Vision 2050

Directorate of Rice Research
Hyderabad - 500030
www.drrricar.org
MESSAGE

The scientific and technological inputs have been major drivers of growth and development in agriculture and allied sectors that have enabled us to achieve self-reliant food security with a reasonable degree of resilience even in times of natural calamities, in recent years. In the present times, agricultural development is faced with several challenges relating to state of natural resources, climate change, fragmentation and diversion of agricultural land to non-agricultural uses, factor productivity, global trade and IPR regime. Some of these developments are taking place at much faster pace than ever before. In order to address these changes impacting agriculture and to remain globally competent, it is essential that our R&D institutions are able to foresee the challenges and formulate prioritised research programmes so that our agriculture is not constrained for want of technological interventions.

It is a pleasure to see that Directorate of Rice Research (DRR), Hyderabad, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision-2050 document. The document embodies a pragmatic assessment of the agricultural production and food demand scenario by the year 2050. Taking due cognizance of the rapidly evolving national and international agriculture, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish DRR all success in realisation of the Vision-2050.

(SHARAD PAWAR)
The Indian Council of Agricultural Research, since inception in the year 1929, is spearheading science and technology-led development in agriculture in the country. This is being accomplished through agricultural research, higher education, and a network of research institutes, agricultural universities and Krishi Vigyan Kendras. Besides developing and disseminating new technologies, ICAR has also been developing competent human resources to address the present and future requirements of agriculture in the country. Committed and dedicated efforts of ICAR have led to appreciable enhancement in productivity and production of different crops and commodities, which has enabled the country to raise food production at a faster rate than the growth in demand. This has enabled the country to become self-sufficient in food and emerge as a net food exporter. However, agriculture is now facing several challenges that are expected to become even more diverse and stiffer. Natural resources (both physical and biological) are deteriorating and getting depleted; risks associated with climate change are rising, new forms of biotic and abiotic stress are emerging, production is becoming more energy intensive, and biosafety concerns are growing. Intellectual property rights and trade regulations impacting technology acquisition and transfer, declining preference for farm work, shrinking farm size and changes in dietary preferences are formidable challenges.

These challenges call for a paradigm shift in our research approach to harness the potential of modern science, innovations in technology generation and delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive.

It is an opportune time that the formulation of 'Vision-2050' by ICAR institutions coincides with the launch of the national 12th Five Year Plan. In this Plan period, the ICAR has proposed to take several new initiatives in research, education, and extension. These include creation of consortia research platforms in key areas, wherein besides the ICAR institutions, other science and development organizations would be participating; short term and focused research project through scheme of earmarked grants; Agri-Innovation fund; Agri-incubation fund and Agri-tech Foresight Centres (ATFC) for research and technology generation. The innovative programme of the Council, 'Farmer FIRST' (Farmer’s farm, Innovations, Resources, Science and Technology) will focus on enriching knowledge and integrating technologies in the farmer’s conditions through enhanced farmer-scientist interface. The ‘Student READY’ (Rural Entrepreneurship and Awareness Development Yojana) and ‘ARYA’ (Attracting and Retaining Youth in Agriculture) are aimed to make agricultural education comprehensive for enhanced entrepreneurial skills of the agricultural graduates.

I am happy to note that the Vision-2050 document of Directorate of Rice Research, Hyderabad has been prepared, based on the assessment of present situation, trends in various factors and changes in operating environment around agriculture to visualize the agricultural scenario about 40 years hence and chalk out a demand-driven research agenda for science-led development of agriculture for food, nutrition, livelihood and environmental security, with a human touch.

I am sure that the ‘Vision-2050’ would be valuable in guiding our efforts in agricultural R&D to provide food and nutritional security to the billion plus population of the country for all times to come.

Dated the 19th June, 2013
New Delhi

( S. Ayyappan )
Preface

Directorate of Rice Research has mandate to coordinate research on rice across the country and conduct strategic and applied research on irrigated rice to enhance and sustain production, productivity and profitability while preserving environmental quality.

India had an all time high rice production of 103.41 million tonnes during 2011-12. The rice varieties released for commercial cultivation have crossed 990 mark. Over 20 rice hybrids are now being aggressively marketed by the private sector. First batch of products of marker technology have been accepted by the farmers and are spreading rapidly. System of Rice Intensification (SRI), aerobic rice and AWD methods of cultivation are effectively addressing production constraints like water and labour shortages. In view of the changing scenario, emerging challenges and opportunities, it is desirable to make a mid-course evaluation of the Vision 2030 and prepare a revised document “Vision 2050” to abreast the challenging scenario.

New threats like climate change, acute water and labour shortages for rice production, escalating input costs and non-commensurate procurement prices are proving deterrent to rice farmers forcing some of them to declare crop holidays. But new opportunities are being opened up through rapid progress in cutting edge sciences of biotechnology, space and nano science. DRR is poised to face these challenges and use opportunities and march ahead to meet the future goals and expectations of the nation towards achieving food and nutritional security. I sincerely hope the current document will serve as a guiding principle towards meeting the future challenges in more meaningful ways.

We are grateful to Dr. S. Ayyappan, Secretary, Department of Agricultural Research and Education and Director General, Indian Council of Agricultural Research for being the constant source of inspiration and driving force behind our efforts in bringing this thoughtful and futuristic document. We are also extremely thankful to Dr. Swapan Datta, Deputy Director General (Crop Science), ICAR, for his keen interest in rice and his constant endeavor to improve the rice research programmes at different levels. We place on record our sincere thanks to Dr. R.P. Dua, ADG (FFC) for his keen interest and support in preparing this important document.

This document is the product of long stretches of brain storming, incisive discussions argumentative points of view of my senior colleagues from time to time. Participation of several of my colleagues in DRR and in the Council in shaping the document and bringing uniformity across those being prepared by other Institutes is also acknowledged.

(B.C. Viraktamath)
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1. Context

Globally rice is planted to about 150 million ha and 696 million tonnes of produce is harvested annually (FAO, 2010). Of this, Asia accounts for 90% of the production and consumption of rice. Only about 31 million tonnes of rice is traded through international market. Leading rice exporting countries are Thailand, Vietnam, USA, India and Pakistan. However, during 2012, India has surpassed Thailand to become the first among the rice exporting countries with the export of 10 million tonnes for the first time in recent years.

India has the world’s largest area under rice with 42.5 million ha and is the second largest producer (103.4 million tonnes- 2010) next only to China. It contributes 21 percent of global rice production. Within the country, rice occupies one-quarter of the total cropped area, contributes about 40 to 43 percent of total food grain production and continues to play a key role in the national food and livelihood security system. Rice export contributes nearly 25% of total agricultural exports from the country. However, productivity of rice is only 2.54 tonnes/ha of milled rice as against the global average productivity of 3.28 tonnes/ha (FAO, 2010).

At the current rate of population growth (1.98%) Indian population is expected to touch 1.63 billion by 2050. Of these about 52% will be the urban population. Considering three divergent scenario of economic growth under ‘Business as Usual’ (BAU); ‘Maintain Momentum’ (MM) or ‘Upside Scenario’ (US), GDP growth rate may vary from 5.43, 6.0 to 8.0%, respectively (Ramesh Chand, 2012). This is likely to result in per capita monthly income, respectively, of Rs. 32,000, 38,000 or 78,000. However, per capita monthly expenditure on food is estimated to be about Rs. 2,500, 3,400 or 4,500, respectively (Ramesh Chand, 2012). Per capita demand for food has been estimated to be about 140 kg cereal/year or about 384 g/day. Considering that about 60% of the cereal requirement will be rice, it may be estimated that rice requirement will be 230 g/day or 84 kg/year/person. This would transform into requirement of about 136 million tonnes
of rice for an expected population of 162 million by the year 2050 for consumption purpose alone.

Rice production systems are also likely to undergo major changes in view of production constraints. Water and labour will be the main inputs in short supply. Thus we need to take stock of the available technologies and evaluate if these could deliver desired results. If not, examine the other emerging technologies and increase the pace of harnessing these science for getting breakthrough in enhancing productivity.

The Directorate of Rice Research has been in effective service of the country for the past 48 years. It was established in 1965 as All India Coordinated Rice Improvement Project (AICRIP) with 12 main centers and thereafter elevated to Directorate status in 1975. Now there are 47 funded centres participating in AICRP on rice and over 60 voluntary centres. DRR has scientific cadre strength of 71 scientists. Over the years, the Institute has strengthened its infrastructure and human resources and is well prepared to face the domestic and global challenges. It is committed to maintain its leadership and is responsive, vibrant and sensitive to the changing scenario and needs of its stakeholders. The directorate with its vision and mission works under ICAR as per the system indicated in the Organogram (Figure 1).

**Vision:** Welfare of the present and future generations of Indian rice farmers and consumers by ensuring food, nutritional and livelihood security.

**Mission:** Develop technologies to enhance rice productivity, resource and input use efficiency and profitability of rice cultivation without adversely affecting the environment
Figure 1: DRR Organogram

Mandate

• To coordinate multi-location testing at national level to identify appropriate varietal and management technologies for all the rice ecosystems
• To conduct strategic and applied research in the major thrust areas of irrigated rice aimed at enhancement of production, productivity and profitability and at preserving environmental quality
• To initiate and coordinate research networks relating to problems of national and regional importance
• To serve as major centre for exchange of research material and information
• To accelerate the pace of technology transfer through frontline demonstrations, training programmes and ICTs
• To develop linkages with national, international and private organizations for collaborative research programme
• To provide consultancy services and undertake contractual research

Over the past 48 years, DRR has been instrumental in development and release of over 990 rice varieties for all the rice ecologies. Impact of these varieties is reflected in doubling rice productivity and tripling production during this period. DRR itself has developed over 39 rice varieties and three hybrids. Of the varieties released under
AICRIP, 19 are being cultivated in 25 other rice growing countries. These high yielding varieties and hybrids cover over 80% of the rice area. The national hybrid rice network coordinated by DRR helped in release of over 59 hybrids both from public sector and private sector. Area under hybrids is now about 2 million ha with a minimum of 1 tonne yield advantage/ ha. Hybrids alone are contributing to production of an additional 2 million tonnes per year. Frontline demonstrations sponsored by Department of Agriculture and Cooperation have identified suitable varietal and other production technologies for all rice ecologies that could increase production by 10-15%. Recently released two rice varieties Improved Pusa Basmati and Improved Samba Mahsuri are the first products of marker assisted back-cross breeding – an example of application of biotechnology in rice improvement. DRR is reaching out to all the stakeholders through effective management of Institute Technology Management Unit (ITMU) and harnessing the ICT tools for managing the Rice Knowledge Portal.

Under the existing scenario more rice needs to be produced under less area with declining and deteriorating resources. The major challenges ahead including climate change are to be tackled through advances in frontier sciences like biotechnology, nanotechnology, information technology and space technology which can provide new tools to effectively address existing and impending problems.

Thus, DRR needs to revisit its earlier Vision 2030 document to provide new thrust for its future research and extension agenda under this document “VISION 2050”
2. Challenges

- High end basic and strategic research, infrastructures are needed to be built for few centers of excellence and many well equipped centers for technology validation are to be established.
- Rapid urbanization is leading to decrease in area under rice and labour availability for cultivation is becoming a great challenge for rice cultivation. This will require emphasis on productivity per unit area and mechanization of field operations.
- Climate change in terms of frequent droughts, cyclones, floods, enhanced temperature and CO$_2$ is the serious concern which needs to be addressed on priority.
- Declining water availability would be a major threat for rice cultivation as some area may be diverted to other crops due to water shortages.
- Cost of cultivation due to escalating input cost is proving disincentive to rice farmers. Hence development of input use efficient cultivars and resource conservation techniques will need major thrust in next decades.
- Deteriorating soil health and declining factor productivity would be a major concern. This would require attention and search for diversification of cropping systems.
- Rapid change in pest composition and population dynamics is threatening pre-harvest and post-harvest losses. This would require a strong programme on survey and surveillance of pest and diseases and identify the environment friendly control measures.
3. Operating Environment

The research programmes will have to be carried out keeping in mind the existing and the factors expected to be encountered during the coming years. Following situations are to likely to be faced and solutions sought for the same through development of suitable technologies with the help of scientific knowledge available in different aspects.

Physical environment

- Less land, less water and less labour
- Deteriorating soil health
- Complex abiotic and biotic stresses
- Hostile environment for marginal farmer with small holdings
- Changing climate leading to adverse effects on productivity

Economic environment

- Aggressive private sector investing in R & D
- Vibrant seed market
- Less remunerative prices to rice farmers
- Escalating cost of agro inputs

Scientific Advancement

- Climate change
- Biodiversity
- Genomics, phenomics, metabolomics and bio-informatics
- Molecular breeding
- Precision farming
- Disease diagnostics
- Conservation agriculture
- Nano-biotechnological applications
- Genetic enhancement, hybrids
- Information technology
- Space technology and GIS
- Genetic Engineering
4. Goals & Targets

DRR is committed to develop technologies to enhance rice productivity, resource and input use efficiency and profitability of rice cultivation without adversely affecting the environment. The goal is also to enhance the efficiency of the organization to take up challenges and deliver desired results with competitive funding and timely delivery. We also aim at delivering means of technology transfer for rapid adoption of the new technologies by the farmer and transform these into enhanced production.

For the estimated population of 1.63 billion people by the year 2050 with a per capita rice consumption of 225 to 275 g/day, country would require 133 to 162 million tonnes of rice.

It is assumed that rice area may further shrink to about 40 million ha for various reasons. Thus, the rice productivity needs to be enhanced from the present 2.05 t/ha to 3.3 to 4.05 t/ha in the next 40 years to keep pace with the increasing demand for rice.

Based on the available trends, target production and productivity of four rice ecologies (Irrigated, Rainfed shallow lands, Rainfed uplands and Deep and Semi-deep lands) has been worked out. It is apparent that productivity of irrigated rice needs to be enhanced to 3.79 to 4.56 t/ha, while that of rainfed shallow land rice needs to be raised to 3.1 to 3.8 t/ha. To achieve the objective our targets will be:

- Redesigning rice plant type with more photosynthetic efficiency, biomass and harvest index to enhance genetic yield potential.
- Germplasm improvement
- Stabilizing rice productivity through improving biotic and abiotic stress tolerance and high quality seed
- Improving the grain and nutritional quality and value addition of rice
- Sustaining soil health/quality in irrigated rice
- Enhancing productivity of irrigation water
- Improving input use efficiency
- Sustaining rice productivity under changing climate
Selective mechanization in rice to reduce drudgery and improve profitability
Integrated pest management
Validation and commercialization of technologies developed and promoting public-private partnership
Evaluation and identification of technologies suitable for different rice ecologies

5. Way Forward

Bridging scientific and technology gap
Scientific developments need to be rapidly converted into adoptable technologies and validated under diverse rice ecologies. The All India Coordinated Rice Improvement Project setup needs to be revamped to meet the future demands. The setup needs to be transformed from routine field testing centers to technology developing and highly proficient evaluating centers. Fewer, well equipped centers would concentrate on technology development and larger voluntary centers would meet such requirement of validation of technologies.

Bridging the technology and adoption gap
Proven technologies need to be aggressively pushed for adoption. Fostering a strong public-private sector partnership is going to be the basis for achieving the desired goals. Development of commercial wing for marketing the in-house technologies not lucrative for the private sector through Agri Innovate India company of DARE, Govt. of India will be an essential step. Self sustaining information campaign using the modern ICT tools under the Rice Knowledge Management Portal needs to be pushed for the benefit of the line Departments.

Developed world and India
Recent trends in rice exports suggest that India can emerge and continue to be the leading rice exporting country. Besides the premium priced aromatic Basmati rice, as per the Government Policy, we can even target to export medium and slender grain rice for which there is a growing demand.

Agriculture and other areas (space, engineering, bio science)
Recent success in achieving the targets of National Food Security Mission (NFSM) during the XI five year plan in increasing the rice production by 10 million tonnes, calls for macro-level planning and execution. Advances in satellite based remote sensing and space application science have empowered us for real time macro-planning, monitoring and execution of disaster management and handling of drought and floods and mitigating their negative impact on rice production. Anticipation of acute labour shortage for rice cultivation driven by large scale migration of rural people to urban areas, escalating labour & input cost and aging population draws our urgent attention to selective mechanization of rice cultivation. Even use of large machineries like combine harvesters on hire-operate basis are proving empirical solutions to the problem. Such a situation calls for development of cultivars and cultural practices suited for such mechanization.

**Strategic partnerships and alliances**

Some of the research goals, like development of C4 rice or engineering biological nitrogen fixation would necessarily involve strategic partnership with leading research laboratories in the world and also of private sector for funding. Internal alliance with organizations like CSIR, DBT and even ICMR would be indispensible.

**User’s perspective: demand driven and responsive research, delivery to end users**

At the other end would be the Institute to take up research on immediate demands like the rice transplanter suited for our soils or mechanical weeder for SRI. Such objectives are taken up on demand by various end users and their representatives like state departments or private sectors and funded by time framed delivery system.

**Research Prioritization**

To achieve the goals set above, a 12 points strategy has been developed to enhance and sustain rice productivity to meet future demands of domestic consumption and
surplus for export. Besides, long term futuristic research and flagship programmes are also outlined.

**Futuristic Research**

- Development of C4 rice
- Designing rice plant with biological nitrogen fixation ability
- Physiological studies on productivity

**Flagship Research Projects**

- Pre-breeding for broadening the genetic base to enhance yield, duality and stress tolerance in rice.
- Soil and plant health management for rice under changing climate.

**Enhancing genetic yield potential through**

- Widening the genetic base
- Improving germplasm
- Wide hybridization and introgression
- Exploiting hybrid vigor
- Allele mining and gene discovery

**Stabilizing rice yields through**

- Incorporation of disease and pest resistance
- Tolerance to soil and water stresses
- Enhanced nutrient use efficiency
- Mitigating arsenic and fluoride toxicity

**Improved grain and nutritional quality, and value addition through**

- Improvement of grain and cooking quality
- Incorporation of aroma determining genes
- Bio-fortification (High Zn, Fe and β carotene)
- Product diversification (low GI, RBO, instant foods, health and cosmetic products)
Sustaining soil health through

- Innovative nutrient management
- Adopting resource conservation technologies
- Building up soil resilience through innovative carbon sequestration strategies
- Utilization of microbial diversity

Enhancing water productivity through

- Innovative cultural practices (DSR, SRI, Aerobic, AWD, micro-irrigation)
- Harnessing synergistic effects of water and nutrient interaction
- Utilization of biomolecules to reduce water loss

Improving input use efficiency through

- Precision nutrient management
- Diagnostics of soil and plant nutritional problems

Selective mechanization for

- Timely operations under labour shortage
- Reduce human drudgery
- Value addition and post harvest processing

Integrated pest (insect, diseases and weeds) management through

- Understanding molecular basis of tritrophic interactions
- Precise delivery system for pesticides
- Designing diagnostic tools
- Developing decision supporting system
- Exploiting ecosystems services
- Pest risk analysis
- Biopesticides

Validation and transfer of technologies through

- Organizing Front Line Demonstrations (FLDs)
- Breeder seed production
• Sponsored and need based training programmes
• Rice knowledge management portal system
• Evaluation and identification of technologies suitable for different rice ecologies through Organizing multi-location evaluation trials
• Impact and constraint analysis of adopted technologies on rice production in the region
• Gender mainstreaming in rice based cropping systems

**Precision macro-level farming**

• Geo Spatial technologies and models for precision farming

References


Agrisearch with a human touch