Jharkhand Journal of Development and Management Studies
XISS, Ranchi, Vol. 14, No.2, June 2016, pp. 7009-7021

EFFECTS OF HYBRIDISATION ON SECONDARY CHARACTERISTICS OF RICE PLANTS

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Concern over feeding the growing population placed increase in yield of cereal crops as the non-compromising priority for the scientific community. This has led to a neglect of secondary characteristics of the plants, which are equally important and desirable. The use of hybrid seeds also raises concerns regarding the inputs required and their overall effect on human health, the soil and environment. In this study, 26 farmers in Bero and Angara blocks of Ranchi district, who were growing hybrid and traditional varieties of paddy, were interviewed. The study assesses the effects of rice hybridization, and shows how it has deleterious effects on the quality of straw, taste of food, storability of cooked food and nutritional content. Appreciation of the value of these qualities in traditional rice varieties, before they disappear due to their unregulated replacement with hybrids, would ensure that rice remains a wholesome food and a source of wealth to the farmer for centuries to come.

Introduction

With a human population forecast to touch nine billion by 2050, the world's agricultural and scientific community has been presented with a challenge to feed the growing population. Discussions in scientific journals, papers and reports generated by agricultural institutions generally take a simplistic view of the problem of rice breeding, reducing it to the number of quintals of grain required to feed so many people in a year. This line of thinking leads to the concept that any variety of rice which is developed and which can give higher yields is a boon and should be taken up by farmers. Commensurate with this, the improvement of rice grain yield has been the main target of rice scientists involved in developing and breeding new rice varieties.

At the time of independence, India was not self sufficient in food production and was dependent on food imports for many years. The major cereals rice and wheat were cultivated with traditional seeds, which suffered from low yields and lodging. In rice, traditional cropping practices like direct sowing without transplantation along with low nutrient inputs and limited irrigation facilities were incapable of giving sufficiently high yield. The Government of India tried to ameliorate this through the Green Revolution by introducing high yielding varieties (HYVs), chemical fertilizers and pesticides, assured irrigation, and mechanisation (Farmer, 1986). India's north-

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western states were the main beneficiaries of the Green Revolution, as the region had assured canal irrigation. With the adoption of HYV seeds during the 1960-70s, production of rice and wheat increased and at the national level, self sufficiency in food grain became a reality. The rice yield in Punjab is reported to have gone up from just 2 tonnes per hectare in the 1960s to 6 tonnes per hectare by the mid 1990s (Barta, 2007). With the use of massive amounts of fertilizer, insecticide and pesticide, the irrigated crops fetched farmers a yield that is impossible with traditional forms of cultivation. The north-western states thus helped India to overcome its grim, food insecure condition.

Although India achieved food sufficiency, the burgeoning population demanded further increases in productivity. This is disregarding the fact that foodgrain production alone cannot solve food security at the household level (Sen, 1981). By the 1990s the yield increase through HYV seeds had reached stagnancy and the biotechnology was no longer able to cope with demand (SEARICE, 2007; GOI, 2010). In this scenario, a new techno-fix was required, and the technique of generating hybrid seeds came into the limelight. Known as F_1 hybrids (henceforth "hybrids"), this biotechnology promised even greater productivity than the HYVs. Hybrids exploit the phenomenon called hybrid vigour, which differentiates them from the open-pollinated HYVs and traditional varieties (landraces), and which guarantees a bumper harvest (SEARICE, 2007). Though hybrids, like the HYV seeds, demand generous amounts of fertilizer, pesticides, and irrigational facilities; they also appear to perform well in the short term with limited inputs. This made them ideally suited to vast tracts of India, specifically Eastern India, which due to a variety of reasons were bypassed by the Green Revolution. Indeed, hybrids were only introduced to Eastern India after attempts were unsuccessfully made to introduce them to farmers in the north-west and south of India (Janaiah, 2002).

Considering only the yield aspect, the hybrids have performed better than HYVs, even with an increase in the overall cost of production. Yet other aspects of rice which are equally important have been neglected, and need to be considered. These aspects include the quality of straw, taste of food grain, storability of cooked food and its nutritional content. The phenomenon of neglecting these characteristics is due to the influence of agricultural scientists, whose positivist epistemological perspective has guided policy in India. The farming population, especially in Eastern India, have been left to succumb to the situation.

HYVs and hybrids in India

Over the centuries humanity increased the production and productivity of crops through various methods. More production meant more wealth and prosperity. Farmers crossed plants to generate offspring with higher productivity and other desired characteristics. Earlier the plant breeders mainly depended upon the phenotypic expression of plants to choose plants with desired qualities, to use them for crossing. But with the discovery of the genetic basis of transmission of plant traits, and other developments in science of plant breeding, the process of producing seed able to give high yields could be accomplished much faster (Hallauer, 2011).

The term 'progressive agriculture' has become synonymous with the use of HYVs and hybrids. Indeed, the term 'progressive farmers' is used as a synonym for 'farmers with large landholdings' in much of the agricultural science literature. With it there is a trend to blame traditional agriculture as backward and incapable of tending to the planned objective of agriculture to feed the growing population (Dogra, 1983). However, the methods of traditional agriculture, through experimentation, produced more than 100,000 varieties of rice in India, suited to its different agro ecological conditions (Special correspondent, 2012). Not only that, some of these rice varieties possessed medicinal values and had aromatic qualities as well. Some of these varieties could indeed be categorised as 'high yielding varieties' based on their yield. The traditional rice varieties were nutritious and the carbohydrate rich water of the cooked rice gave individuals the vitality to work throughout the day (Rahman, Sharma, & Sahai, 2006). The repository of knowledge and skill in traditional agriculture was the common farmer, who planted varieties of rice suited to the soil and land type.

The formal crop breeding process was given a boost during the 20th century through the organised scientific production of HYV seeds on a large scale, which made possible the Green Revolution. The first HYV seed released in India by the International Rice Research Institute (IRRI) was IR8, after which many high yielding varieties were introduced (Kuyek et al., 2001). They all contained the same dwarfing gene which prevented the crop from lodging, introduced to the *Indica* sub-species by crossing it with the *Japonica* sub-species. Farmers had to replace the seeds every three to four years, otherwise yields would decline. However all-in-all farmers were happy with the produced grain, which shared secondary characteristics with their traditional varieties.

During the late 20th century, another process of making seeds with higher yield came into vogue. These seeds became known as hybrid seeds, because they take advantage of the 'hybrid vigour' effect, also known as heterosis (Janaiah, 2002; Kuyek et al., 2001). Though a good yield is gained, the downside is that the effect does not last after the first generation itself. This means that the seeds can only be used once, and thus must be purchased afresh each year; a factor which appeals to the main producers of the hybrid seed, the private sector. Hybrid seeds give better yields than HYVs but they require more inputs. To gain more production using hybrids it is mandatory to use urea and DAP, which increases the cost of production. The Agriculture Department is pushing for the adoption of hybrid seeds to increase production (Viraktamath, 2011). However, the authorities and corporations promoting hybrid rice do not pay much attention to the importance of other qualitative aspects of the cereal, such as the taste of the grain when cooked, its nutritional content, the storability of cooked food, the quality and nutritional content of straw. Loss of seed biodiversity/heritage is another overlooked aspect.

We take for granted the capacity of plants to produce seed, for this is what feeds the world. Since the domestication of wild plants, farming has always relied on the natural ability of plants to reproduce. Historically seed has not produced much profit, for it was open access and could be shared. Therefore to profit from seed production and supply, the reproduction cycle had to be blocked. The F_1 hybrids offer this trait to corporations keen to expand their captive markets. Hybridisation generates something akin to sterility in plants, because the seeds from a hybrid cannot be advantageously saved for re-planting. Thus hybrid seeds offer corporations a captive market. Significantly, the same multinational corporations who control much of the hybrid seed market are also the world's biggest pesticide and biotechnology companies (Kuyek et al., 2001). The government has been supporting the corporations, partly because their success in raising yields has covered up the lack of progress made by the government in the farming sector. Another reason could be the amount of money swishing around in this industry.

Loss of biodiversity

Due to decades of genetic erosion through use of HYVs and hybrids, the biodiversity in rice across Asia is under threat (Anonymous, 2012; Special correspondent, 2012). Traditional varieties, or landraces, are being lost each year as farmers with small holdings and few other options increasingly adopt hybrid rice. Earlier the farmers collected

and preserved their paddy seeds across generations (farmer saved seed). Seeds specific to land types and suited to the climatic conditions of each season were available. But with the advent of hybrids and HYVs, and neglect of the agricultural sector by successive governments, farmers have practically speaking been forced to buy and plant hybrid seeds. The expansion of HYV and hybrids with a narrow genetic base – HYVs dependent on a single dwarfing gene from a *Japonica* variety and the hybrids maintaining a male-sterile line (Cytoplasmic Male Sterility) from a single source – has reduced genetic diversity to biostress levels (Fitzgerald-Moore & Parai, 1996).

The earlier practice of keeping seeds has been lost due to the influence of seed companies and other market forces, which work on a strictly profit-orientated basis. Thus farmers nowadays are not sharing seeds with other farmers, which was the predominant practice in earlier times. The result of this is an erosion of biodiversity in rice; farmers can nowadays count the number of traditional varieties of paddy grown in their locale on the fingers of their hands. Many of the traditional landraces have been collected for ex situ conservation in the germplasm collections of the large breeding institutions, where they are used to create patented rice varieties that are then sold to the very farmers who bred and developed them over generations. Thus a gradual erosion of rice genetic diversity has begun, since thousands of landraces have been replaced by relatively few high yielding varieties or hybrids (Rahman, Sharma, & Sahai, 2006).

Methodology

The study area belongs to Agro-Climatic Subzone IV under Agro-Climatic Zone VII, which covers most of Jharkhand. The average rainfall in the region is 1200-1500mm. Rice is the primary cereal crop cultivated in the region under rainfed conditions during the monsoon period. The region has undulating land, which is a characteristic feature of Jharkhand. The lowland (*don*) is generally used for the cultivation of rice although certain rice varieties are also grown on medium land as well as upland.

A survey was conducted with 26 farmers in Bero block (known for its vegetable production) and Angara block of Ranchi district. Close to the state capital Ranchi, these blocks were chosen as they were more likely to have better penetration of hybrid seeds in their markets and villages. Society for Promotion of Wastelands Development (SPWD) has been working in Angara block for the more than three years and in Bero block for the past two years through its

partner Asian Institute of Sustainable Development (AISD), Ranchi. The farmers selected for the interview survey may or may not have been beneficiaries of SPWD project, as they were randomly selected only on the basis of cultivation of hybrid seeds *and* traditional seeds. Purposive random sampling was used, meaning that only those farmers cultivating hybrid rice for three or more years were included in the survey. Although it was planned that the study should encompass traditional, HYV and hybrid seeds, it was later found that farmers had replaced HYV seeds with hybrids, i.e. farmers were not growing HYVs. The lack of availability of HYV seeds may have been one reason for this.

To gauge the reach of hybrid seeds, and the effects of hybrid rice cultivation on resource poor farmers, small and marginal farmers were selected for the study. Large farmers can access irrigation when required and also apply generous doses of fertilizer for better crop production This is why large farmers are chosen by agricultural scientists wanting to show the 'yield gains' of growing hybrid rice (Hill, 2015). Small and marginal farmers were selected to find out how such households were adopting hybrid seeds, which are more demanding in terms of inputs, and to see whether they were finding the cultivation of hybrid rice remunerative. A semi-structured interview method was adopted during the survey to collect the required information from respondents and to give them the freedom to express their views about the adoption of hybrid rice and its performance. The participants were asked close-ended questions and open-ended questions. The questionnaire prepared for the survey was kept purposively small so as not to inconvenience the respondents and press them for time. Much of the data eked out of the farmer respondents is qualitative in nature and based on their individual perceptions. A Focus Group Discussion (FGD) was also held to find out the impression of the community regarding the changes related to adoption of hybrid rice. The FGD was organised in Hariharpur Jamtoli village in Bero block, where there is high penetration of hybrid seeds and farmers have been exposed to hybrid seeds for more than 10 years. The primary data was analysed using SPSS.

Results and discussion

Reason for shifting to hybrid rice

All the farmers gave one reason, the overwhelming factor, for their shift to hybrid rice from traditional or high yielding varieties – the promised increase in yield of the crop. Although farmers knew that hybrid crop required more inputs, and that they had to buy the seeds

every year, most of the farmers were content with the productivity of hybrid rice. The farmers were well informed about the new seeds and fertilizers coming in the market. Most of the villagers had shifted to cultivation of hybrid rice however some farmers in the village were also cultivating traditional varieties of rice. As the farmers had given up growing traditional rice just a few years ago, they could remember the time when they primarily grew traditional rice varieties such as *kalamdani, gopalbhog, dhusri, karhaini,* and *anjani goda*. The farmers said that they shifted to cultivation of hybrid rice as the yield of traditional rice was low, and hybrid rice seeds gave more yield from the same piece of land. Traditional rice was also affected by diseases like silver soot and *loha rog* and suffered from the problem of lodging. What's more, the choices of farmers are nowadays limited, because traditional seeds are unavailable in most villages and farmers have become dependent on the market for procuring seeds.

Comparative productivity of hybrid and traditional paddy

The yield which the scientific community claims for the hybrid seeds does not crystallize in the form of output at most farmers' field. From the data set we find that the farmers who cultivate hybrid paddy seed got an average yield of 2.6 tonne/ha during the last *kharif* season which is nearly half that of the potential yield (Table 1). Another study shows a yield gap of 52 percent (Kumar, Sinha, Mishra, Ahmad, & Singh, 2015). The production may have been influenced by environmental factors, e.g. low rainfall which resulted in decreased yield. Though this needs further probing, yield increase of hybrid over traditional shows a 142 percent increase for the two scheduled caste (SC) farmers' interviewed, who have assured sources of irrigation. For the six 'other backward caste' (OBC) farmers interviewed, who had no irrigation facilities, the data shows a 6 percent decrease in yield. Finally, the bulk of the interviewed farmers, 18 scheduled tribes (ST), were found to have a slightly improved grain yield (9 percent) when comparing hybrid to traditional rice.

Table -1. Comparative data of hybrid and traditional paddy yield according to social categories

Social category (number of respondents)	Productivity (tonne/ha) hybrid rice	Productivity (tonne/ha) traditional rice	Yield increase of hybrid over traditional
OBC (n=6)	2.76	2.94	-6%
SC (n=2)	4.02	1.66	+142%
ST (n=18)	2.51	2.31	+9%
Average (26)	2.68	2.43	+10%

Delicacy of rice: Hybrid vs. traditional

Earlier surveys conducted to gauge farmers' assessment of the edibility of hybrid rice have shown it has inferior taste, no stickiness, no flavour, etc. (Anonymous, 2011). The present survey gave similar results. Although only 2 of 26 respondents said that hybrid rice tasted bad, 38 percent said the rice had little taste while the remaining 54 percent said that they have now become habituated to eat this form of rice. All agreed that hybrid rice needed tasty vegetables to go with it, and unequivocally said that traditional rice tasted much better than hybrid rice and could be eaten just with salt and no extras. Just one respondent, a young man had not tasted traditional rice for more than seven years, and was undecided about the taste of traditional rice. The survey results show that farmers who have shifted to hybrid rice or are mostly growing hybrid rice are becoming habituated to eating the rice, since they have little choice in the matter. They may prefer traditional rice, but if it is not available they consume hybrid rice or hybrid and traditional rice alternately. In the FGD, the villagers were unanimous that hybrid rice is much less tasty than traditional varieties of rice. Their responses were similar to those found in the survey. They could eat hybrid rice only with vegetables whereas they could eat traditional rice by just mixing salt in it. When not cooked properly, the hybrid rice gets sticky.

Preference in consumption

Although farmers overwhelmingly rated traditional rice as better in taste, their consumption pattern does not show the same preference. This decision is influenced by the availability of the type of rice in the household. Thus over half of the farmers (14 farmers) said they preferred traditional rice over hybrid rice, while one quarter (7 farmers) said that they consumed hybrid rice because they had no choice. Among the respondents, only one farmer was found to grow and consume HYV rice throughout the year, with a total of two farmers saying they prefer to consume HYV rice. All the interviewed farmers had ration cards and were eating the rice they received through the public distribution system (PDS). This shows that the PDS system has a good reach in the villages and that the quality of grains supplied is good, as no one complained about inferior quality rice being supplied. Regarding its nutritional value, the farmers opined that hybrid rice did not give much energy. If they ate hybrid rice, they felt hungry soon, e.g. after just a few hours of hard work, the stomach felt empty and they had no energy to continue. This was not the case with traditional rice, which after consuming in the morning allows one to work all day long.

After cooking storability: Hybrid vs. traditional

All the farmers claimed that after cooking, the keeping quality of hybrid rice was not good, as it degenerated after four to five hours. If rice has been cooked in the morning it had to be finished by the afternoon, and could not be eaten in the evening. However, the keeping quality of traditional rice was rated very well by all respondents and could easily last the day. In fact farmers were in the habit of eating traditional rice in the morning which was cooked the night before. Some of the farmers even recalled times when they ate traditional rice two or three days after cooking. Rice which becomes sour after one day is known as 'kanji bhat' and is eaten with relish. These findings have obvious implications on amount of fuel use and time spent on cooking.

Use of straw as fodder

All the interviewed farmers barring one owned livestock and fed the straw of their harvested paddy to their livestock. 20 of the farmers said that their livestock ate the straw of traditional rice with relish but this was not so with the straw of hybrid rice. The other five respondents said that since the straw got mixed up, they could not say which straw their animals' preferred. The reason for the preference of straw of traditional rice was that the straw was soft and perhaps more tasteful to the animals. The straw of hybrid rice was hard but it was better for cutting it into smaller pieces (*kutti*) which could be fed to livestock after mixing it with gram flour and other additives like *choker*, which are used to make the straw palatable to the animals.

Grain storage issues

Earlier the farmers had used the straw to make rope, which was then used to make *mora* (the traditional method to store crops). However, none of the interviewed farmers reported utilizing straw for the storage of crops. Nowadays they mostly use plastic sacks, available in the market, for the storage of rice. With regards to the storage of hybrid rice, the farmers in the FGD said that hybrid rice was very susceptible to Rice Weevil (*surhi*) so it had to be sold off or eaten within a few months. After that it became damaged by Rice Weevil and had to be cleaned often.

Use of Urea, DAP and cow dung manure in rice cultivation

Every farmer cultivating hybrid rice said that urea and DAP was applied to increase the productivity of the crop. Just over half (58 percent) the farmers had applied cow dung to their fields. The average

amount of fertilizer used was 25-30 kg of urea and 12-15 kg of DAP per acre. The amount of cow dung used as manure could not be quantified as farmers used whatever was available at home, the quantity varying according to the number of cattle owned. Among the farmers who cultivated traditional rice, just over half applied urea and DAP to their fields. The average amount of fertilizer used was 8-10 kg of urea and 4-5 kg of DAP per acre. Thus the amount used for traditional rice was much less (almost a third) than that used in cultivation of hybrid rice. The farmers said that if they used more fertilizer for traditional rice, then the plants grew very tall which led to lodging in the crop and loss in production. So the farmers either applied chemical fertilizers in small doses or did not apply them at all.

Land degradation

The farmers were aware that their farmland was getting hard due to the use of urea and DAP. After continuous use of urea and DAP it was getting difficult to plough the fields using their bullocks. The villagers said that if a farmer takes farmland on lease, they invariably use more fertilizer to get more yield, even though this leads to more hardening of the soil. Nowadays, and as an effect of the above, more people are using tractors to plough the fields.

Comparison of the selling price of hybrid and traditional rice

The majority of respondents (92 percent) said that the selling price of hybrid rice was 1-2 Rupees per kg higher than that of traditional rice. After harvest the farmers sell the paddy to traders. The selling price of hybrid rice during the period of study varied from 12-15 Rupees per kg. The traders preferred the long and thin grains of hybrid rice over the shorter and thicker grains of traditional rice varieties, because urban consumers have a liking for the former Nevertheless, certain traditional varieties like *kalamdani*, which produces long and thin grains, commands the same selling price as hybrid rice.

Preference in selling

Among 26 farmers 18 of the respondents (over two-thirds) preferred to sell their harvested hybrid rice, while about one-quarter (6 farmers) did not sell the paddy as their production was insufficient to last them through the year. In the region, farmers generally grow traditional rice for consumption in the household as it tastes better, and hybrid rice to be sold in the market for cash. Only one participant, who grew *goda dhan* on uplands, sold the traditional rice because it is not as tasteful as other traditional varieties.

Reasons for continuing to grow traditional varieties of rice

When farmers grew traditional rice they mainly used the broadcasting method, besides, they only applied whatever cow dung manure was available at their home. However, when cultivating hybrid rice they applied more inputs in the form of fertilizers and pesticides and used the transplanting method. The villagers were aware that the input costs of hybrid rice cultivation, including price of seeds, fertilizers and pesticides, were higher than that of traditional rice. The high seed cost of hybrid rice, high requirement of fertiliser and pesticide, and use of labour required for its cultivation increases the cost of hybrid rice production, which adversely affects its profitability (Chengappa, Janaiah, & Srinivasa Gowda, 2003). Some farmers expressed the view that if they put the same effort and resources into growing traditional rice, the productivity could match that of hybrid rice. During the individual interviews, some farmers who continued to grow traditional rice but who also grew hybrid rice said that when water availability to plants was ensured, the yield of some traditional varieties was not much lower than that of hybrid rice.

Conclusion

This study reaffirms the view of earlier studies that the secondary characteristics of hybrid rice are hardly acceptable (Janaiah, 2002, pp. 4323-4325). Hybrid seeds are being planted by farmers because of the promise of higher yield and also because they have limited choice. Many farmers have lost access to the traditional seeds which they earlier planted year-after-year. The market supplies hybrid seeds in abundance, whereas HYV seed is less available and traditional seed hard to come by in many villages. The number of villagers planting traditional seed varieties is decreasing fast with a consequent loss in biodiversity. This mirrors the findings of Hill (2015), who shows that over the period 1999-2008, 14 out of 46 sampled farmers stopped sowing traditional varieties altogether, while the number growing hybrid rose from 4 in 1999 to 37 in 2008. Government policy does not seek to preserve biodiversity, but rather narrowly focuses on promoting hybrid seeds (via the private market) for better productivity.

This study brings to forefront the secondary characteristics which have been neglected while promoting hybrids to farmers. Though these characteristics are desirable and important from the farmers' view, they have been neglected by policy makers who consider food security in simplistic terms, equating it with abstract

numbers, and only considering the yield aspect to the neglect of secondary attributes.

Although there is little doubt that we need to produce more to feed the growing population, to say that hybrids are the only way to achieve this goal would be a fallacy. The productivity of hybrids in rainfed areas are lower than what was promised and only farmers with irrigation facilities are ensured of a good crop, which is a cause of concern. As the survey shows the secondary characteristics of hybrids are not desirable. The tastelessness of rice, its poor keeping quality, the inferior quality of the straw produced and the damage to the environment caused by the inputs required for growing hybrid rice do not really inspire much confidence in hybrids, especially keeping in mind the amount of resources and inputs hybrids demand. This implies that a policy of enhancing production only through use of hybrids is not self-sustaining. To sustainably produce food in the future, alternatives to the short-sighted obsession with hybrids are required.

Acknowledgements

We'd like to thank the participants of the FGD, Suresh Manjhi, Ramprasad Lohra, Govind Gop, Raju Lohra, Mukesh Gop, Rajesh Kumar, Lakhan Lohra, Rajesh Oraon and Birsait Lohra and all the farmers who gave their valuable time and shared their experiences during the study. We are also thankful to Mr. Sharat Singh (PD, SPWD) and Ms. Amita Bhaduri (PD, SPWD) for their timely and helpful guidance during the study.

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