Original Research Article

Assessment of Yield Potential of Paddy Variety CR 1009 sub 1 to impart resilience to farmers in NICRA village, Thiruvarur district, Tamil Nadu

ABSTRACT

The study was conducted in the villages of Rayapuram and Keezhapattu in Tamil Nadu, as part of the National Innovation on Climate Resilient Agriculture (NICRA) project in the Needamangalam district of Thiruvarur from 2015 to 2018. These villages frequently experienced floods, particularly impacting the rabi season's crop growth and maturity. The monsoon season (September to December) contributed to about 71% of the total rainfall. A comparative analysis was carried out to assess the economic performance of the flood-resistant paddy variety CR 1009 sub 1 in contrast to the commonly grown CR 1009. Traditionally, farmers in Rayapuram and Keezhapattu favored CR 1009 due to its high market value during the monsoon period. However, they faced low income due to flooding in the rabi season. To address this challenge, scientists from KVK, Thiruvarur, recommended the flood-tolerant paddy variety CR 1009 sub 1 for cultivation during the rabi season under the "National Innovations in Climate Resilient Agriculture (NICRA)" project. Specific climate-resilient technologies, including flood-tolerant paddy variety "CR 1009 sub 1" and a high-yield, long-duration rice variety, were tested and demonstrated in the project villages to ensure rice production despite climatic variations leading to floods. It was crucial to assess how these varieties responded to climate vulnerabilities and how receptive farmers were to adopting them. Calculations were made to compare paddy productivity and economic returns under the improved technology with the traditional practices of farmers. The results indicated that the "CR 1009 sub 1" variety yielded higher harvests compared to the farmers' practices in the years 2015–16, 2016–17, and 2017–18, with increases of 12.60%, 11.69%, and 12.95% respectively. Furthermore, using improved technologies for paddy cultivation generated higher net returns of Rs. 57233, 60768, and 57728 per hectare in 2015–16, 2016–17, and 2017–18, respectively, in contrast to the farmers' practices (which yielded Rs. 49147, 50295, and 46266 per hectare in the same years). In comparison to the farmers' practices (with an average net return of Rs. 48569 per hectare and a benefit-cost ratio of 2.37), the demonstration fields showed an average net return of Rs. 58576 per hectare and a benefit-cost ratio of 2.56.

Key words: Climate resilient paddy, CR 1009 sub 1, Improved Practices, Economics

1.INTRODUCTION

One of the most important crops in the world, rice (*Oryza sativa* L.) is a staple food in Asia, contributing to 35–60% of the calories that around three billion people eat every day [6]. For nearly fifty per cent of the world's population, especially those in countries that are developing, rice is the primary food. Rice production has adverse effects in low-lying regions that receive delayed, but heavy rain and because of this, the crop frequently gets exposed to a number of abiotic stresses in various growth stages, namely early drought, later waterlogged as well as soil salinity. Sea level rise brought on by global climate change and erratic rainfall distribution has contributed to these severe problems in recent years. Submergence has been found to be the third most significant barrier to improving rice productivity, especially in Eastern India [9]. Rain fed low land accounts for approximately 29 per cent of India's 16.1 million hectares (M ha) of total rice area, or 19% of the nations' rice production. In most of flood-prone areas in South and Southeast Asia, rice is the primary crop. In low-lying areas which get monsoon rains, flooding or submergence are frequently observed that have an adverse effect on crop life and development and generate significant losses in production. It causes a complex abiotic stress in environments that are prone to flooding because it significantly decreases crop stand, especially when it happens in the initial phases of vegetative development and lasts more than a week. Of the almost 44 million hectares of rice that are cultivated in India, 16.1 million are fed by precipitation. Rice is grown in a variety of ecologies, from uplands to deep-water places of which 4.4 M hectares are medium rain fed lowlands that are highly vulnerable to submergence [7]. Furthermore, irrigated and rain-fed lowlands could potentially suffer submergence. While the Cauvery Delta regions of Tamil Nadu constitute more than half of the state's rice production, with about 21.65 lakh hectares under rice cultivation, they are also more susceptible to flash and severe flooding. Advanced flood-tolerant plant varieties can be used to improve the ability of farmers to cope with heavy flood events [10].

Thiruvarur district in Tamil Nadu is a major paddy producing district in Tamil Nadu. The National Innovations in Climate Resilient Agriculture (NICRA) project was conducted in the villages Rayapuram and Keezhapattu of Needamangalam block in Thiruvarur district. With a geographic area of about 920 ha, the village of Rayapuram has a population of 3176 (846 farm families/households). During the Samba season (September through January), paddy is the main crop grown. Flooding was a climatic vulnerability in the village. Due to heavy, prolonged rainfall and cyclones during this time, the village's main issue in this season is paddy crop submersion for roughly 10 to 15 days. As a result, the farmers in the village waste all of the paddy straw and lose about 75% of their paddy grain production. The Thiruvarur district is one of the area that is most vulnerable to natural disasters, especially from September to November, which causes varying degrees of damage to wet season rice and other field crops.

CR 1009-Sub1 and Swarna-Sub1, two popular flood-tolerant rice cultivars, may mitigate the impacts of field inundated and ensure an acceptable yield [11]. Because farmers favored the rice variety CR1009 for its higher yield level, it was cultivated in a majority of locations. In general, submergence continues for about 15 days, which is whenever the crop reaches its vegetative phase of 30 days after transplanting, and then it recedes. This type is unable to cope with flood water stagnation that continues for more than a week that significantly decreases yield levels and may result in a 50% yield loss. An improved version of CR 1009, CR 1009 sub-1, has the Sub-1 gene which gives submergence tolerance at the vegetative stage and tolerance at seedling stage for 15 days immediately after transplantation .The work was carried out at the International Rice Research Institute (IRRI), Philippines. With moderate resistance to brown spot, blast, brown plant hopper (BPH), and white backed plant hopper (WBPH), this variety produced a mean grain yield of 5759 kg ha^{-1} in 155 days. Short bold rice with a significant milling percentage and high head rice recovery was discovered in the CR 1009 sub-1. High amylose rice with a medium gelatinization temperature and a soft gel consistency which makes it ideal for idly production; this particular variety is recommended as an alternative for CR 1009.

After DNA-based Marker Assisted Selection (MAS) [17], this was evaluated by Tamil Nadu Agricultural University in flood-prone areas of Tamil Nadu, an improved variant of CR1009 with Sub1 was further developed at IRRI. Under submergence condition, CR1009 Sub1 outscored CR1009 and matured in 155 days. These results have been confirmed by multiple tests of submergence tolerance carried out in farmers' fields and greenhouses [18], and the same result has been observed in flood-prone places [1] for the Swarna sub 1 variety. According to [4], introducing this variety will significantly increase rice yield in low-lying places.

Since 2015 to 2018, flood-tolerant varieties were evaluated for suitability in an effort to lessen the situation. The goal of growing submergence tolerant varieties is to produce higher yield in such unpredictable, unfavorable conditions (particularly on stagnant water conditions).

A project called "NICRA" was started in June 2015 with this goal in mind as well as the desire to produce submergence high yielding rice in flood-affected Needamangalam block in Thiruvarur district of Tamil Nadu. In agricultural trials, CR 1009 sub-1 has proven to be able to withstand floods for up to 17 days. The most common variety of rice grown in lowland areas is CR 1009 sub-1[15]. High production potential and water resistance are two qualities of CR 1009 sub-1. Along with better agronomic practices, other factors that affect paddy production and productivity include farmers' lack of knowledge about new, high yielding varieties and their failure to adopt the right set of practices. In order to introduce and popularize the sowing of the CR 1009 sub-1 variety of paddy in actual farm settings, Krishi Vigyan Kendra, Needamangalam (TN), had undertaken demonstrations.

2.METHODOLOGY

2.1.Details of Study area

The demonstration was conducted in Rayapuram and Keezhpattu villages of Needamangalam block of Thiruvarur district in Tamil Nadu. These village are located 25 meters above mean sea level of cauvery delta zone of Tamil Nadu at 10°26'59 N latitude and 79°35'10 E longitude (Fig.1). During the rabi seasons of 2015–16 to 2017–18, demonstrations were held on 500 farmer fields in the NICRA villages of Rayapuram and Keezhapattu in the Thiruvarur district on medium to deep black soils with low to medium fertility status under a rice-based cropping system.

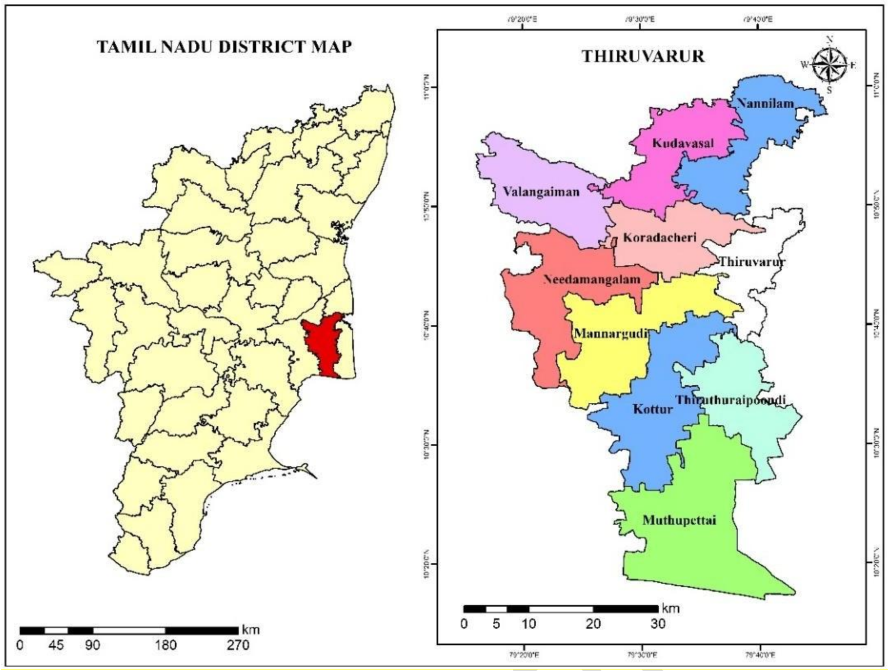


Fig1. Location of Study area in Thiruvarur district of Tamil Nadu, India

2.2. Rainfall details

In the villages covered by NICRA, there is a three-part pattern of rainfall distribution. The first part being the southwest monsoon from June to September and second being the North east monsoon from October to December and third part during summer season from January to May that occur due to the seasonal changes.

The NICRA village received higher amount of rainfall during the month of October, November and December (Table 1).The monthly average rainfall above 100 mm occurred in August (118.9 mm), October (135.2 mm), November (285.8 mm) and December (118.9 mm).The minimum average monthly rainfall was received in the month of March (7.3 mm), June (30 mm), July (31.8 mm) and January (37.1 mm).

Table 1. Distribution of Rainfall in NICRA village (2015-2018)

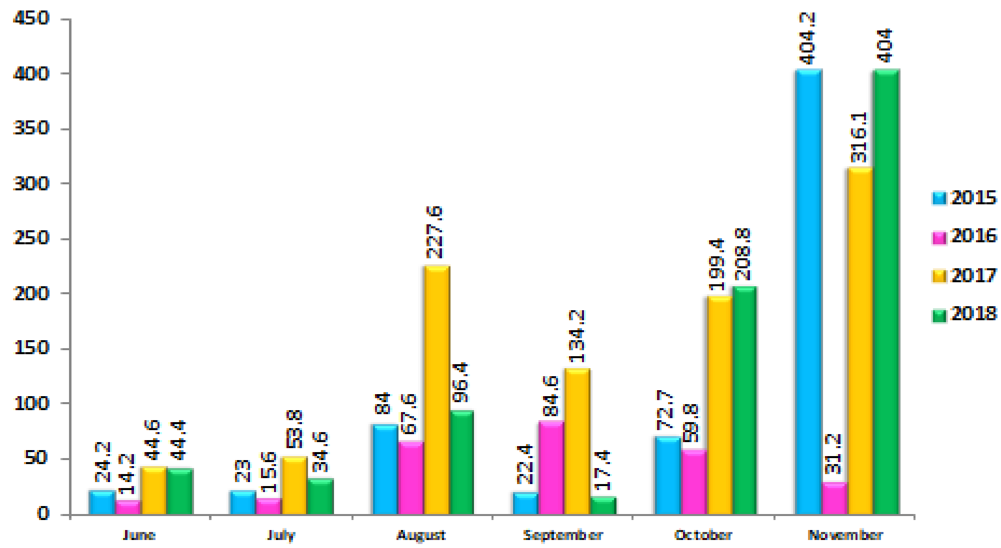
Month	Normal rainfall (mm)	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Average monthly rainfall
January	55	0.00	0.00	107.6 (7)	40.8 (2)	37.1
February	16	0.00	0.00	0	00.0 (0)	0.0
March	19	7.6 (2)	0.00	19.4 (5)	2.0 (1)	7.3
April	38	105.4 (4)	0.00	0	67.2 (5)	43.2
May	53	60.6 (10)	156.4 (7)	31.6 (3)	60.4 (2)	77.3
June	35	24.2 (5)	14.2 (3)	44.6 (5)	36.8 (3)	30.0
July	56	23 (2)	15.6 (2)	53.8 (3)	34.6 (2)	31.8
August	113	84 (7)	67.6 (6)	227.6 (11)	96.4 (4)	118.9
September	101	22.4 (2)	84.6 (6)	134.2 (11)	17.4 (2)	64.7
October	200	72.7 (12)	59.8 (3)	199.4 (10)	208.8 (9)	135.2
November	284	404.2 (22)	31.2 (5)	303.8 (19)	404.0 (12)	285.8
December	170	240.6 (13)	27.8 (3)	188.6 (5)	18.4 (2)	118.9
Total	1140	870.9 (79)	457.2 (35)	1310.6 (79)	986.8 (44)	

(Numbers in brackets indicates number of rainy days)

In particular, an average of 61.3 mm of rainfall occurred during the South West monsoon, which extended from June to September, and 179.9 mm occurred during the North East monsoon, which extended from October to December. There was just an average of 21.9 mm of rainfall in the summer.

Notably, in October and November, there were an increased number of days with substantial rainfall (exceeding 60 mm per day) compared to the usual pattern, particularly in the years 2015, 2017, and 2018, as illustrated in Figure 2. This led to waterlogging issues during the vegetative and flowering stages of the rabi paddy crop, subsequently impacting its overall yield, as indicated in Table1.

Fig. 2. Rainfall characteristic of NICRA Villages in Rabi Season (2015 – 2018)



2.3. Technology Intervention

For demonstration purposes, the improved variety CR 1009 sub-1 was purchased from the Tamil Nadu Agricultural University in Coimbatore. The farmers adhered to the custom of transplanting in the case of the neighborhood check plots. Through demonstration trials, the whole package strategy was shown to farmers and included elements like enhanced variety, line transplanting, advised seed rate, seed treatment, weed and water management, fertilizers, and plant protection techniques (Table 2). Farmers were given essential inputs in the form of improved CR 1009 sub-1 variety seed and balanced fertilizers for the demonstration plots. For local checks, customary procedures were followed. Krishi Vigyan Kendra scientists assisted the farmers taking part in the demonstrations in carrying out proper field operations like timely sowing, transplanting, spraying, and harvesting. Field days, farmer trainings, diagnostic visits, and other extension activities were carried out during this time period with the help of the farmers.

Table 2: Improved production technology and Farmers practices of Paddy under Demonstration

S. No	Technology	Improved practices	Farmers practice	GAP(%)
1.	Variety	CR 1009 sub 1	CR 1009	Full gap
2.	Land preparation	Ploughing and levelling	Ploughing and levelling	Nil
3.	Pre emergent herbicide	Pendimethalin @2.5 l/ha	No herbicide	Full gap
4.	Seed rate	30 kg/ha	75 kg/ha	Partial gap
5.	Seed treatment	Biofertilizers &	No seed treatment	Full gap

		Pseudomonas		
6.	Fertilizer dose	INM	Indiscriminate application	Partial gap
7.	Irrigation	Alternative wetting & drying	Surface irrigation	Partial gap
8.	Plant protection	IPM	Indiscriminate application	Full gap

By using a random crop cutting method, the yield data were gathered from both the farmers' practice and the demonstration. Quantitative information was taken from qualitative data and expressed as a percent increase in yield. Simple statistical tools of maximum, minimum, mean, cost of cultivation, gross return, net return were used to further analyze the data. The benefit cost ratio, extension gap, technological gap, and technological index [17] were calculated as follows:

Technology gap = Potential yield - Demonstration yield -- 1

Extension gap = Demonstration yield - Farmers' yield -- 2

$$\text{Technology index (\%)} = \left\{\frac{\text{Technology gap}}{\text{Potential yield}} \times 100\right\} \quad \text{------ 3}$$

3. RESULTS AND DISCUSSION

3.1. Constraints in Paddy production

The main data analysis for the years 2015–2016 were collected before the demonstrations. Primary data was collected by personal interviews and pretested planning with the group of respondents. A random choice of 100 paddy farmers had been chosen from the study area. Relevant data had been collected with a pre-tested planned routine. General information, holding size, varieties used, and inputs used, cultivation expense, and opinions regarding different production and marketing constraints faced by paddy farmers constitute some of the data collected by the respondents. Interviews with the respondents were conducted at their homes as well as at a community meeting point. The responders were provided with a description of the study's objective. Preferential ranking techniques were used to identify the paddy cultivation problems experienced by the farmers who responded. Ranking by Preference is a technique to implement suitable improvements and solutions in their community and area. Participants can assess and determine issues or preference with the use of a participatory technique termed preference ranking.

Table 3 lists the rankings given by the various farmers. The results show that the three main constraints were a lack of suitable high yielding varieties (84.63%), sucking pest incidence (Leaf folder and Stem borer) (80.27%), and delayed sowing (73.34%). Similar results were published by [20]. The demonstrations were carried out using the high yielding paddy variety (CR 1009 Sub 1) and other crucial cultivation inputs in accordance with the constraints.

Table 3. Ranks given by farmers for different constraints.

Sl. No	Constraints	RBQ	Overall Rank

1.	Lack of high yielding varieties	84.63	I
2.	Sucking pest incidence (Leaf folder & Stem borer)	80.27	II
3.	Delayed sowing	73.34	III
4.	Water logging	71.20	IV
5.	Non adoption of seed treatment	66.00	V
6.	Inadequate nutrient management	63.20	VI
7.	Weed infestation	54.22	VII
8.	Bacterial leaf blight	51.76	VIII
9.	Labour shortage	36.00	IX

RBQ - Rank Based Quotient

3.2. Crop Performance and Yield

During rabi 2015-16, 2016-2017, and 2017-18, the yield of paddy harvested for the demonstration was 62.10, 64.26, and 60.05 q ha^{-1}, respectively (Table 4). By comparison to farmers' practices, the improved practices increased yield by 12.60, 11.69, and 12.95%. The increase in yield for the rice and other crops being tested has been amply documented [13], [8],[13] and [21].

Table 4. Impact of improved production technology on productivity of Paddy

Year	No. of demonstration	Area (ha)	Demo	Local check	% increase in yield over local check
2015-16	100	40	62.10	54.27	12.60
2016-17	200	80	64.26	56.75	11.69
2017-18	200	92	60.05	52.27	12.95
Total	500	212	186.4	163.3	37.2
Average	250	106	93.2	81.6	18.6

3.3. Technology Gap

The difference between potential yield and the yield of a demonstration plot is the technology gap. The demonstration plots' technology gaps were 7.90, 5.74, and 9.95 q/ha in 2015–16, 2016–17, and 2017–18, respectively (Table 4). On average, there was a 7.86 q/ha technology gap under three years of demonstration. The observed technology gap may be attributed to differences in local climatic conditions mainly rainfall, crop production, crop protection methods, and soil fertility status.

3.4. Extension Gap

The term "extension gap" refers to the variations in yield between farmers and demonstration plots. The extension gap was 7.83, 7.51, and 7.78 q/ha in 2015–16, 2016–17, and 2017–18, respectively (Table 4). In a three-year demonstration program, the average extension gap was 7.71 q/ha, highlighting the need for farmers to be educated about adopting better production and protection technologies through various extension programs, such as demonstration. This alarming trend of a bounding extension gap will be changed by increasing the use of cutting-edge production practices with high yielding varieties.

3.5. Technology Index

Technology Index demonstrates the viability of advanced technology in agricultural settings. Higher technology feasibility is associated with lower technology index values [3]. According to Table 5, the technology index ranged from 8.20 to 14.21 percent. During the three years of the demonstration program, a technology index of 11.23 percent on average was seen, demonstrating the effectiveness of technical interventions that perform well. This will hasten the adoption of technical solutions that have been proven to increase paddy yield performance.

Table 5. Impact of paddy var. CR 1009 sub 1 on potential yield, demonstration yield, farmers yield, technological gap, extension gap and technology index

Sl. No	Potential yield (q ha^{-1})	Demonstration yield (q ha^{-1})	Farmers yield (q ha^{-1})	Technological gap	Extension gap	Technology index
1.	70.00	62.10	54.27	7.90	7.83	11.28
2.	70.00	64.26	56.75	5.74	7.51	8.20
3.	70.00	60.05	52.27	9.95	7.78	14.21
Average	70.00	62.14	54.43	7.86	7.71	11.23
Total	210.00	186.41	163.29	23.59	23.12	33.69

3.6. Economic Return

Based on the information provided in Table 6, the adoption of new technology in the paddy industry demonstrated varying costs but proved to be more financially advantageous. When compared to traditional farmer practices (amounting to Rs. 49147, 50295, and 46266 per hectare in 2015–16, 2016–17, and 2017–18, respectively), employing advanced technologies for paddy cultivation resulted in higher net returns of Rs. 57233, 60768, and 57728 per hectare for the same respective years. Furthermore, in contrast to the farmers' practices with a return of Rs. 48569 per hectare and a benefit-cost ratio of 2.37, the demonstration fields yielded an average net return of Rs. 58576 per hectare and a benefit-cost ratio of 2.56.

The studies conducted by [1], [14], and [5] all corroborated these findings. They consistently showed that the benefit-cost ratio of Integrated Crop Management (ICM) in paddy, when utilizing improved cultivation techniques, consistently outperformed traditional farmer practices. This is primarily attributed to the enhanced yield achieved through the adoption of advanced technologies compared to the local check (traditional farmer practices). These outcomes align with the research conducted by [12], [16], and [2].

Table 6. Economics of improved technologies and farmers practice in paddy

Year	Total cost of cultivation (Rs.ha^{-1})	Gross Returns (Rs.ha^{-1})	Net Returns (Rs.ha^{-1})	B:C ratio

	Improved technology	Local check	Improved technology	Local check	Improved technology	Local check	Improved technology	Local check
2015-16	35917	32258	93150	81405	57233	49147	2.59	2.52
2016-17	38192	37100	98960	87395	60768	50295	2.59	2.36
2017-18	38352	37366	96080	83632	57728	46266	2.51	2.24
Average	37487	35575	96063	84144	58576	48569	2.56	2.37

4. CONCLUSION

Farmers in Rayapuram and Keezhpattu villages in the Needamanagalam block of Thiruvarur districts in Tamil Nadu, wanted to plant CR 1009 because of its high yield potential in the district's of rabi season; this variety was prone to flooding. However, paddy crops had been affected with flooding in recent years as a consequence of cyclones and severe intense rainfall. To minimize losses to crops from flooding, Krishi Vigyan Kendra Scientist advised farmers to cultivate flood-tolerant varieties. In NICRA village, CR 1009 sub 1 has been demonstrated from 2015 and 2018. Farmers observed that at later stages of crop growth, CR 1009 sub 1 was capable of withstanding flooding for up to 17 days. Based on the results, the "CR 1009 sub 1" variety produced greater yields in 2015–16, 2016–17, and 2017–18 than the conventional variety CR1009, with yield increases of 12.60%, 11.69%, and 12.95%, respectively. This significantly raised the farming community's lifestyle condition and income in Thiruvarur district of Tamil Nadu. The farming community was impacted by this type of paddy's greater yield (CR 1009 Sub 1).

COMPETING INTERESTS

Authors have declared that there is exist no competing interest.

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