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THE PREVALENCE, PRODUCTIVITY, AND PROTECTION OF TRADITIONAL VARIETIES VIS-À-VIS MODERN VARIETIES IN EASTERN INDIA: AN APPRAISAL

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Eastern India is highly complex, diverse, ecologically fragile, and ethnically and socio-culturally unique. To increase production and productivity in India, after the establishment in 1957 of the first ever coordinated crop improvement project on maize by the Indian Council of Agricultural Research (ICAR), systematic crop breeding programmes in cereals and other crops were initiated in public sector institutions through All India Coordinated Research Project (AICRPs). A large number of high yielding varieties (HYVs)/modern varieties (MVs) have been released for cultivation. However their adoption and diffusion has not been uniform and traditional varieties (TVs)/farmers' varieties (FVs) are still grown. In India, farmers' rights have been protected through legislation by enacting the Protection of Plant Variety and Farmers' Right Act (PPV&FRA), 2001. The PPV&FR authority has opened its regional centre for eastern India in Ranchi. The Krishi Vigyan Kendras (KVKs) within the jurisdiction of Birsa Agricultural University, Ranchi, are working closely with local farmers and playing an important role in the conservation of farmers' varieties. Through the KVKs more than 1800 farmers' varieties have already been registered for Plant Varieties' Protection under PPV&FRA, 2001.

Introduction

Till the 1950s Eastern India was the most prosperous part of the country, with a food grain yield of 644 kg/ha as against 608, 554 and 390 kg/ha in the northern, southern and western regions respectively (Mahapatra, 2007). However, the region lost its leading position after the advent of the Green Revolution. The green revolution technologies, developed during the 1960s, significantly increased production of rice in irrigated areas but they largely bypassed unfavourable growing areas characterised by prevalence of drought, flood, submergence, salinity, toxicity and nutrient deficiencies. This resulted in comparatively low and uncertain yields in Eastern India (Khush, 1990). The green revolution was not widely replicated in the region because of fragmented and smaller land holdings as well as institutional, organizational and technological inadequacies, notably absence of irrigation. As a result diffusion and adoption of green

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revolution technologies for rice and wheat progressed slowly in eastern India's rice-growing region (Walker & Ryan, 1990).

In India, food grain production increased fivefold after the 1960s and the country achieved second rank in wheat and rice production, and third rank in total cereals production globally. An extremely important key input that allowed this increased productivity was the genetic improvement of crops. Overall, it is estimated that at least half of the yield increase attained in wheat and rice between the 1960s and 1990s was due to the utilization of genetically improved varieties (Evenson & Gollin, 2003; Miller, Herman, Jahn, & Bradford, 2010). Adoption of high yielding varieties/modern varieties (HYVs/MVs) and concomitant developments of infrastructure and farming methods augured considerable food security and economic impacts at both household and national levels (Lacoste et al., 2012). The remarkable increases in cereal grain production allowed food supplies to keep pace with population growth from the 1960s with minimal changes in planted area (Miller et al., 2010).

To ensure food and nutritional security, the National Agricultural Research Systems (NARS) has developed a large numbers of varieties in different cereal crops suitable for different agro-ecological zones. However, their adoption is not uniform over different regions and seasons as farmers still prefer traditional/local varieties in certain sub-regions. This paper analyzes the prevalence of traditional varieties/farmers' varieties (TVs/FVs), pattern of their adaptation, and productivity performance in cereal crops in the Eastern India in different seasons during the first decade of the 21st century. It also discusses the factors responsible for the preferences of TVs over the MVs with special reference to Eastern India.

Definitions

Eastern India comprises Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam, Odisha, and Chhattisgarh. 31.4 million hectare of its total area, i.e. 71.84 million ha (22.5 percent of the country's geographical area), is the net sown area (GOI, 2013). In general, the region can be divided into three distinct physiographical units namely (i) plains of eastern Uttar Pradesh, Bihar, West Bengal, and Assam; (ii) hilly and plateau regions in eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Chhattisgarh, and Assam; and (iii) coastal plains of West Bengal and Odisha. The Gangetic plains of Eastern Uttar Pradesh, Bihar, West Bengal and the Brahmaputra and Barak Valley of Assam perennially experience the hazard of water logging and flooding.

The term "modern variety" refers to any variety developed by a scientific plant breeding programme (Morris & Heisey, 2003). The term "traditional varieties" (TVs) refers to local varieties (LVs) or farmers' varieties (FVs), also known as landraces, which have never been subjected to a formal plant breeding programme (Zeven, 1998). In India, the Protection of Plant Variety and Farmer's Right Act (PPV&FRA), 2001 defines farmers' varieties as those varieties that have evolved by traditional cultivation by the farmers in their fields, or are wild relatives or land races of varieties about which the farmers possess common knowledge.

Materials

For this study, secondary data regarding area under modern varieties (high yielding varieties) and traditional varieties (TVs) of different cereal crops (rice, wheat and maize) in the states of Eastern India have been compiled from various issues of 'Agricultural Statistics at a Glance' published by the Directorate of Economics and Statistics, Ministry of Agriculture and Co-operation, Government of India. For some reason statistics are not provided for Jharkhand as for other Eastern Indian states, and therefore the analysis below does not always include Jharkhand state. The drivers for the spreading of MVs of cereal crops in different states of the region have subsequently been analyzed. An analysis of coverage area and yielding pattern with respect to MVs and TVs, crop wise and/or state wise, has been conducted to understand any disparities in MVs adoption. The data pertains to different seasons in the first decade of 21st century (2000-01 to 2010-11), giving actual yield (kg/ha), mean yield (kg/ha), range and the variability in yield measured as coefficient of variation (CV) in percent.

Results

(i) Area under traditional varieties (TVs) in different states of Eastern India

Rice is the most important staple crop of Eastern India and is grown under various water regimes. While summer season rice is grown under fully irrigated conditions, *kharif* (monsoon) and rice is grown under both rainfed and irrigated conditions. The rainfed rice ecosystem is further classified into four broad ecosystems according to the water depth in the major part of the life cycle of the crop. Overall, the rice crop in Eastern India covers approximately 60% of the total area under rice in India. Yet the region produces about 48-49 million tonnes of rice, roughly half of India's total production, which indicates the lower rice productivity of this region (1.82 tonnes/ha, below the national average of 2.17 tonnes/ha) (Mohapatra, 2014).

Modern varieties, including high yielding varieties and hybrids, dominate the scene in Eastern India but traditional varieties (TVs) are still being grown in every state. The area under rice TVs in the respective states are shown in Table 1. In rice the average percent area (2000-01 to 2010-11) under traditional varieties varied from 9.8 percent in West Bengal to 30.3 percent in Odisha, 49 percent in Bihar, and 78.6 percent in Chhattisgarh. The proportion of rice crop under irrigation also varies state-wise: West Bengal (48.2%), Odisha (33.2%), Bihar (55.6%), and Chhattisgarh (33.6%) (GOI, 2011, 2012, 2013). About 26 percent of the area covered by wheat is under traditional varieties while the irrigated area was more than 93 percent In maize approximately 63 percent area was covered by traditional varieties and more than 65 percent irrigated. The modern varieties perform better under high input (irrigation and fertilizer) conditions with better management while farmers' varieties are being grown in less favourable conditions, i.e. rainfed, with low inputs.

Table -1. Area of rice crop (%) under TVs in Eastern India's States (2001 to 2011)

State	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Average	Area under irrigation (%) 2010-11
Rice													
West Bengal*	11.4	10.9	10.8	10.6	10.6	9.3	9.2	8.5	8.5	8.5	-	9.8	48.2
Odisha	40.7	36.5	37.6	35.8	32.8	30.7	28.9	26.5	22.9	21	19.4	30.3	33.2
Bihar	52.5	52.1	48.5	54.1	52.3	50.8	48.7	49	49.2	52.6	29.0	49.0	55.6
Chhatt-isgarh	84.6	83.3	74	80.8	80.5	78.3	76.3	75.8	74.5	77.6	-	78.6	33.6
Wheat													
Bihar	26.7	23	25.8	29.2	27.4	26.2	23.7	25.7	25	26.8	-	26.0	93.2
Maize													
Bihar	66	65.5	51.7	66.2	64.8	63	62.8	61.4	-	64.6	-	62.9	65.6

Source: GOI (2011, 2012, 2013); * Sarkar and Ghosh (2013)

(ii) State and season-wise yield pattern of MVs and TVs in cereal crops

West Bengal, Odisha, Bihar, Chhattisgarh and Assam are the important rice growing states in Eastern India. In West Bengal, the rice crop is grown three times each year (*aus*, *aman* and summer), in Bihar the three rice seasons are *bhadai*, *garma* and *aghani*, while in

Assam and Odisha rice is grown during autumn, winter and summer. In Bihar maize is grown during *bhadai*, *rabi* and *garma*. The yield of MVs and TVs since 2000-01 to 2010-11 grown in different seasons in different states is given in Table 2.

In West Bengal the mean yield of HYVs varied according to the season i.e. 2387 kg/ha, 2634 and 3319 kg/ha, for *aus*, *aman* and summer respectively. The average yield of TVs also varied e.g. 1481 kg/ha, 1863 kg/ha and 2637 kg/ha, respectively. In Odisha, the average yield of HYVs of rice was 1051 kg/ha, in comparison to the average for TVs at 732 kg/ha in autumn season. In winter season it varied from 1726 kg/ha (HYVs) to 1178 kg/ha (TVs) and surprisingly during summer only high yielding varieties are cultivated for which the average yield reported to be 2283kg/ha. The same story continues for Bihar also, in which only local varieties are cultivated during *bhadai* season with average productivity of 1131 kg/ha while during *garma* and *aghani* seasons both HYVs and TVs are grown. During *garma* season the average yield of HYVs was 1790 kg/ha while TVs yield was 1648 kg/ha and for *aghani* season the average yield of high yielding varieties is recorded at 1680 kg/ha while TVs gave an average yield of 1164 kg/ha. In Chhattisgarh state where rice is grown only during *kharif* season the mean yield of MVs was found to be 1737 kg/ha as compared to 1027 kg/ha in case of TVs. In Assam, the higher mean yield of MVs over local varieties was found for all three seasons: autumn (1727 kg/ha vs. 970 kg/ha), winter (2160 kg/ha vs. 1509 kg/ha) and summer (2438 kg/ha vs. 1714 kg/ha). Since modern varieties have been bred for high input conditions, their performance is not consistent under unfavourable, marginal conditions with low input management. However traditional varieties perform well since they are better adapted to these conditions (Ceccarelli, 1996). Hence the data shows that when irrigated, TV yields can outperform HYV yields, e.g. in West Bengal TVs have an average yield of 2637 kg/ha in the summer as compared to HYV yields of 2387 kg/ha during *aus*.

Table -2. State and season-wise yield (kg/ha) of MVs and TVs of cereals (2001-2011)

State	Season	HYV/ local	2000 -01	2001 -02	2002 -03	2003 -04	2004 -05	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11	Mean
								Rice						
West Bengal	Aus.	HYV	3218	2233	2184	2194	2242	2169	2132	2157	3389	2216	2128	2387
		Local	2181	1529	1401	1525	1395	1403	1240	1333	1865	1066	1354	1481
	Aman	HYV	3193	2500	2431	2422	2464	2401	2427	2398	3789	2438	2514	2634
		Local	2568	1738	1621	1744	1746	1662	1701	1409	2542	1781	1982	1863
	Summer	HYV	5155	2860	2940	3076	3089	2913	3123	3136	4148	2821	3252	3319
		Local	4197	1872	2338	2526	2733	2919	2115	1869	3428	2095	2913	2637

Odisha	Autumn	HYV	624	1212	423	1202	949	1055	1144	1838	1146	1037	933	1051
		Local	488	783	326	765	677	670	815	1360	851	692	621	732
	Winter	HYV	1208	1924	844	1795	1668	1777	1755	2878	1637	1742	1754	1726
		Local	905	1303	608	1276	1249	1239	1165	1915	1017	1185	1090	1178
	Summer	HYV	2157	2148	2125	2133	2230	2160	2293	2447	2451	2713	2259	2283
Bihar	Bhadai	Local	1339	1240	1095	1234	912	951	1023	612	2006	897	-	1131
	Garma	HYV	1833	2017	1641	1502	1521	1552	1643	1741	2486	1966	-	1790
		Local	1385	1659	2307	1331	1174	1436	1787	1623	2366	1419	-	1649
	Aghani	HYV	1745	1734	1703	1810	942	1409	1789	1596	2814	1261	-	1680
		Local	1202	1177	1150	1217	551	811	1203	1091	2198	1036	-	1164
Chhattisgarh		HYV	HYV	2035	1163	1267	1840	2134	2221	2145	1747	1827	1827	1737
		Local	Local	1354	582	958	1084	1201	1175	1307	1057	990	990	1027
Assam	Autumn	HYV	1804	1720	1839	1778	1551	1950	1674	1452	1789	1782	1660	1727
		Local	1045	960	963	1012	665	1043	931	1060	1076	934	979	970
	Winter	HYV	2154	2308	2262	2263	2013	2064	1831	1713	2480	2304	2358	2159
		Local	1488	1516	1459	1554	1421	1473	1223	1354	1575	1614	1921	1509
	Summer	HYV	2459	2445	2518	2220	2309	2126	2470	2697	2466	2325	2785	2438
		Local	1783	1636	1677	1399	1704	1580	1662	1370	1882	1907	2249	1714
Wheat														
Bihar		HYV	2265	2169	1979	1860	1706	1442	2069	2407	2199	2157	-	2025
		Local	1812	1732	1648	1552	1393	1233	1794	2094	1794	1823	-	1688
Maize														
Bihar	Bhadai	HYV	1836	1820	1907	1695	1909	1781	1973	1297	1841	2035	-	1620
		Local	1704	1920	1537	1650	1496	1542	1502	768	1276	1511	-	1491
	Rabi	Local	2919	3186	-	3006	3041	3045	3612	3974	3828	2599	-	3246
	Garma	HYV	3151	2804	-	2709	2928	2427	3367	4084	3188	3134	-	3088
		Local	2541	2309		2953	2600	2579	2541	2467	2756	2905	-	2628
Odisha	Autumn	HYV	1257	1047	1005	1892	2178	1932	1927	2314	2297	2401	2734	1908
		Local	873	740	950	891	1006	862	845	921	943	850	1102	908
	Winter	HYV	967	1753	1179	1986	1979	2287	2674	2738	2273	1590	2118	1959
		Local	650	683	667	1291	899	654	831	2472	814	974	1258	1018
	Summer	HYV	1358	1688	1635	1999	2066	2216	2385	2277	2547	2237	2818	2112
		Local	637	875	769	740	837	945	1116	1217	3945	1268	-	1235

Source: GOI (2011, 2012, 2013); (-) data not available

In the case of wheat, in Bihar state the average yield of MVs over TVs is reported to be 2025 kg/ha vs. 1688 kg/ha. Similar to rice, maize is also grown in different seasons. In Bihar where maize is grown around the year, the yield level of HYVs and TVs varies according to the season. Higher average yield was obtained by MVs over TVs during *bhadai* (1620 kg/ha vs. 1491 kg/ha) and *garma* (3088 vs. 2628 kg/ha), while during *rabi* season only local varieties are grown with an average yield of 3246 kg/ha. Similarly, in Odisha, the productivity of HYVs and TVs of maize grown during autumn is recorded as 1908 kg/ha vs. 908 kg/ha, during winter as 1959 kg/ha vs. 1018 kg/ha, and during summer as 2112 kg/ha vs. 1235 kg/ha. MVs clearly record a higher yield (being highly responsive to high inputs) in comparison to TVs. But the superiority of HYVs over TVs with respect to yield varies from one season to another within the same state. In certain seasons farmers prefer to grow only one type, i.e. MVs or TVs, while in other seasons both types are grown.

(iii) Mean yield, range, and variability among MVs and TVs

Data regarding the yield pattern of different varieties, the yield range, average yield, variability in yield as measured though coefficient of variation (CV), and the superiority of one type over another (i.e. MV over TV) in terms of average yield gain loss is given in Table 3 for rice, wheat and maize grown during different seasons. In rice, in West Bengal, the yield of HYVs varies from 2128 kg/ha (*aus*) to 5155 kg/ha (summer), while the yield of TVs also varies from 1066 kg/ha (*aus*) to 4197 kg/ha (summer). The yield superiority of HYVs over TVs for rice ranged from 25.9 percent during summer to 61.2 percent when grown during *aus*. Overall the superiority of MVs in yield over TVs ranges from just 8.6 percent in Bihar (*garma*) to 78 percent in Assam during autumn season. Moreover, in contrast to West Bengal, the recorded variations in yield was found to be more in TVs as compared to MVs in Odisha, Bihar, Chhattisgarh, and Assam, which is against the general assumption that the yield stability is much more in TVs as compared to HYVs.

Table - 3. Yield range, mean, variation and percent superiority of HYVs over TVs

State	Season	HYV/local	Low (kg/ha)	High (kg/ha)	Mean (kg/ha)	CV (%)	Yield gain (%)
				Rice			
West Bengal	Aus	HYV	2128	3389	2387	19.1	61.2
		Local	1066	2181	1481	20.6	
	Aman	HYV	2398	3789	2634	16.9	41.4
		Local	1409	2568	1863	19.8	
	Summer	HYV	2821	5155	3319	21.3	25.9
		Local	1869	4197	2637	27.0	
Odisha	Autumn	HYV	423	1838	1051	34.1	43.6
		Local	326	1360	732	33.5	
	Winter	HYV	844	2878	1726	28.6	46.5
		Local	608	1303	1178	27.0	
	Summer	HYV	2125	2713	2283	8.1	-
Bihar	Bhadai	Local	612	2006	1131	32.9	-
	Garma	HYV	1521	2486	1790	16.9	8.6
		Local	1174	2366	1649	24.4	
	Aghani	HYV	942	2814	1680	28.9	44.3
		Local	551	2198	1164	36.2	
Chhattisgarh	HYV	903	2221	1737	1737.0	69.1	
	Local	582	1354	1027	1027.0		
Assam	Autumn	HYV	1452	1950	1727	8.0	78
		Local	665	1076	970	11.7	
	Winter	HYV	1713	2358	2159	10.8	43.1
		Local	1223	1921	1509	11.6	
	Summer	HYV	2126	2785	2438	7.9	42.2
		Local	1370	2249	1714	14.3	

				Wheat			
Bihar		HYV	1442	2407	2025.3	14.2	20
		Local	1233	2094	1687.5	14.5	
				Maize			
Bihar	Bhadai	HYV	1297	2035	1620	36.9	8.7
		Local	768	1920	1491	20.4	
	Rabi	Local	2599	3828	3246	14.1	-
	Garma	HYV	2427	4084	3088	15.2	17.5
		Local	2300	2953	2628	7.9	
Odisha	Autumn	HYV	1005	2734	1908	30.1	110.2
		Local	740	1102	908	10.4	
	Winter	HYV	967	2738	1959	28.5	92.5
		Local	650	2472	1018	52.4	
	Summer	HYV	1358	2818	2112	20.1	71
		Local	637	3945	1235	78.9	

Source: Own calculations based on GOI (2011, 2012, 2013)

For maize, the average yield superiority of HYVs over TVs ranged from 8.7 percent in Bihar (*bhadai*) to 110.2 percent in Orissa (autumn). In Bihar during *rabi* the highest average yield of 3245 kg/ha has been obtained through the cultivation of TVs, whereas HYVs are not cultivated during this season. In maize, in the case of HYVs the yield ranged from 967 kg/ha in Orissa (winter) to 4084 kg/ha in Bihar (*garma*), while the yield of TVs ranged from 637 kg/ha to 3945 kg/ha, both in Orissa (summer). The variability in yield in maize did not exhibit any specific trend. In wheat, in Bihar the yield superiority of HYVs over TVs is recorded as 20 percent (2025 kg/ha vs. 1688 kg/ha). This same level of variability in yield, about 14 percent, is observed in both MVs and TVs in this state.

As the input responsive semi-dwarf high yielding varieties of rice and wheat are grown with optimum inputs under a good management system, the variability in yield obtained through these varieties is relatively low as compared to TVs. However in maize, different types of MVs (open pollinated varieties, composites, double cross hybrids, three way cross hybrids and single cross hybrids) are grown under different kind of input and management systems (irrigation vs. rainfed, low input vs. high input etc.).

For Jharkhand, comparable data was not available. In 2013-14 the total area covered by rice crop in Jharkhand was 1.35 million ha. The coverage under different rice types was as follows: HYVs (0.65 million ha or 47.8%), hybrids (0.46 million ha or 34.4%), and traditional varieties (0.24 million ha or 17.8%). These contributed 42.5 percent, 44.5 percent and 13 percent respectively, to the total production (Sinha & Xaxa, 2014).

Discussion

(A) Productivity and adoption pattern of MVs over TVs

Unsurprisingly the productivity of MVs was found to be better than TVs, though their adoption was influenced by many factors. The low adoption rate of MVs in rainfed rice environments in Eastern India is mainly due to undulated topography and lack of assured irrigation. The results of this study suggest a tendency for one type (i.e. MV or TV) to dominate over all others in a particular season and state. For example, in Odisha state, exclusively MVs of rice are grown in the summer while in Bihar state, exclusively TVs are grown in the *bhadai*. For maize, both HYVs and TVs are cultivated during *bhadai* and *garma* seasons in Bihar, but during *rabi* only TVs are grown. This indicates that the adoption pattern of MVs is highly skewed in different seasons of the same state, as well as in different regions in the same season.

About one-third of the area under MVs in Eastern India was planted with those MVs that were developed in other regions, largely in the irrigated ecosystem of South India (Janaiah, Hossain, & Otsuka, 2006). Although varietal improvements was slow, inter-state/regional lateral movement of MVs adoption was prevalent and farmers across India adopted 221 out of the 620 MVs released during 1965-2000 (ibid.). Most MVs were adopted in the rainfed-dominant Eastern India through domestic spillovers, especially after the mid-1980s in areas where shallow and tube-well irrigation facilities were created. The expanded coverage of improved MVs after the mid-1980s likely destabilized yields in Bihar and West Bengal. Whereas HYVs of wheat provided yield gains of 40 percent in irrigated areas with modest use of fertilizer, in dry areas gains were often no more than 10 percent (Pingali & Kelley, 2007).

(B) Reasons for the prevalence of TVs in Eastern India

Factors responsible for the preference of farmers' varieties in Eastern India includes bio-geophysical, geographical, topographical, irrigation facilities, timely availability of quality seed, inputs and credits, land holdings and farm size, acceptable nutritional qualities, scale neutrality including economics of production, desirable varietal traits for food, feed and fodder, tolerance to various abiotic and biotic stresses, and socio-economical condition of the farmers. These are each now discussed.

(i) Lack of seed production of upland rice varieties by public/ private sectors: In India, the area under rainfed upland rice covers approximately 6 million ha with productivity levels of less than one tonne per hectare. Although upland varieties of rice are clearly marketable, efforts to involve the private sector in India in their seed production have not been successful because of the unprofitable nature of low yielding upland rice compared with irrigated transplanted rice (Witcombe et al. 2009). Varieties have been developed under conditions not represented by marginal environments (Abay & Bjornstad, 2009). Thus despite the high number of low-input producers in marginal environments, the resource-poor farmers have not benefited much from modern breeding programmes. Characteristics of the new rainfed rice varieties were found to be inferior by scientists' criteria. Thus farmers may not have had access to seed or information about new varieties (Kulkarni, 2013). By contrast, TVs are high performers under low input conditions (Nagarajan, Yadav, & Singh, 2008).

(ii) Lack of progress in irrigation: In India, adoption of HYVs has been strongly correlated with irrigation water availability (Pingali, 2012). Fujita (2013) studied the pattern of HYV adoption in Eastern India, finding that the wheat Green Revolution in Bihar was supported by the introduction of private shallow tube-wells (STWs). This was a result of investment in STWs by large-scale farmers, which enabled the introduction of HYVs of wheat, a totally new crop, in the dry season. In fact, in Bihar the share of irrigated area in rice is 55.6 percent while in the case of wheat some 93.2 percent area is irrigated (Table 1). The important factors influencing adoption of MVs include hydrology, tenurial status and irrigation (Samal, Pandey, Kumar, & Barah, 2011). Farmers did not adopt MVs of rice despite the availability of irrigation water, mainly because of the high cost of irrigation, which was fundamentally caused by investment in a specific type of STW. However, this is not the case for wheat since irrigation is needed only three to four times per season. Farmers in Bihar recently started to adopt hybrid rice varieties, which require much less water compared to HYVs.

(iii) Lack of credit and other inputs: In India, the potential productivity increases from MVs adoption entailed higher yield risks compared to TVs given the higher cash requirement for inputs (Herath & Jayasuriya, 1996). Risk aversion, transaction costs, and environmental constraints can each, to some extent, explain the occurrence of the partial adoption of MVs by farmers in developing countries (Meng, Taylor, & Brush, 1995). The adoption of modern varieties has generally been low among subsistence farmers in marginal areas of developing countries (Lacoste et al., 2012); and for Eastern India, where farmers are poor and provision of credit less than adequate, this is certainly a contributing factor to low take-up of MVs.

(iv) Socio-economic conditions: Poverty in Eastern India is deep rooted. On the basis of socio-economic conditions, the Planning Commission identified 150 disadvantaged districts in the country, of which 69 districts are confined to the Eastern India region (RCER, 2011). Farmers have low purchasing power and poor investment capacity which limits the proper input investment required for MVs.

(v) Incomplete implementation of land reform policies: Following Indian independence, the states in which land reforms took place saw increased production and productivity of crops. In Eastern India, except West Bengal, land reforms were only partially implemented. This is one other important factor for poor adoption of MVs. By contrast, increased production and productivity along with cropping intensity enhancement was observed in West Bengal where post-independence, a series of land reform laws were enacted.

(vi) Nutritional value of MVs: Wheat is an important source of minerals such as iron, zinc, copper and magnesium. Fan, Gulati and Thorat (2008) report that the concentrations of these minerals remained stable in grains from MVs released between 1845 and the mid-1960s, but since then the content of these nutrients decreased significantly, which coincided with the introduction of semi-dwarf, high-yielding cultivars. In comparison, the concentrations of these minerals in the soil have either increased or remained stable. Then post-1968, when high-yielding wheat varieties came into use, grain from all plots showed marked declines of 20 to 49 percent in iron, copper, zinc, and magnesium, plus "broadly similar" declines in phosphorus, manganese, sulphur, and calcium. In the USA, Garvin, Welch and Finley (2006) used side-by-side plantings to compare the micronutrient concentrations of 14 varieties of wheat originally grown between 1919 and 2000, a period in which typical yields more than tripled. Average micronutrient concentrations declined dramatically. Over the 81 years, iron dropped by about 25 percent, zinc by 13 to 29 percent, and selenium by 19 to 31 percent. Similarly in rice, the contents of Fe and Zn in traditional genotypes were significantly higher than those of improved cultivars. There was a negative correlation between grain yield and mineral contents (Anandan, Rajiv, Eswaran, & Prakash, 2011). It is important to note that, according to some studies, problems of zinc deficiency were aggravated in the process of the Green Revolution (Dar, 2004).

(vii) Non availability of quality seed of newly released varieties: A lot of skill, time, energy and money are invested for crop improvement to develop superior genotypes (high yielding varieties/hybrids), which need to reach the farmers' field continuously in their "original form". The purpose of any crop improvement effort would only be met when this is achieved; and this can be achieved only through seed of such superior genotypes (Pattanaik, 2013). In India, a number of reasons explain the recycling of MV seeds by farmers (Singh & Morris, 1997). Rapid diffusion and adoption of improved cultivars can only take place when there is a strong back-up by seed multiplication and distribution systems.

(C) Protection of traditional varieties

(i) Intellectual property and genetic resources, traditional knowledge and folklore protection at the international level: The World Intellectual Property Organization (WIPO) set up the Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC) as part of a larger and structured endeavour to move towards a modern, responsive intellectual property (IP) system that could embrace non-Western forms of creativity and innovation, be comprehensive in terms of beneficiaries, and be fully consistent with developmental and environmental goals (WIPO, 2016). The IGC covers the IP issues that arise in the context of access to genetic resources and benefit-sharing as well as the protection of traditional knowledge and traditional cultural expressions (the terms "traditional cultural expressions" and "expressions of folklore" are used interchangeably in WIPO discussions). Work on the relationship between IP, traditional knowledge (TK) and genetic resources (GRs) is more recent, and stems from concerns regarding the role that IP protection should play in achieving global policy objectives as varied as the conservation of biodiversity (as enshrined in the Convention on Biological Diversity, 1992), food security, free and fair trade, and development. This is thus of great interest to biodiversity-rich Eastern India, which faces serious food security and development challenges.

(ii) Genetic resources protection in India through legislation: Article 27.3(b) of the TRIPS Agreement requires World Trade Organisation (WTO) members to provide intellectual property protection for plant varieties by 'patents or by an effective sui generis system or by any combination thereof'. India adopted the sui generis method, and enacted the Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA), 2001 which became fully operational in 2007 (Koonan, 2014).

A farmers' variety is defined as a variety which has been traditionally cultivated by farmers in their fields, or is a wild relative of a variety about which farmers possess the common knowledge

(Ragavan & Mayer, 2007). Farmers' varieties can be registered separately and also under the category of extant varieties. Section 15(2) provides that an extant variety shall be registered if it conforms to distinctiveness, uniformity and stability as specified under the regulations laid down by the Protection of Plant Variety and Farmer's Right Authority of India (Plant Authority). This registration process is meant to balance breeders' rights with the rights of other players in the agricultural trade.

Thus, the PPV&FRA, 2001 lumps plant varieties into three protectable categories: (a) New Varieties, (b) Extant Varieties, which refer to existing varieties discovered for the first time, and (c) Farmers' Varieties, based on community property concepts. Any breeder, farmer, group, or community of farmers may apply for registration of a new variety. Registration of varieties for their protection through the PPV&FRA, 2001 started in 2007 since when applications from public sector institutions/breeders, private firms and farmers and communities have been submitted. Between 2007 and 10th February 2016, across India, 1470 applications were submitted from the public sector, 3204 from the private sector, and 6322 from farmers themselves (PPV&FR Authority, 2016).

(iii) Genetic resources protection in Jharkhand: The Krishi Vigyan Kendras (KVKs) of Jharkhand have been closely associated with local farmers and have played a pivotal role in conservation of area specific farmers' plant varieties. During the last two years KVKs have organized over 35 awareness-cum-training programmes on plant varieties' protection (PVP) and have identified and registered more than 1800 farmers' varieties for PVP Entitlement at PPV&FR Authority, New Delhi. In 2015, five KVKs located in Jharkhand, in Chatra, Palamau, Simdega, Gumla and Ranchi, jointly received a first prize for special contribution in protection of local crop varieties at Koraput, Odisha during a national seminar (BAU, 2016).

Conclusion

The adoption pattern of modern varieties is highly asymmetrical in different seasons in the same state; and in different regions in the same season. Eastern India no doubt benefited through the spill-over of MVs technologies from elsewhere. Yet traditional varieties are still prevalent in Eastern India and occupy a significant area in cereal crops. In upland rice, traditional varieties are preferred over modern varieties due to their tolerance to abiotic and biotic stresses. Additionally, TVs are preferred for better nutritional quality among other reasons. The PPV&FRA, 2001 recognized the contributions made by farmers for the conservation and management of plant genetic resources in terms of their TVs/landraces. Farmers are actively registering their varieties and in fact, for cereals, pulses and oilseed crops, farmers have submitted the highest number of applications to protect their varieties.

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