J. Indian Soc. Coastal Agric. Res. 38(1): 1-10 (2020) **Review Article**

Augmenting Rice Productivity in Andaman and Nicobar Islands through Improved Varieties and Seed Replacement Rate

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Rice is the staple cereal crop of Andaman and Nicobar Islands with annual paddy production of 12,600 t. The annual rice requirement of the Island populace is around 60,000 t. Therefore, additional requirement of about 47,400 t has to be met by shipment from mainland or enhancing local production. The present per capita availability of rice in the Islands is 40.12 g day^{-1} (14.64 kg yr^{-1}) against the requirement of 175.6 g day^{-1} (64.1 kg yr^{-1}) which is a cause of concern. To meet out the rice requirement, yield enhancement through varietal improvement is very crucial. The ICAR-Central Island Agricultural Research Institute, Port Blair has produced a total of 2.35 t breeder seed and 32.23 t truthfully labelled seed of rice under ICAR-Seed Project and distributed to farmers through "Seed Village Concept" during 2010-17. Thus, seed replacement rate (SRR) of rice has increased to 10.2% from 1.5%, but still there are miles to go ahead to meet the requirement. About 80% of farmers are still using their own farm saved seed. To enhance the rice production, seed chain should be strengthened which not only increases the productivity due to improved seed but also lead to quality control. Farmers' participatory mode of seed production could be a better approach to ensure quality seed and farmers should be trained for establishment of seed villages at community level. Adoption of improved agro-techniques could enhance rice production in the Islands. Marketing and post-harvest facilities should be strengthened by government through establishing the procurement system on the basis of minimum support price (MSP) and mini-modern rice mills in the Islands, respectively.

(***Key words:*** *Breeder seed, Rice, Seed chain, Seed village, Variety and seed replacement)*

Rice is the staple food for more than 50% people of the world (Vanniarajan *et al*., 2012). Rice provides 20% of the world's dietary energy supply followed by wheat (19%) and maize (5%). While brown and white rice have similar calorie and carbohydrate content, former is a whole grain and a good source of magnesium, phosphorus, selenium, thiamine, niacin, vitamin B6 and manganese with high fibre content. India ranks first in area (44 mha), second in production (102 mt) and 9th in terms of productivity, among the rice producing countries in the world. Among the States, West Bengal ranks first in production (14.60 mt) followed by Uttar Pradesh (14.02 mt) and Andhra Pradesh (12.89 mt) (Listz, 2015).

In Andaman and Nicobar Islands (ANI), rice is grown as the major cereal crop and it covers about 4877 ha area of cultivated land (DES, 2016-17). Among the three districts in ANI, the North and Middle Andaman district has the major share of rice growing area (4684.70 ha) followed by the South Andaman district (185.10 ha). Further, the tsunami which struck Indian Ocean during 2004 has rendered a large area of cultivable land unfit, owing to the intrusion of sea water. Since then about 9% (4206.6 ha) of pre-tsunami agricultural land is under partial/permanent submergence. The average annual rainfall of about 3,100 mm is also favourable for rice cultivation in the islands.

The farmers of Islands belong to different socio-ethnic communities *viz*. Bengali, Ranchi, Karens, Tamils, Telugu and Malayali. Each of them is unique in their preference for rice they like to grow. Despite very high yielding varieties available in the Islands, farmers have greater affinity towards local landraces. These landraces cover more than 40% of total area under rice. These local cultivars are highly susceptible to disease but have merits such as minimum management requirements, adaptability to higher rainfall and lowland rain-fed conditions, stability and grain quality including

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aroma. The main attributes for low productivity in rice include lesser area under improved cultivars, lack of genetic purity and potential of popular cultivars, lack of quality seed, susceptibility of major cultivars to biotic and abiotic stress; and improper management practices. About 2,500 ha area of rice is affected by various degrees of abiotic stress like salinity, submergence and drought. The replacement of the existing local cultivars with improved varieties is also limited by low seed replacement ratio due to quality aspects preferred by different communities involved in rice cultivation. Therefore, the obvious and best choice is to grow pest and disease resistant; drought, submergence and salinity tolerant high yielding rice varieties to minimize the loss. The pivotal role of improved seed to obtain food security and farm household livelihood was emphasised by McGuire and Sperling (2011).

Keeping these in view, the present review was undertaken to describe about the different aspects related to rice cultivation in ANI as: 1) The current status of rice cultivation, 2) Seed chain systems, 3) Varietal improvement and varieties in seed chain system, 4) Breeder and TFL seed production and its dissemination, 5) Varietal and seed replacement ratio, 6) Productivity enhancement through HYVs and 7) Future perspectives. For this review, the secondary data obtained from reports of ICAR- CIARI, Port Blair as sub-centre for ICAR- Seed project "Seed Production in Agricultural Crops" of IISR, Mau and Andaman & Nicobar Administration, interaction with extension personnel's, through observations and field experiences in general and seed programme of ICAR- CIARI, Port Blair in particular were used.

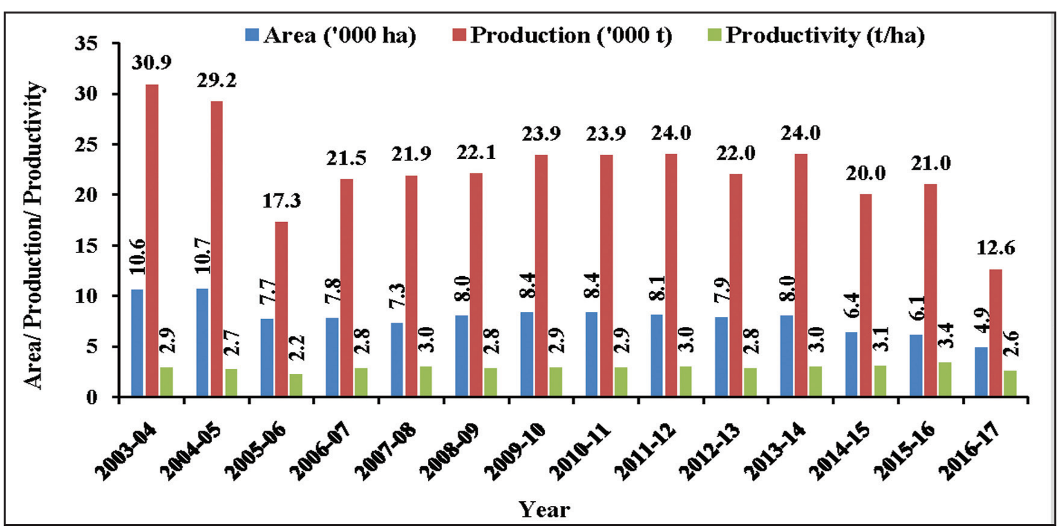
Current status of rice cultivation

Rice is cultivated about 4877 ha area in ANI (Table 1 and Fig. 1). Annual paddy production of this Island is around 12,600 t with productivity of 2.58 t ha^{-1} while the annual rice requirement of island populace is around 60,000 t (Singh *et al*., 2014). Therefore, additional gap of about 47,400 t of rice has to be met either from shipment from mainland or through enhancing local production. The shipment involves transport costs and thus puts additional burden on national exchequer. Alternatively, the demand can be met through enhancing local production of rice. As horizontal expansion of cultivable area is prohibited under Forest Conservation Policy, rice production can only be augmented through improved varieties complemented with quality seed and scientific package of practices

Table 1. *Area, production and productivity of major field crops in A & N Islands (2016-17)*

Crops	Area (ha)	Production (t)	Yield (t ha^{-1})
Paddy	4876.47	12593.54	2.58
Maize	103.50	216.32	2.10
Green Gram	765.90	222.75	0.29
Black Gram	760.75	244.66	0.32
Sugarcane	121.33	1543.64	12.72
Spices	887.59	3597.21	4.05

Source: DES, Andaman & Nicobar Administration, 2016-17



Source: DES, Andaman & Nicobar Administration, 2016-17

Fig. 1. *Trends in area, production and productivity of rice in ANI (2003-04 to 2016-17)*

Seed chain systems

Seed is the most important input for sustainable crop production in agriculture. Quality of seeds is essentially linked to crop yield and production, thus implies that better the quality of seeds, better is the yield. This is true for all agricultural crops, including rice and for all regions of the country (Singh and Kumar, 2014). Seed is the critical determinant of agricultural production on which the performance and efficacy of other inputs depend. The availability of quality seed of improved variety is considered as crucial for realizing productivity and the use of quality seed alone can increase the productivity by 15-20% (Ali, 2016). Seed systems are composed of set of dynamic interaction between seed supply and demand, resulting in farm level utilization of seed and thus plant genetic resource. The seed system is essentially the economic and social mechanism by which farmers' demand for seed and various traits they provide met by various possible sources of supply. Seed system can be defined as a framework of institutions/ farmer producer organizations coming together by their involvement or influence on the seed multiplication, processing, quality assurance and marketing. Three major seed systems *viz*. informal, formal and integrated are being followed in India. Guiding principles in the formal system are notification of varieties in the Act, 1966 and to maintain varietal identity and purity to produce seed of optimal physical, physiological and sanitary quality.

Informal seed system is characterized by small scale supply of locally known varieties without any government interference in quality control. Activity tend to be integrated and locally organized when it embraces most of the other ways in which farmers themselves produce, disseminate and access seed, directly from their own harvest or through exchange/barter among friends, neighbours, relatives and through local grain markets (Chauhan *et al*., 2016). As this evidenced that in India 85% of seed used in farming was produced by the farmer himself (Banerjee, 1984). This informal seed sector was found to be effective in rapidly reaching out to the difficult, inaccessible, small holder pockets of the different regions and it would be a sound alternative method for entrepreneurs to gradually evolve into the formal enterprises. Farmers can produce quality seeds of some self-pollinated crops *viz*., rice, wheat, mustard, and vegetative propagated crops (Neef *et al*., 2004) at their own farm for 2-3 generations, provided they are trained with the suitable package of practices to maintain genetic purity of the concerned crops.

In ANI, there exist two kinds of seed system *viz*. formal and integrated. The formal seed system has been initiated by ICAR- Central Island Agricultural Research Institute (CIARI), Port Blair as novel seed production programme under mega seed project. CIARI continues to make availability of breeder seed of all high yielding notified varieties for Islands as per the indents received from state and other organizations. Further, the farmers' participatory seed production has worked well as far as rice is concerned. The initiative was taken by CIARI during 2011-12 to start seed production at farmers' field and the modus operandi is to enable farmers to produce quality seeds under the guidance of a Breeder from CIARI, buy back the surplus seed and distribute among the farmers (Fig. 2). Besides, integrated seed production system is also in vogue in the Islands.

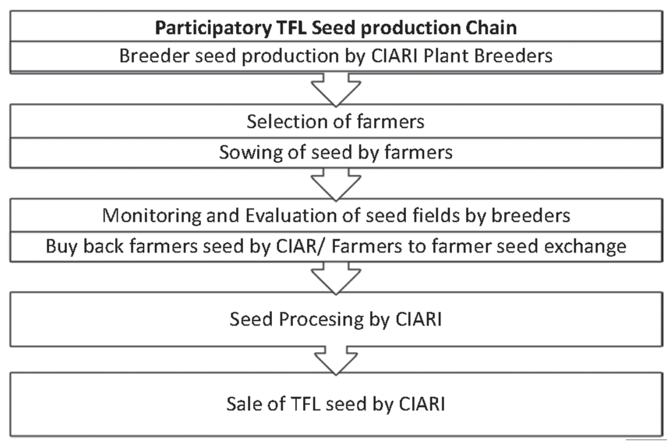


Fig. 2. *Modus operandi of formal seed production initiated by CIARI*

Varietal improvement and varieties in seed chain system

Cultivation of popular local landraces and use of farmers-saved seed from previous year were the main reasons for the low productivity of rice in the Island. High yielding varieties and their quality seed play a very significant role in agriculture. It has been estimated that improved varieties with good quality seed and proper management practices contribute 36-54% to crop production (Zamir Ahmed *et al*., 2014). Since its establishment in 1978, CIARI has initiated a systematic research work on rice varietal improvement. Large numbers of mainland varieties were evaluated for adaptation and various desired characters. These concerted efforts led to the development and release of five rice varieties *viz*. CARI Dhan 1, CARI Dhan 2, CARI Dhan 3, CARI Dhan 4 and CARI Dhan 5 by CIARI (Table 2). These varieties have been recommended by Andaman & Nicobar State Variety Release Committee (Gautam *et al*., 2013). Subsequently, two varieties *viz*. CARI Dhan 1 and CARI Dhan 5 were notified for the ANI in 2017.

Table 2. *Rice varieties developed/introduced by ICAR-CIARI, Port Blair*

Name of Variety	IET No.	Year of release	Maturity days	Yield (t ha^{-1}) (non and salt stress)	Grain type	Recommended ecological condition
CARI Dhan 1	25029	2009	122	>4.5 and NA	MB	Rainfed lowland
CARI Dhan 2	25031	2009	125	>5.0 and NA	LB	Rainfed lowland
CARI Dhan 3	25030	2009	125	>4.8 and NA	LS	Rainfed lowland
CARI Dhan 4	16904	2009	140	>4.5 and >3.2	MB	Rainfed lowland & coastal saline soils
CARI Dhan 5	16885	2009	140	>5.0 and >3.6	MB	Rainfed lowland & coastal saline soils
CARI Dhan 6	25013	2014	120	>5.0 and NA	LS	Rainfed lowland
CARI Dhan 7	25008	2014	125	>5.0 and NA	MB	Rainfed lowland
CARI Dhan 8	25010	2015	180	>3.0 and NA	MB	Rainfed lowland
CARI Dhan 9	25019	2015	180	>3.5 and NA	MB	Rainfed lowland
CSR36	17340	2005	140	>5.5 and >4.0	MS	Sodic & saline soils
CSR23	13769	2004	130	>5.5 and >3.5	LS	Sodic & saline soils
Ranjeet	12554	1994	135	>5.0 and NA	MS	Rainfed shallow lowland
Gayatri	8022	1988	135	>6.0 and NA	SB	Rainfed shallow lowland

MB= Medium bold; LB= Long bold; LS= Long slender; MS= Medium slender; SB= Short and bold
Source: Technical Bulletin, ICAR- CIARI, Port Blair (Gautam et al., 2016)
Note: NA indicates not applicable

Besides this, recent efforts have been made by the CIARI for identification of new high yielding, disease resistant and adaptable rice varieties for Island condition. Consequently, two new medium duration rice varieties *viz*. CARI Dhan 6 and CARI Dhan 7 have been developed and recommended by Institute Variety Release Committee (IVRC), which are high yielding and possess resistance to bacterial leaf blight (BLB) (Gautam *et al*., 2015). Efforts have also been made to purify popular landraces like C14-8 to offer pure and elite strains to the farmers. These efforts resulted in the release of CIARI Dhan 8 and CIARI Dhan 9 which gives more than 20% yield advantage over the landrace C14-8. Further, some high yielding rice varieties suitable to these Islands were also introduced from mainland of India *viz*. CSR 36 (salinity tolerant), Gayatri and Ranjit (high yielding). Out of these, five rice varieties *viz*. CARI Dhan 4, CARI Dhan 5, CARI Dhan 7, CSR 36 and Gayatri are the highly preferred and demanded in the Islands.

Breeder seed production

For any viable seed chain system, production and supply of adequate breeder seed is very essential. CIARI is producing breeder seed of high yielding rice varieties as per indents received from Agricultural Department of the Union Territory and other organisations for production of foundation, certified/truthfully labelled seed. It ensured timely availability of quality seed to farmers of ANI and also to maintain the effective seed chain system of the Island. The total requirement of rice breeder seed of the Island is about 0.61 t yr^{-1}. Against this, totally 2.35 t of breeder seed of high yielding rice varieties has been produced by CIARI during 2010-17 (Table 3 and Fig. 3).

TFL seed production under Seed Village Concept

India is one among of the few countries in the World, following the 'Farmers Participatory Seed Production' (Chowdhury *et al*., 2010) where the seed sector has advanced in parallel with the agricultural productivity. However, availability of quality seed of improved varieties and hybrids is grossly inadequate and is one of the major constraints for enhancing production. In this Island also the non-availability of quality seed has been one of the major constraints in improving the rice productivity. It is estimated that about 48.76 t of quality seed [certified/truthfully labeled seed (TFL)] and 0.61 t breeder seed of rice is required to reach desired seed replacement of 33% in the Islands annually. CIARI and Department of Agriculture are producing rice seed of about 10 t yr^{-1}, which is only about 20.5% of total rice seed requirement of Islands. Under ICAR-Seed project, total of 29 farmers were involved in TFL seed production through farmer's participatory mode. In this program, total of 32.23 t TFL seed of rice of 11 HYVs were produced during 2010 to 2017 (Tables 3 and 4). It was also extended to KVK, North and Middle Andaman for TFL seed production. Besides that, Out Reach Centre (ORC) project had introduced an innovative "Seed Village Concept" in 2011 to produce TFL seeds in participatory mode involving breeders, social scientists and farmers of North and Middle Andaman. A total of 38 progressive farmers were selected from 13 villages and breeder seed of improved varieties were given for TFL seed production. To maintain the seed purity and quality, rice fields were visited and monitored from time to time. Rouging was done at three different stages of the crop *viz*. vegetative, flowering and maturity stage.

Table 3. *Breeder seed production (tonnes) of rice by CIARI, Port Blair over the years 2010-17*

Variety	2010	2011	2012	2013	2014	2015	2016	2017	Total
CARI Dhan 1	0.011	0.004	0.003	0.042	0.043	0.01	0.006	0.007	0.126
CARI Dhan 2	0.008	0.005	0.007	0.034	0.032	0.02	0.025	0.022	0.153
CARI Dhan 3	0.012	0.01	0.018	0.03	0.034	0.01	0.005	0.006	0.125
CARI Dhan 4	0	0.024	0.036	0.063	0.01	0.04	0.049	0.032	0.254
CARI Dhan 5	0.279	0.2	0.047	0.044	0.16	0.026	0.055	0.024	0.835
CARI Dhan 6	0	0	0	0.044	0.011	0.065	0.036	0.024	0.18
CARI Dhan 7	0	0	0	0.049	0.011	0.047	0.036	0.017	0.16
CARI Dhan 8	0	0	0	0	0.018	0.04	0.037	0.098	0.193
CARI Dhan 9	0	0	0	0	0.025	0.087	0.057	0.16	0.329
Total	0.31	0.243	0.111	0.306	0.344	0.345	0.306	0.39	2.355

(Source: Compiled from Annual Reports of ICAR Seed Project: "Seed Production in Agricultural Crops", ICAR- CIARI, Port Blair during 2010 to 2017)

TFL seed dissemination

To meet the rice seed requirement of Island farmers, the TFL seed produced under farmer participation was purchased from the farmers through buyback system and processed quality seed was disseminated to Island farmers at nominal price. About 21.44 t seed of 11 rice varieties *viz*. CARI Dhan 3, CARI Dhan 4, CARI Dhan 5, CARI Dhan 6, CARI Dhan 7, CARI Dhan 8, CARI Dhan 9, Ranjeet, CSR 36, CSR 23 and Gayatri were given to farmers, which coverd about 714.72 ha of area across 64 villages during 2012-18 (Tables 5 and 6).

Under transfer of technology and popularization of rice varieties, a total of 6.8 t TFL seed was given to the farmers for Front Line Demonstrations through CIARI, ORC and KVKs. Moreover 3.4 t TFL seed was provided to Agriculture Department and NGOs (1.25 and 2.14 t) respectively. Similarly, 5.33 t rice seed was also given in the tribal dominated areas (Campbell Bay and Hut Bay) of ANI under Tribal Sub Plan (TSP) now it is Scheduled Tribe Component (STC). The higest area under single variety was CSR 36 (187.60 ha) followed by CARI Dhan 5 (115.27 ha) and CARI Dhan 4 (111.63 ha) accounting 36, 16 and 15.5% of the area respectively (Fig. 3). It ensured availability of good quality seed of HYVs of rice in time to the Island farmers.

Table 4. *Truthfully labelled (TFL) seed production (tonnes) of rice by CIARI, Port Blair during 2011-17*

Variety	2011	2012	2013	2014	2015	2016	2017	Total
CARI Dhan 1	0	0	0	0	0	0	0	0
CARI Dhan 2	0	0	0	0	0	0	0	0
CARI Dhan 3	0	0.17	0.66	0	0	0	0	0.83
CARI Dhan 4	0	0.15	0.51	0.92	1.46	0.82	1	4.85
CARI Dhan 5	1.19	1.13	0.75	0.43	0.31	0.8	1	5.61
CARI Dhan 6	0	0	0.01	0.12	1.04	0.92	0.78	2.87
CARI Dhan 7	0	0	0	0.03	1.03	1.16	1.07	3.29
CARI Dhan 8	0	0	0	0	0.2	0.01	0.05	0.26
CARI Dhan 9	0	0	0	0	0	0.24	0.11	0.35
Ranjeet	0.11	0.5	0.03	0	0.02	0	0	0.65
CSR 36	1.02	1.25	0.66	1	1.08	0.8	0.94	6.74
CSR 23	0.58	0.2	0	0	0	0	0	0.78
Gayatri	0	0.71	1.04	1.15	1	1	1.1	6
Total	2.9	4.11	3.66	3.65	6.14	5.75	6.05	32.23

(Source: Compiled from Annual Reports of ICAR Seed Project: "Seed Production in Agricultural Crops", ICAR- CIARI, Port Blair during 2011 to 2017)

Table 5. *Seed disseminated of rice varieties (tonnes) over the years during 2012-18*

Variety	2012	2013	2014	2015	2016	2017	2018	Total
CARI Dhan 3	0.000	0.095	0.553	0.000	0.000	0.000	0.000	0.626
CARI Dhan 4	0.000	0.170	0.410	0.551	1.068	0.700	0.500	3.259
CARI Dhan 5	0.681	0.621	0.700	0.110	0.096	0.700	0.500	3.308
CARI Dhan 6	0.000	0.000	0.000	0.103	0.400	0.800	0.640	1.943
CARI Dhan 7	0.000	0.000	0.000	0.000	0.974	0.990	0.367	2.281
CARI Dhan 8	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.050
CARI Dhan 9	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.012
CSR 23	0.200	0.165	0.000	0.000	0.000	0.000	0.000	0.365
CSR36	0.563	1.535	0.495	0.700	1.105	0.630	0.600	5.628
Ranjeet	0.038	0.324	0.000	0.000	0.000	0.000	0.000	0.362
Gayatri	0.000	0.643	1.029	0.113	0.560	0.830	0.120	3.295
Total	1.482	3.553	3.187	1.577	4.203	4.650	2.789	21.441

(Source: Compiled from Annual Reports of ICAR Seed Project: "Seed Production in Agricultural Crops", ICAR- CIARI, Port Blair during 2012 to 2018)

High yielding varieties (HYVs) of CIARI entered the farmers' seed chain

HYVs of rice developed/introduced by CIARI have significantly replaced the local varieties and entered the farmers' seed chain. A participatory rural appraisal (PRA) conducted in December 2015 to assess the adoption and spread of high yielding rice varieties in the region revealed that a total of 4,919 farmers have adopted the HYV of rice in an area of 2,109.06 ha spread across 35 cluster villages in North & Middle Andaman district (Fig. 4). Variety Gayatri shared 1,259.31 ha of area followed by CARI Dhan 5 (284.82 ha), CSR 36 (225.61 ha), CARI Dhan 4 (181.06 ha), CARI Dhan 3 (79.41 ha), CSR 23 (55.11 ha), Ranjeet (20.68 ha), CARI Dhan 6 (2.53 ha) and CARI Dhan 7 (0.54 ha).

Table 6. *Area under rice HYVs during 2012-18*

Variety	Area (ha)							
	2012	2013	2014	2015	2016	2017	2018	Total
CARI Dhan 3	0.00	3.17	17.70	0.00	0.00	0.00	0.00	20.87
CARI Dhan 4	0.00	4.33	13.33	18.37	35.60	20.00	20.00	111.63
CARI Dhan 5	22.70	20.70	25.00	3.67	3.20	20.00	20.00	115.27
CARI Dhan 6	0.00	0.00	0.00	4.17	13.33	33.33	21.33	72.17
CARI Dhan 7	0.00	0.00	0.00	0.00	32.48	31.33	13.90	77.72
CARI Dhan 8	0.00	0.00	0.00	0.00	0.00	0.00	1.67	1.67
CARI Dhan 9	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.40
CSR 23	6.67	5.50	0.00	0.00	0.00	0.00	0.00	12.17
CSR36	18.77	51.17	16.50	23.33	36.83	21.00	20.00	187.60
Gayatri	0.00	21.43	34.30	3.77	18.67	21.00	4.00	103.17
Ranjeet	1.27	10.80	0.00	0.00	0.00	0.00	0.00	12.07
Total	49.40	117.10	106.83	53.30	140.12	146.67	101.30	714.72

(Source: Compiled from Annual Reports of ICAR Seed Project: "Seed Production in Agricultural Crops", ICAR- CIARI, Port Blair during 2012 to 2018)

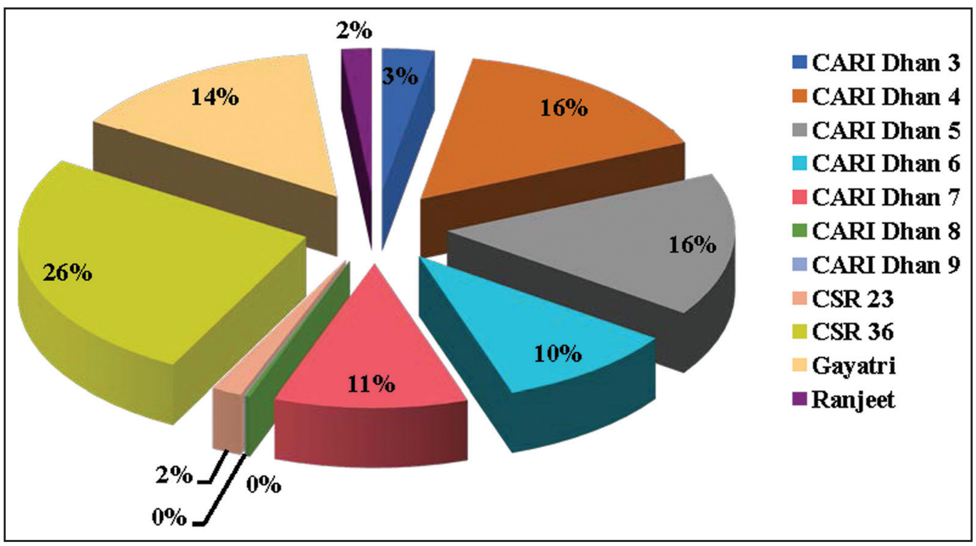


Fig. 3 *Proportion of seed production under different HYV varieties during 2012-18 (Source: Annual Reports of ICAR Seed Project: "Seed Production in Agricultural Crops", ICAR- CIARI, Port Blair during 2012 to 2018)*

Variety and seed replacement

Seed Replacement Rate (SRR), the number of generations up to which the seed could be used from the previous crop is one of the important aspects of crop production. Seed renewal period as recommended by the National Commission on Agriculture (1976) for paddy is three years. At present, the level of SRR for field crops in India is 5-70% (Roy, 2011). A substantial amount of farm-saved seed is being used by the farmers in the Islands generally in self-pollinated crops like rice and pulses. Since its inception, lot of efforts have been made by CIARI for developing improved high yielding, biotic and abiotic stress tolerant rice varieties for normal and saline soils of ANI conditions. As the high yielding rice varieties *viz*. CARI Dhan 3, CARI Dhan 4, CARI and Dhan 5, CARI Dhan 6, CARI Dhan 7, CARI Dhan 8, CARI Dhan 9, CSR 36 CSR 23, Ranjeet and Gayatri were given to farmers, the old, traditional and low yielding rice varieties *viz*. C14-8, Jaya, Jagnnath, Lal Sanno, Pagla Jaya, Ranchi Dhan and Silver Jaya have

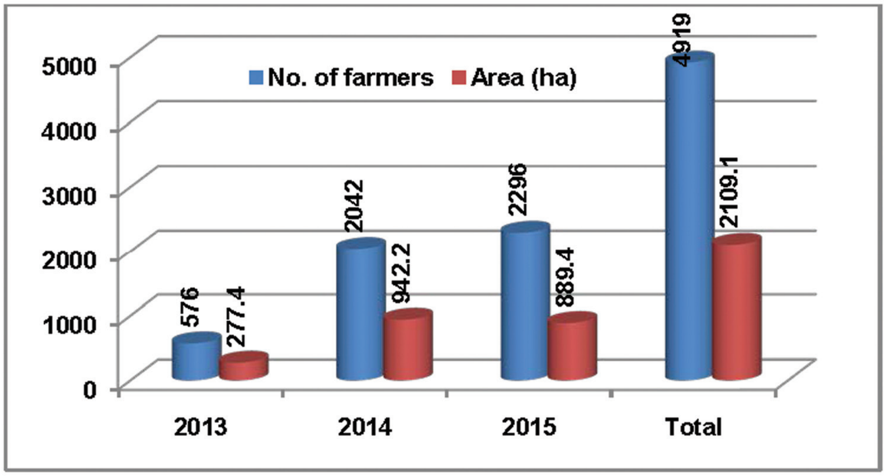


Fig. 4. *Horizontal spread of HYV of rice in North and Middle Andaman*

been replaced, resulting in the reduction of farm-saved seed and significant increase in seed replacement rate (SRR) from 1.5% to 10.2% in the Islands. This low SRR in Islands might be due to lack of awareness about SRR, economic status of farmer, farm size, inadequate supply of seed, traditional way of cultivation, use of farm saved seed, poor extension services, etc. Similar findings were obtained for low SRR in a case in Assam by Kakoty and Barman (2015).

Productivity enhancement

A study carried out from 2013-14 to 2015-16 at farmers' field in 16 villages of rice dominant North & Middle Andaman districts revealed an increase in the productivity of improved rice varieties developed by CIARI over the local varieties by 14-50% (average 30.4%). But the actual yield realized by farmers was found to be much below the yield potential of the varieties (Extension Gap) by 0.84 to 1.62 t ha^{-1} while the Technology Gap, which is attributed to the varying soil fertility and weather conditions across the region ranged between 0.13–1.50 t ha^{-1} (Zamir Ahmed *et al*., 2017).

Future perspectives

The actual milled rice production in the ANI is about 6,930 t. The present per capita availability of rice in the Islands is about 40.12 g day^{-1} (14.64 kg yr^{-1}) against the requirement of 175.6 g day^{-1} (64.1 kg yr^{-1}) is a cause of big concern. Rest of the rice requirement is fulfilled by shipment from mainland India. There could be a comprehensive strategy for enhancing rice production in ANI. Yield enhancement through varietal improvement could be a first approach; new high yielding rice varieties having multiple resistance to biotic and abiotic stress should be developed/ introduced. As bacterial blight is the major disease of rice in the Islands, resistant varieties can be developed for wider adoptability and habitation. About 2,500 ha land has been affected by various levels of salinity. The salt tolerant rice varieties having submergence resistant genes can also be developed for vertical and horizontal expansion and increased productivity of rice area in the Islands.

Strengthening of seed chain system could be a second approach for rice production enhancement. At present there is no viable seed chain system existing in the Islands, which led to meagre seed replacement and thus low production and productivity of crop. The seed chain of nucleus seed to breeder seed to foundation seed to certified/TFL seed must come in force so that Island farmers get best quality seed. This seed chain not only increases the productivity due to improved seed availability but also lead to quality control of seed. The seeds of only notified varieties or recommended varieties for Islands should find an agenda in seed distribution chain by different agencies. CIARI being a research institute should hold the responsibility of providing breeder or foundation seed to interested parties for seed production, be it public or private or farmer association, while the Development Department should share the responsibility of seed multiplication as per Seed Act. Farmers' participatory seed production could also be a better approach in quality seed production. The farmers could be trained for establishing seed villages and community seed banks. Adaptation of modern agro-techniques could be a third approach as farmers are still cultivating rice by traditional cultural practices. They never use fertilizer even for growing high yielding rice varieties which are much responsive to fertilizers. Optimum dose of fertilizers and insecticides/pesticides could be used to enhance rice production in the Islands.

Marketing and post-harvest facilities could be a fourth approach; at present there is no system of procurement of rice like mainland Indian states with Minimum Support Price (MSP). Unless organized marketing facility is provided, rice production will not leap forward. There is a lot of burden on the Government to bring rice from mainland and then distributing among different Islands through retail chains and public distribution system. The gap between production and import is likely to widen with the implementation of Food Security Act, further increasing load on government and taxpayers. It would be an intelligent and timely option to establish the procurement, processing, storage and distribution system at Island level which will drastically reduce the burden of importing rice for each Island and it will finally curtail the expenditure on subsidies and transportation cost.

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