the UNESCO Chair in Ecotechnology at the M. S. Swaminathan Research Foundation (MSSRF), Chennai, which he set up with funds from the World Food Prize. At present he is also a nominated Member of Parliament (Rajya Sabha).



M. S. Swaminathan at the World Food Prize Convocation.
Source: http://www.msswaminathan.com/

filled it up for me (laughs). I had just one month to prepare for the civil services exam, but my subject marks were high because those were areas that I had studied before, like zoology. I got an offer from the Indian Police Service asking me to report to Mount Abu for training. I have got that offer letter still (laughs). Fortunately, at the same time, I also got a letter from UNESCO awarding me the UNESCO–Netherlands Fellowship.

Experiences in the Netherlands, Cambridge and University of Wisconsin

I got the UNESCO Fellowship in early 1948; it is interesting that the letter was signed by Dr Malcolm Adiseshiah. I stayed in Holland for a year, and then went to Cambridge, because the Dutch system of Ph D is very complicated – it takes 5–6 years, and you have to publish a book and so on.

I was working on tuber-bearing Solanums – potato, which is a native of the Titicaca region in the Peru–Bolivia border. There was a very big collection in Cambridge, called the Commonwealth Potato Collection – it had all the species. I started working on it in Holland, and continued work in Cambridge. That helped me because after one year in Holland, I finished my Ph D in two years, and my thesis was published as a monograph. In 1952, I got a letter from the University of Wisconsin saying, 'Will you come to Wisconsin as a Research Associate in genetics to help us set up a potato station at Sturgeon Bay'. I had published a paper in the *American Potato Journal*, and they were very impressed with it. I went to Wisconsin, but in early 1954, it was clear to me that I had to make a decision whether I wanted to return to India or not, because they offered me a regular position in the University of Wisconsin – a good position in those days.

Returning to India

I had told myself that I should equip myself and come back. I was very clear that I didn't want to settle abroad. But in those days you had to apply to UPSC, and wait for them to give you a position. When the University of Wisconsin came to know that I was still not employed after about two months of returning to India, they renewed the offer, but I again said no. I got a temporary position at Central Rice Research Institute, Cuttack, for crossing *japonica* and *indica* varieties of rice. Towards the end of 1954, my UPSC application matured and I went to the Pusa institute, my old alma mater, and started working on wheat.

The scientist and visionary

The beginnings of his work on dwarf wheats

Many people asked me, 'Coming from the Rice Research Institute, how did you suddenly start the dwarf wheat programme?' The Cuttack programme was started by Dr K. Ramaiah, a great man and C. V. Raman's brother-in-law. Ramaiah was in the FAO after World War II and he started the *indica–japonica* hybridization programme. At that time, *indica* rice, which was what we were growing, had a maximum yield of 1–1.5 tonnes; the average was about 800 kg. But *japonica*, grown in Japan, was giving 5 tonnes. So Ramaiah thought we should transfer genes from *japonica* to *indica* to increase the ability of the plant to absorb more nutrients and water, because inputs are needed for outputs. Since it was an FAO programme, my duty was to make crosses, and send it to eight different countries – The Philippines, Malaysia and so on, and they would make selections for their own conditions. Two very good varieties came out of that programme. One was ADT-27 and the other was Mahsuri that was selected in Malaysia.

That project gave me an idea that we must somehow incorporate genes for the enhanced ability of the plant to absorb more nutrients. The rice plant requires about 20 kg of nitrogen to make 1 tonne of rice. In the case of wheat, since protein content is higher, 25 kg of nitrogen is required for one tonne. The average wheat yield was 800 kg/ha when we started the work. So when I came to the Pusa institute, I told Dr Pal who was then the Director that I want to increase the yield potential of wheat. Dr Pal himself was a famous wheat breeder. I looked up the whole germplasm collection, but we didn't have a good dwarf variety of wheat, though there were naturally occurring plants like *Triticum compactum* and *T. sphaerococcum.* (Sphaerococcum is the one which occurred in the Mohenjo Daro excavation; they had spherical grains, and were very short.) I started radiation breeding, because in Sweden at that time, they had what are called erectoides mutants in barley, produced by Ake Gustafson. I thought we will make similar erectoides mutants in wheat. Unfortunately, unlike in barley, when you reduced the height of the wheat plant, the panicle became very short and the yield potential was low. Fortunately, in 1957–58, I found a paper in the *American Journal of Agronomy*, by Dr Orville Vogel. He had written an article on the Norin dwarfing genes, obtained from Japan. After World War II, the Americans had a whole set of scientists go from laboratory to laboratory to see what the new things that these people had were. They did that in Germany too. When Dr Solomon, a biologist, went to the Norin station in Japan, he saw short plants with very big panicles. He took the seeds and gave them to Vogel. Vogel crossed them with what are called the winter wheats, which require long days for flowering, and developed a variety called Gaines, that was the first dwarf wheat variety outside Japan. Vogel knew Borlaug was working in Mexico, and he told Borlaug, 'Why don't you do the same thing in spring wheat'. So Borlaug took the seeds from Vogel and started crossing them with spring wheats, which is what we grow in India. Borlaug, by 1961, had three or four good varieties in Mexico. So when I wrote to Vogel for seeds of these grains, he sent me the seeds, but wrote back to me saying, 'They won't flower under your conditions, except probably in Srinagar or Shimla since they require long days and mild temperature. Why don't you write to Norman Borlaug; he's got the same material in the spring wheat background'. So I wrote to Borlaug and he promptly replied (in those days e-mail wasn't there, and we had to wait for mails to come). He wrote saying 'I'll be very happy to give you the material. But I would like to come to India to study the growing conditions, to make a set for you'. I sent that letter to Dr Pal, because I couldn't invite anybody directly, and Dr Pal sent it to the Ministry. The Ministry took nearly two years to send the invitation. First they said, 'Why, we already know everything'. They told Dr Pal, 'You are the expert. Why do you want another expert' and so on (laughs). Finally, in 1962 or so the invitation went to Borlaug, and the Rockefeller Foundation agreed to pay his airfare. I wrote to

him saying, 'Since you are coming to see the wheat crop, come in March 1963, since the plants would have flowered, and would be getting matured'. So he came, and we both travelled all over North India for a month looking at the wheat crop.

The wheat revolution

I knew from the beginning that Borlaug was an unusual man. In fact, I wrote an article in *Yojana* long before he got the Nobel Prize, saying that he's like the Albert Schweitzer of agriculture. He had a lot of humanism apart from anything else. We went to Punjab, Haryana, Uttar Pradesh, Bihar, Rajasthan... all the major wheat-growing areas. Finally when he came to Delhi, it was his birthday, 25 March I think. My wife had arranged for Mexican music and dinner for him on the lawns on the Genetics Department of IARI.

From India, Borlaug directly went to Lahore and to Pakistan Punjab, because he had sent the material two years earlier there. They didn't recognize the value of that material. In September 1963, he sent us a whole set of seeds. The plants were stiff stalked and short, but had long panicles – that was the beauty of that material, in relation to my earlier erectoides. I divided the material into five to six portions, and said let us get multi-location data on the performance of these strains. Uniformly, whether it was in Pant Nagar, Kanpur, Pusa, Ludhiana or Delhi, they did very well. Then I gave a five-year programme in 1963–64 and being young and enthusiastic, I predicted that by 1968, we will see a quantum jump in production. It really happened that way (laughs). Fortunately we had a Minister in 1964, C. Subramaniam, who was a strong advocate of science and whatever I wanted for the national demonstration – import of Mexican seeds as a purchase of time operation and similar suggestions – were immediately approved; that was a great strength. Unfortunately, Subramaniam got defeated in an election in 1967. But Jagjivan Ram was also equally supportive. In fact, when Indira Gandhi released the stamp on wheat revolution, in 1968, Jagjivan Ram was the Minister.

Indira Gandhi, who eventually became the Prime Minister, was very keen on independence of foreign policy. She knew that without food, there will be food riots, and there'll be enormous problem. She repeatedly said, 'I don't want a Bengal famine to take place in my time'. That is why we had to import food; we imported 10 million tonnes of PL480 wheat in 1966; it was 'ship to mouth' existence. It was a very bad time for India from the point of view of food security. So Indira Gandhi also gave full support. In fact, one day she told me, 'I want to see the material'. So I took her to the Jounti village, the first seed village. She was very impressed with what she saw.

It is a good thing for independent India that we haven't allowed a Bengal famine to repeat, although we have gone through shortages. But there are a large number of people who are undernourished. I gave a lecture in Administrative Staff College in Hyderabad, 'From begging bowl to bread basket', in 1968. There I said that we are now going through a transition from a begging bowl, to a bread basket. The wheat revolution marked a sort of a transition in our agricultural destiny. But bread basket in terms of production is one thing, in terms of equity and access to food is another. The Planning Commission says over 30% of our population is below the poverty line; 30% of 120 million is crores of people. Almost the population of India at the time of independence! In our country 'below poverty line' means inadequate nourishment, because that is how the poverty line is calculated by the Planning Commission.

You had recognized the dangers of 'greed' revolution by 1968. Why was your warning not heeded?

In those days, for the first time, the Government was buying crops at a reasonable price. So if you are a farmer, you want to get as much money as possible. The Punjab farmers, who were producing 4 tonnes, wanted to produce 6 tonnes, so they had to put in more of everything (but now if you go to Punjab, they have become aware of it). After my national demonstration, it became like wild fire. Small farmers want to maximize their income. That is the problem of sustainable development – the balance between today and tomorrow; whatever you do today should not be at the cost of tomorrow's prospects. That's why I coined another term called ever-green revolution, which meant increasing productivity in perpetuity without the associated ecological harm, through green agriculture, organic farming and other methods.

On organic farming and green agriculture

Organic farming is good if you have got a number of farm animals with you. A majority of small farmers don't have farm animals, and will have to purchase compost, or grow a green manure crop. In Pondicherry, there is an Aurobindo Ashram. There the Gloria Farm is one of the best organic farms. But they have about 250 animals and all the dung, all the urine, everything goes to the farm. Green agriculture means integrated pest management (IPM) and integrated nutrient supply. You don't say that you should not apply fertilizers or chemical pesticides, but you apply them in moderation. IPM is by biological methods, genetic methods, and at the same time the use of minimum essential chemicals and fertilizers. Normally in my talk to farmers, I say, a child has a running nose. It requires vitamin C. There are two methods of addressing it – take a 200 mg tablet or six oranges. If you tell a very poor child, 'Take six oranges', where will it go? The same is true with one quintal of urea. Otherwise, the farmer has to buy so many cartloads of farmyard manure. And today, the farmyard manure is also not of good quality. It may contain heavy metals. Take Bangalore for example; all your hospital wastes, everything will be there. So just saying 'organic' doesn't mean everything is all right. You have to be careful.

In the early days, including in Karnataka and Andhra Pradesh, farmers would pay shepherds if they kept the sheep at night in their plot, so that all the urine and everything goes there. It is called penning. They were earlier methods of overcoming soil hunger. Another method is to grow a legume in rotation. They would apply all forms of organic matter from animals. They would make all residues into compost and apply. And finally, where land was in plenty as in the Northeast, they had shifting cultivation – jhuming. It is also called *podu* in Andhra. You cultivate for four to five years, the yield will go down because you have exhausted the soil; abandon that land and go to another land. But today that is not an option that you have.

On precision farming

Precision farming is to apply everything in a precise way. But it also implies no

tillage at all. That is a little controversial because you have to use large doses of herbicide. In the tropics you have to control weeds; otherwise they will take away all your nutrients. And rice is C3 plant, while most of the weeds are C4 plants, and so they are much more efficient and grow faster. I use the term 'precision farming' not in the sense that the companies use it, but in the sense of IPM, etc. The other form of precision farming is called no till method, where no tillage is done. You have the famous Japanese man, Fukuoka – One Straw Revolution. But Fukuoka lives in a temperate region, where 6–7 months a year, there is very heavy snowfall. He is recommending all kinds of things which you can't do in the tropics. Some NGOs quote Fukuoka. They have never gone to the field at all! They don't know what the problems are.

Why are genetically engineered plants not part of organic farming, considering that they help reduce the use of chemical pesticides?

International Federation of Organic Agriculture (IFOA), won't give certification. You can use marker-assisted selection and breed varieties – that is allowed in organic farming. But if it is a transgenic material like *Bt* brinjal or *Bt* cotton, then it is not allowed for certification.

Role of biotechnology in agriculture

Biotechnology is a broad term. There are a number of aspects of biotechnology, including biofertilizers, biopesticides, fermentation technology, medical biotechnology like what Kiran Majumdar Shaw does, and people want vaccines. So the only controversial area is food biotechnology. Even cotton is not as controversial as brinjal or wheat or rice. It comes from apprehension that when you take genes from completely alien organisms, you feel that your stomach is not used to those proteins and therefore, you may have problems. So health safety problem is one thing. Also the chronic dose problem, if it is something that you are eating all the time over a period of time. Then there is environmental safety, impact on biodiversity, if instead of having numerous varieties you have only a few hybrids or varieties. Then there is the question of who controls the technology – intellectual property rights. Actually it all started with who controls technology – whether the whole world's food security will be controlled by half a dozen companies and so on. That is why in 2004 I recommended a National Biotechnology Regulatory Authority approved by the Parliament, which will be very transparent, will measure the risks and benefits in a manner that inspires public confidence, political confidence, media confidence and professional confidence. If you take the United States, they have been consuming *Bt* corn, *Bt* soyabean, canola, mustard, etc. for many years now. You may say, are the Americans not health conscious? But they have three agencies – Federal Food and Drug Administration (FDA), Environmental Protection Agency (EPA) and Agricultural Plant Health Inspection Service (APHIS), and they have extensive testing facilities of their own. They don't depend only on the company's data. Today, the additional secretary or joint secretary in the Genetic Engineering Appraisal Committee (GEAC) is an IAS officer. There's nothing wrong in being an IAS officer, but that person does not last long. When he learns a little bit, he goes somewhere else. We must have a top professional, a biosafety expert, in charge of it. You need a biosafety assessment procedure, a risks and benefits assessment procedure, which inspires the consumer confidence. The sooner we have it, the better.

Biotechnology is a very important tool. It is a continuation, actually. When I started my genetics research, we already had mutation as a tool – H. J. Muller got the Nobel Prize for it. I have myself worked a lot with colchicine for doubling the chromosome number. We used to try other ways too. In fact, when I first developed Alaska Frostless, a potato variety resistant to frost, the genes came from *Solanum acaule*. I had to do what was later called in literature as 'Swaminathan artificial stigma method'. I found that the stigma was inhibiting pollen development. So I cut off a part of it, and put a new medium and germinated pollen grains. Today, with transgenic methods, it is very easy. In those days also we wanted to transfer genes. After all, nobody criticized Triticale, a combination of both *Secale cereale* and *Triticum*. So hybridization came first, then mutation, then aneuploidy, polyploidy, colchicine, and so on. Then after Watson, Crick and Wilkins discovered the double helix structure of DNA in 1953, the field of molecular genetics started. As far as breeding is concerned, it has made two important contributions. One is markers – with molecular markers I can identify the genes and then transfer them by conventional breeding methods. Another is recombinant DNA technology. So I would say that whether we like it or not, science will continue. The power of science is there, but you should use it for public good, not for public destruction.

You are just back after chairing the High Level Panel of Experts to the UN Committee on Food Security. India too has a Food Security Bill that might become law soon. With regard to food security, how would you compare the Indian requirements and international requirements?

Globally the principles are the same. Food security has three components. One is the availability of food which is a function of production (that is all right in our country, not only for grains, but also fruits and vegetables), access to food which is a function of purchasing power or employment, and absorption of food in the body which is a function of safe drinking water, environmental hygiene and primary healthcare. Generally food security nowadays, including our Bill, deals with access. The poorer you are, the higher the percentage of your income that goes to food, because you can do without anything else, but not without food. That is why food inflation hurts the poor more than the others. The Bill gives access to wheat and rice, and I also got the millets included. Ragi is a very good cereal; Mahatma Gandhi used to eat ragi. I also got it announced by the Finance Minister as 'nutricereals'. I said don't call them coarse cereals. The British called them coarse cereals, and in the country with the caste system, you think wheat and rice are superior and jowar, bajra and ragi are all inferior. So we have all the three – the nutricereals at 1 per kg, wheat at 2 per kg and rice at 3 per kg, for 35 kg per month per family, or 7 kg per individual.

The draft Bill has got five sections, one of which is legal entitlements, which will have to be enforced. There are the three kinds of grains, and you can have a choice. If you are in Karnataka, and you want to take only ragi, you can do so if you are eligible. We have taken away terms like below poverty line and above poverty line; we call it priority category

and general category. We are all human beings and members of the same family, but some of them require more support, and that's why they are called priority. Then the Bill has got enabling provisions. The farmers are ultimately the custodians of food security, because it is not possible to enforce the law unless you produce more. Food is not easily available today, the global market is very tight and prices are going up. That's why it is also important to study price volatility.

The Food Security Bill should certainly help all those who are economically undernourished. But this is only one aspect of it, because you also need micronutrients. World over, FAO says that today 1 billion women, children and men are undernourished, and nearly 2 billion have iron deficiency. That is particularly dangerous in women who are pregnant, because then they will get low birth weight babies. In our country, iron, iodine, zinc, vitamin A and vitamin B12 are extremely important. So I define food security as physical, economic and social access to a balanced diet, clean drinking water, environmental hygiene and primary healthcare. That is real food security.

Internationally, of the countries which have made great progress, one is Brazil. The previous President, Lula, started the Zero Hunger Programme. I am the Chairman of the Committee to select the World Food Prize laureates. This time we selected Lula, because whatever you see is a synergy between technology and public policy. Technology alone will not do. That is why the role of C. Subramaniam, Indira Gandhi, or Lal Bahadur Shastri who coined the slogan '*jai jawan jai kisan*', is important. Lula has done a remarkable job in orienting the country towards zero hunger. In Tamil there is a very famous poet called Subramania Bharathi, who said that not even one person should go to bed hungry, and we should destroy the world if even one person does. That was the philosophy of Lula. Today, food security has again come on top of the political agenda. After the green revolution, there was complacence. People thought problems had been solved with production. It is not really so, because so many hungry people are still there.

Decreasing land availability and agriculture

Land is a shrinking resource for agriculture, for the simple reason there will be urban expansion. You also require roads, airports, factories and so on. So in the coming decades and centuries, one will have to produce more and more food from less and less land. In other words, per capita production has to go up by means of more efficient use of available land and water.

Challenges in lab-to-land transfer in agriculture

When you take up lab-to-land transfer, you should know the socio-economic circumstances of the farmer. You should not do experiments with the farmer, because he is already poor. You must be very sure that whatever you are recommending is both economically and ecologically sound. If farm economics and farm ecology go wrong, nothing else can go right in agriculture. Before I took my dwarf wheats to a farmer's field, I had done at least two years of work and understood that they are quite safe and that they are going to make a great difference. So your scientific confidence in the soundness of the technology is very important. And secondly, you should see whether it is feasible for the farmer – is it replicable, can it be scaled up, or will it be a unique showpiece. Therefore, replicability and the extrapolation domain – the ability to extrapolate it to other circumstances – are important in designing a lab-to-land transfer. Another thing is to always go by the farmers' judgement. They are very good, and are very willing to take things up. But they will believe you only for one year. If things don't go right, the next year they won't believe you because they are poor, and they can't afford to.

I always believe that if a small farmer produces more, the credibility is higher. Formerly, the extension officers always used to go to what they called 'progressive farmers'. 'Progressive farmer' is a euphemism for a well-to-do farmer. I changed the paradigm of extension from going to 'progressive' farmers to a really poor farmer, to a resource-poor farmer, because anything that you demonstrate in a poor farmer's field has tremendous extension value. From anything that you do to a poor farmer, even a rich farmer can benefit. The reverse will not happen. And, anything that you do for the woman of a household benefits the whole family. The reverse does not happen. These have been two basic principles with me.

There are two major challenges to farmers. One is soil health and replenishment, just as human health. Secondly, crop health, protection from diseases and pests. That is why in my centre (MSSRF), we used to give soil health pass books to farmers. Now we have changed to farm health pass book, which every farmer can keep, and identify what are all the problems in the health of the soil, in the quality of the water and the problems that the plants and animals may face. When I was the Director General of ICAR, I told the governing body that I want to commemorate the 50th anniversary of ICAR by starting 50,000 lab-to-land demonstrations. There was one committee member who was always a little critical. He said, 'This is the first time I am hearing anything like this, that you want to celebrate it not with international conferences, but like this' (laughs). Last year I told Pranab Mukherjee to organize 60,000 pulses villages in honour of the 60th anniversary of our republic. He did that, and this year also it has been repeated. But all that should be implemented properly. The 50,000 lab-to-land projects had a great impact. The reverse, land-to-lab, is equally important – learning from farmers, since farmers' knowledge is based upon living with the plant; it is lifelong experience. Then land-to-land–farmer-to-farmer learning. In the National Commission on Farmers, I suggested – take outstanding farmers, put a dormitory or a hostel in their field if they are agreeable, so that other farmers can come and stay there for some time and understand the economics of farming, the technology of farming, and so on. And lab-to-lab, that is scientists' collaboration. All the four methods are important from the point of view of extension and learning.

The humanist

The importance of being able to put faces to figures

The Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREGA) is probably the world's largest social security programme – Rs 50,000 crores are being spent on it. But if you go these Bhavans, they refer to the crores of people in NREGA as 'beneficiaries' or 'illiterate labour'. I said, they are also human beings like you and me. You are saying they will do

watershed management, rainwater harvesting, aquifer recharge… If they are to do all that, they are the greatest ecological warriors of the country. So I have been fighting for Environmental Security Saviour Award for the best NREGA team which has done very good work in watershed management, so that they also feel that they are contributing something important to the country. Similarly, there is the Genome Saviour Award for people who have conserved species. They are tribal people, but are exceedingly good in terms of conservation. Conservation ethos is in their blood.

Bridging the gap between policies and people

Normally in a democratic society, policies are made by people whom we put there in power, and we can change them once in five years. But policies will have to be developed by means of consensus building and consultation, particularly in a very varied and diverse country like ours. For example, the Food Security Bill. One text was created by the National Advisory Council, because we thought that we have to make a contribution. Then it goes to the Government. The Government in its own wisdom will modify it. Then it goes to the Parliament and the Parliament will set up a committee consisting members of all parties. So you have a number of checks and balances. I would say that the democratic system of governance itself is one method of bridging policies and people.

The person

You have been many things – scientist, administrator, policy maker… Which role do you like best?

My love is more in the field, and also in teaching young people and sharing knowledge, because you keep your mind fresh when you teach – you have to study before going to the class and so on. I have had nearly a hundred Ph D students so far, and currently there are four or five of them. They have educated me. So I would say research and teaching are my first job.

What are your other interests apart from science and agriculture?

Well, my whole life has been this (laughs). My wife says I have a single-track mind. Those days, when I started working, you would not get food in the market. In fact when my elder brother Krishnamurthy got married in 1947, a month after independence, the rule was that in a marriage a maximum of 30 persons can be fed. And policemen used to sit there and count the number of banana leaves that you throw. More than 30, they would arrest you. I have seen weddings now and money is the limit (laughs). So there is a big transformation. Also if you see the average lifespan, which was 28–29 in 1947, is now 64–65. In Kerala it is 74 or so. I am sure soon it will become 80–90. That is partly also because of food, because without nutrition, it is not possible. So we have had a transformation in our economic well-being. But that is not spread evenly in society; there are still very poor people, the highly deprived. In my view, the first task of both science and society is to address this issue.

About his family

I have got three lovely daughters – they are all grown up now (laughs). My wife, Mina, is an educationist; she has also been working with very poor children, for pre-school education. She, along with Mira Mahadevan, was the founder of the mobile crèche for children who are abandoned. She was also the founder of ICDS – Integrated Childhood Development Service. My eldest daughter, Soumya, is one of the leading authorities on tuberculosis-HIV AIDS relationship. My second daughter, Madhura, was the first girl student from India who was a Rhodes Scholar in Oxford. In 1986 or so she got her D Phil from Oxford. She is the head of the Economics Department of the Indian Statistical Institute, founded by Mahalanobis. The third girl, Nitya, is a rural sociologist. She was from the Institute of Rural Management in Anand. Right now she is the only one who is abroad. She did her Ph D from University of East Anglier, Norwich. She worked in Jharkhand for her Ph D. They liked her work very much, and offered her a regular position to head the Gender and Development Department. So by God's grace, I have three wonderful children and a wonderful wife (laughs).

About the M. S. Swaminathan Research Foundation

We have got three kinds of research in our Foundation (Figure 1). One is anticipatory research for climate change, especially sea-level rise and temperature changes. My colleagues, Ajay Parida, Suja George, Gayatri Venkataraman, Rajalakshmi and others have been able to take genes for sea-water tolerance from mangroves like *Avicennia*, and transfer them to very good rice varieties like *ponni*. If you come to Kalpakkam you can see them – beautiful plants. We started the work on mangroves in 1992, nearly 20 years ago. Similarly, Suja has been able to transfer genes for drought

Figure 1. M. S. Swaminathan Research Foundation, Chennai. Source: http://www.mssrf.org/regional.html

tolerance from *Prosopis juliflora*. Some plants are very rich in iron that is bioavailable according to the National Institute of Nutrition, and iron-rich rice has been developed. I have tasted it; it is quite a good taste. Then we have participatory research with farmers and what we call strategic research.

In my Foundation, the mandate is to impart a pro-nature, pro-poor, pro-women orientation. You can do two kinds of science – you can do something which the poor cannot afford at all, or you can do something which they can. The seed is one good leveller – everybody can benefit from a good seed. So we give a matrix that is pro-nature so that it is environmentally sound; we said pro-poor because it must be economically equitable, and we said pro-women because more than 50% of the labourers in agriculture are women. There are multiple burdens on women's time – child rearing, housekeeping, economic activities, etc. Unfortunately, in our gender-wise division of labour, women also fetch fuel wood, water, fodder, etc. One of our research programmes is to reduce the number of hours of work in the life of a woman, but add value to each hour of work by taking them from unskilled to skilled labour. So in our country at the moment, we must do high science, like strategic research, to advance the frontiers of knowledge. But if you want to advance the frontiers of human happiness, you should start from Gandhiji's *antyodaya* – start from below. *Antyodaya* will lead to *sarvodaya*. Everybody will be happy.

M. S. Swaminathan's message to students and scientists

I followed Swami Vivekananda's teachings when I was young. He said, this life is short, its vanities are transient. He alone lives who lives for others. I think more than any other country, in our country, this is very important today. 'Others' also includes family members, because charity begins at home. But if you are an educated person, do something which can help improve the lives and livelihoods of your fellow people. And then towards the latter part of your life, you feel more satisfied that you have done something not only for yourself or for your family, but you have done something which has made a slight difference in the lives of the less privileged.

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