cides on head mould pathogens and the role of seed and nutrient quality of sorghum, molecular analyses of antifungal antibiotics by *Bacillus thuringiensis* (*Bt*) and other species based on primer synthesis specific to zmaR, application of siderophorogenic fluorescent pseudomonads and their application to increase (18–20%) the yield of groundnuts.

The best paper award was presented to B. R. Sarosh (University of Mysore). The best oral presentation award was given jointly to A. Chakraborty (BARC, Trombay) and Amita Singh (G. B. Pant University of Agriculture and Technology, Pantnagar). The best poster award was presented jointly to S. Kim (Institute of Agricultural Research, South Korea) and S. R. Khandelwal (North Maharashtra University, Jalgaon).

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COMMENTARY

# Future challenges in food grain production in India

*R. R. Daniel*

The overall performance in food grain production in post-independent India, spurred by the Green Revolution, is worthy of the highest admiration. Notwithstanding, the trends in grain (rice, wheat, coarse cereals and pulses) production over the last decade portend a wide variety of major challenges and compulsions to meet the accelerating demands in about 20–30 years. Yet there is no clear expression of governmental action for a long-term strategy and integrated action plan to match the severity of the unprecedented challenges and the exploitation of emerging technologies. The purpose of the present note is to bring together these challenges to highlight how important it is to understand and surmount them in order to increase our future grain production.

## Food grain production

India's food grain production has an impressive record of growth from a mere 50 million tonnes (mt) in 1950 (population: 360 million) to 200 mt in 2000 AD (population: 1 billion). This growth, kick started by the Green Revolution, lost its momentum during the 1980s. In retrospect we have learnt that the energy-intensive Green Revolution relying primarily on a few high yielding crop varieties is unsustainable and that it has polluted and exhausted the soil–water system. During the 1990s, in spite of good monsoons year after year, the growth rate of grain production haltingly rose by 1.7% per year compared to 2.6–3.5% during 1960–1980 (ref. 1) while the population grew at 1.9% (ref. 2). Further, a worrying factor is that over the last four years, the annual production is hovering close to 200 mt only. These days we rightly take pride that we are self-sufficient in grain production. But we must not forget that hidden in this statement is the fact that it is at the cost of the hunger of 350 million of our people in poverty.

## Agriculture and national development

An important factor closely linked to grain production in India is that 70% of our vast but economically weak population is dependent on agriculture. It is therefore evident that if we are to elevate their standard of living, it can only be through productive agriculture augmented by non-farm employment and human development. Thus genuine self-sufficiency in food grain production and poverty alleviation are intrinsically linked. Sustainable national prosperity will be jeopardized if the farm sector does not receive its due priority from the government.

## The challenges

### *Population*

Currently, our population is one billion and we are growing at the rate of 1.9% per year. For the year 2025, the UN Medium Projection is 1.392 billion. It is clear that, in future, the grain demands will depend strongly on how well we control population growth.

### *Grain land*

Land is a fixed resource. The gross cropped area in India is 191 million hectares (m.ha) and the net cultivated grain area is only 124 m.ha[2]. Although over the last 10 years the cultivated grainland area has hardly increased, it is widely believed that it may shrink in future due to soil erosion, urbanization and human settlements, commercial agriculture, laying new highways and rural road networks and migration of farm labour in search of employment. The high population density, rural poverty and scant pasture land for the 450 million heads of livestock[2] also bring pressure on the land and forests. Furthermore, it is important to note that the per capita arable land available in India dipped from 0.36 ha in 1960 to 0.2 ha in 1990 and is forecast by Population Action International Report 1995 to decrease alarmingly further to 0.12 ha. For comparison a Western type diet including pasture land requires 0.5 ha per capita[3].

### *Soil degradation*

The Green Revolution has degraded the soil–water system and depleted the soil

fertility due to a variety of reasons[2]. It has also led to salination of 8 m.ha of irrigated crop land[4] and water logging in some parts. Side by side the neglect of dryland farming and soil erosion are continuing threateningly till today. The present degraded state of irrigated and rainfed agricultural land is a matter of grave concern for increasing productivity. Restoration of the degraded crop land is inescapable for the future but it is going to be capital intensive.

### *Water availability*

Water is yet another fixed natural resource. The annual per capita water availability in India was 5277 $m^3$ in 1955 which declined to 2451 $m^3$ in 1990; according to World Bank Report 1998 it sank further to 1957 $m^3$ in 1995. The projection for 2025 by the Population Action International Report is 1392 $m^3$, well below the water stress limit of 1700 $m^3$. Acute variations in water availability in different parts of the country (in 1990 the water use in Rajasthan was a meagre 562 $m^3$, a state of absolute scarcity) and the dangerously falling water table are other major concerns for the future. Of the net sown area of 142 m.ha (ref. 2), only 48 m.ha are irrigated. The rest 94 m.ha of rainfed fields account for 90% of pulses and coarse cereals, 53% of rice and 15% of wheat with a frighteningly low yield of hardly 1 tonne per ha. It highlights the importance of enlarging the irrigated grain land even if it is capital intensive.

### *Calories and nutrition*

Rural people in India traditionally depended on course cereals, pulses and fish for their intake of calories and nutrition. While the average intake of calories is marginally satisfactory, the consumption of proteins which was 64 g of pulses per day in 1951–1956 has dropped below 40 g in 1998 compared to the WHO–FAO minimum of 80 g per day. Even after allowing for additional intake through fish, meat, milk, etc. the daily consumption rises only to 55 g (ref. 5). The average intake of vitamins and other micronutrients is also grossly inadequate. This hidden hunger stealthily wreaks havoc on children's growth and leads to acute malnutrition among the people. The quality and quantity of grain production using new hybrids to be developed is a decisive factor in the amelioration of protein and nutrient inadequacy in future.

### *Fertilizer use*

The traditional use of organic manure was almost phased out with the introduction of chemical fertilizers heavily subsidized by government and widely promoted by the industry. Even so, the prevalent average annual use of 69 kg per ha of chemical fertilizer[6] is grossly inadequate to restore the nutrient content of the degraded soil and compensate the heavy intake by high-yielding hybrids. This may be compared with the use of 366 kg per ha by China. It is said that the 'miracle rice' with a potential to yield 10 tonnes per ha will need a minimum of 200 kg of nitrogen per ha together with other major and micronutrients[7]. From the foregoing it would also have become evident why our yield is so low.

### *Productivity or yield of food grains*

Our average grain yield of 1612 kg per ha (i.e. 200 mt from 124 m.ha) is one of the lowest among the large countries of the world. The reasons for this, as we have already seen are many. However, our great asset of having perhaps the largest area of arable land in the world could be converted into a unique advantage. If the productivity in China is more than double that in India, there is no reason why we cannot meet our long term demands by doubling the present productivity in the next 2–3 decades.

### *Other challenges*

In addition to the foregoing, we face problems some of which are listed here: (i) As the economy improves, it is expected that the meat-eating diet of the people will burgeon. It is forecast that by 2020 the demand for grain as livestock feed will soar to 50 mt (ref. 8); (ii) It is estimated that of the 42,000 folkland races in rice that originally existed, only about 5% are extant[9]. This reduces our options for selective infusions of favourable hereditary qualities in new hybrids; it also emphasizes the urgency of measures for conservation. (iii) If we are to counter the unprecedented impacts of global warming, India must take wide ranging anticipatory action in the agricultural sector[3,10]. Yet other factors that must receive equally important attention are need for greater support for rural infrastructure, post-harvest management, strengthening R&D in agriculture including plant biotechnology, empowerment of farmers particularly rural women and farm policy reforms.

### *A target for food grain production by 2025 AD*

Having brought together the array of future challenges for increasing food grain production, it will be instructive to make a reasonable estimate of the domestic grain demand in future, say by 2025 AD. Such a target is necessary to assess the magnitude of the task and formulate plans to realize it. This is attempted with the following assumptions. (a) India's population will be 1.392 billion by 2025 AD; (b) the livestock feed needed will be 50 mt of grains; (c) the present level of 35% of population below poverty line will be reduced to 10%; and (d) the present direct per capita grain consumption rate of 210 kg per year of those above poverty line will apply to the 90% in 2025 while for the remaining 10% below poverty line it will be 120–140 kg per year. It is true that some of the assumptions are more subjective than others but the final grain demand is not very sensitive to reasonable variations in the assumptions except (c) above, which is taken as a national goal for poverty alleviation.

The outcome of such an estimate is an annual total demand of 330 mt of food grains in 2025; it corresponds to an annual growth of 5 mt. Considering the wisdom of planning for a modest exportable surplus and allowing for the possibility of a higher per capita direct consumption rate with improving economic performance, a target of 350–375 mt does not seem unreasonable to aim for at the present time.

## National action

Taking note of the foregoing, if the scientific community is convinced with the gravity of the challenges, the paramount need of achieving a target of

330–350 mt of food grain production per year in a matter of 2–3 decades from now and that the nation has the capacity and human resource to overcome the challenges and threats, it is the collective responsibility of the scientists to bring them forcefully to the attention of the people and the government for immediate action.

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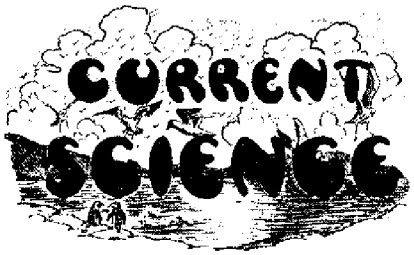
## FROM THE ARCHIVES

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### *Current Science* and the Indian Academy of Sciences

In view of the recent publication of certain disputatious statements in the press regarding the institution of an Indian Academy of Sciences and the totally unexpected and embarrassing trend which the affairs have assumed, the Board of Editors, *Current Science*, desire to announce that the Journal, having taken the initiative in the proposal to establish such a foundation, now stands aside in a spirit of detachment. It will not lend its support to any movement which is apt to produce a factious spirit among the scientific workers, which must be absolutely fatal to the fundamental cause of progress in India. The policy of the Journal is to follow and promote peace, and in pursuance of this declared object, it will seek for opportunities to establish good understanding in all endeavours calculated to advance the higher destinies of science.

This policy of the Journal does not, however, impose restraints on the freedom of action on the part of the individual members of the Editorial Board as also those of the Board of Editorial Co-operation who may desire to participate in any particular movement and if and when they do so, they act either in their own private capacities or as members of some one or other of the scientific institutions favouring such a movement. The public utterances of such members or their action in the committees in which they choose to function, do not reflect the official views of the Journal.

*– Editor*

### "Current Science" and "South Indian Science Association"

Our attention has been drawn by one of our Editorial co-operators and one correspondent to the effect that Dr S. Subba Rao, President, South Indian Science Association, in his opening address at the Easter Congress of Scientists at Bangalore, claimed *Current Science* as an organ of the South Indian Science Association. On referring the matter to him, Dr Subba Rao has written to say that he made no such statement.

It is needless to emphasize that *Current Science* is an independent all-India Journal and stands for the progress of scientific work in India as a whole.

*– Editor*