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An estimate on the adoption of ICAR-IIRR released varieties and their impact on rice production in India during 2015-20

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Abstract

Rice is the most important food crop of India. ICAR-Indian Institute of Rice Research (ICAR-IIRR) was established in 1965 as All India Coordinated Rice Improvement Project (AICRIP) and has been playing a key role in the improvement of rice technologies. Extensive testing under the All India Coordinated Rice Improvement Project, which is one of the largest networks for evaluation of any single crop in India, has contributed to the release of 1375 rice varieties including 117 hybrids for all the major rice growing ecosystems of the country during the last five and half decades (1965-2020). Of the 1375 varieties released, about 267 varieties are still in the breeder seed production (BSP) chain. In the present study, an estimate was made on the area covered by the varieties released by ICAR-IIRR and their contribution to the rice production in India during 2015-16 to 2019-20. It was estimated that, annually, the ICAR-IIRR varieties contribute to about 8 % of the total production of rice in the country. The revenue impact of ICAR-IIRR varieties is estimated at 3161 Million USD annually, which is in the form of gross returns from cultivation.

Keywords: Rice, ICAR-IIRR varieties, area, production, gross returns

Introduction

Globally rice is planted in an area of about 162 million ha and 755 million tonnes of paddy is harvested annually (FAO, 2020). Of this, Asia accounts for 90% of the production and consumption, but only about 46 million tonnes of rice is traded through international markets. Leading rice exporting countries are India, Thailand, USA, Vietnam, and Pakistan. India is the leading exporter of rice with the export of about 9.5 million tonnes (APEDA, 2021). India has the world's largest area under rice with 44 million ha and is the second largest producer (117.94 million tonnes in 2019-20) next only to China (3rd Advance Estimates, GoI, 2020). It contributes to 24 percent of global rice production. Within the country, rice occupies one-quarter of the total cropped area, contributes about 40 per cent of total food grain production and continues to play a key role in the national food and livelihood security system. Rice export contributes to nearly 20% of revenue from total agricultural exports of the country.

Rice is the most important food crop of India. The area under rice crop was 31 million ha in 1950-51 which has increased by 42 percent to 44 million hectares during 2019-20,. However, the rice production has registered an appreciable increase of nearly 5.7 times from 20.58 million tonnes in 1950-51 to 118 million tonnes during 2019-20 (GoI, 2021). The milled rice yield of 668 kg/ha in 1950-51 has increased to 2682 kg/ha during 2019-20.

The Central Rice Research Institute, now named as National Rice Research Institute (NRRI) was established in the year 1946 to work on the crop and subsequently, ICAR-Indian Institute of Rice Research was established in 1965 as All India Coordinated Rice Improvement Project (AICRIP) with 12 main centres.

Later, it was elevated to Directorate status in 1983 and to a full-fledged Institute in December, 2014. AICRP on Rice is the largest research network on a single crop comprising of 45 funded and over 100 voluntary centres covering all the rice growing states in the country. Realizing the limitations imposed by the ecosystem complexities, destabilizing insect pests and disease problems as well as grain quality requirements of different varieties/ cultivars of rice consumed, AICRIP evolved need based programmes / trials over the years to identify suitable genotypes of high yield potential along with appropriate crop management practices. During the initial phase i.e. in the first decade, emphasis was given to achieve higher yields through improved plant type largely for irrigated areas. This led to the development of short statured high yielding varieties (HYVs), which heralded the process of "Green Revolution" in India. During 80s, yield stability and quality improvement received major attention. This led to the development of varieties possessing major biotic stress tolerance and desirable quality to develop prototype of semi-dwarf basmati rice varieties. Nineties witnessed efforts in developing suitable hybrid rice technology and multi-location testing to validate their superiority over varietal checks at least by 10% as well as non-basmati quality trials targeting the export markets. During 2000s emphasis was on soil stress trials for problem soil areas, aerobic trials laying emphasis on developing genotypes for water limited environments and hill trials for incorporating cold tolerance. In recent times, emphasis has been on the near isogenic line development for quick evaluation of marker assisted selection (MAS) derived products introgressed with genes conferring resistance/tolerance against biotic and abiotic stresses. Additionally, nutritional security is stressed by enriching the grain with micronutrients such as zinc, iron along with protein (Babu *et al*., 2016).

First semi-dwarf high yielding variety "Jaya" released by AICRIP in 1968 ushered the green revolution in India. This transformed the country to a state of self-sufficiency by mid eighties and stalled rice imports beginning an era of exporting rice, earning high foreign exchange by early nineties. Till date more than 28,300 elite lines developed by different cooperating centres were tested in multi-location trials across the country under the umbrella of All India Coordinated Rice Improvement Programme (AICRIP) at funded, voluntary centres and in partnership with private sector for hybrid rice. The dynamic time tested multi-location three tier testing programme involving one year of Initial Varietal Trial (IVT) and two years of Advance Varietal Trial (AVT – 1 and AVT -2) as well as screening of elite breeding lines at hotspot locations for generating information on their pest/disease resistance/tolerance, grain quality attributes and agronomic performance has led to release of varieties including hybrids suitable for all the ecosystems. Extensive testing under AICRIP has contributed to the release of 1375 varieties including 117 hybrids for all the major rice ecosystems of the country during the last five and half decades (1965-2020). Of the 1375 varieties released in the country, about 267 varieties are still in the breeder seed production (BSP) chain.

Among the several varieties/hybrids developed and released by ICAR-IIRR, Improved Samba Mahsuri is a product of Marker-Assisted Selection breeding that has successfully introgressed three bacterial blight resistance genes viz., *xa5, xa13* and *Xa21* in the background of one of the most popular rice varieties, Samba Mahsuri (BPT5204) without sacrificing either the yield or the cooking quality (Sundaram *et al.*, 2008). Recently, Improved Samba Mahsuri has been recorded to have low glycaemic index of 50.99, which is desirable for rice consumers suffering from Type II diabetes (Sundaram *et al.*, 2018). The development of Improved Samba Mahsuri has paved the way for more precise molecular breeding programs in rice.

The research efforts in agriculture initially aimed at achieving self-sufficiency of food grains. Presently, bio-fortification of major food crops is considered as a viable strategy to address malnutrition and to ensure nutritional security. The development of high zinc rice varieties, DRR Dhan 45, 48 and 49 by Indian Council of Agricultural Research-Indian Institute of Rice Research (ICAR-IIRR) is an effort to address

malnutrition, through bio-fortification in rice (Nirmala *et al*., 2016).

ICAR-IIRR contributes significantly to the production of breeder seed and currently there are about 11 ICAR-IIRR varieties indented for breeder seed production through Department of Agriculture and Co-operation (DAC) in India. Therefore, the objectives of the present study were to estimate the area covered by the ICAR-IIRR varieties and to assess the contribution of ICAR-IIRR varieties to the overall rice production during 2015-20 and the income gains of the country.

Methodology

In the present study, breeder seed indents of GOI and production, seed produced in mega seed project, truthfully labelled seed sale at IIRR godown, seed distributed through blight-out program and mega seed project was considered mainly for the estimation of area, production and gross-returns.

Estimation of area under ICAR-IIRR varieties

It was considered that one kg of breeder seed (BS) was required to produce 60 kg of foundation seed (FS), which in turn produces another 60 kg of certified seed (CS) (Pathak *et al*.,2018). It was also considered that 50 kg of certified seed or truthfully labelled seed (TLS) is required to plant one ha of rice area.

The area covered by IIRR varieties was estimated using the following equation:

Area (Mha) = ((BSP of IIRR varieties (kg)*60*60))+TLS(kg)/50(kgha^{-1})/10^6**)**

Where:

BSP is the Breeder Seed Produced

TLS is Truthfully Labelled Seed

10^6 is conversion factor to million

Estimation of rice production with ICAR-IIRR varieties

Production of rice (unmilled) with ICAR-IIRR varieties was calculated by using the following equation:

Production of IIRR rice varieties (Mt) = [Area of IIRR varieties (Mha)/ Total area (Mha)] * Total paddy production (Mt)

Estimation of gross returns with ICAR-IIRR varieties

Gross return with ICAR- IIRR varieties was calculated using the following equation:

Value of IIRR rice (Million USD) = Production of IIRR rice (t) * MSP (Rs. t^{-1}) /USD rate/10^6

Where, MSP is minimum support price; USD rate is USD exchange rate in rupees; 10^6 is conversion factor to million.

Results and Discussion

Availability of pure seed is one of the crucial constraints for bridging the gap between technology development and its adoption. Breeder seed production (BSP) is being organized by ICAR-IIRR, Hyderabad under the National Seed Project (NSP) – Crops as per the DAC indents at 32-35 centres every year. BSP activity in rice began with 66 varieties in 1995 and the number of varieties has steadily increased to 234 by 2012 and 336 by 2020. The breeder seed production has increased from 541 tonnes (t) in 2015-16 to 1196 tonnes in 2019-20 (Figure 1).

The ICAR-IIRR plays a significant role in the supply of quality breeder seeds to the country. The major ICAR-IIRR varieties indented through breeder seed indent include Improved Samba Mahsuri, IR 64, Jaya, Varadhan, Mahsuri, Dhanrasi, Rasi, Sampada and Akshayadhan. Annually, in the past five years, at least eleven ICAR- IIRR varieties were indented for breeder seed in India. During the year 2015-16, DRR Dhan 44, Improved Samba Mahsuri and Sampada together constituted more than 70 % of the breeder seed production of the total ICAR-IIRR varieties (Table 1). In the year 2016-17, DRR Dhan 44, Sampada, Improved Samba Mahsuri, DRR Dhan 45 and 46 together constituted about 69 % of the breeder seed production of the total ICAR-IIRR varieties. In the subsequent years, Improved Samba Mahsuri, Sampada, IR 64 and DRR Dhan 44 were the major varieties indented through breeder seed indents.

Improved Samba Mahsuri(ISM) is a fine and medium-slender grain variety having excellent grain and cooking quality with yield potential of 5.5-6 t/ha. It is

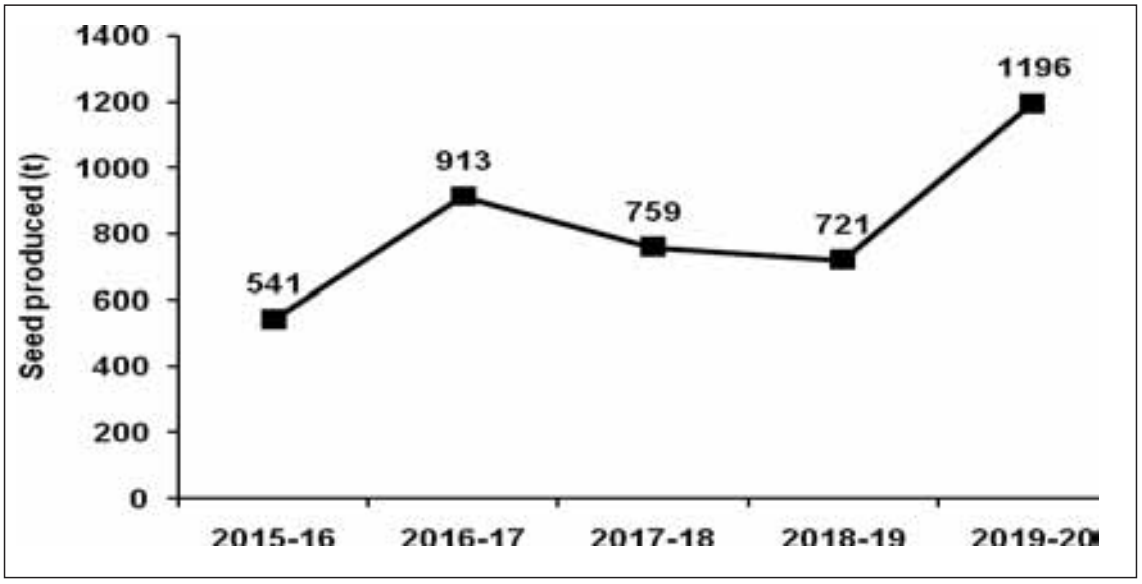

Figure 1: Breeder seed production (t) during 2015 to 2020

Table 1. Breeder Seed Production (tonnes) of ICAR-IIRR rice varieties

Sl. No.	Name of variety	2015-16	2016-17	2017-18	2018-19	2019-20
1.	DRR Dhan-50	-	-	-	-	0.85
2.	DRR Dhan-45	-	4.2	0.18	-	0.25
3.	DRR Dhan-39 Jagjeevan	-	0.84	0.4	0.7	0.6
4.	DRR Dhan-43	-	2	0.4	0.28	0.24
5.	DRR Dhan-44	8	6.3	3	-	1
6.	DRR Dhan-46	-	2.4	0.05	0.7	0.85
7.	DRR Dhan-51	-	-	-	-	0.24
8.	Improved Samba Mahsuri	6.5	3.7	3.55	3	2.3
9.	IR-64	5	5.5	4	6.45	2.1
10.	Jaya	1	0.84	1.4	0.42	0.9
11.	Krishna Hamsa	0.1		0.12	0.03	0.05
12.	Mahsuri	0.3	0.21	0.18	0.28	0.12
13.	Rasi	0.3	0.3	0.1	0.05	0.05
14.	Sampada	3.3	6.38	1.6	4.78	1.14
15.	DRR Dhan 47	-	-	-	0.35	-
16.	Dhanrasi	0.1	0.05	0.05	-	-
17.	Jarava	0.1	-	0.1	-	-
18.	Swarna Dhan	-	0.35	0.15	-	0.12
19.	Akshaya Dhan	0.1	0.3	-	-	-
20.	Vara Dhan	0.3	0.3	-	-	-
21.	IET-23832 (RP 5886 HP3 IR 80463-B39)	0.15	-	-	-	-
22.	Basmati Kasturi	0.1	-	-	-	-
	Total	25.35	33.67	15.28	17.04	10.81

Source: DRR Progress Reports, Varietal Improvement Vol 1,2015 to 2019, IIRR, Hyderabad.

highly resistant to bacterial blight disease. It is almost similar to Samba Mahsuri in yield, grain and cooking quality and agro-morphological traits besides having resistance to bacterial blight. Under bacterial blight infestation, ISM gives more yield than the susceptible varieties. It is one of the first biotechnology derived products in the country. Improved Samba Mahsuri has been recorded to have low glycaemic index of 50.99, which is desirable for rice consumers suffering from Type II diabetes. Sampada, another high yielding variety has medium slender grains with intermediate amylose (23%) and recorded 24% more yield than BPT 5204. It is tolerant to blast, tungro disease and white backed plant hopper (Somasekhar *et al.*, 2009). DRR Dhan 44 is characterized by very high yield under limited water conditions. It performs exceedingly well under dry direct seeded conditions (sprinkler irrigation) with minimal inputs. Due to their unique traits, more number of indents was received for breeder seed production of these varieties.

The ICAR-IIRR plays a pivotal role in the supply of quality Breeder Seed (BS) and Truthfully Labelled Seed to the farmers of the country (Figure 2). The total IIRR seed supplied to the farmers has increased from 134 tonnes in 2015-16 to 143 tonnes in 2019-20 indicating an increase of about 7 percent of the supply of the seed of IIRR varieties.

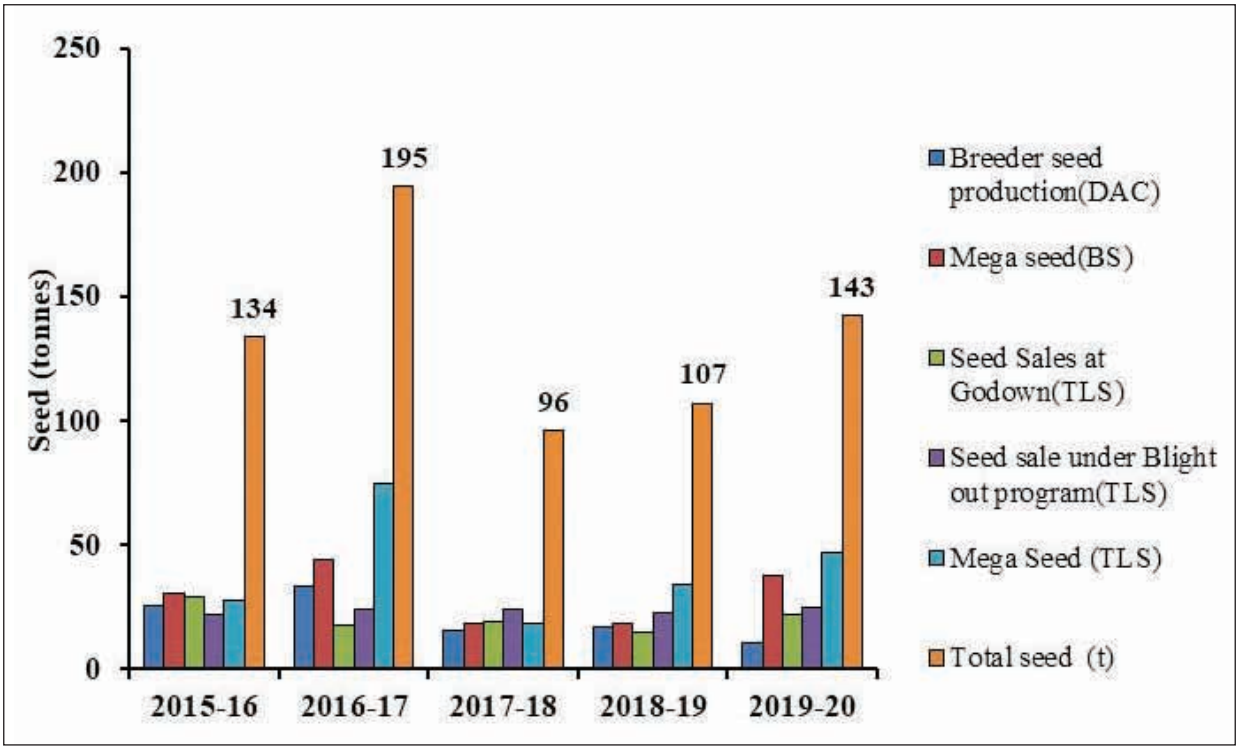

Figure 2: ICAR-IIRR varieties seed (tonnes) distribution details during 2015 to 2020

Source: Computed from i)breeder seed production data from DRR Progress Reports, Varietal Improvement Vol 1,2015 to 2019 and ii)seed sales data from IIRR iii) seed produced and distributed under Mega seed and Blight Out programs

Rice was cultivated on an area of 44 million hectares in India with a record production of 118 million tonnes in 2019-20. The estimated area under IIRR varieties ranged from 2.5 Mha to 5.6 Mha in the past five years. On an average, annually, IIRR varieties occupied an area of about 3.4 Mha in India, for the past five years (Table 2). The cultivation of IIRR varieties resulted in the production of about 14 million tonnes (MT) of paddy (9 MT of rice) in India. Thus, approximately 8% of rice production in India comes from the cultivation of varieties released from ICAR- IIRR. Annual gross returns from the cultivation of ICAR-IIRR released rice varieties in India were estimated to be around 3161 Million USD based on the average estimates for the past five years.

Table 2: Contribution of ICAR-IIRR varieties to area, production and gross returns (2015-20)

Sl. No.	Year	Area under IIRR Varieties (Mha)	Production of rice of IIRR Varieties (Mt)	Gross returns from IIRR Varieties (Mill.USD)
1	2015-16	2.5	9.40	2071
2	2016-17	4.0	15.33	3364
3	2017-18	5.6	21.50	5127
4	2018-19	2.5	10.34	2661
5	2019-20	2.5	10.23	2580
	Average	3.4	13.40	3161

Source: Computed from i)breeder seed production data from DRR Progress Reports, Varietal Improvement Vol 1,2015 to 2019 and ii)seed sales data from IIRR iii) seed produced and distributed under Mega seed and Blight Out programs

Conclusion

The study provides insights on the impact of ICAR-IIRR varieties and quantified the contribution of the IIRR varieties to the total area and production of rice at the national level. It was estimated that, annually, the IIRR varieties contribute to about 8 % of the total production of rice in the country. The significant impact of IIRR varieties is the generation of gross returns to the tune of 3,161 Million USD annually and cumulative returns of 15,803 Million USD for the period from 2015-16 to 2019-20.

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