Seventh Dr C.M. Singh Memorial Lecture

Indian Agriculture-Challenges and Resolves

by

Prof. Panjab Singh

Jointly Organised by

Dr C.M. Singh Endowment Trust, Bareilly (U.P.)

and

ICAR-National Research Centre on Equines, Hisar

2018

Dr C.M. Singh : A Brief Profile

Dr C.M. Singh, was born in a remote village in Distt. Jaunpur (UP) on 30th November, 1922. He obtained BVSc degree from Bihar Veterinary College, Patna and MS, PhD from MSU, East Lansing, USA. Dr C.M. Singh was an eminent Veterinary Pathologist and Microbiologist and has made outstanding contributions in animal diseases mainly listeriosis, salmonellosis, mycoplasmosis, bovine lymphosarcoma and slow viral respiratory diseases. He was an excellent teacher and researcher. Later, when he joined as Dean at Haryana Agricultural University, Hisar and as Director, Indian Veterinary Research Institute, Izatnagar, Bareilly, UP he proved himself as an able administrator and distinguished veterinary educationist. His vision and thoughtful plans converted post-independent IVRI of 5 Divisions into 21 Divisions of National Institute of International fame. Due to enormous extension of research infrastructure during Five Year Plans to meet the need of farmers and industry, IVRI Bangalore Campus was developed for Foot and Mouth Disease vaccine R&D. High Security Animal Disease Laboratory at Bhopal (now NIHSAD) was an institution of his visionary planning, is presently engaged in diagnosis of infectious exotic diseases including bird flu. From IVRI, two research Institutes namely Central Avian Research Institute, Izatnagar and Central Institute for Research on Goats, Makhdoom, Mathura developed separately for poultry production and goat development respectively. His significant contribution in development of Department of Pathology and Bacteriology at Veterinary College, Mathura and IVRI as a whole is a true testimony to his dynamic stewardship. IVRI is known as Mecca for Veterinarians, owing to its uniqueness in integrating research, disease investigation, extension, technology development and teaching. After superannuating, he did not sit idly. He felt the need to reform the Veterinary Education in this country and was instrumental in creation of Veterinary Council of India and National Academy of Veterinary Sciences. He was Founder President of these two prestigious national organizations. Dr C. M. Singh had collaboration and interaction with international agencies like FAO, WHO, UNDP, SIDA, DANIDA, etc. He attended a number of international seminars and symposia on epidemiology and zoonotic diseases in different parts of the world. He guided several eminent veterinarians for their masters and doctoral programmes in the disciplines of Pathology, Bacteriology and Virology. As a person, Dr Singh was simple, honest and hardworking with no time for personal comfort and family affairs. He was a great visionary. Some people called him, "*Doyen of Veterinary Profession*", while others considered him as "*bhismpitamah*" or "*purushottam*" and "*preranashrot*".

During his last visit to this IVRI on 10th January, 2005, scientists of twin Institutes of IVRI & CARI at Izatnagar had the opportunity to listen and meet him. He is still remembered for his talk on philosophy of life interspersed with verses of the Holy Gita. Dr Singh left this world for his heavenly abode journey on 27th July 2005 in UK after a prolonged illness. His demise was great loss to the veterinary profession of this country as well as his family. His dream to establish Indian Council of Veterinary Research is still not fulfilled. It will be best homage to him, if we can achieve this objective for betterment of veterinary profession. Dr C. M. Singh Endowment Trust was established with his directive and blessings in 1999 with objectives of advancement of veterinary science and welfare of livestock, farmers and veterinarians of this country.

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Published by :

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delivered at

World Veterinary Day Seminar

Saturday, 28th April 2018

at

ICAR-National Research Centre on Equines
Hisar

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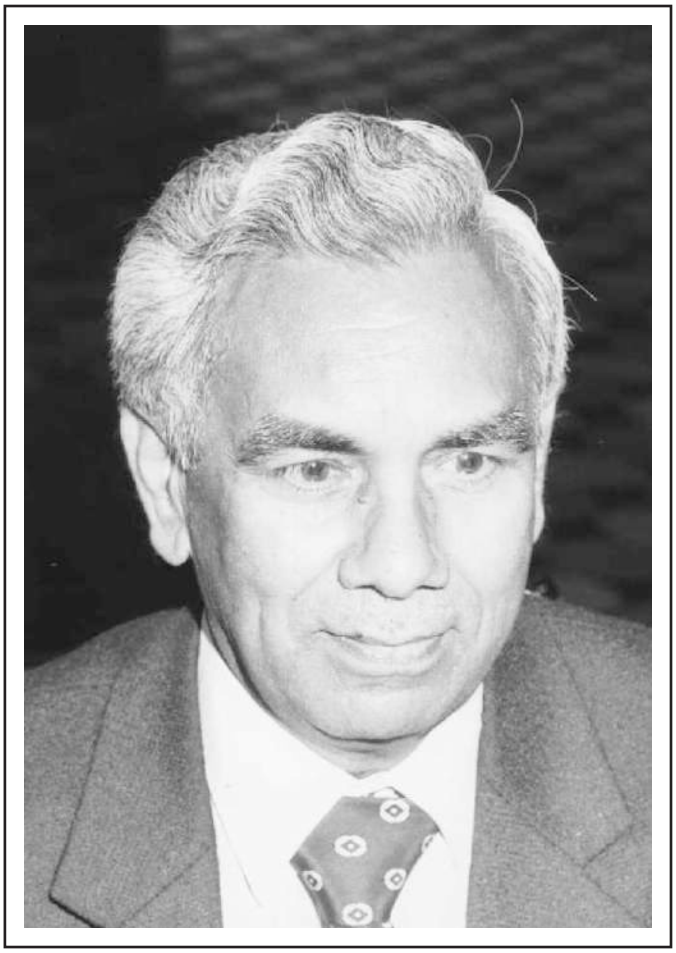

Dr C.M. Singh

(30.11.1922 - 27.7.2005)

Indian Agriculture-Challenges and Resolves

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India stands second in the world in agriculture production, while service and manufacturing sectors rank 11th and 12th, respectively. India's inherent strength in agriculture are- largest cultivated area in the world, abundant sunlight throughout the year, over 260 million people who work in the farms seven days a week, largest irrigated area in the world (91 million ha), rich agro-biodiversity (no country grows as many crops as we do), family managed small farms and their crop-livestock mixed farming system and others. India's ranks first in milk production (160 million tons in 2015-16) which is 18% of the world milk production, and second in global fish production (10 million tons) and ranks highest in consumption of non-vegetarian food (higher than chicken and meat). Indian Agriculture has completely transformed in recent years and is structurally very different. A significant part of Indian Agriculture production now comes from horticulture (vegetables, fruits, flowers, etc.) and livestock (milk, fish, eggs and meat) and both sectors together contribute to 60% of India's agriculture GDP.

Global food security has been threatened by climate change which is the most important challenge of the 21st century to supply sufficient food for the increasing population while sustaining the already stressed environment. Introducing major semi-dwarfing genes in important crops-like rice and wheat doubled our food production during 1960s. In the post-green revolution era, the improvement has been gradual but has further doubled the food production. In the current decade, the productivity has plateaued. It is a gigantic task and a major challenge to further realize any major genetic gain. This gain is expected to come by the use of cutting-edge science and technology. Unlike in the past, though the crisis in agriculture today is not because of food scarcity but due to market volatility. While the prices of the output are falling, input costs are rising, making agriculture risky and increasingly unviable. If we compare Chinese agriculture with that of ours we notice that China has surged ahead of Indian agricultural productivity and also in agricultural value added products which has more than doubled than that of ours (Chart I &II- HT, New Delhi, April 6, 2018).

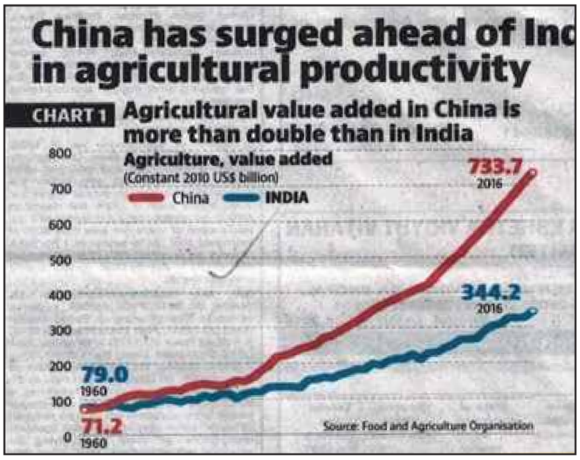

Chart-1 Comparative agricultural productivity of India and China

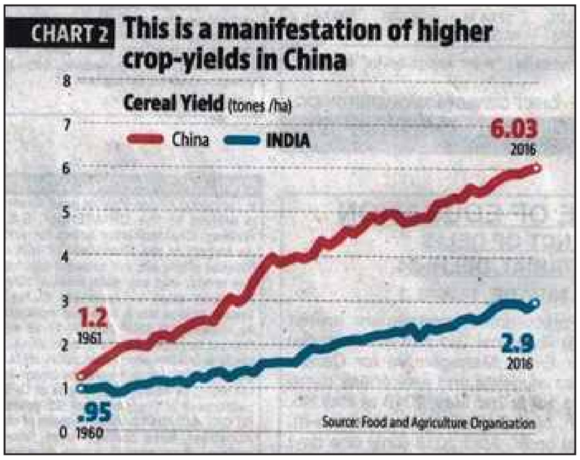

Chart-2 Comparative crop yields in India and China

(Source: Hindustan Times, New Delhi, April 6, 2018)

CHALLENGES

Water:

India with 17.5% of world population and 11.6% of world livestock population is endowed with only 4% global renewable water resources. Currently, the water resources of the country are under severe strain with continuously declining per capita water availability (5177 m^3 in 1951 to 1545 m^3 in 2011-water scare country) accompanied with the challenges of widespread water scarcity, floods and contamination across the states in the face of accelerated demand for food security, industry, per capita income etc.(Table-1).

Table-1. Total water requirements for various sector (Central Water Commission, 2012)

Sectors	Water Demand (BCM)				
	1990	2000	2010	2015	2050
Irrigation	437	541	688	910	1072
Drinking (including livestock)	32	42	56	73	102
Industrial	-	8	12	23	63
Energy	-	2	5	15	130
Others	33	41	52	72	80
Total	501	634	813	1093	1447

Despite all allowed conservation practices and investment under National Rural Employment Guarantee Scheme (NREGS) the number of over-exploited blocks are on continuous rise (839 in 2004 to 1034 in 2013) covering more than 4 lakh sq. km (17% of India's area suitable for groundwater extraction i.e. 23 lakh sq. km) because of indiscriminate extraction exceeding the annual recharge. Similarly, the rivers, glaciers, springs and water bodies are shrinking and drying. Regular recurrence of droughts and persistent farmers' suicides underscore the gravity of the situation. The problems got accentuated with climate change events resulting in erratic spatial and temporal variability in rainfall and other events. It is not surprising that India is the largest user of groundwater in the world with an estimated 251 cubic kilometers of groundwater per year-over a quarter of the global total.

As per the Ministry's 1993 & 1999 estimates the total utilizable water resources of the country is 1123 billion cubic meters (BCM). The per capita availability of water per year is steadily decreasing from 5177 m^3 in 1951 to 1588 in 2010 and is likely to decline to 1341 in 2025 and 1140 in 2050.The National Commission for Integrated Water Resources Development (NCIWRD-1999, GOI), assessed that the annual water requirement by the year 2025 and 2050 will be about 843 BCM and 1180 BCM, respectively while other sources of latest information provide different, rather alarming picture. The International Water Management Institute (IWMI) water scarcity study reveals that, by 2025 one-third of the populations of India (280 million people) would live in regions that will face absolute water scarcity by 2030. Water Resource Group (2009) estimated that by 2030, demand in India will grow to almost 1.5 trillion m^3 against current water supply of approximately 740 billion m^3 with likely severe deficit unless concerted action is taken. World Bank (2012) opined that if current trends continue, in 20 years about 60% of India's aquifers will be in a critical condition. Mihir Shah Committee (2016) stated that, if the current pattern of demand continues, about half of the demand for water will be unmet by 2030.

The North-Western, Western, Central (Bundelkhand region) and Southern region states are seriously suffering from declining water tables because of indiscriminate exploitation of ground water resources, while the states of eastern region, endowed with shallow water tables are affected with underutilization. Rivers particularly peninsular rivers are shrinking because of decline in aquifers and the resulting low base flow contribution. In addition, much of waste water is unused. This manifestly demands better water management.

Of various reasons for steep decline in per capita availability of water and for growing water scarcity, floods and quality challenges, one major reason is lack of effective control on annual water consumption (demand) exceeding the annual water availability (supply) and omissions to monitor and protect quality of water sources from contamination. Ironically the water consuming (demand) sectors are not concerned about water availability nor are there any state level single agency which oversees and coordinates to hold any sector or entity accountable for over exploitation and excessive use (demand).

Sustainable Water Management:

Our popular belief is that water is available in unlimited quantity at virtually no cost and for all time needs to be contested. Developing countries pay little attention in formulating any management policy for its judicious use. In many cases countries with abundant rainfall suffer due to severe water scarcity due to seasonal variations in rain. Other issues like confronting water disputes between different states within country are the direct effect of regional scarcities of water from natural resources. There is an international dimension of this problem where water traverse through Nepal, India and Bangladesh meeting the Bay of Bengal. It is therefore imperative that all the major issues of water from drinking water sustainability to irrigation needs and urban demand should be analyzed and reviewed in overall regional development contexts. Such conservation programmes should take into account of ecology, hydrology, agriculture, industry and other miscellaneous social needs. As water is used by everybody, the management should also be responsibility of everybody.

It may be noted that India presently uses about 40 million hectare metres (Mham) out of 400 Mham that is about 10 per cent of the total annual precipitation. But to meet the requirement in the middle of this century we need to use 25 per cent of the rainfall and therefore simultaneous arrangement should be made to store, conserve and judicious use of this resource. The total estimated ground water resource in India is estimated to be about 43 Mham per year and so far about only one-third resource has been developed. It is also to be noted that 85 to 90 per cent of India's fresh water resource is being used for agriculture, much above the world average of 65 per cent. The industrial sector consumes another 4-5 per cent and rest is used in domestic and miscellaneous or other purposes. There are regional diversities in water. For example, the Bengal Delta with its intricate networks of channels possesses abundant water resources, bulk of which drains in to sea. At the other extreme, there is complete absence of surface flow in the Thar Desert of Rajasthan. The region of heaviest rainfall is Cherrapunji-Mawsynram in Meghalaya and the region of poorest are in the western part of Rajasthan. Depending on the soil, the cropping patterns show diversities. In this whole process the symbiosis relationship between crop selection and water management is very important. Within this scenario, the technology helps in manipulation of natural resources and crop production. The ultimate objective of extracting water for crop use has to be balanced or else excessive use of water results in water logging, salinity etc making land unfit for production as has been noticed in many regions in the country.

The efficiency of irrigation water still remains at 35-40 per cent in India, where as the figure is well above 60 per cent in some other countries like-USA and China. This aspect of water management in crop production needs our highest priority to enhance water use efficiency. Use of sprinkler and drip irrigation have demonstrated 80-90 per cent increase in on-farm water use efficiency with concomitant increase in crop yields to the tune of 20-100 per cent depending on crops. Resource conservation technologies' application plays an important role in efficient management of this important resource. It is therefore necessary to adopt area-specific, season-specific, crop-specific and source-specific water resource management to ensure long term water availability.

There are rich traditions of community based water harvesting and water budgeting in India, to meet the needs of specific environment. Recent efforts of community to harvest rain water and recharge the aquifers in Alwar district of Rajasthan have helped the revival of Arvari river which remained dry during the last 40 years.

Similar participatory water management programmes being pursued in various parts of the country have given excellent results. This effort must be done on large scale for ensuring sustainable water management. Substantial amount of total run-off needs to be conserved by creation of additional water storage facilities in networks of tanks and reservoirs. Prior to any future planning, the perception and awareness of the local people should be given the attention. It is necessary to highlight that development is for the benefit of the masses and it is their responsibility to sustain it. In search of sustainable management, it is necessary to blend the traditional knowledge with modern technology to reap the best benefit.

Land and Soil:

India has total cultivated area of about 143 million ha, but the number of marginal holdings (less than one hectare) has increased from 36 million in 1971 to 93 million in 2011 and the average plot size has reduced from 2.3 ha in 1970 to less than 1.2 ha at present. Almost 70% of farmers own less than 30% of cultivable land. The small size of land holding makes them good only for subsistence agriculture. Since the smaller land holdings are fragments of the large holdings that have passed down generations, farmers who cultivate them often do not have formal lease agreement. In absence of these they are deprived off access to input subsidies or crop insurance benefit given by the government.

Land degradation has been an area of major concern in the past few decades. Nearly 120.4 million hectare (36.6% of total land area) is suffering land degradation of some sort, whether wind and soil erosion, water logging, soil alkalinity/ acidity, seepage of mining and industrial waste, along with excessive use of fertilizers, intensive cropping and depletion of organic matter. Water erosion is one of the most serious degradation removing 5.3 billion ton of top soil and also 5.37 to 8.4 Mt of plant nutrients every year (NAAS Policy Paper) resulting in loss of soil productivity and serious loss of flora and fauna (biological degradation) wealth.

Chart-3 Fragmented land holdings in India

Physical degradation of soil through water logging, submergence, flooding, soil compaction, and crusting, poor infiltrability- all become a limiting factor in soil health and crop production. Similarly, chemical degradation which includes salinization/alkalinization, acidification, soil toxification and depletion of soil nutrients (skewed NPK ratio) and organic matter leading to poor soil health and crop productivity besides other human, animal and environment related problems. The degradation of soil chemical, physical and biological health along with inadequate and imbalanced nutrient use and neglect of organic manures is the cause of multi-nutrient deficiencies in many areas of the country.

Sustainable Land Management:

Initiate land reforms that will encourage consolidation of land holdings; create a land bank where interested land owners can deposit their land parcels for tenants to lease, update and digitize land records and titles. Provide non farm employment to many who wants to move away from agriculture. This will require creation of more jobs in rural settings on rural raw material based industries.

Soil health based fertilizer use and subsidy, reducing the subsidy and providing the subsidy to the farmers rather than fertilizer industries. Promotion of neem coated urea and organic farming, following integrated farming systems for enhancing resource use efficiency and improving soil and environment besides enhancing farm income.

Maintaining soil health/ quality must be our priority for sustaining the productivity and maintaining the ecological balance. Minimizing soil physical degradation through adoption of sunken and raised bed technology, multiple use of water through integrated farming systems in water logged alluvial soil of eastern India is recommended. Conservation tillage protects soil structure, conserves moisture, allows more entry of rain water in to the soil profile, reduces soil erosion and improves the soil chemical and biological health. Sub-surface drainage, bio-drainage, and soil tolerant varieties of different crops and agro-forestry interventions improve the productivity of saline, sodic and water logged soils in the country. For acid soils, liming 2-4 tons/ha with half of fertilizer dose helps in increase productivity of crops especially, oilseeds and pulses in such soils. Soil test based integrated nutrient management (INM) including organic and inorganic source is recommended to meet the demand of nutrient deficiencies especially micronutrients. Soil health card based fertilizer use is a very useful attempt in direction of soil and nutrient management.

Organic agriculture is supportive of the environment and restricts the use of synthetic inputs. With increasing awareness about safety and quality of food, long term sustainability of the system and evidence showing system being equally productive, the demand for organic agriculture has gone up many folds. Also falling agricultural yields in certain areas and decreased soil fertility and environmental awareness has increased interest in organic agriculture.

Climate Change:

Climate change and food security, in my opinion, are the two watch words of the survival of humanity at large irrespective of its origin whether it is developed, developing or under-developed country. The term, quite often exchanged with livelihoods, deals with the access to the food required for a healthy and productive life. Through the last century during which, the world witnessed with pride unprecedented scientific, social and economic achievements also witnessed worst of the documented disasters, both man-made and natural. During the period, the development in the agricultural production system also led to certain degree of stability in the developed and developing countries such as India and China. The surpluses in some parts of the world also led to the apparent complacency that the global food surpluses were sufficient to guarantee global food security. If one looked world as one unit may be, the scenario provides ground for achieving the definition of food security, per se. This, however, is too simple a situation to imagine as a real situation.

In our enthusiasm of realizing the potential of scientific developments in agriculture and industry, we ignored the harm we caused, sometimes, inadvertently and sometimes recklessly, on the natural environment that houses the life support system of the world. We now face the reality-the threat to environment. In other words, environmental degradation is now is equally prevailing reality, beyond a limit of which, all the achievements that insured food security to the world would suddenly become unsustainable or to say, environmental degradation is now being considered as one of the greatest risks to future world food security.

On the eve of UN Conference on Environment and Development held in Rio de Janeiro in June 1992, the union of concerned scientists published an open letter titled, **World's Scientists Warning to Humanity**, which stated that, **"human being and the natural worlds are on the collision course".** It further stated that **"If not checked, many of our current practices put at serious risk for future that we wish for the human society and plant and the animal kingdoms and may so alter the living world that it would be unable to sustain life in the manner that we know"**. This warning was signed by over 1600 scientists, including 104 Nobel Laureates from leading scientific academies of 70 countries.

Recently world community acknowledged that the climate change caused by excessive emission of Green House Gases (GHGs) is one of the greatest challenges facing our planet today. The atmosphere carries out critical function of maintaining life sustaining conditions on earth. GHGs (for example carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and water vapor) re-emit some of the heat to the earth surface. If they did not perform this useful function, most of the heat energy would escape, leaving the earth cold (about -17C) and unfit to support life. Increase in the level of GHGs could lead to greater warming, which, in turn could have an impact on the world climate-the phenomenon known as "Climate Change". Ever since industrial revolution began 150 years ago, manmade activities have added significant quantities of GHGs to the atmosphere. Atmospheric concentration of CO_2 has grown by 31%, CH_4 by 15% and N_2O by 17% between 1750 and 2000 (IPCC 2001). A portfolio of measures on various sectors of economy- like energy, agriculture, urban and rural habitat and all measures related to environmental protection and ecological sustenance are needed to combat this grave problem.

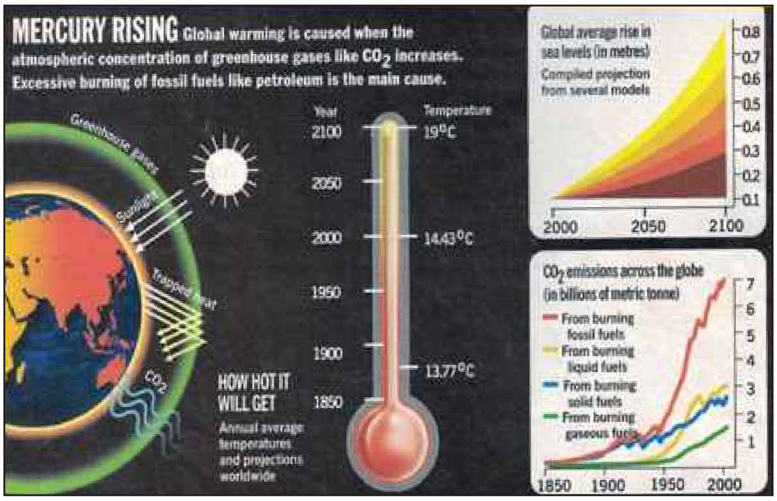

Chart-4 Causes of global warming

In India, where still about two-third of the population depends on agriculture and nearly half of the cultivated land is rain dependent makes livelihoods highly vulnerable to climate change. This poses a serious threat to the food security. Climate sensitive sectors-like agriculture, forestry, water resources, human and animal health and so on, highly vulnerable to climate, will face serious consequences and will have the future effects through: continued change through this century and beyond; continuous temperature rise; longer frost free season (and growing season); changes in precipitation pattern; air will become more and more polluted; more drought and heat waves; more stronger and more intense hurricanes; sea level rise by 1-4 feet by 2100; arctic likely to become ice-free and so on and so forth. Latest WHO study shows that 92% of the world population breaths polluted air. India accounts for 75% of 0. 8 million air pollution related deaths in South-East Asia region, over 0.6 million people die every year in India of ailments caused from air pollution such as acute lower respiratory infection, chronic obstructive pulmonary disorder, ischemic, heart diseases and lung cancer.

Solution exists with sustainable transport in cities, solid waste management, access to clean household fuel and cook-stoves, as well as renewable energies and industrial emission reductions (TOI, Sept. 28, 2016).The impact on human health will be as devastating. The impact, as per UN Panel Report, for India could be summed up as under:

- Thirty eight per cent drop in per capita water availability by 2050 for Indians as great dries becomes frequent.
- Sea level will rise 40 cm higher by 2050 and 50 million people in coastal India would be displaced by flooding.
- In the plains, winter precipitation would decline, causing water shortage, shrinking grasslands and triggering a fodder crisis.
- Seventeen per cent will be the fall in wheat yields in India, if temperatures rise by even half-a-degree Celcius.
- By 2035 Himalayan glaciers may totally disappear, causing catastrophic disruptions.
- The glaciers on the Tibetan plateau will shrink rapidly from 5 lakh km^2 to 1 lakh by 2030.
- The glacial meltdown will first result in river being flooded and then drying up. The Ganga delta would turn infertile.
- About 5 degrees is the expected rise in overall global temperatures by the end of 21st century.
- Vector-born diseases, viz. the dengue and malaria, are expected to rise sharply across India as changes in temperature make it conducive for mosquitoes to thrive.
- Deaths from diarrheal diseases associated with floods and droughts could go up. Coastal water temperature would help spread cholera and heat stress would cause deaths.
- Warmer ocean temperatures would lead to bleaching and destroy vast tracts of India's coral reefs.
- Ocean acidification would lead to shell dissolution, severely affecting marine life and fisheries.
- With erratic rainfall and decrease in precipitation levels, India's forest would deplete rapidly.
- The country's mangroves that are rich in biodiversity would be wiped out because of rising sea levels.
- About 25 per cent of flora and fauna would become extinct by 2030.

Some predict that higher levels of CO_2 may stimulate photosynthesis in certain plants (30-100%), especially in C3 plants and may suppress photorespiration, making them more water efficient. The protein content of the grain decreases under combined increases of temperature and CO_2. For rice, the amylase content of the grain, a major determinant of cooking quality, is increased under elevated CO_2. With wheat, elevated CO_2 reduces the protein content of grain and flour by 9-13 per cent.

Green Technologies for Sustainable Agriculture:

With the development of next generation and third generation sequencing technologies, genome sequence information of most of the cultivated crops such as rice, maize, wheat, pigeon pea, chickpea, ground nut, soybean, pearl millet etc. have been made available. Availability of genomic information has led to development of genome-wide markers which in-turn unveiled plethora of genes governing economically important traits such as genes for bacterial blight resistance, blast resistance, submergence tolerance in rice etc. With the development of statistical techniques such as QTL mapping, genome wide association studies and sequencing based mapping techniques, more than 10,000 QTLs governing complex traits such as drought tolerance, salinity tolerance, heat tolerance, yield and yield related traits etc. have been identified. Simply inherited traits such as disease resistance, submergence tolerance, QPM, etc. have been successfully transferred into elite genotypes through marker assisted backcross breeding. Ex: Swarna Sub1, Vivek QPM 9, HHB67, Pusa Basmati 1637 (blast resistance gene Pi9) etc. However, genomic assisted breeding for improving complex quantitative traits have largely been unsuccessful due to the difficulty in finding the major QTLs stable across environments and genetic backgrounds. Several other advanced strategies such as forward breeding, marker assisted recurrent selection, genomic selection are being utilized to improve complex traits. To improve the abiotic stress tolerance such as drought, salinity, submergence etc., and to improve the nutrient use efficiency such as nitrogen use efficiency, phosphorous use efficiency etc. in crop plants, genomic resources and tools would be indispensable.

Strategies to Cope with Changing Climate:

Plant breeding strategies viz. exploitation of alien genetic variation, enhanced input use efficiency, breeding for earliness, varieties for fragile ecosystems, and genomic tools, viz. marker assisted breeding, transgenics/cisgenics, proteomics etc. TILLING/ECOTILLING (search for new genes) next generation sequencing technologies are important ways to meet the challenges.

Breeding Varieties for No-Till Agriculture:

Adoption of Resource Conservation Technologies (RCTs): Technology-like DSR RICE saves water up to 30%, saves fuel and labour up to 25%, reduces production cost by 22%, reduces CH_4 emissions (19%) and weed infestation significantly. Identifying traits and genes for minimum TILL agriculture through use of genomics for developing varieties with better adaptation is another important technological approach to resolve the problems.

Breeding Varieties with Resistance to Biotic Stresses: Achievements made through improved Pusa Basmati 1 with bacterial blight resistance, Pusa Basmati 1637- a blast resistant variety developed through molecular breeding in addition to 20 varieties of different crops have been developed through molecular breeding in India are of great significance. Similarly, breeding for submergence tolerance rice namely, Ten Sub1 varieties developed in backgrounds of popular varieties, have been commercialized with yield advantage of 1- >3 t/ha after 7-18 days of flooding. Also there is no penalty on yield or quality in absence of floods.

Soil Salinity:

Traits for Salt Tolerance for Research: These are ion exclusion, tissue tolerance and osmotic tolerance. In India total salt affected soils are 6.73 M ha, saline - 2.96 M ha, and sodic - 3.77 M ha which needs our attention. In breeding for salinity tolerance, *Saltola* major gene/quantitative trait locus (QTL) for seedling stage salinity tolerance identified from Kerala's land race *Pokkali* and used in developing salt tolerant rice varieties.

Losses due to Drought: About 86% of the global cultivated land is under rain-fed cultivation. Drought is classified into three major categories, (i) agricultural drought, (ii) meteorological drought and (iii) hydrological drought. It has been reported that about 50% of world rice production is affected by drought, 160 million ha of maize grown globally is rain-fed,loss in wheat production during 2009 was 22% less than in 2008 due to drought and reproductive stage drought leads to 50% yield loss in pearl millet.

Deep Rooting in Rice for Drought Tolerance :

Deep Rooting 1 (DRO1) QTL in rice confers deeper roots that can access moisture reserves, an avoidance strategy and deep-rooting phenotype also enhances nutrient uptake and yield under non-drought conditions.

Genomics for Enhancing Nutrient use Efficiency :

FAO (2008) has projected current world fertilizer trends and outlook 2011-12. According to this the South and East Asia including India, put together consume 58% of N and 57% of global P fertilizer and therefore, managing fertilizer requirement of Indian agriculture remain a major challenge today.

Rice Genes in N Homeostasis :

A large number of genes and quantitative trait locus (QTLs) have been associated with nitrogen metabolism in rice and other plants. They need to be harnessed for enhancing nitrogen use efficiency through genomics tools.

Table-2. Genes and QTLs associated with nitrogen metabolism

Gene	Class	Type	Active site	Function
OsNRT1	Nitrate transporter	LATS	Root epidermis, root hair	Constitutive
OsNRT2.1	Nitrate transporter	HATS	Roots	Induced
OsNRT2.2	Nitrate transporter	HATS	Roots	Induced
OsNRT2.3 a/b	Nitrate transporter	HATS	Roots	Induced
OsNAR2.1	Nitrate transporter	HATS	Roots	Induced
OsAMT1;1	Ammonium transporter	HATS	Shoots, roots	Constitutive
OsAMT1;2	Ammonium transporter	HATS	Roots	Induced
OsAMT1;3	Ammonium transporter	HATS	Roots	Repressible
OsDUR3	Urea transporter	HATS	Roots	-
OsENOD93-1	Nodulin gene	-	Roots	-
OsGS1;1	Glutamine synthetase	-	Whole plant; high in leaf	Constitutive
OsGS1;2	Glutamine synthetase	-	Whole plant; high in leaf	Constitutive
OsGS1;3	Glutamine synthetase	-	Spikelets	Constitutive
OsNADH-GOGAT1	Glutamate synthase	-	Root tips, meristem	Constitutive
OsNADH-GOGAT2	Glutamate synthase	-	Mature leaves, leaf sheath	Constitutive

Map of Global Soil Phosphorus Availability: According to the International Fertilizer Development Center (IFDC) study, phosphate rock will be available for the next 300-400 years. Today Morocco (170,000 mmt), USA (49,000 mmt) and China (16,800 mmt) together have 81.3% of global phosphate rock reserves. India is chronically deficient and does not have any reserve of rock phosphate. Plant available P is too low on about 50% of the world's agricultural land.

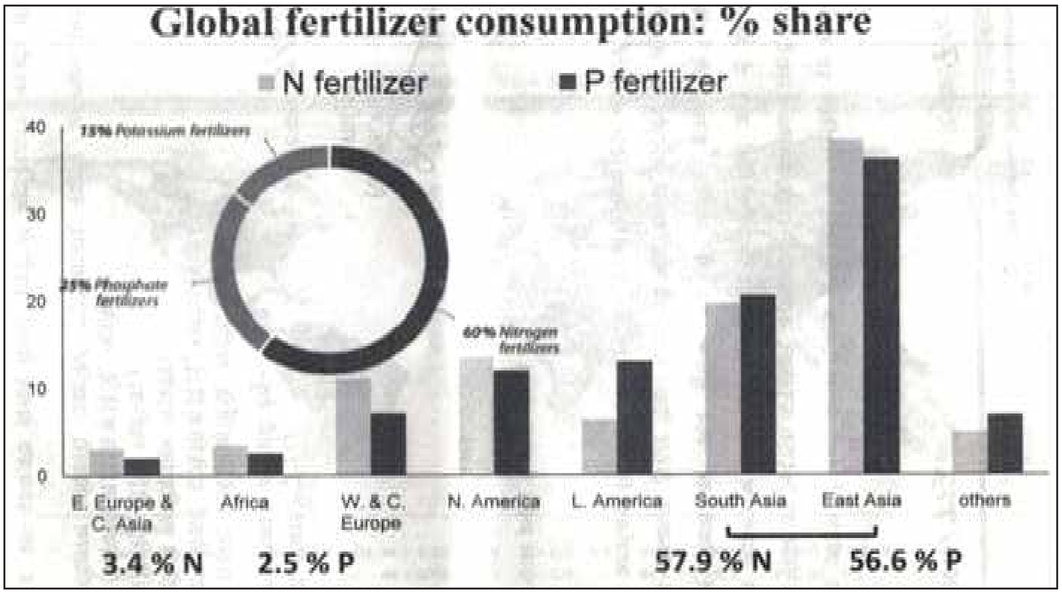

Chart-5 Global consumption share per centage of fertilizers

Table-3. QTLs for phosphorus-deficiency tolerance in rice

Traits	Pop	Cross	No. of QTL MQTL	EQTL	Reference
PUP, PDW, TN, PUE	NIL	Nipponbare / Kasalath	8	-	Wissuwa *et al.*, 1998
RTA, RSDW, RRDW	RIL	IR20 / IR55178	4	-	Ni *et al.*, 1998
RE, SDW, RPC, RIC	F8	Gimbozu / Kasalath	6t	-	Shimizu *et al.*, 2004
REP	CSSL	Nipponbare / CSSL29	1	-	Shimizu *et al.*, 2008
PH, MRL, RN, RV, RFW, RDW,SDW, TDW, RS	ILs	Yuefa / IRAT109	24	29	Li *et al.*, 2009

The gene Phosphorus Starvation Tolerance 1 (PSTOL1) identified in the variety as lath, promotes early root growth and enhances yield by 30% in P- deficient soils.

CONCLUSIONS

Climate change and depleting natural resources are reality and Indian agriculture is likely to suffer losses due to heat, erratic weather, and decreased irrigation availability. Adaptation strategies can help minimize negative impacts and these need research and policy support. Costs of adaptation and mitigation are unknown but likely to be high; costs of inaction could be even higher. Genomics provides a powerful tool for addressing many problems where conventional plant breeding is handicapped. It should be judiciously used to solve the problems of Indian agriculture. We need to have strategic approach to agricultural research and development that target the improved technologies for higher and more profitable production and for the sustainable conservation of natural resources; diversified farming system that reduce risk and improve resource-use-efficiency; enhances vertical integration from grower to consumer; building competent man power at each level of agricultural operations and not the least the institutional, organizational and policy reforms.

Dr C. M. Singh Oration /Memorial Lectures

Oration Lecture

2005
Speaker Dr Utpal Sengupta
Topic Recent Advances in immunology and immunopathology of mycobacterial diseases

Memorial Lectures

2006 First Dr C.M. Singh Memorial Lecture
Speaker Prof. T.P. Singh
Topic Clinical structural proteomics and structure-based new drug discovery: Opportunities and challenges

2006 Second Dr C.M. Singh Memorial Lecture
Speaker Padamvihushan Dr M.S. Swaminathan
Topic Food safety and food security

2007 Third Dr C.M. Singh Memorial Lecture
Speaker Dr S.P.S. Ahlawat
Topic Animal genetic resources and their conservation for the social transformation in the foot hills of Himalayas

2008 Forth Dr C.M. Singh Memorial Lecture
Speaker Dr R.B. Singh
Topic Biosecurity for food security

2010 Fifth Dr C.M. Singh Memorial Lecture
Speaker Dr M.C. Sharma
Topic Cancer in Pet animals: Incidence, diagnosis and its management

2012 Sixth Dr C.M. Singh Memorial Lecture
Speaker Dr Chanda Nimbkar
Topic Biotechnology for the benefit of smallholder sheep owners in the context of a theory of livestock breeds improvement

N.B.: For details Trust website (cmset.org) may be visited

PROF. PANJAB SINGH

Prof. Panjab Singh, Presently Chancellor, Rani Laxmi Bai Central Agricultural University, Jhansi and President, National Academy of Agricultural Sciences (NAAS), was born at Anantpur, a small village in Mirzapur district of Uttar Pradesh. He started his early education from Udai Pratap College, Varanasi and did his MSc in Agriculture in 1964 in First division with distinction of having First position in the Agra University merit; PhD (Water management) from Indian Institute of Technology, Kharagpur in collaboration the University of California, Davis, USA.

Prof. Singh started his career as an Assistant Professor and rose to the position of Secretary, Department of Agriculture Research and Education, GOI and Director General, Indian Council of Agricultural Research. He has held many responsible positions such as Agronomist; Head of the Division; Assistant Director General, ICAR; Director, Indian Grassland and Fodder Research Institute, Jhansi; Director/Vice-Chancellor of the premier Indian Agricultural Research Institute;Vice-Chancellor, Jawaharlal Nehru Agricultural University, Jabalpur. He also worked as Founder Director, School of Agriculture in Indira Gandhi National Open University, one of the world's largest University in Open Distance Learning and Vice-Chancellor, Banaras Hindu University, Varanasi. Prof. Singh also served as Regional Plant Production and Protection Officer in the Food and Agricultural Organization, Bangkok (Thailand). He also worked as an Advisor, Agriculture and Plantation with multinational ETA Star Group of Corporate. He is presently the President, Foundation for Advancement of Agriculture and Rural Development, Varanasi and Advisor, RKDF group of institutions.

Prof. Sing his the elected Fellows of Four Scientific Societies, President of Six Scientific Academies/ Societies. Prof. Singh has been the Chairman/member of various National and International Scientific Bodies, Board of Governors, Board of Management, Advisory Boards both at national and international levels. A few notable once are, Chairman, ICAR Governing Body; Vice-Chairman, ICRISAT (CGIAR) Governing Board; Member, Policy Advisory Board, ACIAR, Australia; Member, Continuing Committees of International Rangeland and International Grassland Congresses; Member, Editorial Board of Grasslands & Herbage Abstracts, CAB International, UK; Japanese Society of Grassland Science, Japan; Expert Member for European Union Projects; Member, Expert Panel for 1992 Ramon Magsaysay Award, Philippines, on policy bodies of ICAR, UGC, HRD, MoA, DST, Planning Commission etc. He had been consultant to the FAO, World Bank, Asian Development Bank etc. Prof. Singh is also decorated with DSc (*Honoris Causa*) by Seven Universities in India and also bestowed with distinguished IIT, Kharagpur Alumnus Award, Life Time Achievement Awards of Indian Society of Agronomy, Range Management Society of India and Society for Bio resources and Stress Management, besides several other recognitions, distinctions, awards and honors at national and international levels.

Prof. Singh has also been Chairman/Member of Search Committee for senior position- like VCs of State and Central Universities, Chairman, UGC, Director of national level institutes, Chairman, National Council of Rural Institutes, Hyderabad and others. He has been Member, Court & Council of Indian Institute of Science, Bangalore, Member, Court, JNU, New Delhi, Member Court, BHU, Varanasi, University of Allahabad and Member, Governing Body, Indian Institute of Advanced Study, Shimla; Member, Executive Council, Manipur and Nagaland Universities; Member, General Assembly, ICCR, New Delhi; Member, Executive Council, National Academy of Agricultural Sciences. He has been the Chairman, Working Groups and policy bodies in planning commission & various Ministries of the GOI.

Prof. Singh has also served as member on the Scientific Advisory Committee to the Cabinet for two terms and as Advisor (Agriculture and Rural Technology) in the Office of Principal Scientific Advisor, Government of India, New Delhi. Prof. Singh has widely traveled time and again in various capacities viz, leader of delegations, expert member, conference participant to about thirty countries in different continents.

Prof.. Singh has made significant scientific contribution in fields of water management and crop production and management systems besides providing leadership in shaping up of national and state level education and research institutions and Universities. Prof. Singh established a new south campus of Banaras Hindu University at Barkachha in Mirzapur district. The campus is flourishing and is offering several courses mostly employment oriented at under graduate and post graduate levels. His initiative steps resulted in establishing IIT, BHU and a huge trauma center in IMS, BHU.