



Extent of adoption and economic impact of NARS rice varieties in Indo-Gangetic Plains

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ABSTRACT

Adoption research has a well-defined position in the development studies of all the scientific disciplines. In this study an attempt has been made for comparative visualisation of extent of adoption and economic impact of different NARS rice varieties among the adopters in Indo-Gangetic Plains. Punjab, Uttar Pradesh, Uttarakhand and West Bengal were selected purposively in the study. From each of the selected states, four districts and from each district two adopted and one non adopted village were selected randomly. Further from each village 30 respondents were selected. Total 1170 respondents were selected for the study. Extent of adoption and economic impact has been analysed for improved NARS rice varieties over the years with primary cross-sectional data collected (during 2016) for the previous five years (2010–11 to 2014–15).

Key words: Adoption, Impact, Rate of change, Rice varieties

Indo Gangetic Plains (IGP), which is known as Great plains, formed by the basin of three distinct rivers systems- the Indus, the Ganga and the Brahmaputra is the major belt of contributions towards India's green revolution (Sekar and Pal 2012). Paddy-wheat, predominant cropping system in IGP, covers 72% of the total cultivated area (Koshal 2014) and has contributed positively on food security (Thakur and Pandey 2009). But over time, it has led to disconcerting consequences for the landscape, leading to unreliable or lower yields for farmers (Mollins 2018). National Agricultural Research System (NARS) of India have developed many crop varieties (especially rice and wheat) which have been identified as suitable for the different terrains of IGP. Though a couple of studies have been conducted to assess and predict the area of coverage and farmers acceptance level on grain varieties all together

in the IGP (Woodhead *et al.* 1994, Hossain *et al.* 2006, Chauhan *et al.* 2012, Sekar and Pal 2012) a comprehensive study showing the rate of adoption and area of coverage of the individual rice varieties in the IGP is lacking. Similarly, there is no synchronous study to assess the extent of adoption and impacts of improved NARS technologies in the IGP in terms of acreage. Therefore, the present study has been aimed to reduce the research gap in this area through analysing the adoption behaviour of the farmers of the IGP for the NARS rice varieties.

MATERIALS AND METHODS

IGP in India comprises of states, viz. Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. Among these states, three states, i.e. Punjab, Uttar Pradesh and West Bengal were selected purposively to conduct the study. As Western Uttar Pradesh represents the agro-ecosystem of Haryana and Eastern Uttar Pradesh represents the agro-ecosystem of Bihar, both these states (Haryana and Bihar) were purposefully eliminated from the study to reduce the similarity and to induce heterogeneity in the sampling frame. The procedure of multi stage random sampling was followed to select the units for the final study. From each of the three states considered for the study, four districts were selected randomly and from each of the districts selected, two villages which were adopted by any of the NARS stations (in technology delivery) and one village which was not under the sway of the NARS station in case of technology dissemination were selected randomly.

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Further from each village 30 respondents were randomly selected. In addition to capture the scenario of Terai region which is another most important fertile belt for the rice cultivation, two adopted and one non-adopted village of Haridwar district of Uttarakhand were also included in the study. Thus a total of 1170 respondents were selected for the study. Overall impact of NARS technologies was assessed in terms of percentage change in average farm level acreage and through comparative analysis of benefit-cost ratio (B:C) of different rice varieties. For measuring change in average farm level acreage and farm level production of improved NARS varieties over the years, primary cross sectional data were collected during 2016 for the previous five years (2010-11 to 2014-15) with 2010-11 as the base year. In order to capture the extent of adoption of different varieties the following formula has been used.

$$\text{Rate of change of adoption (RoCoA)} = 1/N \{(X_i/X_{(i-1)})-1\} \times 100$$

where N, total sample taken; X_i , adopted area for the variety at the present period of time; X_{i-1} , adopted area at the previous period of time.

RESULTS AND DISCUSSION

The extent of adoption (EoA) of improved NARS varieties: EoA of improved NARS varieties were estimated in terms of year wise coverage of these varieties and change in acreage in whole IGP. Later the region wise rate of change of adoption was captured to know and compare the pattern of adoption in a time series basis for the different

rice varieties. Fig 1 represented the year wise proportionate changing pattern of farm level acreage of different NARS paddy varieties from the base year 2010. Among all the NARS paddy varieties, percentage changes were highest (+600%) for PR 126 in terms of acreage followed by Pusa Basmati 1121 with +154%. It implied that from the base year to 2014–15 area under cultivation of PR 126 has increased six times in whole IGP. It was attributed by the varietal characteristics like high yield, resource conservation quality, low duration and disease and pest resistance etc. (Anonymous 2017). At the same time in the five year period considered for the study, a complete discontinuation (-100%) of the cultivation of PB1460 was observed in the rice belt of IGP. Similarly, the varieties like PR114 (-42.43%), PR 124 (-31.69%), PR 122 (-24.00%), IR 1036 (-12.35%), PR 118 (-12.40%) etc. showed a decreasing trend in the case of area under cultivation. Similarly, a study by Singh *et al.* (2006) was found to be supplementing the present study result as it indicated that Sarbati is a rice variety which has an increasing trend in the area under cultivation in IGP.

Average farm level acreage of the variety PR 126 during the year 2011–12 decreased from 0.68 in 2010–11 to 0.58 in 2011–12 (Fig 1) and it constantly increased from 2012–13 to onwards. But for the variety PB 1460 the acreage increased in the year 2012–13 and eventually decreased afterwards in North Western India. Similarly, that there was an increasing trend in average farm level acreage of the variety Pusa Basmati 1121 over the years (Fig 1). But for the years under consideration, variety PR

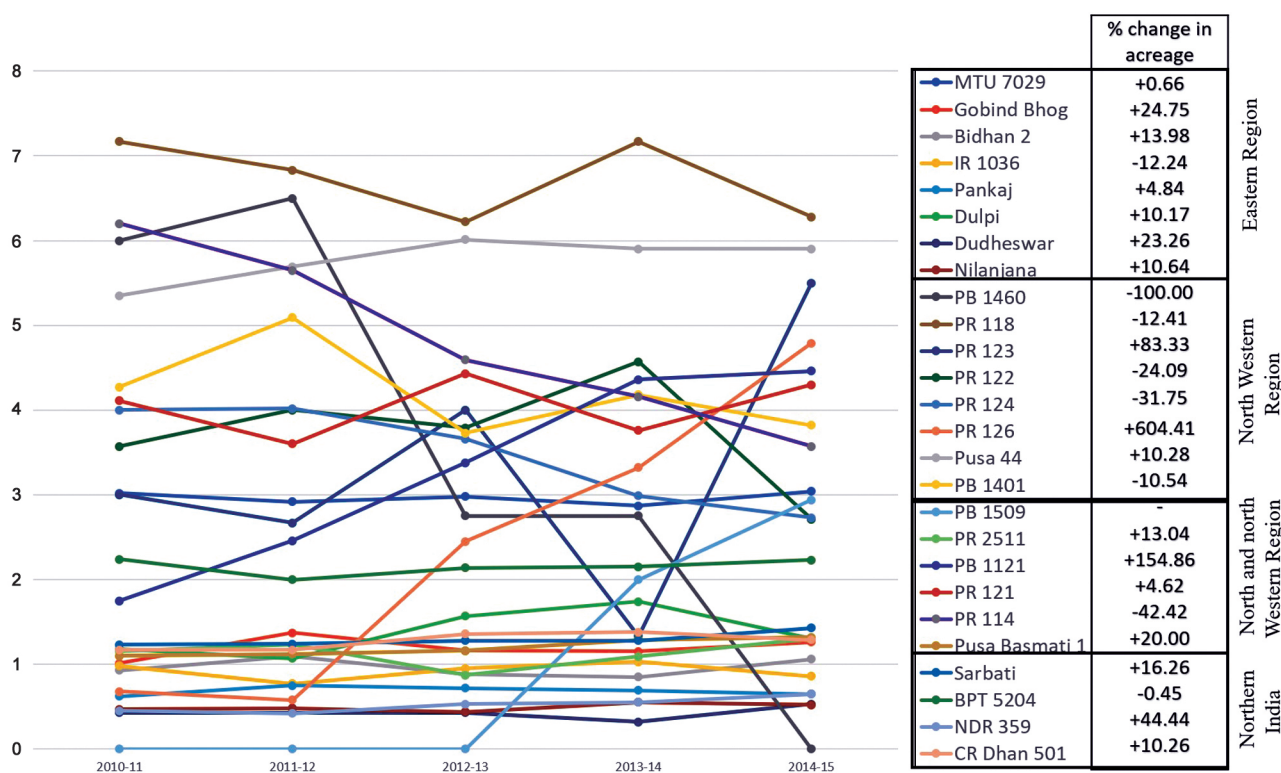


Fig 1 Year wise acreage and percent change in acreage compared to the base year (2010) of NARS paddy varieties in Indo Gangetic Plains of India.

114 showed a gradual decrease in cultivated area over the years in Northern and North Western India. Remarkable change was not observed in average farm level acreage under cultivation for the variety Sarbati during 2010–11 to 2013–14 (Fig 1) but there was an increasing trend for the adopted area during 2013–14 to 2014–15. A declining trend was observed for the variety MTU 7029 and Dupli in terms of cultivated area over the years in Eastern India.

Rate of change of adoption of NARS rice varieties

in Punjab: Total 13 different rice varieties developed by different research centres under NARS were adopted among the farmers of Punjab. Among the rice varieties adopted in Punjab, PR-118 (-0.011), PR123 (-0.115), PR124 (-0.072), PR2511 (-0.079), PR114 (-0.041), PB-1460 (-0.183), Pusa 44 (-0.007) and PB1401 (-0.045) showed a negative change in the rate of adoption over the years (Table 1). The area under cultivation for those varieties has been reduced by farmers. Five other varieties showed a positive rate

Table 1 Average rate of change in adoption of NARS rice varieties

| State | Rice variety | GR1 | GR2 | GR3 | GR4 | Average RoCoA |
|---------------|-------------------|----------|----------|----------|----------|---------------|
| Punjab | PR-118 | -0.06296 | -0.03862 | 0.106481 | -0.05 | -0.011 |
| | PR123 | -3.7E-17 | 0 | -0.66667 | 0.208333 | -0.115 |
| | PR122 | 0.222449 | -0.07143 | 0.349206 | -0.17347 | 0.082 |
| | PR124 | 0.060188 | -0.04679 | -0.16683 | -0.13372 | -0.072 |
| | PR126 | 0.008772 | 0.02193 | 0.042982 | 0.469298 | 0.136 |
| | PR2511 | -0.03704 | -0.375 | -0.04762 | 0.144444 | -0.079 |
| | PR121 | -0.02219 | 0.22416 | -0.23007 | 0.034804 | 0.002 |
| | PR114 | 0.003046 | -0.107 | -0.00229 | -0.05805 | -0.041 |
| | PB 1121 | 0.126373 | 0.063946 | 0.100944 | 0.040368 | 0.083 |
| | PB-1460 | 0.364583 | -0.59722 | 0 | -0.5 | -0.183 |
| | Pusa 44 | 0.035117 | 0.016627 | -0.04607 | -0.03191 | -0.007 |
| | PB1401 | 0.039827 | -0.20443 | 0.025974 | -0.04108 | -0.045 |
| | PB1509 | 0 | 0 | 0 | 0.945988 | 0.236 |
| Uttarakhand | PB1509 | 0 | 0 | 0 | -0.06892 | -0.017 |
| | PR 2511 | 0.090867 | 0.063078 | 0.208035 | 0.273294 | 0.159 |
| | Pusa Basmati 1121 | -0.06383 | 0.224467 | 0.006842 | -0.11704 | 0.013 |
| | PR121 | -0.33333 | 0 | -0.5 | 1 | 0.042 |
| | PR114 | 0 | -0.19277 | 0 | 0.238806 | 0.012 |
| | PB1 | 0.054121 | 0.168629 | 0.218262 | 0.243567 | 0.171 |
| | Sarbati | 0.15238 | 0.133162 | 0.048866 | 0.208623 | 0.136 |
| | NDR 359 | -0.15152 | 0.156863 | 0.106667 | 0.108358 | 0.195 |
| Uttar Pradesh | PB 1509 | 0 | 0 | 0 | 0.116496 | 0.029 |
| | PR2511 | 0.168449 | 0.00182 | -0.6018 | -0.12406 | -0.139 |
| | PB 1121 | 0.244359 | 0.317699 | 0.216171 | 0.150021 | 0.232 |
| | PB 1 | 0.119742 | 0.035324 | 0.190276 | 0.080799 | 0.107 |
| | Sambha Mahsuri | -0.07197 | -0.00527 | -0.01071 | 0.028945 | -0.015 |
| | CR Dhan-501 | -0.01987 | 0.250182 | 0.081313 | -0.05478 | 0.064 |
| | NDR 359 | 0 | 0 | 0.008065 | 0.158266 | 0.042 |
| | West Bengal | MTU 7029 | -0.0475 | 0.062327 | 0.049259 | -0.01813 |
| Gobinda Bhog | | 0.057627 | -0.05706 | 0.008569 | 0.246893 | 0.064 |
| Bidhan-2 | | 0.116162 | -0.04906 | 0.035354 | 0.12583 | 0.057 |
| IR 1036 | | -0.07969 | 0.047351 | 0.143321 | -0.18133 | -0.018 |
| Pankaj | | 0.080189 | 0.106414 | 0.082298 | -0.19853 | 0.018 |
| Minikit | | 0.085714 | -0.10714 | -0.04762 | 0.468831 | 0.100 |
| Dulpi | | -0.05556 | 0.453704 | 0.127778 | -0.17593 | 0.088 |
| Dudherswar | | 0 | -0.10013 | -0.26087 | 0.369565 | 0.002 |
| Nilanjana | | -0.0101 | -0.06061 | -0.01515 | 0.196768 | 0.028 |

of change of adoption over the years. PB1509 (+0.237) was identified with the maximum positive adoption trend among the other rice varieties, i.e. as compared with other rice varieties area under cultivation for the PB1509 has showed 23.64% increase over the years from 2010–11 to 2014–15. In order to capture the variety which has gone through maximum area of adoption and discontinuation among these NARS rice varieties, the rate of change of adoption in area for each variety has been worked out over years starting from 2010–15. The average of rates obtained have been categorised as average positive (+ve) changes and average negative (-ve) changes. PB1509 was adopted in maximum area of Punjab (with +0.39 changes) from the years 2010–15 (Fig. 2) and it showed a very less percent of discontinuation after the adoption by the farmers among these years compared to other varieties. After the adoption maximum percent of discontinuation has been observed in PB 1460 as negative change (-0.260) has been highest for this rice variety.

Rate of change of adoption of NARS rice varieties in Uttarakhand: Growth rates (GR) and average rate of change of adoption among the farmers for eight rice varieties developed by NARS has been worked out (Table 1) and it has been observed that all the seven rice varieties like PR 2511, Pusa Basmati 1121, PR121, PR114, PB1, Sarbati and NDR 359 showed a positive change in the rate of adoption over the years from 2010–11 to 2014–15. But, PB1509 has been identified with the negative rate of change in adoption, i.e. over the years the area under cultivation for PB1509 has being decreased at 1.72% rates. Among the NARS rice varieties of Uttarakhand maximum positive trend for adoption has been observed for NDR 359 (+0.195) and PB 1 (+0.171) (Table 1). Highest adoption occurred for the NDR 359 in Uttarakhand as the average +ve change was higher (0.33) for this variety (Fig 2). This was followed by Sarbati (0.24), PB1 (0.23), PR 2511(0.22), Pusa Basmati

1121(0.19) and PB1509 (0.113). Even though, the average rate of change in adoption was higher for PB 1 than PR 2511 and Sarbati (Table 1), adoption was higher for Sarbati since this variety has been identified with higher average +ve change for the area under cultivation. Higher amount of discontinuation has been observed in case of Pusa Basmati 1121 since it has been identified with largest value for average -ve change (-0.19) for area under cultivation over the years. PR121 and PR114 have showed adoption trend without any form of discontinuation.

Rate of change of adoption of NARS rice varieties in Uttar Pradesh: In Uttar Pradesh PB 1121 showed an exceptionally large average rate of change in adoption (0.23) as compared with other six rice varieties (Table 1) over the five years starting (2010–15), followed by PB 1 (0.107). Even though PB 1509, CR Dhan-501 and NDR 359 showed a positive change in the average adoption rate, they were very minor as compared with PB 1121. All the six rice varieties adopted in Uttar Pradesh have been with both negative (decrease in area) and positive (increase in area) changes in the adoption pattern except PR2511, which showed only a negative trend in adoption. NDR 359 has occupied maximum area for cultivation over the years with an average (+ve) change of 0.395 even though it has identified with a small average rate of change in adoption (+0.042). In the case of PR 2511 the trend showed that while compared with the base year 2010–11, area for cultivation for this variety had never increased (Fig 2) and it decreased year after year (Table 1).

Rate of change of adoption of NARS rice varieties in West Bengal: All the rice varieties cultivated in West Bengal except IR 1036 have been identified with a positive average rate of change in adoption. IR 1036 showed total decrease in the area under cultivation over the years with a rate of 1.75 %. Minikit (9.9%) and Dupli (8.7%) were two NARS rice varieties cultivated in West Bengal with

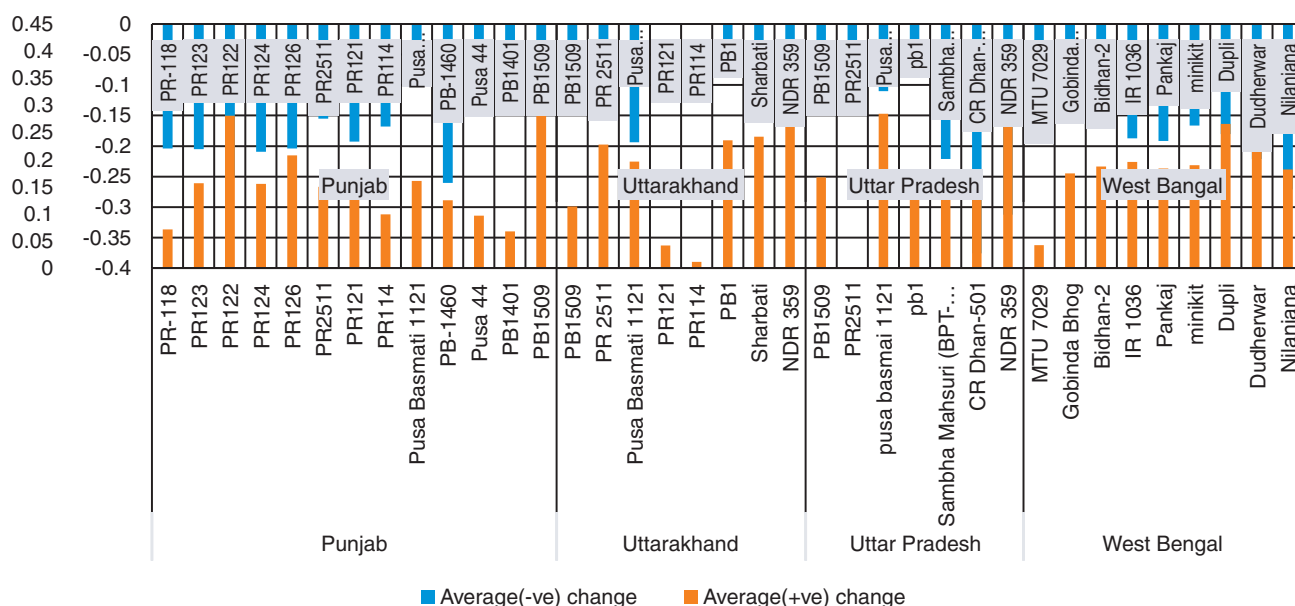


Fig 2 Average (+ve) and (-ve) changes in adopted area for NARS rice varieties.

Table 2 Benefit-cost ratio analysis of NARS paddy varieties

| Variety | Average cost of cultivation (₹/ha) | Average gross return (₹/ha) | Net returns (₹/ha) | BCR |
|--------------|------------------------------------|-----------------------------|--------------------|------|
| PR-114 | 11136 | 43445.5 | 32309.5 | 3.92 |
| PR-121 | 10383.29 | 38483.16 | 28099.87 | 3.72 |
| PUSA-44 | 10002.07 | 36146.94 | 26144.87 | 3.63 |
| PB-1121 | 10818.3 | 38926 | 28107.7 | 3.77 |
| PR-2511 | 11896.667 | 29527.2476 | 17630.58 | 2.51 |
| PR-126 | 11198.95 | 41918.1539 | 30719.2 | 3.73 |
| PR-124 | 11052.56 | 38703.10706 | 27650.55 | 3.50 |
| PR-122 | 10701.429 | 32773.4071 | 22071.98 | 3.06 |
| PR-123 | 10993.3 | 36187.076 | 25193.78 | 3.28 |
| PB-1401 | 9442.727 | 34002.3218 | 24559.59 | 3.60 |
| PR-118 | 10062.222 | 36308.7256 | 26246.5 | 3.62 |
| PB-1460 | 10877.5 | 36662.913 | 25785.41 | 3.36 |
| PUSA-1 | 11726.36 | 26046.08 | 14319.72 | 2.22 |
| Sarbati | 11792.63 | 26840.892 | 15048.26 | 2.27 |
| PB-1509 | 10948.27 | 25805.133 | 14856.86 | 2.35 |
| BPT-5204 | 10616 | 26638.8 | 16022.8 | 2.58 |
| NDR-359 | 11932 | 20961.26 | 9029.26 | 1.74 |
| CR DHAN-501 | 10691.3 | 19807.5 | 9116.2 | 1.85 |
| MTU-7029 | 9861.67 | 27339.6 | 17477.93 | 2.78 |
| Gobindo Bhog | 9951.53 | 20797.5 | 10845.97 | 2.09 |
| Bidhan-2 | 12293.2 | 42770.4 | 30477.2 | 3.47 |
| Paddy-1036 | 12429.7 | 26429.5 | 13999.8 | 2.15 |
| Pankaj | 12801.7 | 27160.9 | 14359.2 | 2.13 |
| Minikit | 12292.5 | 22355.7 | 10063.2 | 1.82 |
| Dupli | 12261.1 | 24335.4 | 12074.3 | 1.99 |
| Dudherswar | 11716.1 | 16697.9 | 4981.8 | 1.42 |
| Nilanjana | 13623.9 | 35154.1 | 21530.2 | 2.58 |

larger average rate of change in adoption. Dupli variety has shown the maximum (+0.265) value with respect to average increase in rate of adoption compared to rest of the varieties. Pandey *et al.* (2012) indicated that the area under MTU 7029 cultivation was decreasing over the years in West Bengal due to the more improved varietal additions. Data showed that, though over the year's farmers showed interest to adopt the rice varieties and in some of the years (under the reference period) they might have discontinued the adoption from some of the areas. Even though, Nilanjana showed a positive average rate of change in adoption over the reference period due to the high grain production compared to other rice varieties (UBKV 2018), it was identified as the variety which has largest rate of discontinuation as the average (-ve) changes in adopted area is -0.2711.

Benefit-cost ratio analysis of NARS rice varieties: Cost of cultivation and the gross returns for NARS rice varieties prevailing in IGP were calculated based on the standard procedure (Table 2). It was found from the analysis results

that among the selected NARS paddy varieties, average cost of cultivation was maximum in case of Nilanjana (₹ 13623.90/ha). North eastern paddy varieties of IGP like Bidhan-2 (₹ 12293.2/ha), IR-1036 (₹ 12429.7/ha), Pankaj (₹ 12801.7/ha), Minikit (₹ 12292.5/ha) and Dupli (₹ 12261.1/ha) were identified with high cost of cultivation as compared to other rice varieties. PB-1401 was identified with least cost of cultivation (₹ 9442.72/ha) among the selected NARS paddy varieties.

Similarly, average gross return was highest for PR-114 (₹ 43445.50/ha) followed by Bidhan-2 (₹ 42770.40/ha) and PR -126 (₹ 41918.15), respectively. Dudherswar paddy variety was with least gross return (₹ 16697.90/ha) over the cost. Net return was highest in PR-114 (₹ 32309.5/ha) over the cost with BC ratio 3.92 followed by PR-126 (NR=₹ 30719.2/ha, BCR=3.7375), Bidhan-2 (NR=₹ 30477.2/ha, BCR=3.47745), PB-1121 (NR=₹ 28107.7/ha, BCR=3.7752) etc. Dudherswar was identified with lowest net return (₹ 4981.8/ha) over the cost of cultivation among selected NARS paddy varieties. Similar results were seen in the studies of Abhay *et al.* (2018), Archanakaruni and Suhasini (2017) and Pushpa *et al.* (2017).

In-depth analysis of the adoption pattern of NARS rice varieties showed that during the year 2010–15 maximum area under cultivation was observed for PB1509 in Punjab, NDR 359 in Uttarakhand and Uttar Pradesh and Dupli in West Bengal. Similarly, maximum discontinuation has been observed for PB 1460 (Punjab), Pusa Basmati 1121 (Uttarakhand), CR Dhan-501 (Uttar Pradesh) and Nilanjana (West Bengal) as the average (-ve) change in the area adopted for cultivation of these varieties were maximum. It has been clear that even though PR 126 has been identified with maximum percentage increase in area adopted over the time, PB1509, NDR 359 and Dupli were cultivated in the larger areas by adopter farmers in Indo Gangetic Plain.

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