WHITEPAPER

Seed Technology Innovation for Sustainable Rice Production: *Increasing Productivity, Sustainability and Profitability*

Climate change has posed the biggest challenge so far to Agricultural productivity. The rising temperatures have led to drought like conditions in some parts of the country and heavy, erratic rainfall in other regions. The severity and unpredictability of weather has wreaked havoc on crop productivity, especially in rain-fed regions of our country. Many farmers have shifted to short duration crops that can withstand harsher conditions, instead of cultivating staple grains as before. The low productivity and shifts in the cultivated crops are posing a challenge for food security for our growing population. The nation needs to manage unpredictable weather conditions, deteriorating soils, water scarcity and resource limitation to improve food productivity for sustained food security.

The farmer is also battling increasing production cost, scarcity of farm labour, declining or stagnating yield and farm income. The vulnerability of farm profitability is pushing farmers towards desperate and reckless use of chemicals to manage crops and enhance yields, making them a target for unscrupulous suppliers. The increased use of fossil fuels, polluted soil and water resources and loss of biodiversity are additional environmental concerns.

Rice is the staple food of more than 60% of the world's population especially in South East Asia. Among the rice growing countries in the world, India has the largest area under rice crop i.e., 43.86 million hectare (Mha) and ranks second in production (163.5 MT) next to China (203 MT). India's average rice productivity is below world average of 4 MT/ha and much lower as compare to China's 6.5 MT/ha. Therefore, India is contributing 1.4 times more land area for producing 1.2 times less rice as compared to China, this is a very harmful statistic for our growing economy. Rice production is critical for India as yearly 1.5 million tons of additional rice is needed for sustainable food security. The low rice productivity in India can be attributed to multiple factors, including low planting density, poor agronomic practices and weed management, low seed replacement rate, long duration crops that are susceptible to diseases/pests and lack of farmer awareness for adoption of new technologies. The lack of provisions for assured irrigation and small land holdings also negatively impacts the productivity. Technology enabled improvements in productivity will make agriculture profitable and a preferred profession for younger generation farmers and people involved in agri-businesses.

The low crop productivity can be addressed by improved seed technologies and agronomic intervention. Cultivation of hybrids is one such option as hybrid yields are 15-25% more than the open pollinated varieties (OPV). This has been demonstrated in many countries in the region, China has 50% of rice area are under hybrids, though, hybrid rice accounts for less than 10 % of the area under rice cultivation in Bangladesh, India, Indonesia and Philippines.

Hybrids have been key in increasing productivity of maize and cotton in India, besides the major crops, hybrids of sorghum, pearl millet and many vegetable crops are also preferred by farmers over OPVs. Despite the benefits of hybridization, a major concern has been the requirement of seasonal seed purchase by the farmers, since seed saving is an important crop management and livelihood strategy among the small holding farmers. It has been observed that progressive farmers purchase seeds (OPV or hybrid) every season, with a rice seed replacement rate of 26 % (Seednet.com) recorded for India. Hybrid rice has been cultivated in India for the past three decades and has been supported by introduction of new hybrids both by public institutions and private industry. Currently around 3 million hectares (2018) area is under hybrid rice, with 105 rice hybrids (70 by private sector and 35 by public sector) released so far. Though the area under hybrid rice has doubled in the last decade, an economical and efficient hybrid rice seed production system is a prerequisite for widespread adoption of hybrid rice in future. Major limitations for hybrid adoption are the diverse consumer preferences for grain quality, limited choice in hybrids adaptable for unfavourable conditions and lack of awareness regarding the benefits. Awareness programs and outreach are critical for the research efforts and products to reach the farmer.

A strategy needs to be developed for refining hybrid seed production to enhance the seed yields to reduce the cost of hybrid by strengthening the existing institutional mechanism. Efficient planning is required for geographical diversification and to establish year-round hybrid seed production capabilities. Other than taking advantage of heterosis, the selected hybrids need to adapt to unfavourable growth conditions, pest infestation, disease as well as transplantation and establish well in the field.

Involvement of seed agencies in the public sector, NGOs, and farmers cooperatives along with private seed sector will help identify promising hybrids for different regions/ conditions and also create much needed awareness among the farmers about the advantages of cultivating hybrid rice. A public-private partnership is being encouraged by leading rice research institutes like Indian Institute of Rice research (IIRR) that includes screening and evaluation of rice hybrids for their agronomy and resistance against target insect pests/pathogens. There is a plan to launch National Hybrid Research Consortium (NHRC) to further strengthen Public – Private Partnership towards the goal of increasing rice productivity through the adoption of hybrid rice technology.

Myths and facts about hybrid Rice

Myth	Fact
Hybrids have higher requirement of water and fertilizer	Hybrids are stress tolerant, short duration crops, hence require less water and fertilizer
Hybrids have higher percentage of broken rice post milling	Hybrid milling breakage percentage is comparable to OPVs and meets FCI standards
Hybrids are suitable only for irrigated regions	Hybrids are stress tolerant and hence better adapted to rainfed regions e.g. Jharkhand

Intensive agriculture over the years has led to soil deterioration at physical, chemical and organic level due to surface water run-off, erosion and nutrients deficiency. The receding water table and saline soils have further complicated the soil health. The climatic changes and intensive agricultural practices have also impacted pest population dynamics. Rice cultivation requires intensive irrigation to ensure waterlogged conditions with 1.5-2.0 inches water for 5-6 weeks post transplantation. A study published in Agropedia estimates that around 2000-3000 litres of water is required to produce 1Kg of rice, therefore, we must have used 327 thousand million litres of water to produce 163. 5 MT rice. With unpredictable and erratic monsoon and receding water tables in multiple regions, the nation cannot afford to spend such amount of water for rice cultivation in near future.

An agricultural system with low inputs, high returns and sustained growth while conserving environment called Conservation agriculture (CA) is the need of the hour. CA utilizes scientific knowhow and technology to improve and conserve input resources like soil health and water to achieve economically and ecologically sustainable agricultural production. Soil carbon retention by minimal tilling and cover crops, nutrient and weed management along with diversified crop rotation are critical attributes of CA. The advantages of CA were demonstrated in a 7-year study conducted at Indian Agricultural Research Institute (IARI), New Delhi with zero tillage and rice-wheat crop rotation. The study showed a higher sustainable yield index for rice-wheat cropping system with 40% labour cost saving, 30 % lower water usage, 60-70 litres/ha lower fossil fuel consumption and 20-25% seed saving, that led to Rs.7000/ hectare net increase in farmer’s income.

Direct Seeded Rice (DSR) is also part of CA that drastically reduces water usage, saves on labour and fuel costs for puddling and transplanting, allows for higher planting density. The optimal plant population for DRS field is 40 plants/ sqm as compared to average 20-22 plant/ sqm in transplanted field. DSR eliminates transplantation shock that makes the seedlings susceptible to diseases and pest, which leads to seedling mortality and reduced plant density. In India 28% (12.3Mha) of the area under rice cultivation practices DSR. It is estimated that DSR saves 30-40% water, reduces labour costs by ~40-45% and fuel costs by 55-60%, thereby increasing farmer’s profitability. Besides water conservation and lower fuel consumption, DSR can reduce greenhouse gas (GHG) emissions by 30-40%.

Since DSR eliminates water logging, it makes farm mechanization possible for the rice field. Though customization is required to develop scale appropriate machines for seeding and harvesting. This is another area, where both economic and policy support is required to encourage and smoothen the adoption of mechanization.

A few limitations for DSR that need to be addressed include region specific selection of hybrids/varieties amenable for direct seeding. The DSR seedlings need to be supplemented for deficiency of Fe and Zn at initial stages of growth. Though methane emissions were dramatically reduced, slight increase in nitrous oxide emission is observed. The aerobic conditions in the DSR field enhance weed growth as well as increase the population of nematodes. Weeds can be managed using weedicides as well as seed treatments and a positive correlation between weed and nematode densities indicates that weed management may indirectly lead to nematode management in DSR. US and Brazil have adopted herbicide tolerant trait for large scale practicing of DSR.

The technology can be exploited for maximum gain by selecting soil and region-specific cropping system, managing soil nutrients, planting Fe and Zn deficiency tolerant rice varieties, appropriate seed treatment, proper weed management, especially in the initial growth stages and using scale appropriate mechanization. Farmers needs to be supported and encouraged to adopted technology and better farm practices. Extensive extension services for creating awareness amongst farmers and related businesses regarding the technology, resources and providing training for new practices would go a long way in adoption of hybrid rice and DSR. The farmers can also be provided easy credit and assured selling price for practicing DSR. Although, CA practices need to be optimized across locations, crops and cropping systems based on sound benefit-cost economics, multi-level intervention by farmers, researchers, extension personnel and policy makers to analyse and understand how conservation can integrate with other technologies will help in promotion of CA.

Our aim of doubling farmer income is a challenge for the scientific community, farmers and policy makers. Together we need to overcome the past mindset and explore the opportunities that technology and newer agronomic practices have to offer for sustainable agriculture. Large scale adoption of DSR as part of conservation agriculture and hybrid rice will increase rice productivity with lesser resources, reducing the demand for increasing farmland and pressure on environment. With the rising food demand for the growing population and paucity of resources, increasing farm productivity in the most efficient manner, seems to be the only sustainable path for improving farmer income and environment.

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