AgriCos e-Newsletter
ISSN: 2582-7049
www.agricosemagazine.com
Volume: 01 Issue: 01 May 2020 Article No: 16

Hybrid rice technology in India: Current status and Future Prospects

Vikram Jeet Singh[1]*, Sri Hima Gampala[2], Brijesh Kumar Singh[1], Sonu Shekhawat[1], Nandakumar S[1] and P K Bhowmick[1]
[1]Division of Genetics, ICAR-IARI, New Delhi-110012
[2]Assistant Professor, Department of GBP and SST, Centurion University, Odissa
[1]ICAR-IIMR, New Delhi-110012
Corresponding Author*: jeet2012vikram@gmail.com

INTRODUCTION

Rice is the staple food crop grown in an area of 44 Mha with a production of 103 m.t. The country witnessed an impressive growth in rice production in the post-independence era due to the adoption of semi dwarf high yielding varieties coupled with the adoption of intensive input based management practices. Rice production was increased four times, productivity three times while the area increase was only one and half times during this period. In order to keep pace with the growing population, the estimated rice requirement by 2025 is about 130 m.t. Plateuing trend in the yield of HYV's, declining and degrading natural resources like land and water and acute shortage of labor make the task of increasing rice production quite challenging. The current situation necessitates looking for some innovative technologies to boost rice production.The commercial success of hybrid rice in China has clearly demonstrated its potential to meet the increased demand for rice. Efforts to develop and use this technology in India began in the 1970s and were systematized and intensified in December 1989 with the launch brids from the public and private sectors were made available for commercial cultivation. During the 1996 wet season, more than 60,000 ha were planted to hybrid rice in India. Some more promising hybrid with better grain quality, resistance to pests and diseases, and a higher magnitude of heterosis are in the final stages of sterility-inducing cytoplasm have been developed. Research on two-line heterosis breeding and the development of intersubspecific indica and tropical japonica hybrids has begun and the results attained appear promising. A seed production technology has been developed and its adaptability demonstrated on a large scale. Seed yields of 1.0-1.5 t ha¹ can be obtained. During the 1996 dry season, 1,300 t of F1 seed were produced by private- and public-sector seed agencies. Crop production and protection practices for the successful cultivation of hybrids in the target areas are being standardized. Future research and development strategies for hybrids rice technology are briefly discussed. Prospects for the large-scale adoption of this technology in India appear to be bright.

Encouraged by the success of hybrid rice technology in enhancing the rice production and productivity in China, the Indian Council of Agricultural Research (ICAR) initiated a national program for development and large scale adoption of hybrid rice in the country in December 1989. The project was implemented through a National Network comprising research, seed production and extension networks. The hybrid rice research network consisted of 11 research centres and many voluntary centres spread across the country. Hybrid rice technology is likely to play a key role in increasing the rice production. During the year 2008, hybrid rice was planted in an area of 1.4 m.ha. and an additional rice production of 1.5 to 2.5 m.t. was added to our food basket through this technology. More than 80 % of the totalhybrid rice area is in eastern Indian states like Uttar Pradesh, Jharkhand, Bihar, Chhattisgarh, with some little area in states like Madhya Pradesh, Assam, Punjab and Haryana. As rice is a key source of livelihood in eastern India, a considerable increase in yield through this technology will have a major impact on household food and nutritional security, income generation,

besides an economic impact in the region. In view of this, hybrid rice has been identified as one of the components under the National Food Security Mission (NFSM) launched by the Government of India (GOI) with the aim to enhance rice production by 10 m.t. by 2011-12. Similarly, added emphasis is being given for adoption of hybrid rice under the special scheme of GOI to bring green revolution to eastern India.

Development of Hybrids

CMS system

Most of the rice hybrids in the country and elsewhere in the world are developed by using the CMS or the three line system. This system involves a CMS or 'A' line, a maintainer or a 'B line and a restorer or 'R' line. Since three lines are required for the production of a hybrid, this is popularly called as the three line system. The 'CMS' line is multiplied by growing it along with its corresponding 'B' line in isolation. The 'A' line seed thus obtained will be grown along with 'R' line in isolation for the production of hybrid rice seed. The three line system is by far the most stable and widely used system in the world, although two line system is being used to a limited extend in China.

The system of evaluation of rice hybrids:

The multilocational evaluation trials are conducted by every state in most crops at selecte locations under different agro-climatic zones to identify a variety/hybrid suitable for these zones. In rice also, multi-location evaluation of promising experimental hybrids at 25 – 30 locations representing different agro-climatic zones of the country is the major activity in the hybrid rice network, coordinated by the Directorate of Rice Research, Hyderabad-500 030 through which hybrids are being tested in replicated trials. The breeders across the country nominate their best hybrids identified based on their performance in preliminary replicated yield trials for evaluation in nation-wide multilocation trials. The test hybrids are nominated both by the public sector research organizations and private sector R&D units. The test hybrids are pooled together based on duration and are evaluated in Initial Hybrid Rice Trials (IHRT). Each nominating hybrid entry is assigned IET (Initial Evaluation Trial) number which indicates its identity. An entry possessing IET number suggests that it has undergone multilocation testing in the AICRIP trials. Based on duration of the hybrid entries three groups of trials viz., Early (<120 days), Mid-Early (121-130 days) and Medium (131-140 days) are constituted. Besides this, one more trial (HRT-MS) is constituted based on grain type viz., medium slender grain type (similar to BPT 5204) with a purpose to identify the promising hybrids in this grain type category. Likewise, special trials are also constituted for evaluation of hybrids under abiotic stress conditions like saline alkaline conditions. A separate trial to evaluate the hybrids suitable for shallow low lands (SLHRT) is also conducted with the help of CRRI, Cuttack. Prior to kharif season 1999, test hybrids were sent for evaluation only at hybrid rice network centers and at the research farms of some private seed companies. Based on the experiences gained over the years and necessity of comparing the hybrids with best available high yielding inbred varieties, the revised system of evaluation of promising hybrids identified in Initial Hybrid Rice Trial (IHRT) along with inbred varieties in advance variety trials has been adapted since kharif season 1999. Test hybrids which record more than 5% yield advantage over the best hybrid check and 10% yield advantage over the best varietal check are promoted to next stage of testing. The hybrids promoted from IHRT are included in AVT-1 and subsequently promoted to AVT-2 if their performance is good in AVT-1. At AVT stage, the experimental hybrids are evaluated along with the best inbred entries in the same trial, this providing opportunity for critical comparison between the hybrids and the inbreds. At the AVT-2 stage, hybrids will also be tested for agronomic performance, disease/insect pest resistance and grain quality traits. Those entries with consistent yield advantage and other desirable traits will be

identified for release at the time of Annual Rice Workshop by a specially constituted Varietal Identification Committee (VIC). The proposals of identified hybrids are placed before the Central Sub-Committee on Crop Standards, Notification and Release of Varieties (CSCCSN & RV) for deliberation and final approval. This is a well organized, proven system tested over the years and found to be very effective. Evaluation of most promising hybrids along with the promising inbred cultures in the same trials has given much credence to this system.

Hybrids released:

As a result of concerted efforts for over two decades, totally 102 hybrids have been released for commercial cultivation in the country. Among these, 67 have been released from the public sector while remaining 35 have been developed and released by the private sector

Multilocational evaluation of released hybrids:

To make a comparative evaluation of hybrids released in the country and to get information on their adaptability in different states across the country, multilocational evaluation of released hybrids was taken up in three phases. In the first phase, all the hybrids released prior to 1999 were extensively tested during three seasons viz., Kharif 1999 (64 locations), rabi 1999- 2000 (15 locations) and kharif 2000 (46 locations). Based on overall mean (125 locations) pooled over three years, the hybrids viz., KRH-2, PHB-71, Sahyadri, PA 6201, NSD-2 and DRRH-1 were found promising and widely adapted. KRH-2 hybrid topped in both the kharif seasons, whereas Sahyadri hybrid was found to be better during rabi season In the second phase, all the hybrids released after 2000 were tested in 32 – 35 locations across the country during kharif 2006 (34 locations), kharif 2007 (35 locations) and kharif 2008 (32 locations) seasons. Based on the criteria of 10% yield advantage over the best varietal check and 5% over the best hybrid check promising hybrids for different states have been identified. In the third phase, the seven hybrids released after 2009 were tested in 26 locations across the country during Kharif 2010. Four hybrids viz., PAC 835, PAC 837, Indam 200-017 and DRH-775 have shown the significant yield advantage over the checks.

Grain quality considerations:

The cooking quality preferences vary from region to region. Rice is one cereal that is consumed mainly as whole milled and boiled grain. The quality in rice will have to be considered from the view point of milling quality, grain size, shape, appearance and cooking characteristics. A hybrid should possess high turnout of whole grain (head) rice and total milled rice, with varying length:breadth ratio (L/B) ranging from 2.5 to 3 mm and medium (5.5 – 6.6 mm) to long slender (>6.6 mm) translucent grain, intermediate gelatinization temperature (GT) and amylose content (AC). Besides this, high quality rices like Basmati should have length wise expansion without increase in girth coupled with distinct aroma. The large scale adoption of hybrid rice depends on the profitability of the technology, which in turn depends on level of heterosis and market price of the produce as determined by region specific grain/cooking quality requirements. Hence, quality considerations are of paramount importance for the popularization and large scale adoption of hybrid rice in India. Grain quality features of all released hybrids in the country are furnished in It is evident from the table that most of the hybrids have grain quality features either better or on par with that of popular varietal checks like Jaya, IR 64 and Annada which are grown in different parts of the country. By choosing appropriate parental lines, it is possible to develop hybrids with desirable grain and cooking quality traits as per the region specific requirement of the consumer.

Release of Pusa RH 10 - The world's First Superfine Grain Aromatic Rice Hybrid:

Using the Basmati quality parental lines (CMS and restorer lines) developed at Indian Agricultural Research Institute, (IARI), New Delhi, the hybrid Pusa RH 10 was developed and it was released by CSCCSN&RV in July 2001 for commercial cultivation in the irrigated eco-systems of Haryana, Delhi and Uttaranchal. It has excellent grain quality and is early duration hybrid, maturing in 115 days as against 135 days taken by the best check variety Pusa Basmati 1, with 40% higher yield. By virtue of its earliness, it is suitable for planting after the onset of monsoon without any yield reduction and has high per day productivity. The release of Pusa RH 10 is the hallmark achievement of the Indian Agricultural Research Institute and the Indian Council of Agricultural Research.

Resistance to insect pests and diseases:

For the stable performance of hybrids across locations/seasons, it is necessary that the hybrids should possess resistance/tolerance to major insect pests and diseases. Hence incorporation of resistance to major insect pests and diseases is one of the major objectives of the hybrid rice breeding programme. In addition to development of parental lines with high level of resistance to biotic stresses, hybrids in the coordinated trials are being regularly screened for resistance to major insect pests viz., stemborer, BPH, WBPH, leaf folder and gall midge and diseases viz., blast, bacterial leaf blight (BLB), rice tungro disease (RTD), brown spot, sheath blightand sheath rot through national hybrid rice screening nurseries. Major emphasis is being given now for the development of parental lines with inbuilt resistance to major pests and diseases.

Improvement of parental lines

Development and evaluation of CMS lines:

Development of commercially useable CMS lines with desirable traits is an important activity of the hybrid rice network project in India. Work on development of region specific CMS lines is actively done by many centres. Presently 48-50 promising maintainers are at various stages of conversion program in the backcross nursery. Some promising CMS lines developed by different centres in India are given below:

Large scale cultivation of Hybrid Rice:

It is one and half decade now since the first hybrids was developed and released for commercial cultivation in India in 1994. At present, India has about two million hectares under hybrid rice cultivation of the total of 44 million hectares under rice cultivation. More than 50 per cent of rice area is under hybrid varieties. India is the second nation to develop its own hybrid rice and adopt it on a commercial scale. During the first decade, adoption of hybrid rice has been much slower than expected mainly because of lower grain quality and consequently lower market price for the produce. However, the yield advantage of hybrids in the range of 15-20% over the high yielding inbred varieties has been well established in the farmers' field. The adoption of hybrid rice in the initial years has been rather slow but steady one. It has picked up during the last five years since 2004, mainly because of increasing popularity and profitability of hybrid rice among the rice farmers of eastern Uttar Pradesh, Bihar, Jharkhand and Chhattisgarh. Large scale adoption of hybrid rice is expected in these states during next decades. Hybrid rice is also picking up in Haryana and Punjab states in recent years. It is reported from these states that less fertilizers and water are needed for hybrid rice as compared

to the high yielding varieties. The earliness of hybrids is also another advantage reported, facilitating timely sowing of wheat crop or creating possibility of growing short duration inter crops. It is expected that by 2010 and 2015, hybrids may be cultivated in India in an approximate area of 2.5 and 4.0 million hectares respectively. To intensify the cultivation of hybrid rice and popularize this technology with farming community, Government of India has recently has constituted a 'Task Force on Hybrid Rice' with Dr Swapan K Datta, DDG (CS), ICAR, New Delhi, Sri Siraj Hussain, CMD, FCI, New Delhi & Sri S K Roongta, CMD, NSC, New Delhi as members and Sri Ashish Bahuguna, Additional Secretary, Dept. of Agriculture & cooperation, GOI, as Chairman, to develop state specific strategies for promotion of hybrid rice cultivation to accelerate its adoption and address various constraints. The task force started reviewing the status of hybrid rice cultivation in various rice growing states & seed production issues and is contemplating various options to intensify the utilization of this technology in a much bigger way in the country.

Major Challenges:

Despite having great potential to enhance production and productivity of rice in the country, hybrid rice has not been adopted on large scale as was expected. This is due to several constraints. Some of the major constraints are:

1. Lack of acceptability of hybrids in some regions such as Southern India, due to region specific grain quality requirement.
2. A few hybrids are reported to have stickiness and presence of mild aroma which is not liked in Southern India.
3. Moderate (15 – 20%) yield advantage in hybrids is not economically very attractive and there is a need to increase the magnitude of heterosis further.
4. Lower market price offered for the hybrid rice produce by millers/traders, is acting as a deterrent for many farmers to take up hybrid rice cultivation.
5. Higher seed cost is another deterrent for large scale adoption and hence there is a need to enhance the seed yield in hybrid rice seed production plots.
6. Efforts for creating awareness and for technology transfer were inadequate in initial stages.
7. Involvement of public sector seed corporations in large scale seed production has been less than expected.
8. Non-availability of hybrids for boro season and long duration hybrids for shallow lowland conditions.

Most of the constraints mentioned above are being addressed with right earnestness through the on-going research projects and through aggressive transfer of technology efforts.

Future Outlook

A good beginning has been made by ushering in to an era of hybrid rice in the country. Development of heterotic hybrids by the researchers, large scale production of hybrid seeds by various seed agencies and transfer of this technology to the end users by the extension agencies must go hand in hand to have the real impact of this technology in the Indian agriculture. Though the hybrid rice technology has been introduced to Indian agriculture, the successful large scale adoption of this innovative technology, in future, primarily depends upon the economic attractiveness of this technology. Rice hybrids with still higher magnitude of heterosis coupled with better grain, cooking and eating quality and possessing resistance to major pests and diseases are being developed. In the special mission mode programme to bring Green Revolution in eastern India, greater emphasis is being given for enhancing rice production and hybrid rice adoption is one of the key components identified, as it is the eastern

India, where hybrid rice technology has made an impact. Many promising parental lines with better floral traits have been developed. Seed production technology has to be further refined to obtain average seed yields of 2.5 to 3.0 t/ha on a large scale, so that the cost of hybrid rice seed can be reduced to Rs. 100/- kg. Top priority has to be given to maintain the purity of parental lines and to produce high quality hybrid seed. Involvement of seed agencies in the public sector, NGO's and farmers cooperatives along with the private seed sector will be crucial to meet the increased demand for hybrid seed in the years to come. Extension agencies have to play a greater role in creating much needed awareness among farmers about the advantages of cultivating hybrid rice by various innovative approaches. Policy decisions of providing subsidy to meet the higher seed cost and giving minimum support price for rice hybrids for the next 4-5 years would be very helpful to bring more area under hybrid rice. The national food security mission launched in the last year envisages increasing of annual rice production by at least 10 million tons by the end of eleventh five year plan by 2011-2012. Hybrid rice technology is likely to play a major role in increasing rice production in the country. It is expected that by the year 2012 hybrids will be cultivated in India, in 3 million hectares and by 2015 hybrids are expected to cover at least 5 million hectares of the rice area in the country, thereby contributing significantly towards national food security.

REFERENCES

Annual bulletin (2015), ICAR-IIRR, Hyderabad

Hari Prasad, A.S., Ramesha, M.S., Sundaram, R.M., Rao, R.N., Mnonmani, S., Neeraja, C.N., Sarla, N., Singh, A.K., Shobha Rani, N. and Viraktamath, B.C. 2012. Hybrid rice breeding in India. *6th International symposim on hybrid rice*: Public- Private Partenership for Hybird Rice 141-150.

www.irri.org.in