

Spread of New Varieties of Hybrid Rice and their Impact on the Overall Production and Productivity in West Bengal

Executive Summary

Introduction

Background of the study

The spread of HYV technology resulting in the green revolution in India in the last decades and achievement of self-sufficiency in food-grains represent a success story for the Science and Technology sector. The gains from the green revolution have so far been limited largely to wheat and rice grown more or less in homogeneous tracts – both agro-climatically and socio-economically served with assured sources of irrigation. Rice being the dominant staple food for millions of people in the country, agricultural scientists and policy makers are constantly making efforts to find solutions to various production problems through technology development. The research scientists considered hybrid rice technology as a readily available option to shift the yield frontier upward in the face of declining trend of the yield potential of the existing varieties. Although a number of varieties of hybrid rice are released by the Government, the extent of adoption of hybrid rice varieties in the country is too meagre to make an impact on rice production. Against this backdrop, the present study is conceptualised and undertaken at the instance of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India with a view to assessing the actual spread of hybrid rice varieties replacing the conventional HYVs to make an overall impact of rice production.

Need for the Study

There is no concrete data to prove that the newer hybrid varieties of rice are spreading faster and replacing the older ones. Therefore, it is essential to conduct a study to assess the actual spreading of these newer hybrid varieties of rice in terms of area with simultaneous reduction in the area under older varieties for rice crop and the increases in the average yield/ha. This will help the Government of India to draw a plan for augmenting the spread of the superior newer varieties in place of the age old varieties.

Objectives of the Study

The specific objectives of the study are

1. to indicate the extent of adoption and the level of participation by the different categories of farmers in the cultivation of hybrid rice;
2. to assess the overall impact on rice production and productivity of hybrid rice cultivation;
3. to study the economics of cultivation of hybrid rice varieties vis-a-vis inbred varieties;

4. to identify factors determining the adoption of hybrid rice varieties;
5. to address various constraints and outline the prospects for increasing hybrid rice cultivation and
6. to suggests policy measures for expansion of hybrid rice cultivation.

Data Base, Sampling Design, Methodology and Coverage of the Study

The study is based on both secondary and primary data. The study period was divided into three sub-periods viz. 1984-85 to 1993-94, 1994-95 to 2003-04 and 2004-05 to 2009-10. Primary survey is confined to the National Food Security Mission (NFSM) districts in the state. The two districts viz. Howrah and Uttar Dinajpur having relatively higher concentration of hybrid seeds cultivation within the group of NFSM districts are chosen for the present study. In each of the district, two representative blocks are taken and within each block two villages are selected. In each village, a complete list of cultivating households growing hybrid rice varieties and inbred varieties are prepared and stratified according to four standard land size groups such as marginal (less than 1 hectare), small (1 to 2 hectares), medium (2 to 4 hectares) and large (more than 4 hectares) including SC, ST and women farmers. In each district, 40 hybrid rice growers from the list of hybrid rice growing cultivators are drawn at random from different land size groups on the basis of their proportion in the universe. In addition to this sample, 10 inbred variety (traditional HYVs) rice growers but non-adopters of hybrid rice are selected randomly from the different land size groups amongst inbred rice growing cultivators following the same procedure. Thus altogether, 50 rice growing cultivators are selected from each selected district. In all, 100 rice growing cultivators in the state equally spread over two selected districts constitute the size of the sample in the study. For the primary survey, the reference years are 2009-10 and 2010-11. Accordingly, 2 kharif seasons and 2 rabi seasons for the rice crop are covered in the study. Primary data are obtained by administering a structured schedule/questionnaire.

Analytical Approach

A simple tabular analysis is followed to analyze the farm level data in ascertaining the farm level spread and impact of hybrid rice technology. In order to identify the factors affecting the yield of rice, yield response function separately for hybrid and inbred rice are estimated using Log linear models. Several explanatory variables are regressed upon the dependent variable yield per hectare of rice. The explanatory variables included seed (kg/ha), manure (Rs./ha), fertilizer (Rs/ha), irrigation (number of irrigation/ha), human labour (man days/ha), machinery labour (hrs/ha), plan protection Chemicals (Rs./ha). In finding out the determinants of participation in hybrid rice cultivation logit analysis is done. For secondary data obtained from the official publications, the equation of the exponential curve is used to

measure the growth in area, production and productivity of the crop. Besides, in measuring the instability in crop production, the co-efficient of variation technique is used.

Status of Rice in West Bengal

In spite of these favourable conditions, for many years, the growth of agricultural production in the state was low compared to the same in other parts of eastern and north-eastern India and lagged behind the national average. James Boyce estimated that the growth rate of agricultural output in West Bengal between 1949 and 1980 was only 1.74 per cent per annum. By comparison, the annual rate of growth of the rural population and total population was 2.31 per cent and 2.42 per cent respectively (Boyce 1987).

Fitting a semi-log trend on the data for a longer period, *Rawal and Swaminathan (1998)* observed that West Bengal experienced acceleration in the growth of agricultural production in 1980s. The rate of growth, as experienced in 1980s was 6.5 per cent for food grains and the high growth rate was noticeable in most of the major crops in the state. Rice being the primary crop in West Bengal production grew at the rate of 6.4 per cent annually in the 1980s and at 5 per cent during 1980 to 1995 as compared to 2.2 per cent from 1950 to 1980. Rice, the most important crop of the state that came under the green revolution technology in 1980s was growing at the rate of 2.5 per cent per year in the 1990s. This rate was higher than the average growth rate of rice in 1970s. *Khasnabis* noted that the average growth rate of rice in West Bengal in 1990s was lower than the growth rate that it had recorded during 1960s, during the period when the rice crop of the state was yet to switch over to the green revolution technology.

Trend and Composition of Rice in the State

Aman, the *Kharif* rice is the most important of the three rice growing seasons both in terms of acreage sown and production. In 2009-10, *Aman* rice accounted for 66.9 per cent of total rice output and 70.8 per cent of total area cultivated under rice. The importance of *Aman* rice output in total production has however fallen from 76.1 per cent in 1984-85 to 66.9 per cent in 2009-10 while that of *Boro* crop has risen significantly from 17.9 per cent in 1984-85 to 29.8 per cent in 2008-09 exceptionally at 17.9 per cent in 2009-10. For *Summer* rice, increased share in production is attributable to increase in both area and production. The relative importance of *Autumn (Aus)* rice has also sharply fallen both in terms of acreage planted and production. The relative share of *Autumn* rice in total production declined from 8.2 per cent in 1984-85 to 3.3 per cent in 2009-10. The *Boro* or *Summer* rice was introduced in the 1960s and area cultivated with *Boro* increased rapidly thereafter. The share of *Boro* (*Summer* rice) in total rice acreage increased from 9.1 per cent in 1984-85 to 25.4 per cent in 2009-10 as against the figure of 26.2 per cent in 2008-09. It is important to note that average rice yield in West Bengal increased to 2547kg per hectare in 2009-10 which was 2061kg in

1993-94 and 1556kg in 1984-85, the period when rice crop of the state was yet to switch over to the hybrid technology. In case of *Summer* rice, yield rate increased from 2698kg per ha. in 1984-85 to 3101kg in 1993-94, which again increased to 2991kg per ha. in 2009-10. For *Winter* rice (*Aman*) yield level increased from 1504kg per ha. in 1984-85 to 2407kg in 2009-10 through 1885kg in 1993-94. *Autumn* rice recorded yield levels of 2179kg per ha. in 2009-10 which was 1683kg in 1993-94 as against 1046kg in 1984-85. In short, there has been overall increase in rice production during the period under study 1984-85 to 2009-10. Such an increase in production is driven by increases in productivity of rice of three major rice seasons whereas *Summer* rice (*Boro*) contributed to the enhancement of rice output both in terms of acreage and production.

Trend and Composition of HYV Rice in the State

It is evident that the coverage of HYV seeds in *Aman*, *Aus* and *Boro* rices increased over the time span of 1995-96 to 2009-10. In 1995-96, 97 per cent of area under *Aus* and 63 per cent of area under *Aman* was sown with HYV seeds. In 2009-10, the corresponding figures were 99.4 per cent and 87.7 per cent respectively. Evidently, 100 per cent of the *Boro* crop was planted with HYV seeds. For rice produced grown in the three seasons combined, HYVs accounted for over 90 per cent of the total area under rice in 2009-10 which was 73.1 per cent in 1995-96. Thus in terms of coverage of HYV seeds in *Aus*, *Aman* and *Boro* rice cultivation, all the varieties of rice experienced increase in acreage under HYVs.

Growth and Instability of Rice Production in the State

Rice production grew at the rate of 1.41 per cent annually in the post-introduction period (1994-95 to 2009-10) which was to 5.13 per cent in the pre-introduction period (1984-85 to 1993-94). Hybrid rice was introduced in 1994-95. Immediately after the introduction of hybrid rice, rice production grew at around 2.30 per cent per annum between 1994-95 to 2003-04 but subsequently during the latter period 2004-05 to 2009-10, there was a decline in the production front. Most of the rice production increases during the pre and post-introduction periods of hybrid rice have come from yield enhancements. Decline in area and increase in yield has been the phenomenon observed in post-introduction period of hybrid rice in the state. However, there has been a visible deceleration in rice yield growth in the post-introduction period of hybrid rice. Yields increased at a compound growth rate of 3.62 per cent per year during the period 1984-85 to 1993-94 which slowed down to 2.29 per cent per year during the period 1994-95 to 2003-04. Again in the subsequent period 2004-05 to 2009-10 there was a marginal (0.09 per cent) decline in growth of yield. Notably the period 2004-05 to 2009-10 is characterized by decline in production of rice by 0.23 per cent per annum accompanied by decrease in both area (0.14 per cent) and productivity (0.09 per cent).

Production of *Aman* grew at the rate of 1.57 per cent annually during the post-introduction period of hybrid rice i.e. 1994-95 to 2009-10 which was 3.99 per cent in the pre-

introduction period (1984-85 to 1993-94). There has been a decline in production of *Aus* consistently after the introduction of hybrid rice. The *Boro* or *Summer* crop which was introduced in the mid sixties grew significantly at high rates of 8.08 per cent and 9.23 per cent in terms of acreage and output respectively in the pre-introduction decade of hybrid rice cultivation viz. 1984-85 and 1993-94 as compared to 1.94 per cent and 1.95 per cent respectively in the post-introduction period 1994-95 to 2009-10. Yield of *Summer* rice grew at the rate of 1.06 per cent in the pre-introduction period of hybrid rice which fell abnormally to 0.01 per cent in the post-introduction period. There has been a visible deceleration in *Summer* rice output in the decade of post 1994 period (year of introduction of hybrid rice) viz. 1994-95 to 2003-04. Output of *Summer* rice grew at 9.23 per cent annually between 1984-85 and 1993-94 which slowed down to 4.15 per cent per year during the period between 1994-95 and 2003-04. The rice producing economy of the state now fails to attain even a modest growth rate, not to speak of attaining the growth rate that it recorded during the 1984-85 to 1994-95 when there was no hybrid technology in rice production.

Growth of High Yielding Varieties of Rice (HYVs) in the State

The fitted semi-log trend revealed that rice crop that came under the green revolution technology in the mid-sixties was now (1995-96 to 2009-10) growing only at the rate of 1.24 per cent per annum. This rate was higher at 2.35 per cent during the period 1995-96 to 2003-04 but subsequently the rate of growth in acreage slowed down to 1.51 per cent per year during the period 2004-05 to 2009-10 making an overall increase of 1.24 per cent in acreage under HYVs during the time span of 1995-96 to 2009-10.

Instability of Rice Production

Yield levels may vary according to the pattern of investment or the methods by which growth is brought about. For instance, irrigation from perennial sources e.g. tube wells, river-lift etc may counteract the vagaries of weather. Instability is measured by the coefficient of variation technique.

Variation in production of rice is largely contributed by variation in yield. Importantly however, instability in rice crop production has got reduced after the introduction of hybrid rice technology. As a whole, the pre-introduction period of hybrid rice, showing highest growth rates of rice in respect of area, production and productivity was associated with higher instability. For *Summer* rice, yield has been the stable component as compared to area. Similar to *Summer* rice, for HYVs variation in area has been the declining component as between the pre and post introduction periods of hybrid rice.

The output of rice grew at the rate of 2.30 per cent per annum during the decade 1994-95 to 2003-04 as against 5.10 per cent in the previous decade 1984-85 to 1993-94. In the subsequent period 2004-05 to 2009-10, the annual growth rate in the output of rice decreased by 0.20 per cent per annum. If we regard 1994-95 as the base year for the introduction of

hybrid rice technology, then over the whole period of hybrid technology, 1994-95 to 2009-10, the annual growth rate in output of rice declined from 5.10 per cent to 1.41 per cent between the pre and post introduction period of hybrid rice.

During the decade 1984-85 to 1993-94, the cropped area grew at the rate of 1.50 per cent per annum. During the period after the introduction of hybrid technology 1994-95 to 2009-10, the growth rate of cropped area declined by 0.17 per cent per annum.

Contribution of hybrid rice technology

It is reasonable to regard 1994-95 as the base year because hybrid technology in case of rice was introduced in Indian agriculture on commercial basis in the year. From a comparison of the growth of output of rice achieved during pre-introduction period 1984-85 to 1993-94, it appears that output of rice would have grown by about 5 per cent per annum in the absence of hybrid technology. This is discernible from the fact that despite technological innovation in the mid 1990s, the growth rate in the output of rice as a whole decelerated during the period 1994-95 to 2009-10 compared to the pre-introduction decade 1984-85 to 1993-94, although output of rice has shown an upward trend in the post introduction period.

Status of Adoption of Hybrid Rice at the Farm Level

Sample Farmers and Their Distribution According to Farm Size

It can be seen that small and marginal farmers together account for 97.50 per cent of the total sample farmers among hybrid adopters. The incidence of such farmers among non-adopters is 95 per cent of total sample farmers. As between small and marginal farmers, the latter constitute more in both the categories of sample farm households accounting for 75 and 80 per cent among hybrid adopters and non-adopters respectively.

Socio-Economic Characteristics of Sample Farm Households

The relatively larger size is to be found among the adopters who have an average size of 6 members per household. In contrast, non-adopters have an average size of 5. The average number of males is 3 and females are 2 per household in case of hybrid adopters. The number of workers is estimated at 3.04 per adopter household whereas for non-adopters the figure comes to 2.55. Average education of majority of the adopters (56.25 per cent) and non-adopters (65.00 per cent) is up to secondary level. A total of 37.50 per cent of adopters studied up to primary standard as against 30 per cent of non-adopters.

Caste composition of households reveals that 25 per cent of adopter households belong to scheduled castes, 1.25 per cent of the households belong to other backward castes whereas the balance 73.75 per cent of the households goes to general castes. The proportion of scheduled caste and general caste is of the order of 25 per cent and 75 per cent respectively, for non-adopters households. Survey data reveals that among the adopter

households, 88.75 per cent have the main occupation farming, 8.75 per cent are salaried, 1.25 per cent is engaged in business and the rest 1.25 per cent are wage earners working as agricultural labourers. Within the group of non-adopters, 90 per cent are engaged in farming and the rest 10 per cent are employed in self business. The average size of ownership holdings works out to 0.72 ha for adopter households and 0.67 ha for non-adopters. The average size of holdings as measured by the size of operational holdings is estimated at 0.77 ha for adopters as against 0.71 ha for non-adopters. The average size of irrigated land (all seasons combined) is estimated to be 1.39 ha for adopter households as against 1.11 ha for non-adopters. Out of the total gross irrigated area, about 60 per cent of area receives irrigation during *rabi/summer* seasons in case of adopter households while the corresponding figure stood at 54.88 per cent for non-adopters.

Cropping Pattern

Rice, maize wheat, betel leaf (pan), jute and maskalai are dominant crops in order of importance amongst the hybrid adopters in the study area. These crops together covered 98.13 per cent of the gross cropped area. Hybrid rice is mainly grown during summer and upgraded its status in the cropping pattern over the period under study.

Extent of adoption of hybrid rice at the farm level

It can be seen that during the year 2009-10 the proportion of rice area allocated to hybrid rice accounted for 18.03 per cent in marginal sized land holdings which declines consistently with the rise in the size of holding to 11.52 per cent. Similar relationship is also observed during the year 2010-11. Considering all the farm sizes together, the percentage of rice area allocated to hybrid rice is 21.09 per cent in 2010-11, which was 14.72 per cent in 2009-10. The small and marginal farmers who produce mainly for household consumption have shown interest in hybrid rice. Needless to say, hybrid technology has vast potential for improving the level of productivity of rice.

Access to hybrid rice technology

In particular it gives the proportion of households accessing various sources of information on hybrid rice technology such as training programme organized by the government, frontline demonstration programme conducted by the government, krishi vigyan kendra, extension worker of state department of agriculture, television, radio, input dealer, progressive farmer, private agency including NGOs, output buyers or food processor, credit agency and so on.

Determinants of Participation in Hybrid Rice Cultivation

The education level of farmers had a positive relationship suggesting that higher the level of education of the farmers, higher the probability of extending more area under hybrid rice. Age of the participant is having negative impact on the farmers' participation in hybrid

rice cultivation which suggested that higher the age, the lower is the probability of participation. Farm size has shown a negative association with the adoption of hybrid rice. It implied that small farmers – who make up the majority of all farmers are the potential adopters of hybrid rice in future in the state. The size of worker has shown a positive association with the adoption of hybrid rice. Household size has a negative coefficient suggesting that the larger the household size, the lower is the probability of participation in hybrid rice cultivation.

Impact of Hybrid Rice Cultivation on Overall Production of Rice

Yield performance of hybrid and HYVs

Overall, rice hybrid performed better with an average yield of 6408.53kg per ha than average yield of 5377.60kg per ha for HYVs during the 2009-10. During 2010-11, too hybrid rice recorded higher yield at 6551.28kg per ha as against 5340.89kg per ha for HYVs. Among various farm size groups, smaller sized holdings obtained highest yield in both the years. The mean yield of HYV rice however increased with the increase in the size of farm over the years. In other words, mean yield levels of HYVs were higher on larger sized holdings as compared to smaller ones in case of HYVs.

Yield Gain from Hybrid Rice over the Inbred Rice Varieties

On an average the yield gain of hybrids over HYVs was 19.17 per cent in 2009-10. During 2010-11 it was about 22 per cent. Across farm sizes, smaller sized holdings obtained higher yield gain as compared to larger sized holdings in both the years under study. Thus based on farm level performance of hybrid rice over the period it is clearly indicative of the fact that hybrid rice technology has its higher yield potential under the production environments prevailing in West Bengal.

Factors Affecting the Yield of Hybrid and Inbred Rice

The fitted Log linear model explained 75 per cent of the variation in yield in case of hybrid rice. The estimated coefficients indicated that fertilizer, human labour and machinery labour influenced the yield levels in hybrid rice. Among them, the coefficient of human labour and machinery labour were of higher magnitude in case of hybrid rice indicating that the marginal efficiency of these two inputs was higher for hybrid rice. This implies that yields of hybrid rice respond more to these inputs. The positive coefficients for human labour and machinery labour indicate that there is still scope for expanding the use of human and machinery labour in hybrid rice cultivation. The positive coefficient of fertilizer input indicated that higher the level of fertilizer use, higher the yield of hybrid rice. Obviously, the

availability of fertilizer at a reasonable price will help in pushing up the yield levels and consequently the production of hybrid rice.

For inbred rice, the fitted model explained 22 per cent of the variation in yield. The estimated coefficients indicated that seed and human labour influenced the yield levels to a great extent. This clearly shows that yield of HYVs rice respond more to these inputs. The positive coefficients of these inputs indicate that there exists scope to expand the use of these two inputs in inbred rice cultivation. Among positive coefficients, the coefficient of manure turns out to be statistically significant both for hybrid adopters and non-adopters. This implied that greater use of manure would lead to increase in productivity of HYVs (inbred).

Comparative Economics of Hybrid and Inbred Rice Cultivation

Input Use Pattern for Cultivation of Hybrid and HYV Rice

Importantly seed rate (kg/ha) is significantly lower for the hybrid than for HYVs. This is because hybrids required only one or two seedlings per hill for transplanting. Seed rate for hybrids is 11.51 kg per hectare where as it is 68.57 kg per hectare for HYVs. In case of non-adopter more or less similar seed rate is used. Organic manure use for hybrids was nearly 5 times higher than that for HYVs. The use of chemical fertilizer is 14.38 per cent higher than that for HYVs. In comparison with non-adopters, it is higher by 5 per cent. The number of pesticides sprays is relatively lower for hybrid varieties than HYVs showing hybrids relatively less sensitive to pest attack. But irrigation is almost the same for the hybrid and the inbred varieties. Labour use is significantly higher for the hybrid than for HYVs. Within the group of hybrid adopters the intensity of human labour use is about 168 days per hectare for hybrids as compared to 145 days per hectare for HYVs.

For non-adopters, it is 148 days for HYVs as against 168 days for hybrids as experienced by the adopters of hybrids. Bullock labour use in terms of days per hectare is significantly higher for hybrids than HYVs for the hybrid adopters those who cultivated HYVs along with hybrids. For non-adopters, bullock labour use for HYVs is marginally lower than that for hybrids.

Operation-wise Labour Absorption in Hybrid and HYV Rice

Higher labour use associated with hybrid cultivation as compared to HYVs was mainly for transplanting the seedlings of paddy since it involved a cumbersome method of planting one or two seedlings per hill unlike multiple seedlings per hill in inbred varieties. Operation-wise labour use pattern indicated that labour requirement is highest in post harvesting operations followed by harvesting and transplantation operations respectively both in hybrids and HYVs.

However, more labour is used in transplantation operation for hybrids (34.84 days) as compared to HYVs (32.11 days). In addition for hybrid paddy, more labour is used for ploughing, spraying plant protection chemicals and for irrigation. More importantly, hybrid rice cultivation involves greater use of female labour in the transplantation operation including uprooting of seedlings in comparison with the cultivation of conventional varieties of HYVs or inbreds. Hybrid rice cultivation is thus likely to generate additional employment opportunities for female workers in rural areas. Further operations associated with higher labour content involved more of hired labour as compared to family labour both in case of hybrids and HYVs.

Cost of Inputs Incurred on Hybrid and HYVs of Rice

During 2010-11 the average cost of production of hybrid rice worked out at Rs.28,887.40 per hectare while for inbred rice (HYVs) it was Rs.23,549.66. Among the components of total cost, expenditure on human labour formed the single largest item and accounted for 39.38 per cent and 46.82 per cent of the total cost for hybrid and inbred varieties respectively. Machinery charges accounted for the next most important item at about 16-17 per cent of the total cost in hybrid and HYVs respectively. The cost incurred on fertilizer was the next one which formed about 13 per cent of total cost for both hybrids and HYVs. Manure and fertilizer together formed about 19 per cent of the total cost in case of hybrids as against 17 per cent for HYVs. The cost of irrigation, seeds and pesticides were significantly higher in hybrid rice production. Cost of irrigation was 12.49 per cent of total cost in hybrid rice while it was 9.33 per cent for inbred (HYVs) rice. The seed accounted for 5.90 per cent of total cost for HYVs while it was 7.18 per cent of total cost for hybrids. Pesticide use was significantly higher for hybrid rice. It was about 2.05 per cent and 1.07 per cent of the total cost for hybrid and inbred rice respectively. Pesticide use was significant for hybrid rice implying that hybrid rice varieties did not possess adequate resistance to pest and diseases and are more susceptible pests and diseases.

Evidently thus as recorded in 2010-11, the total cost of inputs was about 22.66 per cent higher for hybrids than for HYVs. The largest difference in cost items between the hybrids and the inbreds was on account of seeds, pesticides and irrigation charges. The total seed cost for hybrid varieties was 1.50 times that for HYVs. This was due to the large difference in seed prices of hybrid and inbred rice although the seed rate for the hybrids was substantially lower (about 6 times). The cost of hybrid seed per kg being much higher than that of HYV seeds of rice discourages farmers from taking advantage of the hybrid technology unless it is compensated by additional yield gains. Notably the cost structure does not vary much over the years under study.

Economic Returns to Hybrid and Inbred Rice Cultivation

During the year 2010-11 the farmers growing hybrid rice realised a gross return of Rs.67,583.51 per hectare while the gross return realised in inbred varieties was Rs.61,327.32. Thus the gross return was 10.20 per cent higher in hybrid rice cultivation. However the profit (net return) realised in hybrid rice and inbred rice was of the order of Rs.38,696.10 and 37,776.32 per hectare respectively. Thus the profit gain realised in hybrid rice production was only Rs.919.78 per hectare or 2.43 per cent over inbred varieties of rice. Consequently the benefit cost ratio was also lower in hybrid rice cultivation (2.34:1) in comparison with that for inbred rice (2.60 : 1). Inter-temporarily net return from hybrids over the reference periods has increased from Rs.35,549.76 per hectare in 2009-10 to Rs.38,696.10 per hectare in 2010-11. Correspondingly for inbred rice, the net return decreased from Rs.38,383.69 per hectare to Rs.37,776.32 during the same period. The net result has been increase in benefit cost ratio for hybrid rice cultivation from 2.24: 1 in 2009-10 to 2.34 : 1 in 2010-11. Correspondingly, there has been decline in benefit cost ratio from 2.63 : 1 to 2.60 : 1 during the same period.

What are the factors that accounted for the lower profit margin in case of hybrid rice cultivation? Hybrid rice growers incurred an additional expenditure of Rs.683.25 per hectare on seed alone. Similarly hybrid growers incurred higher expenditure on labour (Rs.352.68) per hectare for performing various cultural operations. More expenditure on fertilizer (Rs.647.29), irrigation (Rs.1410.28) and pesticides (Rs.339.81) also contributed to pushing up the cost of production of hybrid rice. Coupled with higher production cost was low market price realisation for hybrid paddy. On an average, during the year 2010-11 the hybrid rice growing farmers realised a sale price of Rs.931.01 per quintal of paddy sold in the market which was lesser by Rs.8.45 per quintal realised for inbred rice. The product price difference was quite sharp during 2009-10 and during the year, price per quintal of hybrid paddy was lesser by Rs.29.13 compared with inbred rice. During the year 2010-11, hybrid rice was more profitable by Rs.919.78 per ha (2.43 per cent) than HYVs, while in 2009-10, the net return (profit) realized in hybrid rice cultivation was lower by Rs. 2833.93 per hectare as compared to HYVs.

Grain Quality Considerations and the Aspect of Marketing

Grain Quality Traits of Hybrid and HYV Rice

The quality of grain is judged from the view point of three ratios viz. hulling ratio, milling ratio and head rice recovery ratio. It is evident that hybrids have grain quality features by and large on par with those of varieties of conventional HYVs. Hybrids have milling and head rice recovery ratios of 61 per cent and 54 per cent respectively. The corresponding figures for HYVs were estimated at 61 per cent and 55 per cent respectively. Over the years under study, the ratios remained unaltered. All these suggest that the parameters that

primarily influence the adoption of hybrid rice cultivation are almost same across hybrid and inbred varieties of rice.

The Volume of Marketing

Evidently for hybrid rice, volume of output sold is higher in comparison with the receipt of paddy per farm. While, the percentage of paddy output sold was 75.24 per cent in the case of hybrid rice, it was 69.91 per cent for conventional HYVs during the year 2009-10. Similar is the phenomenon observed in 2010-11. Across size classes of land holdings, the proportion of output sold increases unmistakably with increase in the size of holdings. During the year 2009-10, in the case of hybrid rice, the proportion of output sold rose from 71.14 per cent in the group below 1 ha to 85.22 per cent in the group 2-4 hectares. During the year 2010-11, proportion of output sold increased from 74.93 in below 1 ha group to 94.46 per cent in the size group 2-4 hectares. The same tendency is noticeable in the case of HYV rice for the years under study where proportions of output sold is consistently on the rise with the increase in the size of holdings.

In case of hybrid non-adopters, of the total output, 71.52 per cent was sold during the year 2009-10 which, however fell to 68.92 per cent in 2010-11. Across size classes of land holdings, the proportion of output sold increased with the increase in the size of holding.

The price fetched in the market for hybrid paddy grain was lower as compared to inbred varieties of rice during the year 2009-10. However, during the year 2010-11 hybrid rice received somewhat higher price in comparison with inbred varieties of rice. On an average, during the year 2009-10 the hybrid rice farmers realised a sale price that was Rs.872.90 per quintal of paddy sold in the market as against Rs.881.63 per quintal for HYVs. During 2010-11 price fetched by the farmers was relatively lower both for hybrid and inbred rice with a marginally higher market price realization for hybrid paddy (Rs.863.71) as compared to HYVs (Rs.856.05).

In case of sales of husked paddy of the total outturn of hybrid rice, only 4.06 per cent was sold in the market during the year 2009-10. The corresponding proportion of output of husked paddy sold in the market was estimated at 2.03 per cent for HYVs. Similarly for hybrid non-adopters the comparable figure was 3.20 per cent. What follows therefore is that processed paddy is marginally sold in the market.

Size-group wise analysis shows that in case of hybrid rice, bigger sized holdings sold relatively higher proportion of outturn of rice as compared to smaller sized holdings. With regard to price received for milled rice, it is found that on an average hybrid adopters realized a sale price of Rs.1440 per quintal for hybrid rice against the corresponding sale price of Rs.1520.91 for HYVs. Thus during the year 2009-10 hybrid adopting farmers realized a sale price of hybrid rice that was Rs.80.91 (5.62 per cent) lesser per quintal of rice sold in the market compared with inbred rice.

During the year 2010-11, the proportion of outturn of rice sold in the market accounted for 4.68 per cent, in case of hybrid rice which was marginally (0.62 per cent) higher than what it was in 2009-10. For HYVs the corresponding proportion accounted for 2.80 per cent which is again marginally higher by 0.77 per cent as compared to the previous year 2009-10. On an average, in case of hybrids, a greater proportion of milled rice is marketed as compared to HYVs. Hybrid rice adopters received market price of Rs.1582.24 which is lesser by Rs.14.49 per quintal of rice sold in the market as compared to inbred rice.

Seasonal Flow of Marketing

Agricultural produce usually fetches lower price if sold just after the harvest and a higher price if sold during the lean period. Thus the account of sales will be incomplete without a picture of the seasonal flow of marketing. It has been revealed that hybrid adopters sold relatively greater proportion of paddy output immediately after the harvest in the months of October and November, although the marketing was spread over the months. This is discernible both in the case of hybrids and HYVs, which indicated that immediate cash needs compelled them to sell immediately after the harvest. During the year 2009-10, across months, the proportion of sales in the months of October and November ranged between 12.75 and 19.52 per cent for hybrid paddy. Almost similar proportion of sales occurred in the months of October and November in the case of HYV paddy. For non-adopters, the corresponding proportion of sales of paddy accounted for 14.52 per cent and 20.97 per cent respectively. During the year 2010-11, in case of hybrid adopters, 14.06 per cent and 18.82 per cent of total annual sales of hybrid paddy occurred in the months of October and November as against the corresponding proportions of 14.15 per cent and 18.40 per cent respectively for HYVs. The proportion of sales took place in each of these two months for non-adopters accounted for 15.52 per cent of total annual sales. The proportion of sales in the lean months viz. during March, April and August was rather small in case of hybrids and HYVs during both the reference years. This is indicative of the fact that sample farmers (both hybrid adopters and non-adopters) have not been able to take advantage of the high prices ruling at this time of the year. In contrast, greater proportion of sales in the months of October and November was mainly affected by the small sized landholders who compelled to sell their produce to meet their bare requirements.

Problems and Prospects for increasing hybrid rice cultivation

Farmers' awareness about hybrid rice technology

When asked how he has become aware about hybrid rice technology, 71.25 percent of the sample farmers reported extension worker of the state department of agriculture as their source of awareness about the hybrid rice technology. The other sources were reported to be news paper (10.00 percent) and cultivators (18.75 percent). When asked whether front line

demonstration programme was conducted in the area, majority of the respondents (65 percent) reported that frontline demonstration programme was organized by the government in order to create awareness about hybrid rice technology. With regard to their participation in the demonstration programme, 70 per cent of the farmers reported affirmative. Rice hybrids, demonstrated for the popularization hybrid rice cultivation included KRH – II (as reported by 44 per cent) having yield advantage of 80 per cent over HYVs, DRRS-II (38 per cent) with 70 percent yield advantage and PAC-835 (36 per cent) with 65 percent yield advantage. Asked whether the government organized training programme for the farmers, cent percent of the farmers held the view that training programme was organized by the government and of them 73.75 per cent reported their participation in the training programme, majority of those being one day duration.

Problems faced by the farmers in input accessibility, production and marketing

Regarding accessibility to hybrid seed input, information were asked from the farmers regarding sources of seed, quality of seed, yield gain from hybrid seed and replacement of seed over the years. One of the easily available policy options on the part of government to promote hybrid rice cultivation is subsidizing the seed supply at the initial stage of adoption. Thus when asked what is the usual source of seed for the farmers a total of 77.50 percent of farmers reported government supply as source of seed. However, seeds available during planting time were reported only by 41.25 per cent of farmers. Importantly seeds were not available at reasonable price. It was only 8.75 per cent of farmers who reported availability of seeds at reasonable price. As far as quality of seeds is concerned, a total of 48.75 per cent of farmers reported to be satisfied with the quality of seeds. Asked whether hybrid seed is easily available in the area, only 36.25 percent of farmers reported affirmative and from the rest 63.75 per cent of farmers, negative responses were received. In response to the question related to yield superiority of hybrid rice over conventional HYVs, hybrid adopters unanimously (100.00 per cent) reported that hybrid seed yields better results than the inbred seeds. A total of 11.25 percent of respondent farmers reported yield gain of 10 – 15 percent over conventional inbred varieties. Yield gain of 15 – 20 percent in hybrid rice production was reported by 43.75 per cent of farmers. Yield realized in hybrid rice higher by 20 percent and above as compared to inbred (HYV) rice was reported by 45.00 percent of farmers. The adoption of hybrid seeds prevented traditional practice of saving and exchanging of seeds. When asked how often did they replace hybrid seed varieties, 80 percent of the hybrid adopters indicated that they are replacing seeds every year while the rest 20 percent reported replacing seeds every alternative year. Thus, the availability of quality hybrid seed at reasonable price is crucial to the success of hybrid rice technology. For the popularization of hybrids there is a case for government sector intervention in quality seed production and distribution.

All the sample hybrid adopters unanimously reported that they have used fertilizer input in hybrid rice cultivation. A good proportion (84.15 percent) of sample farmers also reported to have used fertilizer input in recommended doses. Of the sample farmers those who have not used fertilizer in recommended doses, cited lack of knowledge (53.57 percent) and financial bottlenecks (43.43 percent) as the reasons for non-application of recommended doses of fertilizer. The hybrid adopting farmers have good access to fertilizer input as revealed from the responses relating to access to fertilizer input.

Sample farmers were asked whether hybrid rice crop are more susceptible to pests and diseases, a good majority of the farmers (86.25percent) reported that hybrid rice varieties are more susceptible to pests and diseases. Notably however 86 percent of the sample farmers reported to have used pesticides. When asked whether farmers know the correct does of pesticides for hybrid rice varieties, a total of 81.25 percent of farmers reported affirmative. All the sample farmers unanimously reported that pesticides are easily available in the area.

A total of 81.25 percent of farmers were of the view that hybrid rice cultivation is highly sensitive to crop management practices-use of key inputs and time bound operations. When asked whether they would require more credit for using hybrid seed, a good majority of respondents (73.25 percent) reported to be negative. Of those who require credit, 54.17 percent reported that they get credit from the institutional sources, either commercial banks or co-operatives. Farmers in major (66.67 percent) receive credit from commercial banks. Farmers those who are not availing of credit encountered one major problem of procedural formalities as perceived by 76.39 percent of farmers apart from the problem of collateral (23.61 percent).

Sample farmers were asked whether they face problems in marketing of hybrid rice produce. All the hybrid adopting farmers unanimously reported that they face problems in marketing of hybrid rice. Lack of consumer demand for hybrid rice grain, lower head rice recovery and ultimately lower price received in the market were the major problems faced by the hybrid growers. All the sample farmers reported these problems in the field of marketing of hybrid rice.

Other problems reported by the adopters included poor cooking and keeping quality (83.75 percent), poor grain quality and as a result lack of market acceptance (86.25 percent), traders not accepting hybrid rice grain lack of demand from millers and consumers (83.75 percent) and more broken rice after milling (56.25 percent).

Famers' overall perception of hybrid rice cultivation

The responses of farmers regarding overall perception of hybrid rice cultivation were elicited. When asked whether there is any yield gain from cultivation of hybrids over the best popular inbred rice varieties, all the sample farmers (cent percent) unanimously reported that there was yield gain in hybrids over connectional HYVs (inbred). Also hybrid rice production

was reported to be profitable as conceived by 78.75 percent of sample farmers. Hybrid rice varieties till now are inferior to currently available inbred varieties. Nearly 96 percent of the sample farmers reported that grain quality of hybrid rice is poor compared with the grain quality of the existing popular HYVs of rice. A total of 63.75 percent of farmers felt hybrid rice is not suitable for their taste. Many farmer respondents (81.25 percent) said hybrid rice has poor cooking quality. High stickiness of cooked rice is also reported by majority of the farmers (85.00 percent). Asked whether hybrid rice grain is acceptable to traders and millers, a total of 80.00 percent of farmers respondent reported that traders and millers do not want to accept hybrid rice grain from them on account of its poor grain qualities. Farmers are however convinced with the economic viability of hybrid rice cultivation. A good majority (75 percent) of the farmers reported that they are convinced with the economic viability of hybrid rice cultivation. Those who are not convinced cited reasons comprised of less/ non-availability of seeds and higher cost of cultivation (25.00 per cent), more susceptible to pest and diseases (15.00 per cent), poor quality of grain (35.00 per cent) and poor knowledge about hybrid cultivation, technology and management (25.00 per cent). Among hybrid growers 7.50 per cent were not in favour of continuing cultivation of hybrid rice. A total of 92.50 of hybrid adopters expressed their intention to continue cultivating the hybrid variety rice mostly (92.50 per cent) because of higher yield of hybrid rice. Some of them (31.25 per cent) are expecting new hybrids with better quality in future. In short, analysis of farmers' overall perception about hybrid rice cultivation hinted that future research on hybrid rice development should focus on improvement of grain quality besides yield in the next generation hybrids.

Reasons for non-adoption of hybrid rice cultivation (non-adopters' experience)

It has been found that 35 per cent of sample non-adopters indicated that they have not heard any of the new hybrid varieties of rice. However, a total of 65 per cent of the non-adopting farmers reported that they have heard about few varieties of hybrids and such varieties are KRH – II as reported by 67.86 per cent of farmers DRRS – II (53.57 per cent) and PAC – 835 (69.05 per cent). When asked whether they have heard of the government's hybrid rice promotion programme, nearly 55.00 per cent of the farmers reported affirmative. Asked whether they have seen any standing rice crop of hybrid variety, negative responses were received from a total of 55 per cent of non-adopting farmers. 35 per cent of the sample non-adopters reported that nobody had suggested to grow hybrid variety of rice on their farms. Among those (65.00 per cent) who received suggestions from any source, majority (54.77 per cent) reported that they have received suggestions from Agricultural Extension Officer (AEO) of the state department of agriculture. The next in importance from whom suggestion was received was village level worker (VLW).

A total of 70 per cent of the sample non-adopters had expressed their willingness to grow the hybrid variety of rice next year. According to non-adopting farmers, lower price of

hybrid rice as compared to inbred variety is the major (75 per cent) reason for non-adoption of hybrid rice. Among other reasons, 35 per cent of the non-adopters reported that they are completely unaware about the hybrid seed variety, another 35 per cent of the non-adopting farmers reported that they are not at all aware about the government assistance for the promotion of hybrid seeds, non-availability of seeds at all is reported by 15 per cent of non-adopters, a total of 20 per cent of non-adopters reported that seed is too costly, reportedly 10 per cent of the farmers are not convinced that the seed is of high quality, a total of 20 per cent of non-adopters are not convinced that hybrid yield is sufficiently high, higher yield gain but lower profitability of hybrid rice is reported by 10 per cent of non-adopters, hybrid rice cultivation involves higher risks as reported by 25 per cent of non-adopters and hybrids are not insects, pests and disease resistant variety as reported by 25 per cent of non-adopting farmers. A total of 30 per cent of non-adopters reported that the extent of yield loss due to pests and diseases is higher for hybrids. Also all the non-adopting farmers unanimously reported that they are ready to accept new hybrid rice varieties in future considering higher yield potential.

In short, the main reasons for non-adoption of hybrids were lower price of hybrid rice as compared to inbred, poor extension activities by the government for the popularization of hybrids, un-availability of quality hybrid seed, higher seed cost, higher yield loss for hybrids due to pests and diseases and higher risks associated with hybrid rice cultivation. Though higher seed cost is considered a constraint, it was given the least importance compared with other constraints. The foremost constraint confronting the diffusion of hybrid rice technology is poor grain quality and as a result lack of market acceptance leading to lower price fetched for hybrid rice as compared to inbred variety.

Policy Implications

Hybrid rice technology is considered as a readily available option to shift the yield frontier upward where rice yields are either stagnant or declining. Although this technology has got potential to increase rice yields, it has not been accepted by the farmers on a larger scale due to various constraints as discussed above. The adoption hybrid rice is not being popular in the farmers' fields largely because of inferior grain quality compared with the popular conventional HYVs (inbred). A few implications from the findings of the present study are drawn for policy interventions.

Higher yield potential alone does not induce farmers to adopt hybrid variety as shown by the experience of hybrid rice growing farmers. It is the profitability gains from production of hybrid that would motivate farmers, particularly, Commercial farmers to replace existing varieties of HYVs with new hybrids. Hybrid rice would not make the desired impact on the rice economy unless consumer demand for hybrid rice grain is created through grain quality

improvement. Therefore hybrid rice research programme need to be reoriented towards the refinement of this technology with a focus on breeding for high value varieties of hybrids.

Hybrid rice is still at an introductory stage in the state of West Bengal. Still farmers devoted more area to inbred varieties. None of the farmers had previous experience in hybrid rice cultivation. Of the 80 farmers 58 (72.50 per cent) in 2010-11 and 56 (70.00 per cent) in 2009–10 obtained seeds from public source on full subsidy and the remaining from private source on payment. Thus subsidizing the seed supply for the popularization of hybrid is the policy option followed by the government. However, subsidy on hybrid seed would not add much extra value to hybrid rice production. What is crucial is the supply of quality seeds. The present study brings out that although, many of the farmers received seeds from government sources, quality hybrid seeds are not availed of by the farmers. Moreover seeds were not available during planting time and also at reasonable price. As a matter of policy it is thus essential to ensure easy availability of quality seeds in right time to achieve the overall goal of spreading of hybrid rice on a larger scale.

A critical assessment of hybrid adopting farmers' experiences with regard to hybrid rice adoption revealed that consumers perceive hybrid as inferior to inbred in respect of grain quality. Many of them (63.75 per cent) felt hybrid rice is not suitable for their taste. Majority of the respondents said hybrid rice has poor cooking quality and high stickiness of cooked rice. Obviously, all these would have useful implications on hybrid rice research and strategy and development which should lay more emphasis on improvement of grain quality apart from the improvement in yield. Research infra-structure should be strengthened for evolving farmer- consumer acceptable varieties of rice hybrids.

Considerable progress has been made in the development and release of new hybrids since the development and release of the first hybrids for commercial cultivation in the mid 1990s. Farmers are however still not convinced with the economic superiority of hybrid rice over the inbreds (conventional HYVs). Rice breeders should therefore develop and evolve input efficient hybrids to popularize the cultivation of hybrid rice. Higher cost of production and lower market price realization has contributed to lower profitability of hybrid rice cultivation even though yield (19-22 percent) was higher. This calls for improvement of technology to reduce cost of cultivation and enhancing the quality attributes of hybrid rice.