Release and Adoption of Improved Cultivars in South and Southeast Asia: Rice

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Abstract

The International Rice Research Institute, in collaboration with partner institutions, collected rice varietal release and adoption data for 11 countries in Asia: China, India, Pakistan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, and Vietnam. For China, data were collected for the top eight rice producing provinces (Anhui, Guangxi, Heilongjiang, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan). For India, five states with predominantly irrigated rice were included in this study (Andhra Pradesh, Haryana, Punjab, Tamil Nadu, Telangana). Adoption data in some countries were derived from existing farm surveys or seed sales. Fourteen expert elicitation meetings were conducted between 2014 and 2016 in areas where there are no data on varietal adoption.

Overall, adoption rate of modern rice varieties was 92%. The average varietal age ranged from four to 40 years. Varietal turnover was fastest in China, where there are several breeding institutions that release many varieties annually, and slowest in Myanmar and Thailand due to popular rice varieties that are pureline selection and which were released before 1980.

Keywords: rice varieties; modern varieties; varietal adoption; Asia

Introduction

Rice is an important crop in Asia where more than 90% of the world's rice is produced and consumed (GRiSP, 2013). The International Rice Research Institute (IRRI) has played a key role in the improvement of rice productivity in the region by providing breeding lines and varieties, and through capacity building activities (Brennan and Malabayabas, 2011). Since the release of IR8 developed by IRRI 50 years ago, several improved rice varieties have been developed either at IRRI or using breeding lines from IRRI.

Considerable time and resources are needed before a new variety is released. Knowing which varieties are adopted by farmers and identifying the characteristics of these varieties can

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contribute to a more targeted development and dissemination of new varieties that would have a high probability for adoption (Laborte et al., 2015).

The Strengthening Impact Assessment in CGIAR (SIAC) is an initiative to bridge the gap in quality data on the uptake and diffusion of CGIAR research outputs, and to assess their impact. As part of this initiative, IRRI in collaboration with partners from various countries, assembled, documented, and processed data on rice varietal releases and rice varietal adoption in 11 rice growing countries in Asia: China, India, Pakistan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, and Vietnam. For China, data were collected for the top eight rice producing provinces (Anhui, Guangxi, Heilongjiang, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan). In the case of China, provincial level data were collected for its top 8 rice-producing provinces and in India, four irrigated states were included. For India, data for five states with predominantly irrigated rice were collected (Andhra Pradesh, Haryana, Punjab, Tamil Nadu, Telangana).

This paper summarizes varietal release data collected and characterizes the varieties adopted in various countries in Asia. An assessment of the expert elicitation (EE) method for estimating varietal adoption is also included.

Data and Methods

Varietal release data were based on various sources including databases from national partner institutions, publications, and online sources. These were checked and verified for duplicates (e.g., different names but same varieties) through the help of various breeders from different countries.

Rice varietal adoption data were derived from nationally/regionally-representative farm household surveys in the Philippines, Thailand, South Vietnam, Punjab in India and Jiangsu and Sichuan in China (Table 1). In Indonesia and Malaysia, statistics that were derived from seed sales data were also available. In countries where data on varietal adoption are not available, EE was conducted to estimate perceived adoption of rice varieties.

In the EE method, experts from various disciplines (breeding, agronomy, social science, extension) with knowledge on rice varietal adoption in the country/region were identified and invited to attend a one-day meeting. At the start of this meeting, geographic, agro-climatic and/or seasonal domains for estimation of varietal adoption estimates were defined in consultation with the experts.

The estimation was done following the steps below, which were adapted from the guidelines provided by the SIAC project:

Step 1: Each expert was asked to provide individual estimates of varietal adoption at the national or disaggregated level depending on their knowledge and experience.

Step 2: A list of released varieties was provided to experts and they were asked to provide revised estimates of varietal adoption at the national or disaggregated level.

Steps 1 and 2 served as practice for the experts in the elicitation process.

Step 3: Groups were formed to obtain group estimates which were arrived at through discussion and consensus. To ensure different perspectives are included, members of each group should belong to different disciplines. In some cases groupings were based on geography as in Laos (North, Central and South), Cambodia (provinces near Thailand, provinces near Vietnam), and Pakistan (regions). As such, estimates from each group were referred to the geography the group members are from and/or familiar with. In other cases (e.g., provinces in China and states in India), several groups were formed but each group estimated the same area (whole province or whole state).

Step 4: For groupings by geography, whole country estimates were derived by taking the average weighted by rice area under each geographic unit. For whole country groupings, results from each group were simply averaged.

Step 5: Combined estimates were presented to the whole group and the whole group discussed whether the adoption values per variety arrived at are reasonable. In some cases adjustments were made and the final estimates were based on consensus.

In each step, the form used for the elicitation is the same (Appendix A). Experts' perception of percentage area grown to each modern variety (Section C of the form) was elicited such that total of these percentages add up to 100%. The percentages were then rescaled to obtain share of each modern variety (MV) to total rice area. This was the procedure followed because it was deemed easier for the experts to allocate 100% area under modern varieties to the different modern varieties grown.

Varietal age was calculated by subtracting the year the adoption data refer to from the year of release for each variety and taking the sum for all varieties weighted by the rice area under each variety.

Data from a series of farm household surveys conducted by the Cambodian Agriculture Research and Development Institute (CARDI) from 2010 to 2013 were used to assess results of varietal adoption data obtained through EE. The farm surveys cover 12 provinces with a total survey area of 11,499 ha and covering 87% of rice area between 2010 and 2013 (4-year average). The survey covered 5-8 provinces each year. In years when the survey was repeated in a province which was already covered in earlier years, a different set of districts was selected. For the estimation of varietal adoption, the years were ignored and samples in each province were combined. Estimates were weighed using share of each province in the total rice area covered by the 12 provinces. Estimation was done separately for the wet season and the combined dry and early wet season, and compared with those obtained using the EE method.

Results and Discussion

Rice Varieties Released

A total of 5,588 rice varieties developed by 1,286 institutions engaged in rice breeding have been released in 11 countries (eight provinces only in China and four states only in India) (Table 2). Notably, the major rice producing provinces in China have a large number of institutions engaged in rice breeding and have been prolific in releasing improved rice varieties. Nearly all of these have no IRRI parents (Table 3). In contrast, about 30-40% of varieties released in the predominantly irrigated states in India were developed at IRRI or have at least one IRRI parent. The proportion varies in Southeast Asia but is highest in Laos at 73%. Next is the Philippines, which hosts the IRRI headquarters, with 54% of released varieties developed at IRRI and 12% with at least one IRRI parent.

Rice varieties recently released in the Philippines have longer grains compared to those released in previous years (Figure 1). Most varieties released prior to 1985 have medium grain size, and long grains thereafter. This trend follows changes in reported consumer preference for grain size from short in 1980s (Abansi et al., 1992) to medium in 1990s (Juliano and Villareal, 1993) and long grains (Calingacion et al., 2014).

Amylose content is a grain quality that affects the cooking and eating quality of rice. High amylose rice (25–30%) tends to cook firm and dry, whereas intermediate amylose rice (20–25%) tends to be softer and stickier (IRRI, 2016). Prior to 1985, mostly high amylose rice were released in the Philippines. In contrast, mostly low to intermediate amylose (softer) rice were released after 2005 which follows the consumer preference for soft rice in the Philippines (Custodio et al., 2015).

Rice Varieties Adopted

Overall, adoption rate of MVs was 92%. Most countries/regions have over 90% MV adoption rate (Table 4). In Myanmar and Cambodia, however, large areas were still grown under traditional varieties (TVs). In these countries, some improved varieties are pureline selection of traditional varieties. There is scope to increase yields in these countries, however, new varieties to be developed should have the grain quality characteristics of the preferred traditional varieties. Use of hybrid rice was highest in the provinces of Guanxi (81% of total rice area) and Sichuan (77%) in China.

The top three varieties adopted by farmers comprise at least one-third of total rice area in each of the 11 countries/regions in this study except for four provinces in China (Table 6). The highest share is in Malaysia with 91%. Characteristics of these varieties can be assessed to identify farmers' preference for rice varieties.

The top three rice varieties adopted in Indonesia in 2014 (Ciherang, Mekongga, and Situ Bagendit), were grown in half of total rice area. All three varieties have long and slender

grains, intermediate amylose content (22-23%), and high milling (>63%) and head rice (>83%) recoveries.

The top three rice varieties adopted in the Philippines in 2011-12 (PSB Rc18, NSIC Rc222, and PSB Rc82), were grown in 32% of total rice area. From focus group discussions with farmers conducted in 2014 in three sites in the country, NSIC Rc222 and PSB Rc82 were also identified as preferred varieties by farmers because they are both high yielding. In addition, PSB Rc82 was preferred by farmers in the focus group because they said its grains are soft when cooked. All three varieties have long and slender grains, intermediate amylose content (21.5-24%) and high milling recovery (>65%).

From analysis of five decades of farm household surveys in one region in the Philippines, farmers adopt MVs that are high yielding, mature faster, and have long and slender grains, high milling recovery, and intermediate amylose content (Laborte et al., 2015). Analysis for other major rice growing regions can be done to aid the development of MVs that are more responsive to farmers' needs and preferences.

Assessment of Expert Elicitation Method

Results showed that estimates obtained using EE corresponded well with estimates derived from a farm household survey conducted in Cambodia except for dry season and early wet season estimates for IR 66 and Chul'sa (Table 7). IR 66 is a 24-year old variety and experts perceive a lower adoption level for the variety compared to the survey results, whereas Chul'sa is a relatively new variety (released in 1999) and experts may perceive a higher adoption level for the variety compared to the survey results. Overall, there is good agreement between varietal adoption data obtained from the farm household survey and the varietal adoption as perceived by the experts invited during the EE. This suggests that experts invited to the meeting were well aware of field level varietal adoption and that the process of elicitation worked well in Cambodia.

The following were the observed advantages of the EE method. The assessment was quick and cost effective. Estimates of varietal adoption were available in half a day as compared to conducting surveys and the associated data processing needed. Convening experts from various disciplines worked. Through discussion, experts elaborate their reasons and justifications for estimates. The experts appreciated the value of this discussion. They also found it relatively easy to estimate area under widely grown varieties. Providing a list of rice varieties released helped experts in most cases.

There were, however, challenges with this methodology. Identifying the right experts and convening them is not trivial. In some cases, some experts dominate the discussion highlighting the importance of the facilitator to ensure all experts are heard. Likewise, experts find it difficult to estimate area under varieties that are not widely grown. Moreover, many varieties are known under different names in different locations such as in Cambodia, making it difficult to have aggregated summaries for the whole country. Finally, EE does not always

work. In Anhui and Guanxi, where there are many varieties released and adopted experts find it difficult to estimate rice area by variety.

Conclusion

Overall, adoption of modern rice varieties is high but rice varietal turn over remains low except for China. The average varietal age ranged from four to 40 years. Varietal turnover was fastest in China, where many varieties have been released, and slowest in Myanmar and Thailand with the adoption of popular rice varieties that were released before 1960. The top three varieties grown in countries/regions in South and Southeast Asia cover at least one third of total rice area in these locations. Analysis of characteristics of these varieties can give insights into traits preferred by farmers.

The expert elicitation method is a cost-effective and quick method for obtaining perceived estimates of varietal adoption in cases where no such data exist or are readily accessible. Suitable experts must be invited and the meeting should be facilitated well to contribute to a successful implementation. However, there will be cases when the method is not applicable (e.g., some provinces in China) where there are many varieties developed and adopted making it difficult for experts to provide exact values for varieties that are not widely grown.

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Tables and Figures

Table 1 Summary of sources of rice varietal adoption data.

Country	Year data refers to	Source of data	No. of panel members (EE)	Date of EE
Cambodia	2013-14	Expert elicitation (EE)	18	01/29/2015
Indonesia	2014	Seed sales		
Laos	2013-14	EE	10	09/18/2014
Malaysia	2013	Seed sales		
Myanmar	2012-13	WB report, Feb 2014		
Philippines	2011-12	Farm household survey by PhilRice		
Thailand	2013-14	Farm household survey by Rice Department		
Vietnam (North & Central)	2015-16	EE	9	07/19/2016
Vietnam (South)	2013-14	Farm household survey by SSD-IRRI		
Pakistan	2014	EE	21	02/10/2015
India (Andhra Pradesh & Telangana)	2014-15	EE	16	03/18/2016
India (Haryana)	2014	EE	9	06/16/2015
India (Punjab)	2013, 2014	Farm household survey by PAU		
India (Tamil Nadu)	2015-16	EE	13	06/14/2016
China (Anhui)	2014	EE	10	01/09/2015
China (Guangxi)	2014	EE	11	02/11/2015
China (Heilongjiang)	2014	EE	8	12/11/2014
China (Hubei)	2014	EE	10	02/07/2015
China (Hunan)	2014	EE	11	04/07/2015
China (Jiangsu)	2014	Farm household survey		
China (Jiangxi)	2014	EE	10	08/02/2015
China (Sichuan)	2014	Farm household survey		

Table 2 Summary of varietal release data collected.

Country/State/Province	No. of rice breeding institutions	No. of varieties released	Period
Cambodia	4	43	1990 - 2013
Indonesia	4	200	1953 - 2012
Laos[a]	17	60	1975 - 2012
Malaysia	2	57	1964 - 2012
Myanmar	24	148	1915 - 2015
Philippines	23	294	1960 - 2014
Thailand	21	135	1935 - 2014
Vietnam	62	530	1960 - 2015
Pakistan	49	150	1932 - 2015
India (Andhra Pradesh and Telangana)	27	194	1968 - 2013
India (Haryana)	15	36	1933 - 2011
India (Punjab)	14	51	1933 - 2013
India (Tamil Nadu)	32	260	1921 - 2015
China (Anhui)	126	327	1983 - 2013
China (Guangxi)	181	631	1983 - 2014
China (Heilongjiang)	70	268	1964 - 2014
China (Hubei)	94	251	1985 - 2013
China (Hunan)	148	596	1985 - 2014
China (Jiangsu)	87	365	1982 - 2014
China (Jiangxi)	172	613	1987 - 2013
China (Sichuan)	114	379	1985 - 2014
Total	1,286	5,588	

Note: [a]Includes traditional varieties widely grown by farmers in Laos.

Table 3 IRRI's contribution to rice varietal development in Asia (% of varieties with known parentage)

Country/State/Province	IRRI variety	1 IRRI parent	2 IRRI parents	No IRRI parents
Cambodia	32	2		66
Indonesia	26	21	7	45
Laos	52	17	4	28
Malaysia		14		86
Myanmar	24	10	1	65
Philippines	54	11	1	33
Thailand	3	19	1	77
Vietnam	30	15	1	54
Pakistan	10	12	4	74
India (Andhra Pradesh and Telangana)	2	23	2	73
India (Haryana)	8	33		58
India (Punjab)	19	22		59
India (Tamil Nadu)	7	20	2	71
China (Anhui)	1	3	1	95
China (Guangxi)		2		98
China (Heilongjiang)				100
China (Hubei)		1		99
China (Hunan)		1		99
China (Jiangsu)		2		98
China (Jiangxi)		2		98
China (Sichuan)		2		98

Table 4 Area under modern varieties (MV) and varietal age of adopted varieties[1].

Country/ Region	Area under MVs (% of rice area)	Area under hybrids (% of rice area)	Varietal age (years)
Cambodia	59	0	16
Indonesia	92	0	17
Laos	71	0	13
Malaysia	100	0	12
Myanmar	58	0	40
Philippines	99	3	14
Thailand	100	0	34
Vietnam (Central)	90	14	11
Vietnam (North)	90	0	15
Vietnam (South)	100	0	15
Pakistan	99	56	18
India (Andhra Pradesh)	100	0	23
India (Haryana)	100	0	13
India (Punjab)	100	5	15
India (Tamil Nadu)	99	0	26
India (Telangana)	100	0	22
China (Anhui)	100	2	variety series
China (Guangxi)	100	81	variety series
China (Heilongjiang)	100		5
China (Hubei)	100	39	10
China (Hunan)	100	29	8
China (Jiangsu)	100	5	5
China (Jiangxi)	100	30	4
China (Sichuan)	100	77	6

[1]Estimates are based on varieties with known year of release.

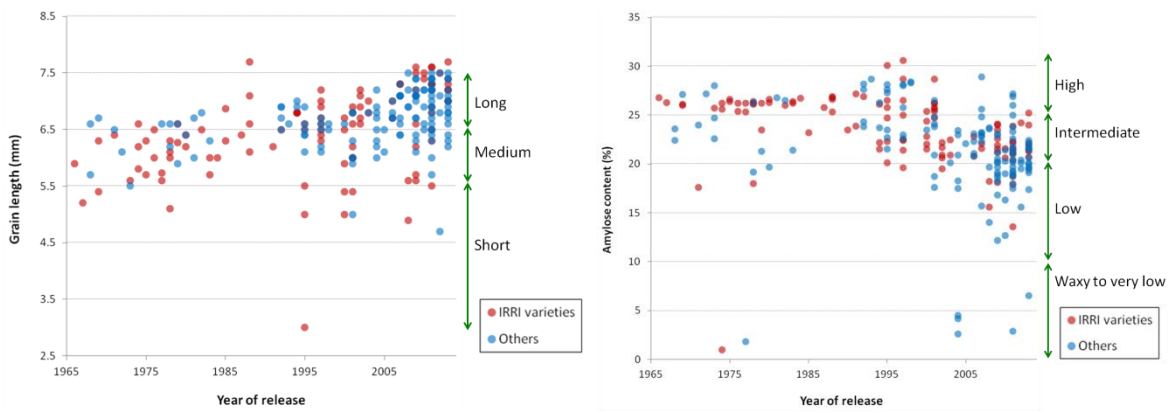
Table 5 Top three rice varieties adopted in major rice producing countries and regions in Asia.

Country/State/Province	Variety	Year of release	%Area by variety	% Area under top 3
Southeast Asia				
Cambodia	Phka Rumduol	1999	17	34
	IR50404	1992	10	
	Riang Chey	1999	7	
Indonesia	Ciherang	2000	36	51
	Mekongga	2004	8	
	Situ Bagendit	2003	7	
Laos	TDK8	2006	14	34
	TDK11	2006	12	
	TDK1	1993	8	
Malaysia	MR 219	2001	55	91
	MR 220 (CL 2)	2010	19	
	MR 220	2003	17	
Myanmar	Manawthukha	1978	20	32
	Shwewartun	1974	6	
	Paw Hsan Hmwe	1944	6	
Philippines	PSB Rc18	1994	12	32
	NSIC Rc222	2009	12	
	PSB Rc82	2000	8	
Thailand	Khao Dok Mali 105	1959	34	57
	RD 6	1977	12	
	RD 31 (Pathumthani 80)	2007	11	
Vietnam (South)	IR 50404	1992	30	56
	Jasmine 85	1993	13	
	OM5451	2011	13	
Vietnam (North)	Khang Dan 18	1999	20	50
	BC15	2008	16	
	BAC THOM 7	1992	14	
Vietnam (Central)	BC15	2008	11	30
	Khang Dan 18	1999	10	
	OM4900	2009	9	
South Asia				
India (Andhra Pradesh)	Samba Mahsuri	1986	19	47
	Cottondora Sannalu	2000	18	
	Swarna	1979	10	
India (Telangana)	Cottondora Sannalu	2000	43	77
	Samba Mahsuri	1986	31	
	IR64	1989	3	
India (Haryana)	Pusa Basmati 1121	na	33	58
	CSR 30	2001	15	
	Pusa Punjab Basmati 1509	na	10	
India (Punjab)	Pusa 44	na	24	57
	Pusa Basmati 1121	na	22	
	Pusa Punjab Basmati 1509	na	11	
India (Tamil Nadu)	CR 1009	1982	23	46
	Samba Mahsuri	1986	14	

Country/State/Province	Variety	Year of release	%Area by variety	% Area under top 3
	ADT 43	1998	9	
Pakistan	Super Basmati	1996	27	62
	PS-2	2013	18	
	IR 6	1971	17	
East Asia				
China (Anhui)	Inbred japonica rice	variety series	15	41
	guangzhan series	variety series	14	
	Yyou series/Y58S series	variety series	12	
China (Guangxi)	Inbred rice	variety series	23	51
	boyou series	variety series	14	
	Yliangyou series	variety series	14	
China (Heilongjiang)	longjing31hao	2011	30	48
	longjing25hao	2009	9	
	kendao12hao	2006	9	
China (Hubei)	yangliangyou6hao	2003	6	14
	fengliangyouxiang1hao	2007	5	
	ezao series	variety series	3	
China (Hunan)	huanghuazhan	2007	4	10
	xiangzaoxian45hao	2007	3	
	zhuliangyou819	2006	3	
China (Jiangsu)	Ningjing4	unidentified	15	34
	lianjing7hao	2010	10	
	Nanjing9108	2013	9	
China (Jiangxi)	huanghuazhan	2007	3	9
	zhongjiazao17	2012	3	
	tianyouhuazhan	2011	3	
China (Sichuan)	Yixiangyou2115	2011	3	7
	Fyou498	2009	2	
	Dexiang4103	2008	2	

Table 6 Comparison of varietal adoption data derived from farm household surveys and expert elicitation, Cambodia.

Season/ Type	Variety	Year of release	CARDI household survey	Expert elicitation (EE)	Difference (%)
Wet season					
MV	Phka Rumduol	1999	18	19	-1
	Riang Chey	1999	10	8	2
	CAR9	1996	3		3
	IR50404	Vietnam	2	2	0
	CAR5	1995	1		1
	CAR6	1995	1	2	-1
	Sen Pidao	2002	1	2	-1
	Phka Rumdeng	2007	1		1
	Phka Romeat	2007	1	2	-1
	CAR4	1995	1	2	-1
	Phka Chansensar	2010	0	5	-5
	IR66	1990	0	2	-2
	Chul'sa	1999	0	2	-2
	Sen Kra Ob	Thailand	0	2	-2
	Other MVs		4	4	0
TV			57	48	9
Dry season and Early wet season					
MV	IR50404	Vietnam	60	59	1
	IR66	1990	26	14	12
	Sen Kra Ob	Thailand	4	8	-4
	Sen Pidao	2002	4	6	-2
	Chhlang Den		2		2
	Kru	1990	1		1
	IR variety		1		1
	Chul'sa	1999	0	9	-9
	IR72	1990	0		0
	CAR9	1996	0		0
	OM		0		0
	OM4900	Vietnam	0	1	-1
	Malis Braing			1	-1
	Other MVs		1	2	
TV			0	0	0



(a) (b)

Figure 1 Grain size (a) and amylose content (b) of rice varieties released in the Philippines, 1966-2014.

Appendix A. Form Used For Expert Elicitation

Expert-level Data Collection Instrument

(To be completed for each step)

Country:_____ Season:

Sub-region/Agro-ecology:_____ Year:

A1. Name of expert/Group name:_____ Iteration step:_____

B. Please provide your estimate of the relative importance of modern varieties vs. traditional varieties as measured by percentage area harvested:

Varietal type	% Area
Traditional/Local/Landraces	B1.
Modern/Improved	B2.
Total	100%

C. Please list all the modern varieties (in descending rank order) you believe farmers are currently growing in this sub-region by season combination	D. Please share your perception of percentage share of area harvested devoted to each variety identified
C1.	D1.
C2.	D2.
C3.	D3.
C4.	D4.
C5.	D5.
C6.	D6.
C7.	D7.
C8.	D8.
C9.	D9.
C10.	D10.
C11. Other Modern/Improved varieties	D11.
Total	100%

E. Please list top 1-2 traditional varieties if percentage area grown to traditional varieties (B2) is >30%	F. Please share your perception of percentage share of area harvested devoted to each variety identified
E1.	F1.
E2.	F2.