Study No. 172

Assessment of Pre and Post Harvest Losses in Rice and Wheat in West Bengal

Debashis Sarkar
Vivekananda Datta
Kali Sankar Chattopadhyay

Agro-Economic Research Centre
Visva-Bharati
Santiniketan
2013

Preface

Loss in the yield of any annual field crops (cereals/pulses/oilseeds) is due to a variety of reasons. In the present agricultural scenario, except maize, all the other cereals are only food grains not the commercial crops. In such crops, after applying all the cash inputs viz., fertilizers, pesticides, herbicides etc., the profit is far less as compared to the commercial crops. If that be the case, extraneous factors such as rains, low night temperature, extremely hot temperature, damage by bird causing yield loss would further narrow down the profit. In the event of facing all these extraneous factors, maximum yield has to be secured as far as possible. There are many technologies to minimise yield loss after the harvest of cereals. When the loss is imminent, more certain (example incessant rains at harvest), then necessarily pre-harvest measures are to be followed to reduce the yield loss. The reasons of the pre and postharvest losses which occur in rice are (1) when the optimum stage of harvest is missed, (2) due to continuous and intermittent rain, (3) due to lapse of time between harvesting and threshing, (4) due to un-threshed grains remaining on panicles, (5) due to grain shedding and (6) damage by birds during grain development. Intending the same, a study entitled "Assessment of Pre and Post Harvest Losses in Rice and Wheat in West Bengal" has been assigned by the Ministry of Agriculture, Government of India to look into the pre and post harvest losses of two important crops i.e. rice and wheat in West Bengal under the coordination of ISEC, Banagalore.

As per the available data, the crop losses caused by pests and diseases are huge. But, the knowledge on the crop loss at the farm level is very much limited. In addition to losses that occur during the growth period of the crop, there is a huge quantity of grains lost during the process of harvesting, threshing, transportation and storage. Therefore, the present study makes a comprehensive attempt to estimate the dimension of losses occurring during the pre and post harvest stages of rice and wheat in West Bengal. The study estimates yield losses due to pest and diseases in the crops namely, rice and wheat. For the pre harvest losses, generally animal pests (insects, mites, rodents, snails and birds), plant pathogens (bacteria, fungi, virus, and nematodes) and weed are collectively called pests, which cause economic damage to crops. This broader definition of pests and diseases is followed in the present study. For estimating post harvest losses, there is a need to establish the extent of losses during storage under different agro climatic conditions. Causes of storage losses include sprouting, transpiration, respiration, rot due to mould and bacteria and attack by insects. Sprouting, transpiration and respiration are physiological activities that depend on the storage environment (mainly temperature and relative humidity). These physiological changes affect the internal composition of the grains and result in destruction of edible material and changes in nutritional quality. But it would be difficult to measure the loss due

to physiological changes at the farm level. Nevertheless, an attempt has also been made to estimate such losses based on the visual observations and according to farmer's estimates.

The study was initially entrusted to Sri Vivekananda Datta and Sri Kali Shankar Chattopadhyay under the supervision of Debashis Sarkar. The primary data collection, analysis and preparation of tables were done by Sri Vivekananda Datta and Sri Kali Shankar Chattopadhyay with an active support of Sri Sudeep Kulkarni. The secondary data was collected by Sri Sumantra Hazra. However, the entire drafting of the report was done by the authors themselves.

On behalf of the Centre, I would like to extend my sincere thanks and gratitude to Prof. Paramod Kumar, ISEC, Bangalore for his excellent coordination starting from the initiation of this study. I also extend my sincere thanks to the Director of Agriculture, Government of West Bengal, Dy. Director of Agriculture, District Bankura,Burdwan,Uttar dinajpur and Murshidabad for their active support in conducting the field survey and collection of necessary information from the respondents. I am personally indebted to Dr. Bholanath Mondal, Assistant Professor in Plant Protection, Institute of Agriculture, Visva-Bharati for his technical help and support at the time of tabulation and formation of tables. Last but not the least I would like to extend my heartfelt thanks to the numerous respondents who have devoted their valuable times in providing useful information for conducting this study.

Santiniketan
May, 2013

Saumya Chakrabarti
Hony.Director

Contents

Chapter	Particulars	Page No.
1.	**Introduction**	**6 - 9**
	1.1 Status of agricultural economy in West Bengal	6
	1.2 Importance of rice and wheat in West Bengal	6
	1.3 Background of pre and post harvest losses	7
	1.4 Need for the present study	7
	1.5 Objectives of the study	8
	1.6 Data base and methodology	9
	1.7 Organisation of the report	9
2.	**Area, Production and Productivity of Rice and Wheat in West Bengal**	**10 – 18**
	2.1 Trend and growth in area, production and yield of rice and wheat in West Bengal	11
	2.2 Changes in costs and profitability of rice and wheat (based on CACP reports)	14
	2.3 Secondary estimates of losses caused by pests and diseases in rice and wheat: A review	16
	2.4 Summary of the chapter	18
3.	**Households Characteristics, Cropping Pattern and Production Structure**	**19 - 27**
	3.1 Socio-economic characteristics of the selected farmers	20
	3.2 Characteristics of operational holdings	21
	3.3 Structure of tenancy	21
	3.4 Sources of irrigation	22
	3.5 Cropping pattern	23
	3.6 Percentage of area under HYV	24
	3.7 Crop productivity , marketed surplus and value of output by farm size	25
	3.8 Summary of the chapter	27
4.	**Assessment of Pre Harvest Losses of Rice and Wheat**	**28 -40**
	4.1 Constraints faced in cultivation of rice and wheat	29
	4.2 Assessment of incidence of pests and diseases attack and crop losses	29
	4.3 Methods of pests and diseases control adopted by the selected sample households	34
	4.4 Sources of information for pests and diseases control by the selected households	38
	4.5 Household suggestions on how to minimise pre harvest losses	39
	4.6 Summary of the chapter	40
5.	**Assessment of Post Harvest Losses of Rice and Wheat**	**41 - 52**
	5.1 Production loss during harvest	42
	5.2 Production loss during threshing and winnowing	43
	5.3 Production loss during transportation and handling	45
	5.4 Production loss during storage	46
	5.5 Capacity utilisation of storage by the selected households	47
	5.6 Quantitative aspects of storage and their pests control measures adopted by the selected households	47
	5.7 Households suggestions how to minimise post harvest losses	50
	5.8 Summary of the chapter	
6.	**Summary, Conclusions and Policy Suggestions**	**53 -59**
	6.1 Introduction	51
	6.2 Objectives of the study	51
	6.3 Data base and Methodology	52
	6.4 Main findings	53
	6.5 Conclusions and policy suggestions	57
References		**60-61**
Annexure-I		62
Annexure-II		**63-64**
Annexure-III		**65-66**

List of Tables

Table	Particulars	Page No.
2.1	Growth rates of production of rice and wheat in West Bengal during 1970-71 to 2009-10	13
2.2	Growth rates of area of rice and wheat in West Bengal during 1970-71 to 2009-10	13
2.3	Growth rates of yield of rice and wheat in West Bengal during 1970-71 to 2009-10	13
2.4	Different costs in the production of rice and wheat at all-India level	15
2.5	All India trend growth rates of different costs and yields in rice and wheat	15
2.6	CoP of different states in relation to all-India average in rice and wheat	16
2.7	Major pests in various rice based cropping systems	17
2.8	Ecology-wise key insect pests of rice in India	**17**
3.1	Demographic profile of the selected farmers (per cent of households)	20
3.2	Characteristics of operational holdings (acres per household)	21
3.3	Nature of tenancy in leasing-in/leasing-out land (per cent households)	22
3.4	Source of irrigation of net irrigated area (per cent)	23
3.5	Cropping pattern of selected farmers (per cent of GCA for the whole year)	24
3.6	Percentage of area under HYV seeds	25
3.7	Average yield of major crops grown by the selected households (quintal per acre)	26
3.8	Percentage of output marketed by the selected households	26
3.9	Value of output and marketed surplus (aggregate of all crops)	27
4.1	Constraints faced in cultivation of reference crop (percentage of households)	29
4.2	Identification of pests and diseases attack (percentage of households)	30
4.3	Incidence of major pests and disease (percentage of households) – Rice	31
4.4	Incidence of major pests and disease (percentage of households) – Wheat	**32**
4.5	The magnitude of crop loss due to pests, disease and weed infestation- Paddy	34
4.6	The magnitude of crop loss due to pests, disease and weed infestation- Wheat	34
4.7	Details of biological methods adopted for pests and disease control	36
4.8	Cost of chemical methods adopted for pests and disease control in rice	37
4.9	Cost of chemical methods adopted for pests and disease control in wheat	37
4.10	Extension services on pests and disease control management (percentage of hh)	39
4.11	Households suggestions on how to minimize pre harvest losses	39
5.1	Quantity lost at different stages of harvest (Crop – Rice)	42
5.2	Quantity lost at different stages of harvest (Crop – Wheat)	43
5.3	Quantity lost during threshing and winnowing (manual)	44
5.4	Quantity lost during threshing and winnowing (mechanical)	44
5.5	Quantity lost during transportation and handling (Crop – Rice)	45
5.6	Quantity lost during transportation and handling (Crop – Wheat)	45
5.7	Quantity lost during storage	46
5.8	Capacity utilization of storage by the households	47
5.9	Total post harvest losses per quintal by farm size	48
5.10	Some quantitative aspects of storage (percentage of households)	49
5.11	Households suggestions on how to minimize post harvest losses	50

Chapter-I

1. Introduction

1.1 Status of agricultural economy in West Bengal

Economy of West Bengal, a state in eastern India, is highly dependent on agriculture, although services and industries play an increasingly significant role in the economy of the state. A significant part of the state is economically backward, namely, large parts of six northern districts of Cooch Behar, Darjeeling, Jalpaiguri, Malda, North Dinajpur and South Dinajpur; three western districts of Purulia, Bankura, Birbhum; and the Sundarbans area. Years after independence, West Bengal was still dependent on the central government for meeting its demands for food; food production remained stagnant and the Green Revolution bypassed the state. However, there has been a significant spurt in food production since the 1980s, and the state now has a surplus of grains. The state's total financial debt stood at 191,835 crore (US$34.91 billion) as of 2011.

In 2009-10, the tertiary sector of the economy (service industries) was the largest contributor to the gross domestic product of the state, contributing 57.8 per cent of the state domestic product compared to 24 per cent from primary sector (agriculture, forestry, mining) and 18.2 per cent from secondary sector (industrial and manufacturing).

Agriculture is the leading occupation in West Bengal. Rice is the state's principal food crop. Rice, potato, jute, sugarcane and wheat are the top five crops of the state. Other major food crops include maize, pulses, oil seeds, wheat, barley, and vegetables. The state supplies nearly 66 per cent of the jute requirements of India. Tea is produced commercially in northern districts; the region is well known for Darjeeling and other high quality teas. State industries are localised in the Kolkata region, the mineral-rich western highlands, and Haldia port region. The Durgapur-Asansol colliery belt is home to a number of major steel plants. Manufacturing industries playing an important economic role are engineering products, electronics, electrical equipment, cables, steel, leather, textiles, jewellery, frigates, automobiles, railway coaches, and wagons. The Durgapur centre has established a number of industries in the areas of tea, sugar, chemicals and fertilisers. Natural resources like tea and jute in and nearby parts have made West Bengal a major.

1.2 Importance of rice and wheat in West Bengal

Rice and wheat are the two major food crops of India in general and West Bengal in particular. Therefore, primary food security concerns are focused on improving and sustaining their productivity. With the advent of the “Green Revolution”, these two crops have come to occupy a significant area in the Indo-Gangetic Plain (IGP) of South Asia, which extends from Pakistan in the west to Bangladesh in the east. Rainfed rice predominates in the abundant rainfall zones of the eastern IGP where there is scope for growing rice under ponded water conditions, during the rainy season while irrigated rice is grown in the western IGP. Wheat assumes greater prominence in the western IGP, where it is normally grown with irrigation in the winter, in

rotation with rice. Cultivation of rice and wheat in the IGP of Nepal and adjoining parts of India including West Bengal is prehistoric, although in the north-western IGP of Pakistan and India it is a recent phenomenon. Its adoption accelerated after the introduction of short-statured, fertilizer responsive varieties in the 1960s. The photo-insensitive nature of these cultivars of rice and wheat has extended the span of their feasible sowing/transplanting times. This has extended their growing region much beyond their traditional environmental limits. There has been a steady expansion in the area of rice and wheat in non-traditional areas. Therefore, considerable new areas of wheat cultivation in the IGP and the expansion of rice in the north-western IGP has occurred during the past quarter century. Both of these crops are highly exacting in their water and nutrient needs and have been extensively supported by rapid and vast development of surface irrigation systems. The comparative short-duration (100–120 days of rice after transplanting and 135 to 150 days of wheat) of recent varieties of rice and wheat has offered a unique opportunity for extension of area under a two crops-a-year, rice-wheat sequence. The flexibility in planting time has induced farmers to advance the transplanting schedules of rice to still earlier dates so as to enable them to practice double cropping according to convenience of management of the rice-wheat cropping system (RWCS) within the overall limitation of their specific agro-eco-regional domains.

1.3 Background of pre and post harvest losses

Grains may be lost in the pre-harvest, harvest and post-harvest stages. Pre-harvest losses occur before the process of harvesting begins and may be due to insects, weeds and rusts. Harvest losses occur between the beginning and completion of harvesting, and are primarily caused by losses due to shattering. Post-harvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed and dried, as well as losses along the chain during transportation, storage and processing. Important in many developing countries, particularly in Africa, are on-farm losses during storage, when the grain is being stored for auto-consumption or while the farmer awaits a selling opportunity or a rise in prices.

Loss in the yield of any annual field crops (cereals/pulses/oilseeds) is due to a variety of reasons. In the present agricultural scenario, except maize, all the other cereals are only food grains not the commercial crops. In such crops, after applying all the cash inputs viz., fertilizers, pesticides, herbicides etc., the profit is far less as compared to the commercial crops. If that be the case, extraneous factors such as rains, low night temperature, extremely hot temperature, damage by bird causing yield loss would further narrow down the profit. In the event of facing all these extraneous factors, maximum yield has to be secured as far as possible. There are many technologies to minimise yield loss after the harvest of cereals. When the loss is imminent, more certain (example incessant rains at harvest), then necessarily pre-harvest measures are to be followed to reduce the yield loss. The reasons of the pre and postharvest losses which occur in rice are (1) when the optimum stage of harvest is missed, (2) due to continuous and intermittent rain, (3) due to lapse of time between harvesting and threshing, (4) due to un-threshed grains remaining on panicles, (5) due to grain shedding and (6) damage by birds during grain development

Harvesting rice immediately after the cessation of the biological maturity ensures maximum yield and better milling .characteristics. Too early harvest results in more chaff and ill-filled grains while delayed harvest results in low yield as the crop suffers various pre-harvest losses and milling quality is impaired. The rice harvested one week before the age of maturity exhibited the lowest level of average grain loss whereas a delay in the harvest operation by 3 or 4 weeks resulted in higher grain loss. Timely harvesting ensures good grain quality, high market value and improved consumer acceptance. As the quantity and quality of the produce is related to the stage of harvest, a critical assessment of the optimum stage for harvesting the crop is necessary.

1.4 Need for the present study

As per the available data, the crop losses caused by pests and diseases are huge. But, the knowledge on the crop loss at the farm level is very much limited. In addition to losses that occur during the growth period of the crop, there is a huge quantity of grains lost during the process of harvesting, threshing, transportation and storage. Therefore, the present study makes a comprehensive attempt to estimate the dimension of losses occurring during the pre and post harvest stages of rice and wheat in West Bengal. The study estimates yield losses due to pest and diseases in the crops namely, rice and wheat. For the pre harvest losses, generally animal pests (insects, mites, rodents, snails and birds), plant pathogens (bacteria, fungi, virus, and nematodes) and weed are collectively called pests, which cause economic damage to crops. This broader definition of pests and diseases is followed in the present study. For estimating post harvest losses, there is a need to establish the extent of losses during storage under different agro climatic conditions. Causes of storage losses include sprouting, transpiration, respiration, rot due to mould and bacteria and attack by insects. Sprouting, transpiration and respiration are physiological activities that depend on the storage environment (mainly temperature and relative humidity). These physiological changes affect the internal composition of the grains and result in destruction of edible material and changes in nutritional quality. But it would be difficult to measure the loss due to physiological changes at the farm level. Nevertheless, an attempt has also been made to estimate such losses based on the visual observations and according to farmer’s estimates.

1.5 Objectives of the study

Keeping in view about this important subject, the specific objectives of the study are given below. The specific objectives of the study are:

1. To estimate the physical and financial losses caused by pest and diseases in rice and wheat at farm level
2. To estimate the measures of pest and disease management to reduce the crop loss due to pests and diseases at farm level
3. To arrive at post harvest losses in rice and wheat under different agro climatic conditions.
4. To identify factors responsible for such losses and suggest ways and means to reduce the extent of losses in different operations national productivity.

1.6 Data base and methodology

The study has been conducted based on the farm level data collected from the selected respondents in West Bengal. The crop production constrains particularly infestation by pests and diseases, and losses caused by them have been worked out based on the estimates provided by the farmers. As not only pests and diseases cause crop damage when their population reach beyond a threshold level, there are also other bio-economic factors like soil fertility, water scarcity, poor seed quality, high input costs and low output prices result in considerable financial loss to farmers. Thus, data on these bio-economic variables have also been collected from the farmers. The post harvest losses during the process of harvesting, collection and threshing, transportation and storage have also been quantified based on the estimates provided by the farmers. Storage material used by the farmers is generally mud, bamboo, stone, plant materials etc. it is essential to identify the structure of storage at the farmers' level and enumerate the losses occurring in the process of storage at the farmer level.

To collect the primary data, a sample survey has been conducted in four districts viz. Bankura & Burdwan for rice and Murshidabad & Uttar Dinajpur for wheat in West Bengal for the reference period rabi 2010-11 (November to May) and kharif 2011-12 (June to October). In the present study, season for the wheat crop is rabi while for rice belong to kharif season. The selected districts represent major producing districts of rice and wheat and fall in two different agro-climatic regions of the state. From each district, two villages with one nearby the market/mandi centre and one far off from the market centre have been selected for canvassing the questionnaire. A random sample of 30 farmers have been selected from each village and thus constituting a total sample of 240 farmers for two crops i,e rice and wheat from four districts and eight villages . In addition to the primary data collected from the farmers, personal visits have been made to the district office of the Department of Agriculture to compile the crop loss estimates (if any) for pre and post harvest losses.

1.7 Organisation of the report

The study report has been organised into six chapters. Chapter-I introduces the issue of the problem. The specific objectives of the study along with data base and methodology adopted have also been described in Chapter-I. Area, production and productivity of rice and wheat in West Bengal have been narrated in Chapter-II. Chapter-III deals with the household characteristics, cropping pattern and production structure of rice and wheat. Chapter-IV dealt with assessment of pre harvest losses of rice and wheat. Chapter-V highlights the assessment of post harvest losses of reference crops. The report has been concluded in Chapter-VI with a concluding remarks and policy suggestions based on the findings of the study.

Chapter-II

2. Area, Production and Productivity of Rice and Wheat in West Bengal

2.1 Trend and growth in area, production and yield of rice and wheat

The performance of agriculture in West Bengal over the last three decades has witnessed a dwindling picture. Growth rates have increased and per capita incomes have gone up. Liberalization and deregulation have yielded impressive results and the economy is increasingly integrated to the world economy. Still, agriculture continues to be the backbone of the economy of the state of West Bengal. Agriculture remains the most crucial sector of the state economy as around 72 per cent of the total population lives in rural areas and agricultural continues to be their mainstay. However, along with the structural transformation of the economy of the state, the contribution of agriculture in State Domestic Product (SDP) is observed to follow a declining trend. It contributes a significant share to the SDP as compared to other sectors of the economy even the contributions of agriculture to total SDP (at constant prices) has declined from 41.16 per cent in 1970-71 to 27.1 per cent in 2000-01.

It is fact that food grain dominates the cropping pattern in West Bengal (De, 2002; Ghosh and Kuri, 2005). Food grain crops are grouped as cereals crops and pulse crops. The important cereals crops of the state include rice, wheat and maize. Food grain crops including cereals and pulses occupied 68 per cent of Gross Cropped Area. With the production of 16501.24 thousand tones, West Bengal occupied the top position in the food grain production in India. Though the state performed well in food grain production among the states of India, in recent years there is evidence of the stagnancy in food grain production growth rate (Ghosh and Kuri, 2007). Further, the expansion of area under cultivation is hardly possible in West Bengal. Productivity growths of most of the important crops were stagnated in the 1990s after the liberalization process began.

It has been found that the growth performance of the state has been analyzed by many scholars (Saha and Swaminathan, 1994; Boyce, 1987; Chattopadhyay and Das, 2000). The pioneer work came from Boyce (1987) who measured the growth rates of crop output in West Bengal agriculture during 1949-80. He observed that the stagnancy of agriculture of the state comes to an end during 1980s and the growth of agricultural rose to its highest level during the decade of eighties. Saha and Swaminathan (1994) estimated growth of aggregate crop output of 6.40per cent during the eighties was the highest among the Indian states and this spectacular growth of the agricultural sector was widespread in the districts of the state. They argue that the land reforms measures introduced in the state during the early 1980s have significantly contributed to the impressive growth of the agriculture of the state. Chattopadhyay and Das (2000) also claimed that the agricultural growth in West Bengal during eighties is higher than the seventies. However, their estimate of the annual growth rate (3.6 per cent) of agricultural production in West Bengal during 1977-78 to 1994-95 is much lower than that of the growth (6.4 per cent) estimated by Saha and Swaminathan (1994) during the period from 1981-92 to 1990-91. They concluded that agricultural production in West Bengal is still dependent on rainfall and fluctuations in rainfall index significantly positively contribute to the fluctuations in agricultural production in the state. Sanyal *et al*. (1998) and Mukherji and Mukhopadhyay (1995) also supported the view of Saha and Swaminathan (1994) that land reforms programmes is primarily responsible for the breakthrough in West Bengal agriculture. Harris

(1992), however, argued that this high growth has taken place in the absence of any reform of the agrarian structure. According to his opinion, the growth was rather technological-'suitable technology' coined with favourable fertilizer-paddy price ratio. To analyze the performance of agricultural sector of the state the main emphasis has been given on the decadal growth rates of the major crops.

In this section, an effort has been made to measure the sub-period growth rates of area, production and yield of the crops as measured by the kinked exponential growth model. For convenience, the whole period of 40 years (1970-71 to 2004-05) is divided into three sub-periods; first sub-period (1970-71 to 1980-81), second sub-period (1981-82 to 1991-92) and third sub-period (1992-93 to 2009-10). These three sub-periods have special significance to the economy of West Bengal. Clearly, the agricultural development of the state during the period 1970-71 to 1980-81 was not up to the mark, rather it was underdeveloped in nature. However, some institutional and technological changes took place in the state during the early 80s. These institutional and technological changes had some positive impact on the agricultural development of the state. The productivity and production of all important crops have increased significantly. Lastly, the third sub-period (1992-93 to 2009-10) is the period of LPG (liberalisation, privatisation and globalisation). Clearly, the final sub-period captures the impact of globalisation on the agriculture of the state.

During the first sub-period (1970-71 to 1980-81) it has been observed that the growth rates of production of almost all important crops were either low or even negative (barring Boro rice). For example, total rice grew only at 0.51 per cent per annum during the 70s. The growth rates of production of Aman and Aus were 0.52 and -4.37 per cent per annum, respectively. However, Boro rice was growing at a rate of 2.53 per cent per annum. The growth rate of production of wheat was also negative (-3.18 per cent) during this period (Table-2.1). In most cases, the area and yield growth rates (Tables- 2.2 and 2.3) were either very slow or even negative, which in turn forces the output growth rate to be negative (barring growth rate of area under Boro rice). Thus, it has been found that during the period 1970-71 to 1980-81, with the exception of Boro rice, the growth rates of production of rice and wheat were slow. Both the area expansion under crops and the yield of these crops were responsible for this slow growth of output.

Table 2.1: Growth rates of production of rice and wheat in West Bengal during 1970-71 to 2009-10 (Production in thousand tonnes)

Crop	Kinked exponential growth rate			Trends break^{++}		R^2	DW
	1970-71 to 1980-81	1981-82 to 1991-92	1992-93 to 2009-10	First break 1980-81	Second break 1991-92		
Aus rice	-4.37 (-5.394)*	4.47 (6.561)*	-2.51 (-2.82)**	7.19 (5.43)*	-6.89 (-5.16)*	0.61	2.18
Aman rice	0.52 (0.649)	4.45 (6.48)*	1.41 (1.43)	4.12 (2.91)**	-3.43 (-2.16)*	0.85	2.19
Boro rice	2.53 (2.24)**	11.07 (11.49)*	3.69 (3.12)*	8.71 (4.63)*	-31.08	0.96	2.12
Total	0.51 (0.612)	5.31 (7.409)*	1.82 (2.11)**	4.89 (3.53)*	-3.65 (-2.22)**	0.89	2.09
Wheat	-3.18 (-1.642)	-0.43 (0.072)	4.13 (1.85)***	2.71 (0.89)	4.92 (1.32)	0.62	1.29

Note: *p = 0.01, **p = 0.05, ***p = 0.1
Source: Bureau of Applied Economics and Statistics, Government of West Bengal

Table 2.2: Growth rates of area of rice and wheat in West Bengal during 1970-71 to 2009-10 (Area in thousand hectares)

Crop	Kinked exponential growth rate			Trends break^{++}		R^2	DW
	1970-71 to 1980-81	1981-82 to 1991-92	1992-93 to 2009-10	First break 1980-81	Second break 1991-92		
Aus rice	-2.63 (-4.181)*	-1.57 (-2.938)**	-.4.75 (-6.876)*	1.09 (1.07)	-2.85 (-2.91)**	0.88	1.46
Aman rice	0.07 (0.324)	0.51 (2.809)**	-0.61 (-2.81)**	0.47 (0.92)	-1.45 (-2.456)**	0.22	2.38
Boro rice	3.18 (3.09)*	9.65 (10.99)**	3.78 (-3.691)*	6.89 (3.89)*	6.23 (-1.23)	0.93	2.04
Total	-0.20 (-0.783)	1.23 (5.564)*	-0.20 (0.81)	1.56 (3.34)*	-1.41 (-2.561)**	0.74	2.17
Wheat	-2.07 (-1.059)	-1.42 (-0.794)	3.79 (1.891)***	0.89 (0.231)	5.45 (1.651)	0.55	1.51

Note: *p = 0.01, **p = 0.05, ***p = 0.1
Source: Bureau of Applied Economics and Statistics, Government of West Bengal

Table 2.3: Growth rates of yield of rice and wheat in West Bengal during 1970-71 to 2009-10 (Yield rate in kg per hectare)

Crop	Kinked exponential growth rate			Trends break^{++}		R^2	DW
	1970-71 to 1980-81	1981-82 to 1991-92	1992-93 to 2009-10	First break 1980-81	Second break 1991-92		
Aus rice	1.74 (-2.779)**	6.05 (11.13)*	1.91 (3.19)*	7.81 (8.05)*	-4.56 (-4.421)*	0.92	1.61
Aman rice	0.45 (2.504)**	3.94 (-5.01)*	0.56 (0.561)	3.53 (1.215)	-3.654 (-2.75)**	0.83	1.73
Boro rice	-0.65 (-1.44)	1.42 (3.671)*	0.12 (0.21)	2.34 (3.561)*	1.54 (-1.34)	0.40	1.46
Total	0.72 (0.855)	4.07 (5.665)*	173 (1.235)***	3.45 (2.41)**	-2.54 (-1.81)***	0.82	1.91
Wheat	-1.11 (-1.001)	0.98 (0.987)	0.81 (0.715)	2.12 (1.21)	-0.43 (-0.21)	0.33	1.69

Source: Bureau of Applied Economics and Statistics, Government of West Bengal

Note: *p = 0.01, **p = 0.05, ***p = 0.1
$^{++}$First trend break (1981-82) and second trend break (1992-93) measure the differential value of estimated slopes and their significance at the break points respectively, with t values in parentheses. Thus the trend breaks provide us with the estimated values of the change in the decadal growth rates of production, area and yield rate respectively of the crops concerned. Figures in parentheses present the t values corresponding to each of the estimated growth rates. The corresponding *'s signify the level of significance of the estimates of decadal growth rates and that of the differential growth rates at the trend breaks.

This situation of slow growth, however, changed during the 80's when the growth rates of area, production and yield of rice improved significantly, while those for wheat have either deteriorated or remained stagnant. From Table-2.1, it has been found that during the second sub-period (1981-82 to 1991-92), the growth rate of area of total rice improved significantly from a negative growth rate observed during the previous decades of 70s to 1.23 per cent per annum during the second sub-period and this incremental growth rate was significant (as tested by the significance of trend breaks). The yield growth rate of total rice jumped from 0.72 per cent per annum during seventies to 4.07 per cent per annum during the period 1981-82 to 1991-92 (Table- 2.3). During the

second sub-period, more than 70 per cent of the output growth came from yield growth. The similar fashion of growth trend has been observed for Aman rice. For Aus rice the growth rate of area was negative (-1.57 per cent) per annum during the second sub-period (Table- 2.2). However, a massive increase in the yield growth rate (6.05 per cent) during the 80s resulted in the impressive growth of output at a rate of 4.47 per cent per annum. In case of Boro paddy quite an opposite scenario has been observed where the area growth rate plays the major role behind its impressive output growth of over 11 per cent per annum during the second sub-period. Boro was introduced on massive scale as HYV crop in the state during the early 80s. As it was a HYV crop, its yield level was already high and its high yield was the main factor for its rapid expansion in the state. As far as wheat is concerned, it has been found that the state has been able to achieve a marginal positive growth rate in yield rate as against the negative growth of the 70s. However, area and production of wheat have registered marginal improvement, though the rates still remain negative. Due to the impressive growth, performance of paddy crops has turned the growth of food grain production to an optimum level of 4.52 per cent per annum during the second sub-period. This was one of the best food grain production performances among the Indian states.

However, West Bengal failed to sustain the high growth path as achieved during the eighties. The growth rate of production of rice and wheat declined in the subsequent periods. The area growth rate of Aman rice becomes negative during the decade of nineties and the yield growth rate also reduced significantly. As a result of which the output of Aman rice declined only to 2.51 per cent per annum. During the nineties, the output growth rate of Boro rice declined to 3.69 per cent per annum and this fall in growth rate is significant (Table-2.1).

2.2 Changes in costs and profitability of rice and wheat (based on CACP reports)

The trends in C2 cost of cultivation per hectare and C2 cost of production per quintal and A2 cost of cultivation for the period 1981-82 to 2007-08 for rice and wheat crops are examined in this section. There have been debates that rice should be given similar minimum support prices (MSP) as compared to wheat as the costs of both the crops are similar. Similarly, an effort has been made to examine this issue here by looking at the trends in ratio of rice costs to wheat costs. The total cost of production per unit of rice and wheat, which includes imputed values of land, labour and capital, shown in Table-2.4, reveals that the unit costs of the former are somewhat lower than those of the latter. However, the situation seems to have changed after 1994-95 and there are several years in which paddy cost of production per unit exceeded that of wheat. This was particularly noticeable after 1999-2000.

The ratio of paddy cost of production to that of wheat is lower than the ratio of their cost of cultivation because of higher yields in paddy. The ratio of A2 CoC of rice to wheat was higher than the corresponding ratio of C2 cost of cultivation (CoC) as shown in Table-2.4. This may be because of lower imputed values of land, labour and capital in case of paddy compared to wheat. The conclusion is that the costs of rice have been similar to those of wheat since the mid-1990s. The ratio came down to 0.90 and 0.91 in the case of cost of production (CoP) in the years 2005-06 and 2006-07. On the whole the demand that the MSP of rice should be closer or slightly below wheat based on cost data may need sympathetic hearing. However, it may be noted that although cost is a major one, it is only one factor among many factors in determining MSP.

Table 2.4: Different costs in the production of rice and wheat at all-India level

Year	Rice			Wheat			paddy cost as a percentage of wheat cost		
	CoP*	CoC**	A2 CoC**	CoP*	CoC**	A2 CoC**	CoP	CoC	A2 CoC
1981-82	99	2892	1705	122	3260	1946	81	89	88
1982-83	116	2824	1680	125	3475	2065	93	81	81
1983-84	108	3351	1959	135	3462	2039	80	97	96
1984-85	113	3582	2107	133	3752	2121	85	95	99
1985-86	118	3718	1966	123	3959	2335	96	94	84
1986-87	124	3717	2240	132	4058	2391	94	92	94
1987-88	144	4653	2828	146	4826	2777	99	96	102
1988-89	147	5704	3636	168	5636	3292	87	101	110
1989-90	172	6340	3539	172	5769	3361	100	110	105
1990-91	185	6526	3734	197	6872	3800	94	95	98
1991-92	218	7884	4161	204	7693	4303	106	102	97
1992-93	238	7684	3957	238	8808	4823	100	87	82
1994-95	279	11212	6369	294	10990	5446	95	102	117
1995-96	306	11207	6324	318	11681	6100	96	96	104
1996-97	338	12651	6703	361	13760	6927	94	92	97
1997-98	370	13581	7246	381	13236	6853	97	103	106
1998-99	398	15495	8710	383	14316	7268	104	108	120
1999-00	442	16978	9275	415	16459	8038	106	103	115
2000-01	448	17365	9798	450	17132	8751	99	101	112
2001-02	469	18655	10619	466	17279	9058	101	108	117
2002-03	530	19193	10949	499	18837	10027	106	102	109
2003-04	483	19583	10988	498	18925	10195	97	103	108
2004-05	529	20670	11776	537	19810	10975	98	104	107
2005-06	529	21182	11845	592	21847	11584	89	97	102
2006-07	546	22059	12543	586	23847	12681	93	93	99
2007-08	NA	NA	NA	617	25575	13166	-	-	-

Source: CACP, Government of India

* Measured in Rs. per quintal. ** Measured in Rs. per hectare.

Table 2.5: All India trend growth rates of different costs and yields in rice and wheat

Period	Rice	Wheat
Cost of production (Constant prices)		
1981-82 to 1992-93	-0.2(-0.44)	-2.1(-3.21)**
1994-95 to 2006-07	1.2(2.04)*	1.4(3.22)**
Cost of cultivation (Constant prices)		
1981-82 to 1992-93	2.2(3.37)**	1.2(2.06)*
1994-95 to 2006-07	1.7(2.66)*	1.7(3.44)**
A2 Cost of cultivation (Constant prices)		
1981-82 to 1992-93	1.3(1.65)	0.5(0.92)
1994-95 to 2006-07	1.9(2.64)*	2.4(5.35)**
Yield (kg/ha)		
1981-82 to 1992-93	2.4(6.79)**	-0.3(-0.63)
1994-95 to 2006-07	0.8(9.20)**	-0.1(-0.27)

Note: The deflator used is WPI for Non-food articles with 1981-82 = 100 and *= 95% confidence level; **=99% confidence level. 't' values are given in parentheses.

Source: CACP, Government of India

The growth rates in the real costs of production declined in the background of a robust gain in per hectare yields in the first period, while these costs went up in real terms in the second period (Table- 2.5). As

can be seen from the table, the growth rate in yields came down from 2.4 to 0.8 in rice and from -0.3 to -0.1 in wheat in the first and second periods respectively. The growth in yield outstripped growth in cost of cultivation during the eighties enabling the cost per quintal to go down. Another important point to be noted is that the cost of cultivation has grown at a more or less same rate in the recent period indicating that the lower profitability might have discouraged farmers to invest in higher use of inputs and technology.

Table 2.6: CoP of different states in relation to all-India average in rice and wheat

(Per quintal for different triennium)

State	Rice (per cent)			Wheat (per cent)		
	TE 1984-85	TE 1996-97	TE 2006-07	TE 1984-85	TE 1996-97	TE 2006-07
Andhra Pradesh (AP)	93	92	73	-	-	-
Assam	88	114	126	-	-	-
Chhattisgarh	-	-	94	-	-	149
Himachal Pradesh (HP)	102	-	50	121	130	109
Haryana	111	124	106	103	78	84
Jharkhand	-	-	-	-	-	187
MP	102	109	138	95	122	116
Punjab	105	96	77	98	92	84
Rajasthan	-	-	-	104	85	77
Tamil Nadu	-	-	128	-	-	-
West Bengal	119	117	121	-	-	157
All-India	100					

Source: CACP, Government of India

Now the question is which states are relatively efficient in costs of production relative to all-India average. The states of HP, AP and Punjab are the efficient producers of rice in the triennium ending 2007 (Table-2.6). The farmers of AP and Punjab could produce a quintal of rice at 27 per cent and 23 per cent lower cost than that of the all-India average and they have improved efficiency of production by reducing the cost of production relative to all-India average during the study period. The obverse is true in case of Assam and M.P. Madhya Pradesh, produces rice at 30 per cent higher costs. Also, farmers from Assam and Tamil Nadu are expensive in rice production, which may be impinging on their profitability seriously. Rajasthan, Punjab and Haryana are the efficient producers compared to all-India average for wheat. Here, Jharkhand, West Bengal and Chattisgarh produce wheat at whopping 87 per cent, 57 per cent and 49 per cent higher cost than all-India.

2.3 Secondary estimates of losses caused by pests and diseases in rice and wheat

Rice continues to remain as the staple food for more than 65 per cent Indian population and with largest area of 44.6 million hectares and with second largest milled rice production of 93.3 million tonnes (2006-2007). Rice cultivation extends from 8O to 35ON latitudes across diverse ecosystems such as irrigated (52.6 per cent), upland (12 per cent), rainfed low land (32.4 per cent), semi deep water and deep water (3 per cent) as well

as coastal saline regions. Based on the water availability rice is taken up as a single crop or as high as three crops in a year. A study carried out by Rockfeller foundation (Herdt, 1991) reveals that seven out of 20 major challenges in rice production are insect pest and diseases. Among the biotic stresses insect pests cause about 10-15 per cent yield losses. The average yield losses in rice have been estimated to vary between 21-51 per cent. Yellow stem borer, brown plant hopper (BPH) and gall midge were the key pests in rice causing 25-30 per cent, 10-70 per cent and 15-60 per cent yield losses, respectively. At National level, stem borers accounted for 30 per cent of the losses while plant hoppers (20per cent), gall midge (15 per cent), leaf folder (10 per cent) and other pests (25 per cent).

Table 2.7: Major pests in various rice based cropping systems

Sl. No.	Cropping system	Major pests
1.	Rice- Rice-Rice	YSB, LF, BPH, WBPH, GM, RH, GLH, LM, PM, WM
2.	Rice – Wheat	YSB, PSB, LF, RH, WM
3.	Rice – Maize	YSB, PSB
4.	Rice –Green gram or Rice-Black gram	YSB, BPH, WBPH, LF, LM, PM
5.	Rice – Groundnut, Rice-Rice-Fallow	SBs, GM, LF, BPH, WBPH, GB

Note: YSB: yellow stem borer, PSB: Pink Stem borer, WSB: White stem borer, GB: Gundhi bug, MB: Mealy bug, LF: Leaf folder, BPH: Brown plant hopper, WBPH: White backed plant hopper, RH: Rice Hispa, RG: Root grub, BB: Black beetles, BSB: Brown shield bug, CW: Case worm, SwC: Swarming caterpillar, PM: Panicle mite, LM: Leaf mite, GM: Gall midge, GLH: Green leafhopper, RT: Rice thrips, WM: Whorl maggot

Table 2.8: Ecology-wise key insect pests of rice in India

Sl. No.	Rice Ecology/sub-ecology	Area m.ha (yield t/ha) 44.3 (2.11)	Insect and mite
1.	**Rainfed upland**	6.0 (1.3)	
	a. Plain area upland (bunded and unbunded)	5.0 (1.2)	YSB, GB, MB, Termites, Root Aphids
	b. Hill rice (High altitude Upland)	1.0	PSB, LF, WBPH, RH, RG, BB, BSB
2.	**Deep water (>50cm)**	4.0 (0.8)	YSB
3.	**Semi-deep water (25-50cm)**	3.0 (1.0)	YSB, RH, CW
4.	**Shallow rainfed low land (0-25cm)**	10.0 (1.4)	
	a. Drought prone	4.0 (1.5)	YSB, GM, SwC, PM
	b. Low land favourable	3.0 (2.0)	RKN, YSB, GM, BPH, WBPH, LF
	c. Submergence prone	3.0 (0.5)	YSB, GLH, RH, LF, CW
5.	**Coastal saline** (Coastal wetland)	1.0 (1.0)	YSB, PSB
6.	**Irrigated rice** (Non-Scented/Scented/Hybrid rice)	20.3 (3.3) Dry (3.5) Wet (2.8)	SBs (YSB/PSB/WSB), GM, BPH, WBPH, GLH, LF, GB, RT, MB, LM, PM, WM

Note: YSB: yellow stem borer, PSB: Pink Stem borer, WSB: White stem borer, GB: Gundhi bug, MB: Mealy bug, LF: Leaf folder, BPH: Brown plant hopper, WBPH: White backed plant hopper, RH: Rice Hispa, RG: Root grub, BB: Black beetles, BSB: Brown shield bug, CW: Case worm, SwC: Swarming caterpillar, PM: Panicle mite, LM: Leaf mite, GM: Gall midge, GLH: Green leafhopper, RT: Rice thrips, WM: Whorl maggot

Various rice based cropping systems prevalent in different areas are rice-rice-rice, rice-rice-pulse, rice-pulse, rice-wheat, rice-rice-vegetables, rice-sugarcane, rice-rice-fallow, rice-fallow, rice mustard, rice-maize,

rice-potato-summer rice, rice-oil seed, etc. Among these rice-wheat cropping system is the major system in the country occupying 9.8 million hectares (Yadava and Subba Rao, 2001) followed by rice-rice (5.9 m ha) and rice fallow (4.4 m ha). In this context, there is a change in resource utilization pattern and also pest dynamics within diverse ecologies or cropping systems (Tables- 2.7 and 2.8). Among the cropping systems, the insect pest problems are relatively more in rice-rice-rice or rice-pulse than rice-maize or rice–wheat cropping systems. Among the different ecologies, irrigated ecology harbours most number of insect pests.

Before green revolution, stem borer, gall midge, rice hispa, whorl maggot, cut worm and thrips were considered as major pests of rice. The major insect pests of National significance today are, rice yellow stem borer (SB) *Scirpophaga incertulas* (Walker), brown plant hopper (BPH), *Nilaparvata lugens* (Stal), whitebacked plant hopper (WBPH), *Sogatella furcifera* (Horvath), leaf folder *Cnaphalocrocis medinalis* (Linnaeus), gall midge (GM) *Orseolia oryzae (*Wood-Mason), green leafhopper (GLH) *Nephotettix virescens* (Distant) and gundhi bug *Leptocorisa* spp. Whorl maggot, *Hydrellia* spp., rice hispa, *Dicladispa armigera*, climbing cutworm, *Mythimna separate* Walker, swarming caterpillar, *Spodoptera mauritia* Boisduval, panicle mite, *Steneotarsonemus spinki* and thrips, *Stenchaetothrips biformis* have regional significance.

2.4 Summary of the chapter

It has been observed that that the agriculture of the state had been able to boost its performance during the decade of eighties, at least in terms of growth rates production of rice and wheat, mainly for tremendous increment in the yield growth rates of the crops along with expansion of area under cultivation. The effective introduction of HYV technology coupled with successful implementation of land reforms programme at the very grass root level set the path of agricultural development in the state of West Bengal. However, this scenario of impressive growth performance did not sustain for a very long period of time. The fall in the yield growth rates of crops reduces the production growth rates during the era of globalisation which have been started in the early nineties. During this period, crops such as Boro rice, and total food grain experienced fall in their growth rates to a significant extent with marked deceleration in growth trend.

The cultivation of the same crop on the same piece of land over a long period and non-optimum doses of chemical fertilizer might cause the soil fertility to decline in the state. This is also very much prominent from the stagnation of yield level of rice and wheat in West Bengal in the recent years. And this stagnation or slowing down of yield growth rates of rice and wheat cause the total agricultural output to grow at a slower rate in the recent times. This is the main cause of concern of today, especially with respect to the food security issue of the state.

The trend of declining cost of production with higher growth in yields got reversed in the nineties and beyond and they went up at nearly 1.5per cent per annum for rice and wheat. The returns over paid-out costs also for rice farmers declined at 1.15 per cent per annum in real terms leading to distress for them. This declining profitability seems to have discouraged them in increasing spending on yield augmenting technology as shown by the relatively declining growth rate of cost of cultivation.

The price intervention in enhancing MSPs for wheat in 1997-98, 2006-07 and 2007-08, keeping in view of the fact that the market prices are higher, has distorted the intercrop price parity between rice and wheat. Though the costs of production are similar for these two crops since the mid-nineties, the wheat MSP has been 14per cent higher than that of paddy since then and up to 2007-08. In the recent period, the rice farmers have also suffered from lower price realization than the respective MSPs since 2000-01, lower (7 per cent) returns over total costs compared to 27 per cent in wheat and higher growth in costs of production compared to the whole sale price indices between 2002-03 and 2006-07. On the whole, the analysis presented in the paper shows that there is some merit in the argument that the MSP of rice should be closer or slightly below that of wheat. Therefore, hikes in support prices for rice are justified in this background.

Depending upon the crop age, the incidence of insect pests and resultant yield losses vary. During the first 30 days after transplanting significant yield losses are reported due to stem borer and gall midge only in 10-15per cent of the locations tested under AICRIP. The crop growth period between 30-60 days after transplanting was most vulnerable resulting in major yield losses (20-68 per cent) mainly due to stem borer, gall midge, leaf folder and brown plant hopper. Beyond sixty days after transplanting, the crop damage is inflicted by stem borer and leaf folder causing 10 to 48 per cent damage. With the introduction of changes in types of varieties being cultivated, practicing of different cultivation systems and concomitant alterations in rice based cropping systems, certain pests earlier regarded as minor pests have now assumed significance as pests of regional significance.

Chapter-III

3. Household Characteristics, Cropping Pattern and Production Structure

3.1 Socio-economic characteristics of the selected farmers

West Bengal is a state in the eastern region of India and is the nation's fourth-most populous. It is also the seventh-most populous sub-national entity in the world, with over 91 million inhabitants. Spread over 34,267 sq mi (88,750 km^2), it is bordered by the countries of Nepal, Bhutan, and Bangladesh, and the Indian states of Orissa, Jharkhand, Bihar, Sikkim, and Assam. The state capital is Kolkata (formerly *Calcutta*). West Bengal encompasses two broad natural regions: the Gangetic Plain in the south and the sub-Himalayan and Himalayan area in the north.

Table -3.1 gives a picture of demographic profile of the selected farmers. It has been found that 59.17 per cent of the households belong to marginal farmers followed by 27.92 per cent are small,10.42 per cent are medium and 2.50 per cent are large categories. The household size increases with the increase in farm size except in case of medium farms. The household size has been found to be highest in this category. Average number of earners is more in medium and large farms than that of marginal and small farms. Majority of the respondents are in the age group of above 40 except large farms. The majority of households in large farms are in the age group of 25 to 40 years. The education of the respondents is more or less concentrated to secondary education and the distant from the main market varies from 5.84 km to 8.92 km. The annual family income increases with the increase in farm size.

Table 3.1: Demographic profile of the selected farmers (per cent of households)

Characteristics		Marginal	Small	Medium	Large	Total
No of HH		142 (59.17)	67 (27.92)	25 (10.42)	6 (2.50)	240 (100.00)
Household size (numbers)		5.01	5.76	8.32	7.33	5.62
Average numbers of earners		1.90	1.88	2.84	2.00	2.00
Proportion of Male/Female/Children (per cent)	Male >15	40.93	40.67	43.75	36.36	41.14
	Female >15	37.41	37.30	39.42	38.64	37.73
	Children <15	21.66	22.13	16.83	25.00	21.13
Identity of respondent (per cent)	Head	74.65	68.66	68.00	66.67	72.08
	Others	25.35	31.44	32.00	33.33	27.92
Average age of the respondent (per cent households)	Less than 25	2.11	0.00	0.00	0.00	1.25
	Between 25 to 40	42.25	34.33	42.00	66.67	41.25
	Above 40	55.65	65.67	52.00	33.33	57.50
Highest Education status of a family member (per cent households)	Illiterate	7.04	7.46	4.00	0.00	6.67
	Up to primary	36.62	16.42	8.00	0.00	27.08
	Up to secondary	47.89	52.24	56.00	50.00	50.00
	Higher secondary	3.52	11.94	32.00	50.00	10.00
	Graduate and above	4.93	11.94	0.00	0.00	6.25
Caste (per cent households)	SC	16.90	17.91	24.00	16.67	17.91
	ST	0.70	0.00	0.00	0.00	0.42
	OBC	4.23	5.97	8.00	0.00	5.00
	General	78.17	76.12	68.00	83.33	76.67
Distance from the main market (km)		8.92	7.27	5.84	6.33	8.11
Annual family income (Rs)		56056.34	89567.16	133000.00	212500.00	77337.50

3.2 Characteristics of operational holdings

An operational holding is defined as a techno-economic unit wholly or partly for agricultural production and operated (directed/managed) by one person alone or with the assistance of others, without regard to title, size or location. The holding might consist of one or more parcels of land, provided these are located within the country and form part of the same technical unit. In the context of agricultural operations, a technical unit is a unit with more or less independent technical resources covering items like land, agricultural equipment and machinery, draught animals, etc. Holdings used exclusively for livestock and poultry raising and for production of livestock and poultry products (primary) and/or pisciculture are considered as operational holdings whereas holdings put exclusively to uses other than agricultural production are not considered as operational holdings. Holdings operated by cooperative farms are also not considered as operational holdings.

Table 3.2: Characteristics of operational holdings (acres per household)

Farm size	Owned land	Un- cultivated land	Leased-in	Leased - out	NOA	Irrigated area	GCA	Cropping intensity (per cent)
Marginal	1.19	0.00	0.40	0.02	1.56	1.40	2.74	175.64
Small	3.04	0.02	0.55	0.03	3.54	2.95	5.15	145.48
Medium	6.12	0.00	0.85	0.00	6.92	5.96	10.84	156.65
Large	13.22	0.00	0.47	0.00	13.69	11.83	20.21	147.63
Total	2.52	0.01	0.49	0.02	2.98	2.57	4.69	157.38

The characteristics of operational holdings of the respondents are presented in Table-3.2. It has been observed that the net operated area (NOA) varies from 1.56 acres in marginal farms to 13.69 acres in large farms. It is very interesting to note that the gross cropped area (GCA) decreases with the increase in farm size and thereby the cropping intensity is highest in marginal farms followed by medium, large and small farms.

3.3 Structure of tenancy

Reform of land relations was one of the earliest and most consistent aspects of West Bengal government policy for the first two decades after the Left Front came to power in 1977. It reflected part of a more general vision of the ruling party and governing essential for social and economic change in progressive directions, for greater empowerment of ordinary peasant and workers, and indeed for meaningful democracy. From the early 1950s, therefore, in West Bengal as in other states of India, land reform was a concern of the government. Nevertheless, West Bengal is till date the only state in India, with the exception of Kerala, to have undertaken both tenancy reform and redistributive land reforms. The amount of land redistributed in West Bengal has by far surpassed that in any of the other states. More spectacular and widely discussed, has been West Bengal's programme of tenancy reform or 'Operation Barga', as it is more popularly known. This effort marked a solid departure from the earlier attempts at land reform.

Table 3.3: Nature of tenancy in leasing-in/leasing-out land (per cent households)

Farm size	Crop sharing	Crop and cost sharing	Fixed rent in cash	Others	Total	per cent share of tenancy in NOA	Rent amount Rs. Per acre
(Leasing-in)							
Marginal	23.94	15.49	7.25	0.70	47.88	25.91	5730.30
Small	14.92	10.45	8.95	0.00	34.33	15.46	5410.00
Medium	24.00	8.00	4.00	0.00	36.00	12.18	9020.00
Large	16.67	0.00	0.00	0.00	16.67	3.41	0.00
Total	21.25	12.92	7.50	0.42	42.08	16.51	5770.00
(Leasing-out)							
Marginal	0.00	1.41	0.00	0.00	1.41	1.48	0.00
Small	1.49	0.00	0.00	0.00	1.49	1.14	0.00
Medium	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.42	0.83	0.00	0.00	1.25	0.77	0.00

The nature of tenancy in leasing-in/leasing out land is presented in Table -3.3. It has been observed that in the event of leasing-in the crop sharing is a predominant phenomenon in almost all farms. Crop and cost sharing is followed in marginal, small and medium farms. Similarly, fixed rent in cash is shared by these farms. Crop and cost sharing along with fixed rent in cash are not followed by large farms. When we look to the figure of percentage share of tenancy in net operated area, it varies from 25.91 per cent in case of marginal, 15.46 per cent in case of small, 12.18 per cent in case of medium and 3.41 per cent in case of large farms. In the event of leasing-out, the crop sharing phenomenon exists in small farm only. Crop and cost sharing exists in marginal farms. There is no case of fixed rent in cash in the event of leasing-out tendency. Rent amount varies from Rs. 5410/- per acre in case of small farms to as high as Rs. 9020/- per acre in case of medium farms.

3.4 Sources of irrigation

West Bengal is well endowed with groundwater. Net annual groundwater availability is high (30.36 billion cubic meters) as is rainfall (1500-200 mm per year), yet its potential for development in many regions has not been reached. Only around 42 per cent of the state's groundwater resources are being used because of policy restrictions and concerns over groundwater scarcity and quality. Historically, groundwater has played an important role in West Bengal's agriculture. In the late 1980s and early 1990s, agricultural growth rates were 6 per cent per annum, which was attributed to expansion in the area under boro rice cultivation and an increase in yield of all paddy crops due to assured irrigation from tube-wells. Carefully crafted groundwater policies could help the state return to these high agricultural growth rates and this in turn can support poverty alleviation.

Table 3.4: Source of irrigation of net irrigated area (per cent)

Farm size	Only canal	Canal + tube-well	Only electric tube-well	Only diesel tube-well	Tanks	Open well	Others	Net Irrigated Area (Acres per H.H)
Marginal	2.06	51.22	0.00	6.74	0.00	0.00	39.98	1.40
Small	0.00	73.75	2.53	3.21	0.00	0.00	20.51	2.95
Medium	0.00	56.82	3.13	0.00	0.00	0.00	40.05	5.96
Large	0.00	14.08	0.00	0.00	0.00	0.00	85.92	11.83
Total	0.33	55.50	1.56	3.20	0.00	0.00	39.74	2.57

The sources of irrigation of net irrigated area of the respondents are presented in Table-3.4. It has been found that canal + tube-wells dominate the irrigation profile of the selected farms. More than 50 per cent of the land is irrigated by these sources. Canal irrigation is very scanty and it is applicable to marginal farms only. Diesel tube-well is more prominent than that of electric tube-well. It is very surprising to note that tank is not important in the irrigation profile of the respondents though tanks play a very important role in irrigation in West Bengal. The state of West Bengal partially depends on tanks for irrigation, though main sources of irrigation are canal and different tube wells. It has been observed that the respondents in the selected districts have no dependence over the tank water, may be due to the availability of underground water sources and government canal are in abundance. It has also been witnessed that with time the dependence over tank has been declined throughout West Bengal and in almost all the districts except Purulia district.

3.5 Cropping pattern

Cropping patterns of a region are decided by and large, by a number of soils and climatic parameters which determine overall agro-ecological setting for nourishment and appropriateness of a crop or set of crops for cultivation. Nevertheless, at farmers' level, potential productivity and monetary benefits act as guiding principles while opting for a particular crop/cropping pattern. These decisions with respect to choice of crops and cropping patterns are further narrowed down under influence of several other forces related to infrastructure facilities, socio-economic factors and technological developments, all operating interactively at micro-level. Multiplicity of cropping patterns has been one of the main features of West Bengal agriculture. This may be attributed to (1) rainfed agriculture still accounts for over majority of the cropped area. A large diversity of cropping pattern exists under rainfed and dry land areas with an overriding practice of intercropping, due to greater risks involved in cultivating larger area under a particular crop, and (2) due to prevailing socio-economic situations (such as; dependency of large population on agriculture, small land-holding size, very high population pressure on land resource etc.), improving household food security has been an issue of supreme importance to many million farmers of West Bengal. An important consequence of this has been that crop production in West Bengal remained to be considered, by and large, a subsistence rather than commercial activity. One of the typical characteristics of subsistence farming is that most of the farmers resort to grow a number of crops on their farm holdings, primarily to fulfil their household needs and follow the practice of rotating a particular crop combination over a period of 3-4 years interchangeably on different farm fields.

The cropping pattern of the selected farms is presented in Table-3.5. It has been observed that the cropping pattern of the selected farms spread over to kharif, rabi and summer cultivation. However, a small portion of the gross cropped area is cultivated by perennial crop like vegetables. In kharif season, aman paddy dominates the cropping pattern in all farms. The share of aman paddy increases with the increase in size of holdings. Similarly in rabi season, wheat occupies a larger portion than that of other crops viz., potato, mustard and pulses. The share of summer paddy in the gross cropped area is also important.

Table 3.5: Cropping pattern of selected farmers (per cent of GCA for the whole year)

Name of the crop	Marginal	Small	Medium	Large	Total
Kharif crops					
Aman Paddy	48.54	53.62	54.55	66.09	53.19
Jute	11.43	9.03	5.29	0.00	8.15
Maize	2.96	2.57	1.47	0.00	2.21
Rabi crops					
Wheat	10.74	8.96	8.83	1.32	8.77
Potato	5.56	4.42	5.87	9.78	5.74
Mustard	5.78	7.07	7.87	6.38	6.74
Pulses	2.74	2.32	1.46	1.65	1.99
Summer crops					
Boro Paddy	7.79	6.45	12.22	13.20	9.09
Perennial crops					
Vegetable	4.46	5.56	2.97	1.59	4.13
Gross cropped Area	388.72 (100.00)	344.50 (100.00)	271.13 (100.00)	121.25 (100.00)	1125.60 (100.00)

Note: Pumpkin ,Brinjal, Chilly ,Zinger etc. vegetables are cultivated through out the year in W.B.

3.6 Percentage of area under HYV

The use of high-yielding varieties (HYV's) of wheat and rice has expanded sharply in West Bengal. There are three seasons for growing rice and one season of growing wheat in West Bengal viz., autumn, winter and summer in case of rice and rabi in case of wheat. Autumn or pre-kharif rice is known as *Aus* in West Bengal. The pre-monsoon *Aus*, covers April to July in the northern region and May to September in the southern region of the state and accounts for only 5per cent of total rice area and with the expansion of irrigation facilities, the area under this crop has gradually been declining. This is a low-yielding relatively drought-tolerant upland crop with a yield of 1.5 - 2.0 tons per hectare. During *Aus* season, at present, more than 99 per cent of the total area is covered with high yielding varieties. The winter or monsoon rice, known as *Aman*, is grown from June to December. It accounts for 69 per cent of the total rice area, and is grown under rainfed conditions in the semi-deep, deep and flooded land (mostly indigenous improved and traditional varieties) and under irrigated conditions in the flood-free medium and shallow lowlands (mostly modern high yielding varieties). Mainly during *Aman*, farmers still grow some traditional or local rice varieties having special features and it covers near about 12 per cent of the total rice area cultivated during *Aman*. The remaining 26per cent of the rice area is covered by the summer or dry season rice popularly known as *Boro*. This is a totally irrigated rice crop with the entire area cropped with high yielding modern varieties. The sowing time of summer rice is November to February and harvesting time is March to June. The growing season for the crop sometimes overlaps with *Aus*. With the expansion of irrigation facilities, farmers have been releasing land from *Aus* and deepwater *Aman* rice for raising *Boro* crop.

Table 3.6: Percentage of area under HYV seeds

Name of the crop	Marginal	Small	Medium	Large	Total
Kharif crops					
Aman Paddy	100.00	100.00	100.00	100.00	100.00
Jute	100.00	100.00	100.00	100.00	100.00
Maize	77.68	100.00	100.00	100.00	90.32
Rabi crops					
Wheat	100.00	100.00	100.00	100.00	100.00
Potato	100.00	100.00	100.00	100.00	100.00
Mustard	98.53	90.72	100.00	100.00	96.59
Pulses	54.66	0.00	0.00	0.00	17.73
Summer crops					
Boro Paddy	100.00	100.00	100.00	100.00	100.00
Perennial crops					
Vegetable	40.00	46.00	52.00	60.00	49.50

The percentage area under HYV seeds of different crops in the cropping pattern of the selected respondents is presented in Table-3.6. It has been observed that cent per cent of HYV seeds have been adopted in almost all crops except mustard and vegetables. Even in case of aman paddy though this is not a totally irrigated rice crop but the entire area is cropped with high yielding modern varieties. The similar experience has been observed in case of wheat.

3.7 Crop productivity, marketed surplus and value of output by farm size

In the liberalized era, improving productivity, competitiveness and increasing marketed surplus are important goals of agriculture sector. Identifying price and non-price factors in a specific geographical setup for accelerating the growth in agriculture sector is critical to remove bottlenecks for overall development of the state. In the background of increasing need for food security along with market driven policies, one needs reliable empirical knowledge about the degree of responsiveness of demand and supply for factors and products to relative prices, technological change and other institutional factors. Studies in the factor productivity with special emphasis on regions/districts in West Bengal will help in characterizing the districts according to productivity growth of different crops and will facilitate the planners to focus on potentially high productivity growth areas for increasing area and productivity under different crops. By simultaneously studying the factor share and output supply of major crops policy options can be suggested for different farmer groups/agro-ecosystems based on their factor endowment to increase output supply and marketed surplus. The outcome of these adjustments in factors/outputs will be linked to marketed surplus for optimum allocation of factors of production to increase marketed surplus of major crops.

Table 3.7: Average yield of major crops grown by the selected households (quintal per acre)

Name of the crop	Marginal	Small	Medium	Large	Total
Kharif crops					
Aman Paddy	18.47	18.86	18.69	19.89	18.83
Jute	11.67	12.51	13.56	0.00	12.26
Maize	23.89	28.14	24.62	0.00	25.55
Rabi crops					
Wheat	13.54	14.16	14.87	11.72	14.01
Potato	110.00	115.36	120.92	97.72	111.90
Mustard	7.08	6.22	4.22	5.11	5.80
Pulses	3.83	4.26	2.82	3.50	3.60
Summer crops					
Boro Paddy	23.37	24.21	23.50	25.83	23.98
Perennial crops					
Vegetable	25.12	22.14	27.18	44.04	25.03

Table 3.8: Percentage of output marketed by the selected households

Name of the crop	Marginal	Small	Medium	Large	Total
Kharif crops					
Aman Paddy	71.18	82.21	89.01	93.79	82.11
Jute	99.76	96.91	98.97	0.00	98.62
Maize	96.27	98.39	95.92	0.00	97.07
Rabi crops					
Wheat	78.40	85.11	92.54	90.67	84.11
Potato	87.74	89.30	91.27	95.51	90.31
Mustard	52.68	57.41	70.04	88.61	63.14
Pulses	66.16	78.01	75.89	78.57	73.05
Summer crops					
Boro Paddy	69.30	75.87	83.14	90.26	78.71
Perennial crops					
Vegetable	85.21	86.22	90.85	92.94	87.20

Average yield of major crops grown by the selected households are presented in Table-3.7. It has been observed that the average productivity of aman paddy is 18.83 quintal per acre, whereas the same for boro paddy is comparatively much higher (23.98 quintal/acre). Similarly, the productivity of wheat varies from 11.72 quintal per acre in large farms to 14.87 quintal per acre in medium farms. It has been also observed that on an average 82.11 per cent of aman paddy is marketed, whereas on an average 78.71 per cent of boro paddy is marketed by the selected households (Table- 3.8). On an average 84.11 per cent of wheat output is being marketed by the selected households. The value of output and marketed surplus increases with the increase in size of holdings (Table-3.9).

Table 3.9: Value of output and marketed surplus (aggregate of all crops)

Category	Value of output (main + by product)		Value of marketed surplus		per cent of output marketed
	Rs Per household	Rs Per acre	Rs Per household	Rs Per acre	
Marginal	58617.51	21413.06	43532.80	15902.60	80.13
Small	107566.33	20920.01	88037.88	17122.03	84.77
Medium	244259.45	22521.80	207318.60	19107.71	89.34
Large	467166.67	23117.00	433391.67	21446.19	93.82
Landless	-	-	-	-	-
Total	76390.13	21712.83	58134.80	17647.04	85.56

3.8 Summary of the chapter

As per the socio-economic characteristics are concerned, it has been found that majority of the respondents are in the middle age group. The education of the respondents is more or less concentrated to secondary education and the marketing facilities are not well developed as the distance of the main market varies from 5.84 km to 8.92 km. However, the annual family income increases with the increase in farm size.

As per the characteristics of operational holdings of the respondents, it has been found that the net operated area (NOA) varies from 1.56 acres in marginal farms to 13.69 acres in large farms. It is very interesting to note that the gross cropped area (GCA) decreases with the increase in farm size and thereby the cropping intensity is highest in marginal farms followed by medium, large and small farms. It has been observed that in the event of leasing-in the crop sharing is a predominant phenomenon in almost all farms. Crop and cost sharing is followed in marginal, small and medium farms. Similarly, fixed rent in cash is shared by these farms. Crop and cost sharing along with fixed rent in cash are not followed by large farms. The percentage share of tenancy in net operated area, it varies from 25.91 per cent in case of marginal, 15.46 per cent in case of small, 12.18 per cent in case of medium and 3.41 per cent in case of large farms. In the event of leasing-out, the crop sharing phenomenon exists in small farm only. Crop and cost sharing exists in marginal farms. There is no case of fixed rent in cash in the event of leasing-out tendency. Rent amount varies from Rs. 5410/- per acre in case of small farms to as high as Rs. 9020/- per acre in case of medium farms. It has been found that canal + tube-wells dominate the irrigation profile of the selected farms. More than 50 per cent of the land is irrigated by these sources.

It has been observed that the cropping pattern of the selected farms spread over to kharif, rabi and summer cultivation. However, a small portion of the gross cropped area is cultivated by perennial crop like vegetables. In kharif season, aman paddy dominates the cropping pattern in all farms. The share of aman paddy increases with the increase in size of holdings. Similarly in rabi season, wheat occupies a larger portion than that of other crops viz., potato, mustard and pulses. The share of summer paddy in the gross cropped area is also important in the selected districts. Similarly, it has been observed that cent per cent of HYV seeds have been adopted in almost all crops except mustard and vegetables. Even in case of aman paddy though this is not a totally irrigated rice crop but the entire area is cropped with high yielding modern varieties. The similar experience has been observed in case of wheat.

In the selected district the average productivity of aman paddy is 18.83 quintal per acre, whereas the same for boro paddy is comparatively much higher (23.98 quintal/acre). Similarly, the productivity of wheat varies from 11.72 quintal per acre in large farms to 14.87 quintal per acre in medium farms. On an average 82.11 per cent of aman paddy and 78.71 per cent of boro paddy is marketed by the selected households. The same for wheat is 84.11 per cent. The value of output and marketed surplus increases with the increase in size of holdings.

Chapter-IV

4. Assessment of Pre Harvest Losses of Rice and Wheat

4.1 Constraints faced in cultivation of rice and wheat

The problems and constraints faced by the farmers in rice and wheat production are worked out in this section. The main problems and constraints are focused on poor seed quality, water deficiency, pest & disease problems, high cost of inputs and low output price. These constraints have been sub-divided into three categories viz., most important, important least important according to the occurrence of the problems.

Table 4.1: Constraints faced in cultivation of reference crop (percentage of households)

S.N.	Constraints	Most important	Important	Least important	Constraint faced.	Most important	Important	Least important	Constraint faced
		Crop – Rice				Crop – Wheat			
1	Poor seed quality	20.83	31.67	47.50	100.00	52.50	47.50	0.00	100.00
2	Water deficiency	55.00	40.83	4.17	100.00	70.00	30.00	0.00	100.00
3	Pest & disease problems	57.50	32.50	10.00	100.00	59.17	40.83	0.00	100.00
4	High cost of inputs	86.67	12.50	0.83	100.00	90.00	10.00	0.00	100.00
5	Low output price	87.50	12.50	0.00	100.00	82.50	17.50	0.00	100.00

Table 4.1b: Rank Sum values for the constraints faced by the farmers

Constraints	Rice	Wheat
Poor seed quality	288	177
Water deficiency	175	156
Pest & disease problems	183	169
High cost of inputs	135	120
Low output price	120	120

The constraints faced in cultivation of rice and wheat is presented in Table-4.1. As perceived by the respondents, cent per cent of the farmers are facing constraints in rice and wheat cultivation. However, the degree of severity of these constraints varies. Among these constraints, high cost of inputs and low output price ranked first both in rice and wheat. Similarly, farmers perceived water deficiency as one of the most important constraints (55.00 per cent of respondents) in rice cultivation. The farmers in the study areas in West Bengal depended mostly on monsoon and almost all of them just cultivated rice in kharif season based on availability of rains. Despite of most of them have pumps, they could not be able to tackle this constraint due to lack of water and increase in cost of production leading to the loss in their farming business. It has been found that poor quality of seed is one of the important problems in wheat.

4.2 Assessment of incidences of pests and diseases attack and crop loss

Assessment or measurement of disease is the basis of epidemiology which is the study of disease at the level of populations of pathogens and hosts. It is also the basis of the study of the effects of disease on crop yield and of disease forecasting, which involves the prediction of the amount of disease that is likely to occur at some time in the future. It is usually not sufficient to determine whether a disease is present or absent. The critical information required is the amount of disease that is present. Disease often has to exceed a certain threshold before it reduces the yield of a crop. Small amounts have little effect on yield and the disease may not be worth controlling. The amount of disease is measured as the proportion of the crop population (counted as individual plants or branches or leaves etc.) that is infected (disease incidence) or the proportion of the area of a plant or plant organ (e.g. leaf area) that is affected (disease severity). In some cases, the proportion of leaves or branches infected may provide a measure of disease severity.

Table 4.2: Identification of pests and diseases attack (percentage of households)

Description		Crop – Rice	Crop – Wheat
HH able to distinguish pests and disease attack		90.00	83.33
Assessment about the severity of the attack	Quantitative assessment	0.00	0.00
	Qualitative assessment	82.50	85.00
	Both	17.50	15.00

Although it is known that plant diseases reduce crop yields compared to yields that could be expected in the absence of disease, it is usually difficult to obtain accurate quantitative estimates of yield reductions caused by specific diseases. Many diseases occur on senescing tissue which may not have been contributing much to yield. Plants are capable of compensating for loss of a certain amount of leaf area, especially in crowded crop populations. The only diseases where the effect on yield is relatively easy to measure are those that kill entire trees in orchards or plantations (e.g. phytophthora root or collar rot of citrus or apple), and those that destroy the actual harvested product, either just before harvest (e.g. the smuts, which destroy cereal grain, and fruit rots such as cocoa pod rot caused by (*Phytophthora palmiuora*) or after harvest (all postharvest rots of fruits and vegetables). However, the identification of pests and diseases attack at the farm level has been discussed in this and presented in Table -4.2. It has been observed that the 90 per cent of the rice farmers and 83.33 per cent of the wheat farmers are able to distinguish pests and diseases attack. However, their identification is completely restricted to qualitative assessment. They are not in a position for quantitative assessment.

Climatic factors especially temperature and relative humidity are the key factors influencing development of any insect pest and disease of rice. CO_2 is the key factor for global climate change, resulting increase in temperature. The intergovernmental panel on climate change predicted that with the current emission scenario, global mean temperature would rise between 0.9°C and 3.5°C by the year 2100. Under such condition frequency of precipitation, intensity of drought and UV-B radiation is predicted to increase, which might affect the structure of rice plant and intensity of insect pests and diseases. Climate change may change the pest–plant

relationship resulting in positive or negative impact on incidence and severity of different diseases and insect pests. Sheath blight (*Rhizoctonia solani*), a minor

Table 4.3: Incidence of major pests and disease (percentage of households) – Rice

Name of the pest/disease/weed		Rank of severity*				Frequency of attack**			Production loss***				
		1	2	3	4	1	2	3	1	2	3	4	5
Major Pests – Local variety													
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
Major Pests - HYV variety													
BPH	8	100	0	0	0	100	0	0	3.48				
GLH	2	27.51	39.16	33.33	0	100	0	0	1.36				
LF	5	39.16	27.51	0	0	100	0	0	1.76				
GH	6	0	33.33	27.51	0	100	0	0	1.58				
REHB	9	33.33	39.16	0	0	100	0	0	0.87				
TOTAL	-	100	100	100	0	100	0	0	**9.05**				
	Major Diseases – Local variety												
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
Major Diseases – HYV variety													
SB	6	100	0	0	0	100	0	0	2.55				
B	1	0	71.66	0	0	100	0	0	2.00				
BLB	2	0	0	100	0	100	0	0	0.98				
SR	5	0	0	62.50	0	100	0	0	0.45				
BS	4	0	28.33	37.50	0	100	0	0	1.14				
TOTAL	-	100	100	100	0	100	0	0	**7.12**				
	Major Weeds – Local variety												
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
Major Weeds – HYV variety													
Lh	1	25	25	0	0	100	0	0	1.59				
Fl	4	0	50	25	0	100	0	0	0.99				
Ai	2	25	25	25	0	100	0	0	1.25				
Lp	5	25	50	0	0	100	0	0	0.49				
Mq	6	25	0	25		100	0	0	1.08				
Ec	3	25	25	25	0	100	0	0	0.99				
TOTAL	-	100	100	100	0	100	0	0	**6.39**				
G. Total	-	100	100	100	0	100	0	0	**22.55**				

Note: * very important=1; important=2; not important=3
** every season=1; once in two seasons=2; once in three seasons=3
*** <5per cent=1; 5-10per cent=2; 10-25per cent=3; 25-50per cent=4; >50per cent=5

disease in early 1970s, is now a most destructive disease of rice. Similar change has also been observed on the incidence and severity of some other diseases and insect pests. Ear-cutting caterpillar (*Mythimna separata*), a

major pest of rice in West Bengal in 1960s had only a few occurrences in the last few decades. Besides, leaf roller (*Cnaphalocrocis medinalis*, *Marasmia exigua*) that had lower ranks in the list of major pests has been coming at the top of the list since 1980s. In West Bengal many interventions such as change in crop diversity, variety, cropping intensity, irrigation, fertilization, etc. along with climate change in the rice production system affected incidence and severity of insect pests and diseases. However, exact and individual contribution of such factors or interventions has not been worked out in West Bengal or elsewhere.

Table 4.4: Incidence of major pests and disease (percentage of households) – Wheat

Name of the pest/disease/weed		Rank of severity*				Frequency of attack**		Production loss***				
		1	2	3	4	1	2	1	2	3	4	5
Major Pests – Local variety												
		-	-	-	-	-	-	-	-			
Major Pests - HYV variety												
Aphids	1	100	0	0		100	0	1.78				
Aw	2	0	100	0		100	0	1.08				
SB	3	0	0	100		100	0	0.59				
Rodents		100			0	100	0	**5.59**				
TOTAL		**100**	**100**	**100**		100	0	**9.04**				
Major Diseases – Local variety												
		-	-	-	-	-	-	-	-			
Major Diseases – HYV variety												
LB	6	100	0	0	0	100	0	1.38				
LR	1	0	100	0	0	100	0	0.87				
SR	2	0	0	100	0	100	0	0.47				
YER	4	0	0	55.84	0	100	0	0.26				
Stripe rust	3	0	0	44.16	0	100	0	0.28				
TOTAL		**100**	**100**	**100**	**0**	100	0	**3.26**				
Major Weeds – Local variety												
		-	-	-	-	-	-	-	-			
Major Weeds – HYV variety												
go	1	100	0	0	0	100	0	2.73				
ca	2	0	100	0	0	100	0	1.99				
af	3	0	0	50	0	100	0	0.80				
sf	4	0	0	50	0	100	0	0.88				
TOTAL		**100**	**100**	**100**	**0**		0	**6.39**				
Grand Total		100	100	100	0	100	0	**18.68**				

Note: * very important=1; important=2; not important=3

** every season=1; once in two seasons=2; once in three seasons=3

*** <5per cent=1; 5-10per cent=2; 10-25per cent=3; 25-50per cent=4; >50per cent=5

In view of the above, an attempt has been made in this section to document the incidence of major pest and diseases of HYV rice and wheat in terms of rank of severity, frequency of attack and production loss. The incidences of major pests and diseases separately for rice and wheat are presented in Tables -4.3 and 4.4. It has been observed that BPH is very important pest in HYV rice, occurring every season and causing 3.48 per cent crop loss out of the identified pests for rice viz., BPH, GLH, LF, GH, REHB. These identified pests are occurring every season and loss of production varies from 0.87 per cent to as high as 3.48 per cent. Among diseases, SB is very important which is also occurring every season and causing crop loss in the tune of 2.55 per cent. Similarly other diseases viz., B, BLB, SR and BS are also occurring every season and causing crop loss in the tune of 0.45 per cent to 2.00 per cent. Among weeds, Lh is important which causing 1.59 per cent crop loss. Other weeds of rice are Fl, Ai, Lp, Mq and Ec. The level of crop loss due to these weeds varies from 0.49 per cent to 1.59 per cent. It has been observed that conservation farming promotes a diversity of insect life, influences pest populations and also favours many beneficial insects. The beneficial insects which act as natural control agents help to create a more stable agricultural system. Reducing cultivation and maintaining mulch provides a more favourable habitat for certain soil dwelling insect pests and disease organisms. A range of pests including caterpillars, beetles, grasshoppers, foliage feeders and sap-sucking insects occur in all crops and pastures and will require control from time to time.

Wheat is another important cereal crops in West Bengal and is sown throughout the state in rabi season. During 2007-08, the production under wheat in the State was 7.7 thousand tons. It has been found that wheat diseases frequently report impressively high potential yield losses and suggest that sizable areas of wheat are at risk to specific diseases or pests. High yield loss figures are often obtained in trials conducted on experiment stations or under controlled conditions, generally using as a check, a commercial cultivar that has become susceptible. Although risks are not undermined and must be properly calculated, crop health and actual losses in farmers' fields are significantly different, particularly when modern and broadly adapted resistant cultivars are cultivated, as is generally the case in intensive production systems. It has been suggested that the global average of actual yield losses caused by all wheat diseases, including developed and developing countries, was about 12.4 per cent on an annual basis. Unfortunately, in developing countries, precise data on actual yield losses caused by diseases in farmers' fields are often unavailable or are difficult to assess. Thus, an attempt has been made in this section to document the incidence of major pest and diseases of wheat in terms of rank of severity, frequency of attack and production loss. It has been observed that aphid is very important pest in wheat, occurring every season and causing 1.78 per cent crop loss out of the identified pests for wheat viz., Aw and SB. These identified pests are occurring every season and loss of production varies from 0.59 per cent to as high as 1.78 per cent. Among diseases, LB is very important which is also occurring every season and causing crop loss in the tune of 1.38 per cent. Similarly other diseases viz., LR, SR and YER are also occurring every season and causing crop loss in the tune of 0.26 per cent to 0.87 per cent. Among weeds, go is important which causing 2.73 per cent crop loss. Other weeds of wheat are ca, af, and sf. The level of crop loss due to

these weeds varies from 0.80 per cent to 1.99 per cent. Among pests and diseases, it is worthwhile to mention that rodent is very severe and causing maximum loss in wheat cultivation. The crop loss due to rodents is as high as 5.59 per cent.

The magnitude of crop loss due to pests, disease and weed infestation in paddy has been depicted in Table-4.5. The actual production with attack is varied from19.36 quintal to 20.88 quintal per acre. The overall loss with attack has been found to be 3.54 quintal per acre. Similarly, the overall normal production without attack is 23.52 quintal per acre. However, the percentage loss over normal production is less (15.05 per cent) than that of percentage loss over actual production.

Table 4.5: The magnitude of crop loss due to pests, disease and weed infestation- Paddy

Description	Marginal		Small		Medium		Large		Total	
	Local	HYV	Local	HYV	Local	HYV	Local	HYV	Local	HYV
Actual production with attack (quintal/acre)	-	19.36	-	19.65	-	20.22	-	20.88	-	19.98
Normal production without attack (quintal/acre)	-	22.78	-	23.18	-	23.72	-	24.61	-	23.52
Loss of output (quintal/acre)	-	3.42	-	3.54	-	3.51	-	3.73	-	3.54
Percentage loss over actual production	-	17.68	-	18.00	-	17.34	-	17.87	-	17.72
Percentage loss over normal production	-	15.03	-	15.25	-	14.77	-	15.16	-	15.05

The magnitude of crop loss due to pests, disease and weed infestation in wheat has been depicted in Table-4.6. The actual production with attack is varied from 3.90 quintal to 5.96 quintal per acre. . The overall loss with attack has been found to be 0.92 quintal per acre.

Table 4.6: The magnitude of crop loss due to pests, disease and weed infestation- Wheat

Description	Marginal		Small		Medium		Large		Total	
	Local	HYV	Local	HYV	Local	HYV	Local	HYV	Local	HYV
Actual production with attack (quintal/acre)	-	5.96	-	3.90	-	5.01	-	-	-	5.12
Normal production without attack (quintal/acre)	-	7.02	-	4.80	-	5.93	-	-	-	6.04
Loss of output (quintal/acre)	-	1.06	-	0.71	-	0.92	-	-	-	0.92
Percentage loss over actual production	-	17.84	-	18.12	-	18.44	-	-	-	18.05
Percentage loss over normal production	-	15.14	-	15.34	-	15.57	-	-	-	15.29

Similarly the overall normal production without attack is 6.04 quintal per acre. However, the percentage loss over normal production is less (15.29 per cent) than that of percentage loss over actual production.

4.3 Methods of pests and diseases control adopted by the selected sample households

Rice pests are any organisms or microbes with the potential to reduce the yield or value of the rice crop (or of rice seeds). Rice pests include weeds, pathogens, insects, nematode, rodents, and birds. A variety of factors can contribute to pest outbreaks, including the overuse of pesticides, improper irrigation, and high rates of nitrogen fertilizer application. Weather conditions also contribute to pest outbreaks. For example, rice gall midge and army worm outbreaks tend to follow periods of high rainfall early in the wet season, while thrips outbreaks are associated with drought.

Several nematode species infect rice crops, causing diseases such as Ufra (*Ditylenchus dipsaci*), White tip disease (*Aphelenchoide bessei*), and root knot disease (*Meloidogyne graminicola*). Some nematode species such as *Pratylenchus* spp. are most dangerous in upland rice of all parts of the world. Rice root nematode (*Hischmanniella* spp.) is a migratory endoparasite which on higher inoculum levels will lead to complete destruction of a rice crop. Beyond being obligate parasites, they also decrease the vigour of plants and increase the plants' susceptibility to other pests and diseases.

Crop protection scientists are trying to develop rice pest management techniques which are sustainable. In other words, to manage crop pests in such a manner that future crop production is not threatened. Sustainable pest management is based on four principles: biodiversity, host plant resistance (HPR), landscape ecology, and hierarchies in a landscape from biological to social. At present, rice pest management includes cultural techniques, pest-resistant rice varieties, and pesticides (which include insecticide). Increasingly, there is evidence that farmers' pesticide applications are often unnecessary, and even facilitate pest outbreaks. By reducing the populations of natural enemies of rice pests, misuse of insecticides can actually lead to pest outbreaks. The International Rice Research Institute (IRRI) demonstrated in 1993 that 87.5 per cent reduction in pesticide use can lead to an overall drop in pest numbers. IRRI also conducted two campaigns in 1994 and 2003, respectively, which discouraged insecticide misuse and smarter pest management in Vietnam.

Rice plants produce their own chemical defences to protect themselves from pest attacks. Some synthetic chemicals, such as the herbicide 2-4-D, cause the plant to increase the production of certain defensive chemicals and thereby increase the plant’s resistance to some types of pests. Conversely, other chemicals, such as the insecticide imidacloprid, can induce changes in the gene expression of the rice that cause the plant to become more susceptible to attacks by certain types of pests. Alkylresorcinols are chemicals that can also be found in rice.

Botanicals, so-called "natural pesticides", are used by some farmers in an attempt to control rice pests. Botanicals include extracts of leaves, or a mulch of the leaves themselves. Some upland rice farmers in Cambodia spread chopped leaves of the bitter bush (*Chromolaena odorata*) over the surface of fields after planting. This practice probably helps the soil retain moisture and thereby facilitates seed germination. Farmers also claim the leaves are a natural fertilizer and helps suppress weed and insect infestations. Chloroxylon is used for Pest management in organic rice cultivation.

Among rice cultivars, there are differences in the responses to, and recovery from, pest damage. Therefore, particular cultivars are recommended for areas prone to certain pest problems. The genetically based ability of a rice variety to withstand pest attacks is called resistance. Three main types of plant resistance to pests are recognized as non-preference, antibiosis, and tolerance. Nonpreference (or antixenosis) describes host plants which insects prefer to avoid; antibiosis is where insect survival is reduced after the ingestion of host tissue; and tolerance is the capacity of a plant to produce high yield or retain high quality despite insect infestation. Over time, the use of pest resistant rice varieties selects for pests that are able to overcome these mechanisms of resistance. When a rice variety is no longer able to resist pest infestations, resistance is said to have broken down. Rice varieties that can be widely grown for many years in the presence of pests and retain their ability to withstand the pests are said to have durable resistance. Mutants of popular rice varieties are regularly screened by plant breeders to discover new sources of durable resistance.

Table 4.7: Details of biological methods adopted for pests and disease control*

Item		Crop – Rice		Crop – Wheat	
		Percentage of HH adopted this method	Details about the method	Percentage of HH adopted this method	Details about the method
Biological methods		0	0	0	0
Other Control measures	1	0	0	0	0
	2	0	0	0	0
* No information available regarding application of biological method for Pests & Disease control					

It has been observed earlier that major rice pests include the brown plant hopper the rice gall midge, the rice bug, the rice leaf roller, rice weevils, stem borer, panicle rice mite, rats, and the weed *Echinochloa crusgali*. Major rice diseases include Rice ragged stunt, Sheath Blight, and tungro. Rice blast, caused by the fungus *Magnaporthe grisea*, is the most significant disease affecting rice cultivation. There is also an ascomycete fungus, *Cochliobolus miyabeanus* that causes brown spot disease in rice. The details of biological methods adopted for pest and diseases control of rice and wheat by the respondents are presented in Table-4.7. However, the respondents were not in a position to report the biological methods for pests and diseases control either in rice or wheat in the study areas.

Pesticides are substances or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. They are a class of biocide. The most common use of pesticides is as plant protection products (also known as crop protection products), which in general protect plants from damaging influences such as weeds, diseases or insects. This use of pesticides is so common that the term *pesticide* is often treated as synonymous with *plant protection product*, although it is in fact a broader term, as pesticides are also used for non-agricultural purposes. A pesticide is generally a chemical or biological agent (such as a virus, bacterium, antimicrobial or disinfectant) that through its effect deters, incapacitates,

Table 4.8: Cost of chemical methods adopted for pests and disease control in rice

(Rs/acre)

Particulars	Marginal	Small	Medium	Large	Total
per cent HH adopted control measures					
Weedicide					
per cent HH adopted control measures	57.14	100	100	100	77.50
No. of sprays/acre(labour hrs)	3	1.70	1.02	0.58	1.58
Cost of chemicals (Rs./acre)	81.51	53.49	36.40	26.18	48.06
Labour charges (Rs./acre)	79.04	53.60	32.04	18.63	44.88
Total Cost (Rs./acre)	160.55	107.09	68.45	44.81	92.94
Total Cost (Rs.)	11030	14115	7145	3680	35970.00
Insecticide					
per cent HH adopted control measures	95.24	100	100	100	97.50
No. of sprays/acre(labour hrs)	2.46	1.29	0.89	0.66	1.32
Cost of chemicals (Rs./acre)	171.68	106.60	92.44	66.97	110.36
Labour charges (Rs./acre)	97.74	58.04	45.98	36.53	60.00
Total Cost (Rs./acre)	269.42	164.64	138.42	103.49	170.36
Total Cost (Rs.)	26050	21700	14450	8500	70700.00
Fungicide					
per cent HH adopted control measures	0	0	33.33	100	
No. of sprays/acre(labour hrs)	0	0	0.28	0.30	
Cost of chemicals (Rs./acre)	0	0	28.41	21.92	23.86
Labour charges (Rs./acre)	0	0	8.52	4.93	6.01
Total Cost (Rs./acre)	0	0	36.93	27.46	30.30
Total Cost (Rs.)	0	0	1300	2255	3555.00

Table 4.9: Cost of chemical methods adopted for pests and disease control in wheat

(Rs/acre)

Particulars	Marginal	Small	Medium	Large	Total
per cent HH adopted control measures	82.5	100	100	0.00	87.5
Weedicide					
No. of sprays/acre	2.48	2.42	6.10	0.00	1.62
Cost of chemical	124.97	98.51	73.64	0.00	1.00
Labour charges	63.84	39.15	40.45	0.00	0.48
Total Cost (Rs./acre)	188.81	137.67	114.09	0.00	157.57
Total Cost	28010.00	10935.00	8010	0.00	46955.00
Insecticide					
No. of sprays/acre	0.00	1	5.10	0.00	0.60
Cost of chemical	0.00	21.40	84.03	0.00	0.35
Labour charges	0.00	12.59	36.82	0.00	0.17
Total Cost (Rs./acre)	0.00	33.99	120.85	0.00	37.53
Total Cost	0.00	2700.00	8485	0.00	11185.00
Fungicide					
No. of sprays/acre	0.00	0.00	0.00	0.00	
Cost of chemical	0.00	0.00	0.00	0.00	0.00
Labour charges	0.00	0.00	0.00	0.00	0.00
Total Cost (Rs./acre)	0.00	0.00	0.00	0.00	0.00
Total Cost	0.00	0.00	0.00	0.00	0.00

kills or otherwise discourages pests. Target pests can include insects, plant pathogens, weeds, molluscs, birds, mammals, fish, nematodes (roundworms), and microbes that destroy property, cause nuisance, spread disease or are vectors for disease. Although there are human benefits to the use of pesticides, some also have drawbacks, such as potential toxicity to humans and other animals. According to the Stockholm Convention on Persistent Organic Pollutants, 9 of the 12 most dangerous and persistent organic chemicals are pesticides. Pesticides are categorized into four main substituent chemicals: herbicides; fungicides; insecticides and bactericides.

In view of the above, the detailed cost of chemical methods adopted for pests and diseases in rice and wheat at the farmers field are presented in Tables-4.8 and 4.9. It has been found that in rice cultivation cent per cent of the farmers use weedicide except marginal farms. Even the use of weedicides is very high (57.17 per cent) in marginal farm also. The cost due to application of weedicides per acre in small (Rs. 160.55/-) and marginal farms (Rs. 107.09/-) is very high than that of medium (Rs. 68.45/-) and large farms (Rs. 44.81/-). Interestingly, the cost due to application of insecticides per acre is also high in small (Rs. 269.42/-) and marginal farms (Rs. 164.64/-) than that of medium (Rs. 134.42/-) and large farms (Rs. 103.49/-). Surprisingly, the use of fungicides is restricted to medium and large farms only and the cost due to use of fungicides varies from Rs.27.46/- to 36.93/- per acre.

In general, the attack of pest and diseases in wheat is low than that of rice. However, it has been found that cent per cent use of weedicide is restricted to small and medium farms in wheat cultivation. Similarly, use of weedicides is also extended to majority (82.50 per cent) of the marginal farms. The cost due to application of weedicides per acre in marginal farm is very high (Rs. 188.81/-) than that of small (Rs. 137.67/-) and medium farms (Rs. 114.09/-). Interestingly, the cost due to application of insecticides is restricted to small and medium farms only. Per acre cost for insecticides varies from Rs. 120.85/- in medium farms to Rs. 33.99/- in small farms. However, there is no evidence in use of fungicides in wheat cultivation.

It is fact that a moderately high cost is involved for chemical control of pests and diseases in rice and wheat cultivation. Simultaneously, pesticides that reach waterways can seriously affect ecosystem health. It is fact that only a small portion of pesticides applied to crops, however, actually reaches target pests. Crop losses to pests have remained stable in recent years despite increased pesticide use. Chemical pesticides can control pests in the short-term but over time, pest problems may increase. This is because pesticides not only kill pests but pest predators as well. Also, the use of pesticides selects for pests that are immune to the pesticide and the pest population becomes increasingly resistant. As more pests survive, more and different pesticides are applied. This pattern results in increased pesticide use and increased pesticide pollution problems.

4.4 Sources of information for pests and diseases control by the selected sample households

In reality, a source or sources of information refers to the origin of information . As close to the definition that we can lend to the concept of ‘source’ must be careful not to confuse it with the "reference". A reference in its purposes does not purport to identify objective and rational elements of literature, including the author's name, relative to the document. As for the source, it can make a judgment on the validity of information

since it tends to detect and report intentions media information producers. In other words, to learn about the source, is to focus on the nature and location of the original speech information. This allows, among other things, to highlight its accuracy, relevance, and usefulness of its use. Extension service is one of the important sources of information to control pests and diseases. Usually, different infrastructural, environmental, technical knowledge of pest control methods are being transmitted to the actual users through different processes. In reality, the extension services are provided either by the public agencies or private agencies. Public agencies include agricultural universities, Krishi Vigyan Kendras, government personnel, radio, TV etc., whereas private agencies include input dealers, fellow farmers etc.

Table 4.10: Extension services on pests and disease control management (percentage of hh)

	Rice				Wheat			
Percentage of HH seeking advice								
Sources of advice								
Rank of sources	Most imp	Important	Least imp	Details of advice	Most imp	Important	Least imp	Details of advice
Government extension agent	5.83	50.83	43.34	-	29.16	46.67	24.17	-
Private input dealer	41.67	58.33	0.00	-	28.33	71.67	0.00	-
Fellow farmers	57.50	42.50	0.00	-	56.67	43.33	0.00	-
TV/Radio service/Newspaper	22.50	77.50	0.00	-	14.17	85.83	0.00	-
Agricultural University/KVK	0.00	0.00	100.00	-	0.00	0.00	100.00	-
Any other	-	-	-	-	-	-	-	-

Table 4.10b: Rank Sum values for the sources of advice seeking by the farmers

Sources of advice	Rice	Wheat
Government extension agent	294	238
Private input dealer	240	240
Fellow farmers	172	172
TV/Radio service/Newspaper	360	360
Agricultural University/KVK	360	360
Any other	-	-

In view of the above, the details about the extension services on pest and disease control management in the study area are presented in Table-4.10. It has been found that both rice and wheat farmers mostly depend on private input dealers and fellow farmers in controlling pests and diseases in crop cultivation. Surprisingly as perceived by the farmers, agricultural universities and Krishi Vigyan Kendras have no role in disseminating extension services especially in case of pests and disease control management.

4.5 Household suggestions on how to minimize pre harvest losses

Pre-harvest damage due to pests and diseases in rice and wheat cultivation is a chronic problem in West Bengal. It has been found that losses are reported to be substantial. Use of several measures including

indigenous technologies, biological and chemical control of pest and diseases are a common practice in cultivation of rice and wheat. As a result, considerable information existed on pests control measures at the farm levels. What remained to be determined was when during the year control could be the most cost-effective under the agro-ecological conditions existing at the farm itself.

In view of the above, an effort has been made to document the suggestions of the respondents to minimize the pre-harvest losses in rice and wheat and these are presented in Table-4.11. In general and according to the suggestions of the respondents, provision of pest and disease resistant quality seeds along with technical know-how, soil testing facility etc. are call for the day to minimize the losses at pre-harvesting stage of rice and wheat. Similarly, provision of infrastructural facilities including ware houses, marketing infrastructure and good condition of road can restrict the losses at the stage of pre-harvest of rice and wheat.

Table 4.11: Households suggestions on how to minimize pre harvest losses

Description	Rice	Wheat
Pre harvest losses	1. To provide adequate seeds, resistant to pests and diseases from government sources. 2. Technical know-how would be provided well in advance of sowing and hence agricultural extension activities should be widened with increase in frequencies and in regular way. 3. Pesticides, weedicides should be provided by government agencies and with reasonable rates. 4. Facilities of soil testing should be widened and in regular intervals. 5. Sprayer may be supplied by government sources with reasonable prices	1. To provide adequate improved hyv seeds which will increase production from government sources. 2. Irrigation facilities should be provided by government agencies and with reasonable rates. 3. To provide adequate chemical fertilizers by government agencies and with reasonable rates. 4. Technical know-how would be provided well in advance of sowing and hence agricultural extension activities should be widened with increase in frequencies and in regular way. 5. Pesticides, weedicides should be provided by government agencies and with reasonable rates. 6. Facilities of soil testing should be widened and in regular intervals.

4.6 Summary of the chapter

As perceived by the respondents, cent per cent of the farmers are facing constraints in rice and wheat cultivation. However, the degree of severity of these constraints varies. Among these constraints, high cost of inputs and low output price ranked first both in rice and wheat. Similarly, farmers perceived water deficiency as one of the most important constraints in rice cultivation. It has been found that poor quality of seed is one of the important problems in wheat.

It has been observed that BPH is very important pest in HYV rice, occurring every season and causing a perceptible damage to rice. In rice, the other identified pests are BPH, GLH, LF, GH, REHB. These identified pests are also occurring every season and loss of production varies from farms to farms. Among diseases, SB is very important and occurring every season and causing crop loss. Other diseases viz., B, BLB, SR and BS are

also very common in rice. Among weeds, Lh is important. Other weeds of rice are Fl, Ai, Lp, Mq and Ec. The level of crop loss due to these weeds varies from 0.49 per cent to 1.59 per cent.

Aphid is very important pest in wheat, occurring every season and causing crop loss. Other identified pests in wheat are Aw and SB. Among diseases, LB is very important. Similarly other diseases viz., LR, SR and YER are also occurring every season and causing crop loss. Among weeds, go, ca, af, and sf are very important. The level of crop loss due to these weeds also varies. It is worthwhile to mention that among pests and diseases, rodent is very severe and causing maximum loss in wheat cultivation.

It has been found that a moderately high cost is involved for chemical control of pests and diseases in rice and wheat cultivation. Simultaneously, pesticides that reach waterways can seriously affect ecosystem health. It is fact that only a small portion of pesticides applied to crops, however, actually reaches target pests. Crop losses to pests have remained stable in recent years despite increased pesticide use. Chemical pesticides can control pests in the short-term but over time, pest problems may increase. This is because pesticides not only kill pests but pest predators as well. Also, the use of pesticides selects for pests that are immune to the pesticide and the pest population becomes increasingly resistant. As more pests survive, more and different pesticides are applied. This pattern results in increased pesticide use and increased pesticide pollution problems.

Among the extension services on pest and disease control management, it has been found that both rice and wheat farmers mostly depend on private input dealers and fellow farmers. Surprisingly as perceived by the farmers, agricultural universities and Krishi Vigyan Kendras have no role in disseminating extension services especially in case of pests and disease control management. It has been found that provision of pest and disease resistant quality seeds along with technical know-how, soil testing facility etc. are call for the day to minimize the losses at pre-harvesting stage of rice and wheat. Similarly, provision of infrastructural facilities including ware houses, marketing infrastructure and good condition of road can restrict the losses at the post-harvest stage of rice and wheat.

In fact, rice and wheat produced on the farm fields have to undergo a series of operations such as harvesting, threshing, winnowing, bagging, transportation, storage, processing and exchange before they reach the consumer, and there are appreciable losses in crop output at all these stages. It has been estimated by the Ministry of Food and Civil Supplies, Government of India that the total preventable post-harvest losses of food grains at 10 per cent of the total production. According to a World Bank study (1999), post-harvest losses of food grains in India are 7-10 per cent of the total production from farm to market level and 4-5 per cent at market and distribution levels. Thus, the pre and post-harvest losses have impact at both the micro and macro levels of the economy and these have to be carefully handled at the farm levels.

Chapter-V

5. Assessment of Post Harvest Losses of Rice and Wheat

5.1 Production loss during harvest of rice and wheat

Food production system consists of two sub-systems – crop production and post harvest operations systems. The efficiency of the food production system can be increased by increasing the technical efficiency of the crop production system i.e. reducing the technical inefficiency as well as increasing the efficiency of post harvest operations i.e. reducing the post harvest losses of the crop. This implies that considerable emphasis should be given not only on the crop production but also on the post harvest operations. Modern technological packages of post harvest operations may reduce the post harvest losses at farms. But there is a large variation in the losses among the farms in different regions within West Bengal. Therefore, an estimation of quantity lost at different stages of harvest is desirable for clear understanding of the extent of the post harvest losses. Knowledge of the losses in the different post harvest operations is essential to determine the leverage points and design action programs to reduce the post harvest losses and thereby to reduce food insecurity.

Table 5.1: Quantity lost at different stages of harvest (Crop – Rice)

Stages of harvest and variety		Early		Mid		Late	
		Local	HYV	Local	HYV	Local	HYV
Area harvested per hh (acres)		-	-	-	3.48	-	-
Percentage area harvested (early, mid and late)		-	-	-	100.00	-	-
Area manually harvested (percentage)		-	-	-	100.00	-	-
Area mechanically harvested (percentage)		-	-	-	0	-	-
Rank of loss (percentage of households)	High	-	-	-	-		-
	Medium	-	-	-	-	-	-
	Low	-	-	-	100.00	-	-
Quantity lost during harvest	Kg per acre of harvest	-	-	-	17.45	-	-
	Kg per quintal of harvest	-	-	-	0.78	-	-
	Loss per cent of harvest amount	-	-	-	0.78	-	-

An attempt has been made in this section to quantify the loss at different stages of harvest of rice and wheat as per the perception of the respondents in terms of ranking i.e. high, medium and low. Similarly, effort has been made to quantify the loss in terms of quantity i.e. quantity of loss in kilogram per acre along with kilogram per quintal. The quantity of loss at different stages of harvest for rice is presented in Table -5.1. It has been found that quantity of loss at different stages of harvest is low as perceived by the farmers. However, the quantity of loss could be captured at the mid transplanting of rice. In the study area rice is transplanted at the mid season. Therefore, the quantity lost at different stages of harvest in case of early and late transplanting of rice could not be captured. Similarly, this estimate has been restricted to HYV rice only. However, it has been observed that the quantity lost per acre during harvest is 17.45 kg. The loss per quintal of harvest turns out to be 0.78 kg.

Table 5.2: Quantity lost at different stages of harvest (Crop – Wheat)

Stages of harvest and variety		Early		Mid		Late	
		Local	HYV	Local	HYV	Local	HYV
Area harvested per hh (acres)		-	-	-	0.74	-	-
Area harvested per hh (percentage harvested early, mid and late)		-	-	-	100	-	-
Area manually harvested (percentage)		-	-	-	100	-	-
Area mechanically harvested (percentage)		-	-	-	0	-	-
Rank of loss (percentage of households)	High	-	-	-	-	-	-
	Medium	-	-	-	-	-	-
	Low	-	-	-	100	-	-
Quantity lost during harvest	Kg per acre of harvest	-	-	-	18.63	-	-
	Kg per quintal of harvest	-	-	-	1.26	-	-
	Loss per cent of harvest amount	-	-	-	1.26	-	-

The quantity lost at different stages of harvest for wheat is presented in Table -5.2. It has been found that quantity lost at different stages of harvest is also low as perceived by the farmers. However, the quantity lost could be captured at the mid transplanting of wheat. In the study area wheat is transplanted at the mid season. Therefore, the quantity lost at different stages of harvest in case of early and late transplanting of wheat could not be captured. Similarly, this estimate has been restricted to HYV wheat only. However, it has been observed that the quantity lost per acre during harvest is 18.63 kg. The lost per quintal of harvest turns out to be 1.26 kg.

5.2 Production loss during threshing and winnowing of rice and wheat

Post harvest losses present one of the main problems not only in rice and wheat but also in all grain production. It has been observed in many studies that losses in food crops, occurring during harvesting, threshing, drying, storage, transportation, winnowing etc. have been estimated to be between 30 and 40 per cent of all food crops. Similarly, winnowing is one of the post harvest operations that incur high amount of loss. It has been reported that winnowing incurs a loss of as high as 4 per cent. These losses were attributed to improper handling and inefficient machine.

Production loss during threshing and winnowing both for manually and mechanically of rice and wheat is presented in Tables- 5.3 and 5.4. An attempt has been made to quantify the lost during threshing and winnowing of rice and wheat as per the perception of the respondents in terms of ranking i.e. high, medium and low. Similarly, effort has been made to quantify the lost in terms of quantity i.e. quantity lost in kilogram per acre along with kilogram per quintal. The quantity lost during manual threshing and winnowing for rice

Table 5.3: Quantity lost during threshing and winnowing (manual)

Stages of harvest and variety		Crop – Rice		Crop – Wheat	
		Local	HYV	Local	HYV
Area/quantity manually threshed (percentage of hh)*		0	0	0	0
Rank of loss (percentage of households)	High	-	-	-	-
	Medium	-	-	-	-
	Low	-	-	-	-
Quantity lost during threshing	Average loss (Kg per acre)	-	-	-	-
	Average loss (Kg per qtl)	-	-	-	-
	Loss per cent of threshed amount	-	-	-	-
Area/quantity manually winnowed (percentage of hh)			-	-	-
Rank of loss (percentage of households)	High	-	-	-	-
	Medium	-	-	-	-
	Low	-	100.00	-	100.00
Quantity lost during winnowing	Average loss (Kg per acre)	-	2.94	-	6.21
	Average loss (Kg per qtl)	-	0.13	-	0.42
	Loss per cent of winnowed amount	-	0.13	-	0.42

*per cent of manually threshed product is 0

Table 5.4: Quantity lost during threshing and winnowing (mechanical)

Stages of harvest and variety		Crop – Rice		Crop – Wheat	
		Local	HYV	Local	HYV
Area/quantity mechanically threshed (percentage of hh)		-	100	-	100
Rank of loss (percentage of households)	High	-	-	-	-
	Medium	-	100	-	-
	Low	-	-	-	-
Quantity lost during threshing	Average loss (Kg per acre)	-	7.04	-	13.45
	Average loss (Kg per qtl)	-	0.31	-	0.91
	Loss per cent of threshed amount	-	0.31	-	0.91
Area/quantity mechanically winnowed (percentage of hh)		-	-	-	-
Rank of loss (percentage of households)	High	-	-	-	-
	Medium	-	-	-	-
	Low	-	-	-	-
Quantity lost during winnowing	Average loss (Kg per acre)	-	-	-	-
	Average loss (Kg per qtl)	-	-	-	-
	Loss per cent of winnowed amount	-	-	-	-

and wheat is presented in Table -5.3. It has been found that quantity lost is low as perceived by the farmers when threshing and winnowing is done manually. However, the quantity lost could be captured only in case of HYV rice and wheat only. There are no evidences of threshing through manual operations as well winnowing through mechanical operations either in rice or wheat. Similarly, the quantity losses per acre during manual winnowing of rice and wheat are 2.94 kg and 6.21 kg, respectively. The losses per quintal of rice and wheat during winnowing turn out to be 0.13 kg and 0.42 kg, respectively.

The quantity lost during mechanical threshing and winnowing for rice and wheat is presented in Table - 5.4. It has been found that quantity lost is medium as perceived by the farmers when threshing is done mechanically. However, the quantity lost could be captured only in case of HYV rice and wheat only. The quantity losses per acre during mechanical threshing of rice and wheat are 7.04 kg and 13.45 kg, respectively. The losses per quintal of rice and wheat during winnowing turn out to be 0.31 kg and 0.91 kg, respectively.

5.3 Production loss during transportation and handling of rice and wheat

In West Bengal, the transportation of agricultural commodities is mainly done by head load, bullock carts, tractor-trolleys, tempo and trucks, depending upon the availability, quantity and the stage of marketing. Transportation infrastructure consists of roads, railways and transport vehicles. As of 2011, the total length of surface road in West Bengal is over 92,023 km; national highways comprise 2,578 km and state highways 2,393 km. As of 2006, the road density of the state is 103.69 km per 100 km², higher than the national average of 74.7 km per 100 km². Average speed on state highways varies between 40–50 km/hour; in villages and towns, speeds are as low as 20–25 km/hour due to the substandard quality of road constructions and low maintenance. As of 2011, the total railway route length is around 4,481 km. Kolkata is the headquarters of two divisions of the Indian Railways—Eastern Railway and South Eastern Railway. The Northeast Frontier Railway (NFR) plies in the northern parts of the state. However, the problems in the transportation of agricultural commodities are very serious not only in West Bengal but also in India. The problems are serious because of special factors associated with perishibility of the product, bulkiness, small quantity, and a large number of suppliers and purchasers. Therefore, the quantity lost during transportation and handling is a serious problem in agricultural commodities.

Table 5.5: Quantity lost during transportation and handling (Crop – Rice)

Mode of transportation		Head load-1	Bullock cart-2	Trolley -3	Tempo-4	Truck	Others	Total
Average quantity transported (qtls per hh)		4.50	60.45	83.81	27.49	-	-	76.10
Average distance covered (kms)		1.00	1.75	2.26	4.18	-	-	9.19
Transportation cost (Rs per quintal)		-	-	-	-	-	-	12.05
Rank of loss (percentage of hh)	High	-	-	-	-	-	-	-
	Medium	-	-	-	-	-	-	-
	Low	100	100	100	-	-	-	100
Quantity lost during transport	Average loss (Kg per qtl. of amount transported)	0.04	0.34	0.43	0.15	-	-	0.55
	per cent of amount transported	0.04	0.34	0.43	0.15	-	-	0.55
Quantity lost during handling	Average loss (Kg per qtl of amount handled)	0.16	0.08	0.06	0.03	-	-	0..24
	per cent loss of amount handled	0.16	0.08	0.06	0.03	-	-	0.24

Table 5.6: Quantity lost during transportation and handling (Crop – Wheat)

Mode of transportation		Head load	Bullock cart	Trolley	Tempo	Truck	Others	Total
Average quantity transported (qtls per hh)		0.53	5.79	-	4.21	-	-	10.52
Average distance covered (kms)		1.0	1.3	2.1	3.4	-	-	7.80
Transportation cost (Rs per quintal)		-	-	-	-	-	-	13.75
Rank of loss (percentage of hh)	High	-	-	-	-	-	-	
	Medium	-	-	-	-	-	-	
	Low	100	100	100	100	-	-	100
Quantity lost during transport	Average loss (Kg per qtl of amount transported)	0.02	0.08	-	0.05	-	-	0.6
	per cent of amount transported	0.02	0.08	-	0.05	-	-	0.6
Quantity lost during handling	Average loss (Kg per qtl of amount handled)	0.05	0.03	-	0.01	-	-	0.63
	per cent loss of amount handled	0.05	0.03	-	0.01	-	-	0.63

The quantity lost during transportation and handling in rice and wheat is presented in Tables-5.5 and 5.6. An attempt has been made to quantify the loss during transportation and handling of rice and wheat as per the perception of the respondents in terms of ranking i.e. high, medium and low. However, it has been observed that quantity lost during transportation and handling both in rice and wheat is low. The quantity of loss per quintal during transportation varies from 0.04 to 0.43 kg in case of rice and 0.03 to 0.08 kg in case of wheat depending upon the mode of transport. Similarly, the quantity of loss per quintal during handling varies from 0.03 to 0.16 kg in case of rice and 0.01 to 0.05 kg in case of wheat depending upon the mode of transport.

5.4 Production loss during storage of rice and wheat

Storage is another important marketing function, which involves holding and preserving goods from the time they are produced until they are required for consumption. Storage is an exercise of human foresight by means of which commodities are protected from deterioration, and surplus supplies in times of plenty are carried over to the season of scarcity. It has been observed that losses of rice and wheat due to inefficient and inadequate storage and other post-harvest factors at the farm, village and commercial levels of up to 4 per cent (McFarlane, 1989; Abdullahi and Haile, 1991), though losses in excess of 40 percent for other cereals are not uncommon (NRC, 1996). Deterioration of stored grain is influenced by physical (temperature, humidity), biological (microflora, arthropod, vertebrate) and technical (storage conditions, methods and duration) factors. Experience has shown that such losses are not easily reduced in the absence of well-integrated policies and plans to develop the total system of production, marketing, storage and distribution (Tyler and Boxall, 1984).

Table 5.7: Quantity lost during storage

Place of storage*		Crop- Rice				Crop- Wheat			
		1	2	3	4	1	2	3	4
Mode of storage (percentage of amount stored	Open	0.14	-	-	-	10.64	-	-	-
	Gunny/plastic bag	20.30	-	-	-	-	89.36	-	-
	Kothi/bin kuchha, Pucca	-	-	-	-	-	-	-	-
	Steel drums	-	-	-	-	-	-	-	-
	Others	-	-	-	79.56	-	-	-	-
Amount stored (Qtls per hh)		0.54	-	-	72.17	0.95	7.91	-	-
Percentage of hh who dried before storing		100	-	-	100	100	100	-	-
Average number of days stored (per hh)		7			75	-	147	-	-
Rank of loss in storage	High	-	-	-	-	-	-	-	-
	Medium	-	-	-	-	-	-	-	-
	Low	100	-	-	100	100	100	-	-
Quantity lost during storage (kgs per quintal of storage)	Due to weight loss	0	-	-	1.33	-	2.00	-	-
	Due to rodents	0	-	-	0.41	-	1.38	-	-
	Due to fungus	0	-	-	0.05	-	0.54	-	-
Storage cost Rs. per quintal		0	-	-	-	-	12.87	-	-

Note: * Kutcha house =1; Pucca house =2; Scientific godown/warehouse =3; Others = Morai (Indegenous made store)=4

Quantity lost during storage in rice and wheat is presented in Tables-5.7. An attempt has been made to quantify the loss during transportation and handling of rice and wheat as per the perception of the respondents in terms of ranking i.e. high, medium and low. However, it has been observed that quantity lost during storage both in rice and wheat is low. In the study area, storage of rice and wheat is done either in gunny/plastic bags or open. The quantity of loss per quintal during storage is happened due to weight loss, rodents or fungus. The loss in storage due to weight loss has been observed to be 1.33 kg in rice and 2 kg in wheat. The losses due to rodents are 0.41 kg in case of rice and 1.38 kg in case of wheat and the same for fungus are 0.05 kg for rice and 0.54 kg for wheat. However, it has been observed that 100 per cent of the farmers used to dry the commodities before storing.

5.5 Capacity utilisation of storage by the selected households

Farmers in villages use various kinds of storage structures such as gunny bags, plastic bags, bins made of mud or cement, steel drums etc. to absorb losses during storage. Sometimes products are kept open before sale or consume. It has been observed that most of the cases the capacity has not been fully utilised in case of rice and wheat (Table-5.8). The capacity utilisation varies from 72 per cent to 85.57 per cent in rice and 63 per cent to 75.90 per cent in case of wheat.

Table 5.8: Capacity utilization of storage by the households

Mode of storage	Crop- Rice			Crop- Wheat		
	Capacity (qtls)	Actual storage (qtls)	Capacity utilization (per cent)	Capacity (qtls)	Actual storage (qtls)	Capacity utilization (per cent)
Open	15.00	10.80	72.00	180.00	113.40	63.00
Gunny Plastic bag	1775.00	1518.90	85.57	1255.00	952.60	75.90
Kothi/bukhari/bin kachha	-	-	-	-	-	-
Kothi/bukhari/bin made of cement	-	-	-	-	-	-
Steel drums	-	-	-	-	-	-
Others	7140.00	5948.30	83.31	-	-	-
Total	8930.00	7478.00	83.74	1435.00	1066.00	74.28

5.6 Quantitative aspects of storage and their pests control measures adopted by the selected households

It has been perceived by the respondents that the storage structure should be located on a raised well-drained site. It should be easily accessible and the land of the site should be protected from moisture, excessive heat, insects, rodents, and bad weather conditions. They argued that in storages, sufficient space should be provided between two stacks for proper aeration. For safe storage, storage structure should be clean. There should be no left-over grains, cracks, holes and crevices in the structure fumigated before storage. Before storage, paddy/rice grains should be cleaned to avoid quality deterioration. They always try to use new and dry gunny bags. In the event of use of old bags, they try to disinfect the old gunny bags by boiling with 1 per cent Malathion solution for 3-4 minutes and dry it. The respondents try to use bags of pad along with a cover of polythene sheet to avoid absorption of moisture from the floor. Before storing, the respondents try to make the structure and bags properly dried to check infestation and to maintain hygienic. It has been observed that rice and wheat are kept either in mud or cement bins and proper care has been taken for aeration during clean weather condition. Special care has been be taken by the respondents to avoid aeration in rainy season.

Table 5.9: Total post harvest losses per quintal by farm size

Particulars	Crop – Rice					Crop – Wheat				
	Marginal	Small	Medium	Large	Total	Marginal	Small	Medium	Large	Total
Quantity lost in harvest (kg per qtl)	0.96	0.85	0.74	0.58	0.78	1.30	1.30	1.26	-	1.26
Quantity lost in threshing (kg per qtl)	0.46	0.34	0.28	0.23	0.32	0.89	0.89	0.93	-	0.26
Quantity lost in winnowing (kg per qtl)	0.20	0.15	0.12	0.10	0.13	0.44	0.44	0.43	-	0.12
Quantity lost in transport (kg per qtl)	0.71	0.61	0.52	0.39	0.55	0.78	0.77	0.85	-	0.83
Quantity lost in handling (kg per qtl)	0.34	0.35	0.33	0.25	0.31	0.58	0.59	0.68	-	0.63
Quantity lost in storage (kg per qtl)	0.59	1.04	2.13	4.36	1.78	0.30	0.37	0.69	-	3.93
Total post harvest loss (kg per qtl)	1.51	2.66	5.34	9.39	3.51	0.66	0.76	2.03	-	7.22
Total post harvest loss (kg per acre)*	33.41	51.37	122.40	229.49	76.84	3.21	2.18	9.08	-	30.59

Note: Post harvest loss per acre is calculated by multiplying losses in kg per quintal by the productivity per acre.

The total post harvest losses per quintal by farm size are presented in Table-5.9. It has been observed that the quantity lost in harvest is 0.78 kg in rice and 1.26 kg in wheat. Quantities losses during threshing in rice and wheat are 0.32 kg and 0.26 kg, respectively. Similarly, 0.55 kg and 0.83 kg are lost during winnowing of rice and wheat. The transport lost varies from 0.55 kg in rice to 0.83 kg in wheat. Quantity losses in handling are 0.31 kg in rice and 0.63 kg in wheat and quantity lost during storage is 1.78 kg in case of rice and 3.93 kg in case of wheat. The total post harvest loss in rice has been found to be 76.84 kg per acre, whereas it is 30.59 kg per acre in case of wheat. It is worthwhile to note that the total post harvest loss increases with the increase in farm size. Therefore, it has been observed that post-harvest handling has led to considerable loss in rice and wheat. The share of storage loss has been found to be maximum than that of other losses. The improvement in storage facilities required immediate attention of the policy makers for reducing post-harvest loss in rice and wheat. It has been observed that most of the cases crop by-product is used by the farmers as roof of the storage structure and a very less percentage (31.67 per cent) of farmers use burnt brick/cemented wall in storage structure. Most of the households (82 per cent) having platform in storage of 6 to 12 inches high and they use to make expenditure for maintaining the storage every year. Sun drying is done annually by every farmer and the walls of the storage are maintained every alternative year. Removal of infested grain from storage and destroying operation is done annually by 100 per cent farmers. Smoking is also done to disinfect the storage space. However, it has been observed that there is still significant scope to boost for improvement in storage structure in the study area.

Table 5.10: Some quantitative aspects of storage (percentage of households)

Description		Crop- Rice	Crop- Wheat
1. Nature of storage structure			
Roof made of	Grass thatched	-	-
	Crop by product	35.00	16.67
	Plastic cover	33.34	40.83
	Metal/cemented	31.66	42.50
	Asbestos sheet	-	-
	Others	-	-
Walls made of	Burnt bricks/cemented	31.67	16.67
	Woven basket	-	-
	Mud	-	-
	Crib	-	-
	Open wall	-	-
	Others	68.37	83.33
Floor made of	Concrete	30.83	15.83
	Earth	-	-
	Woven basket	-	-
	Wooden	69.17	84.17
	Others	-	-
2. Percentage of households having platform		83.33	100.00
Height of the platform	Less than 6 inches	0.00	0.00
	6-12 inches	82.00	88.00
	Above 12 inches	18.00	12.00
	Others	-	-
3. Physical condition of storage			
Roof	Leaking roof	12.00	8.00
	Good roof	88.00	92.00
Walls	Damaged wall	10.00	6.00
	Good condition walls	90.00	94.00
Guards	Rat guard installed	70.00	100.00
	No rat guards	30.00	0.00
Floor	Cemented good condition roof	75.00	90.00
	Broken floor, mud coming out	25.00	10.00
4. Cost of storage			
The average age of the storage structure (years per household)		5	3
Cost of permanent storage, e.g., steel drums etc. (Rs per household)		-	-
Cost of kutcha or cemented house for storage (Rs. Per household)		600.00	200.00
5. Maintenance status – Frequency of repair of grain storage		-	-
Roof	Every year	100.00	100.00
	Every two years	-	-
	2-5 Years	-	-
	No maintenance required	-	-
Walls	Every year	-	-
	Every two years	100.00	100.00
	2-5 Years	-	-
	No maintenance required	-	-
Rat guards	Every year	100.00	100.00
	Every two years	-	-
	2-5 Years	-	-
	No maintenance required	-	-
6. Storage pests control measures		-	-
Sun drying	Monthly	-	-
	Quarterly	-	-
	By-annual	-	-
	Annual	100.00	100.00
	Never	-	-
Removal of infested grain from storage and destroying it	Monthly	-	-
	Quarterly	-	-
	By-annual	-	-
	Annual	100.00	100.00
	Never	-	-
Admixing with ash and other plant materials	Monthly	-	-
	Quarterly	-	-
	By-annual	-	-
	Annual	-	-
	Never	100.00	100.00
Smoking	Monthly	-	-
	Quarterly	-	-
	By-annual	-	-
	Annual	-	-
	Never	100.00	100.00
Others	Monthly	-	-
	Quarterly	-	-
	By-annual	-	-
	Annual	-	-
	Never	-	-

5.7 Households suggestions how to minimize post harvest losses

Post-harvest damage due to inefficient storage, during threshing, winnowing, transport, handling etc. in rice and wheat cultivation is also a chronic problem in West Bengal. It has been found that losses are reported to be substantial. Use of several measures including indigenous technologies and chemical control of pest and diseases are a common practice in pro-harvest period. As a result, considerable information existed on pests control measures at the farm levels. What remained to be determined was when during the year control could be the most cost-effective under the agro-ecological conditions existing at the farm itself.

Table 5.11: Households suggestions on how to minimize post harvest losses

Description	Rice	Wheat
Post harvest losses	1. Setting up of rural godown in every village is necessary 2 .During harvesting season polythene sheets should be supplied in adequate numbers and with reasonable rate. 3. Marketing facilities should be widened 4. Condition of roads should be improved 5 . Subsidies should be given to individual farmer for setting up grain gola or warehousing.	1. Owing to labour problem harvester should be provided with reasonable prices. 2.Marketing facilities should be widened 3. Measures should be adopted to restrict or eradicate rodents. 4. Condition of roads should be improved. 5. .Measures should be taken by government for getting reasonable prices of output.

In view of the above, an effort has been made to document the suggestions of the respondents to minimize the post-harvest losses in rice and wheat and these are presented in Table-5.11. In general and according to the suggestions of the respondents, setting up of rural godown, provision of polythene sheets with reasonable rate, improved marketing infrastructure etc. are call for the day to minimize the losses at post-harvesting stage of rice and wheat. Similarly, modern techniques in connection with control the rodents along with good condition of roads can restrict the losses at the post-harvest stage of rice and wheat.

5.8 Summary of the chapter

In case of rice, it has been found that quantity of loss at different stages of harvest is low as perceived by the farmers. However, it has been observed that the quantity lost per acre during harvest is 17.45 kg. The loss per quintal of harvest turns out to be 0.78 kg.

In case of wheat, it has been found that quantity lost at different stages of harvest is also low as perceived by the farmers. However, it has been observed that the quantity lost per acre during harvest is 18.63 kg. The lost per quintal of harvest turns out to be 1.26 kg.

It has been found that quantity lost is low as perceived by the farmers when threshing and winnowing is done manually. There are no evidences of threshing through manual operations as well winnowing through

mechanical operations either in rice or wheat. Similarly, the quantity losses per acre during manual winnowing of rice and wheat are 2.94 kg and 6.21 kg, respectively. The losses per quintal of rice and wheat during winnowing turn out to be 0.13 kg and 0.42 kg, respectively.

It has been found that quantity lost is medium as perceived by the farmers when threshing is done mechanically. The quantity losses per acre during mechanical threshing of rice and wheat are 7.04 kg and 13.45 kg, respectively. The losses per quintal of rice and wheat during winnowing turn out to be 0.31 kg and 0.91 kg, respectively. An attempt has been made to quantify the loss during transportation and handling of rice and wheat as per the perception of the respondents in terms of ranking i.e. high, medium and low. However, it has been observed that quantity lost during transportation and handling both in rice and wheat is low. The quantity of loss per quintal during transportation varies from 0.04 to 0.43 kg in case of rice and 0.03 to 0.08 kg in case of wheat depending upon the mode of transport. Similarly, the quantity of loss per quintal during handling varies from 0.03 to 0.16 kg in case of rice and 0.01 to 0.05 kg in case of wheat depending upon the mode of transport.

However, it has been observed that quantity lost during storage both in rice and wheat is low. In the study area, storage of rice and wheat is done either in gunny/plastic bags or open. The quantity of loss per quintal during storage is happened due to weight loss, rodents or fungus. The loss in storage due to weight loss has been observed to be 1.33 kg in rice and 2 kg in wheat. The losses due to rodents are 0.41 kg in case of rice and 1.38 kg in case of wheat and the same for fungus are 0.05 kg for rice and 0.54 kg for wheat. However, it has been observed that 100 per cent of the farmers used to dry the commodities before storing.

It has been observed that most of the cases the capacity has not been fully utilised in case of rice and wheat .The capacity utilisation varies from 72 per cent to 85.57 per cent in rice and 63 per cent to 75.90 per cent in case of wheat.

It has been observed that the quantity lost in harvest is 0.78 kg in rice and 1.26 kg in wheat. Quantities losses during threshing in rice and wheat are 0.32 kg and 0.26 kg, respectively. Similarly, 0.55 kg and 0.83 kg are lost during winnowing of rice and wheat. The transport lost varies from 0.55 kg in rice to 0.83 kg in wheat. Quantity losses in handling are 0.31 kg in rice and 0.63 kg in wheat and quantity lost during storage is 1.78 kg in case of rice and 3.93 kg in case of wheat. The total post harvest loss in rice has been found to be 76.84 kg per acre, whereas it is 30.59 kg per acre in case of wheat. It is worthwhile to note that the total post harvest loss increases with the increase in farm size. Therefore, it has been observed that post-harvest handling has led to considerable loss in rice and wheat. The share of storage loss has been found to be maximum than that of other losses. The improvement in storage facilities required immediate attention of the policy makers for reducing post-harvest loss in rice and wheat. It has been observed that most of the cases crop by-product is used by the farmers as roof of the storage structure and a very less percentage (31.67 per cent) of farmers use burnt brick/cemented wall in storage structure. Most of the households (82 per cent) having platform in storage of 6 to 12 inches high and they use to make expenditure for maintaining the storage every year. Sun drying is done annually by every farmer and the walls of the storage are maintained every alternative year. Removal of infested grain from storage and destroying operation is done annually by 100 per cent farmers. Smoking is also

done to disinfect the storage space. However, it has been observed that there is still significant scope to boost for improvement in storage structure in the study area.

In general and according to the suggestions of the respondents, setting up of rural godown, provision of polythene sheets with reasonable rate, improved marketing infrastructure etc. are call for the day to minimize the losses at post-harvesting stage of rice and wheat. Similarly, modern techniques in connection with control the rodents along with good condition of roads can restrict the losses at the post-harvest stage of rice and wheat.

Chapter-VI

6. Summary, Conclusions and Policy Suggestions

6.1 Introduction

Grains may be lost in the pre-harvest, harvest and post-harvest stages. Pre-harvest losses occur before the process of harvesting begins, and may be due to insects, weeds and rusts. Harvest losses occur between the beginning and completion of harvesting, and are primarily caused by losses due to shattering. Post-harvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed and dried, as well as losses along the chain during transportation, storage and processing. Important in many developing countries, particularly in Africa, are on-farm losses during storage, when the grain is being stored for auto-consumption or while the farmer awaits a selling opportunity or a rise in prices.

As per the available data, the crop losses caused by pests and diseases are huge. But, the knowledge on the crop loss at the farm level is very much limited. In addition to losses that occur during the growth period of the crop, there is a huge quantity of grains lost during the process of harvesting, threshing, transportation and storage. Therefore, the present study makes a comprehensive attempt to estimate the dimension of losses occurring during the pre and post harvest stages of rice and wheat in West Bengal. The study estimates yield losses due to pest and diseases in the crops namely, rice and wheat. For the pre harvest losses, generally animal pests (insects, mites, rodents, snails and birds), plant pathogens (bacteria, fungi, virus, and nematodes) and weed are collectively called pests, which cause economic damage to crops. This broader definition of pests and diseases is followed in the present study. For estimating post harvest losses, there is a need to establish the extent of losses during storage under different agro climatic conditions. Causes of storage losses include sprouting, transpiration, respiration, rot due to mould and bacteria and attack by insects. Sprouting, transpiration and respiration are physiological activities that depend on the storage environment (mainly temperature and relative humidity). These physiological changes affect the internal composition of the grains and result in destruction of edible material and changes in nutritional quality. But it would be difficult to measure the loss due to physiological changes at the farm level. Nevertheless, an attempt has also been made to estimate such losses based on the visual observations and according to farmer's estimates.

6.2 Objectives of the study

Keeping in view about this important subject, the specific objectives of the study are given below. The specific objectives of the study are:

1. To estimate the physical and financial losses caused by and diseases in rice and wheat at farm level
2. To estimate the measures of pest and disease management to reduce the crop loss due to pests and diseases at farm level
3. To arrive at post harvest losses in rice and wheat under different agro climatic conditions.

4. To identify factors responsible for such losses and suggest ways and means to reduce the extent of losses in different operations national productivity.

6.3 Data base and methodology

The study has been conducted based on the farm level data collected from the selected respondents in West Bengal. The crop production constrains particularly infestation by pests and diseases, and losses caused by them have been worked out based on the estimates provided by the farmers. As not only pests and diseases cause crop damage when their population reach beyond a threshold level, there are also other bio-economic factors like soil fertility, water scarcity, poor seed quality, high input costs and low output prices result in considerable financial loss to farmers. Thus, data on these bio-economic variables have also been collected from the farmers. The post harvest losses during the process of harvesting, collection and threshing, transportation and storage have also been quantified based on the estimates provided by the farmers. Storage material used by the farmers is generally mud, bamboo, stone, plant materials etc. it is essential to identify the structure of storage at the farmers' level and enumerate the losses occurring in the process of storage at the farmer level.

To collect the primary data, a sample survey has been conducted in four districts viz. Bankura & Burdwan for rice and Murshidabad & Uttar Dinajpur for wheat in West Bengal for the reference period rabi 2010-11 (November to May) and kharif 2011-12 (June to October). In the present study, season for the wheat crop is rabi while for rice belong to kharif season. The selected districts represent major producing districts of rice and wheat and fall in two different agro-climatic regions of the state. From each district, two villages with one nearby the market/mandi centre and one far off from the market centre have been selected for canvassing the questionnaire. A random sample of 30 farmers have been selected from each village and thus constituting a total sample of 240 farmers for two crops i,e rice and wheat from four districts and eight villages .In addition to the primary data collected from the farmers, personal visits have been made to the district office of the Department of Agriculture to compile the crop loss estimates (if any) for pre and post harvest losses.

6.4 Main Findings

The performance of agriculture in West Bengal over the last three decades has witnessed a dwindling picture. Growth rates have increased and per capita incomes have gone up. Liberalization and deregulation have yielded impressive results and the economy is increasingly integrated to the world economy. Still, agriculture continues to be the backbone of the economy of the state of West Bengal. Agriculture remains the most crucial sector of the state economy as around 72 per cent of the total population lives in rural areas and agricultural continues to be their mainstay. However, along with the structural transformation of the economy of the state, the contribution of agriculture in State Domestic Product (SDP) is observed to follow a declining trend. It contributes a significant share to the SDP as compared to other sectors of the economy even the contributions of agriculture to total SDP (at constant prices) has declined from 41.16 per cent in 1970-71 to 27.1 per cent in 2000-01. However, West Bengal failed to sustain the high growth path as achieved during the eighties. The growth rate of production of rice and wheat declined in the subsequent periods. The area growth rate of Aman rice becomes negative during the decade of nineties and the yield growth rate also reduced significantly. As a

result of which the output of Aman rice declined only to 2.51 per cent per annum. During the nineties, the output growth rate of Boro rice declined to 3.69 per cent per annum and this fall in growth rate is significant.

It has been also found that the states of HP, AP and Punjab are the efficient producers of rice in the triennium ending 2007. The farmers of AP and Punjab could produce a quintal of rice at 27 per cent and 23 per cent lower cost than that of the all-India average and they have improved efficiency of production by reducing the cost of production relative to all-India average. The obverse is true in case of Assam and M.P. Madhya Pradesh produces rice at 30 per cent higher costs. Also, farmers from Assam and Tamil Nadu are expensive in rice production, which may be impinging on their profitability seriously. Rajasthan, Punjab and Haryana are the efficient producers compared to all-India average for wheat. Here, Jharkhand, West Bengal and Chattisgarh produce wheat at whopping 87 per cent, 57 per cent and 49 per cent higher cost than all-India.

As per the socio-economic characteristics of the selected respondents are concerned, it has been found that majority of the respondents are in the middle age group. The education of the respondents is more or less concentrated to secondary education and the marketing facilities are not well developed as the distance of the main market varies from 5.84 km to 8.92 km. However, the annual family income increases with the increase in farm size.

It has been found that the net operated area (NOA) varies from 1.56 acres in marginal farms to 13.69 acres in large farms. It is very interesting to note that the gross cropped area (GCA) decreases with the increase in farm size and thereby the cropping intensity is highest in marginal farms followed by medium, large and small farms. It has been observed that in the event of leasing-in the crop sharing is a predominant phenomenon in almost all farms. Crop and cost sharing is followed in marginal, small and medium farms. Similarly, fixed rent in cash is shared by these farms. Crop and cost sharing along with fixed rent in cash are not followed by large farms. The percentage share of tenancy in net operated area, it varies from 25.91 per cent in case of marginal, 15.46 per cent in case of small, 12.18 per cent in case of medium and 3.41 per cent in case of large farms. In the event of leasing-out, the crop sharing phenomenon exists in small farm only. Crop and cost sharing exists in marginal farms. There is no case of fixed rent in cash in the event of leasing-out tendency. Rent amount varies from Rs. 5410/- per acre in case of small farms to as high as Rs. 9020/- per acre in case of medium farms. It has been found that canal + tube-wells dominate the irrigation profile of the selected farms. More than 50 per cent of the land is irrigated by these sources.

Cropping pattern of the selected farms spread over to kharif, rabi and summer cultivation. However, a small portion of the gross cropped area is cultivated by perennial crop like vegetables. In kharif season, aman paddy dominates the cropping pattern in all farms. The share of aman paddy increases with the increase in size of holdings. Similarly in rabi season, wheat occupies a larger portion than that of other crops viz., potato, mustard and pulses. The share of summer paddy in the gross cropped area is also important in the selected districts. Similarly, it has been observed that cent per cent of HYV seeds have been adopted in almost all crops except mustard and vegetables. Even in case of aman paddy though this is not a totally irrigated rice crop but the entire area is cropped with high yielding modern varieties. The similar experience has been observed in case of wheat.

In the selected district the average productivity of aman paddy is 18.83 quintal per acre, whereas the same for boro paddy is comparatively much higher (23.98 quintal/acre). Similarly, the productivity of wheat varies from 11.72 quintal per acre in large farms to 14.87 quintal per acre in medium farms. On an average 82.11 per cent of aman paddy and 78.71 per cent of boro paddy is marketed by the selected households. The same for wheat is 84.11 per cent. The value of output and marketed surplus increases with the increase in size of holdings.

As perceived by the respondents, cent per cent of the farmers are facing constraints in rice and wheat cultivation. However, the degree of severity of these constraints varies. Among these constraints, high cost of inputs and low output price ranked first both in rice and wheat. Similarly, farmers perceived water deficiency as one of the most important constraints (55.00 per cent of respondents) in rice cultivation. The farmers in the study areas in West Bengal depended mostly on monsoon and almost all of them just cultivated rice in kharif season based on availability of rains. Despite of most of them have pumps, they could not be able to tackle this constraint due to lack of water and increase in cost of production leading to the loss in their farming business. It has been found that poor quality of seed is one of the important problems in wheat.

It has been observed that the 90 per cent of the rice farmers and 83.33 per cent of the wheat farmers are able to distinguish pests and diseases attack. However, their identification is completely restricted to qualitative assessment. They are not in a position for quantitative assessment. It has been found that BPH is very important pest in HYV rice, occurring every season and causing 3.48 per cent crop loss out of the identified pests for rice viz., BPH, GLH, LF, GH, REHB. These identified pests are occurring every season and loss of production varies from 0.87 per cent to as high as 3.48 per cent. Among diseases, SB is very important which is also occurring every season and causing crop loss in the tune of 2.55 per cent. Similarly other diseases viz., B, BLB, SR and BS are also occurring every season and causing crop loss in the tune of 0.45 per cent to 2.00 per cent. Among weeds, Lh is important which causing 1.59 per cent crop loss. Other weeds of rice are Fl, Ai, Lp, Mq and Ec. The level of crop loss due to these weeds varies from 0.49 per cent to 1.59 per cent. It has been observed that conservation farming promotes a diversity of insect life, influences pest populations and also favours many beneficial insects. The beneficial insects which act as natural control agents help to create a more stable agricultural system. Reducing cultivation and maintaining mulch provides a more favourable habitat for certain soil dwelling insect pests and disease organisms. A range of pests including caterpillars, beetles, grasshoppers, foliage feeders and sap-sucking insects occur in all crops and pastures and will require control from time to time.

Aphid is very important pest in wheat, occurring every season and causing 1.78 per cent crop loss out of the identified pests for wheat viz., Aw and SB. These identified pests are occurring every season and loss of production varies from 0.59 per cent to as high as 1.78 per cent. Among diseases, LB is very important which is also occurring every season and causing crop loss in the tune of 1.38 per cent. Similarly other diseases viz., LR, SR and YER are also occurring every season and causing crop loss in the tune of 0.26 per cent to 0.87 per cent. Among weeds, go is important which causing 2.73 per cent crop loss. Other weeds of wheat are ca, af, and sf. The level of crop loss due to these weeds varies from 0.80 per cent to 1.99 per cent. Among pests and diseases,

it is worthwhile to mention that rodent is very severe and causing maximum loss in wheat cultivation. The crop loss due to rodents is as high as 5.59 per cent.

It has been found that the magnitude of crop loss due to pests, disease and weed infestation in paddy is very high. The actual production with attack is varied from19.36 quintal to 20.88 quintal per acre. The overall loss with attack has been found to be 3.54 quintal per acre. Similarly, the overall normal production without attack is 23.52 quintal per acre. However, the percentage loss over normal production is less (15.05 per cent) than that of percentage loss over actual production.

Similarly the magnitude of crop loss due to pests, disease and weed infestation in wheat has also been found very high. The actual production with attack is varied from 3.90 quintal to 5.96 quintal per acre. The overall loss with attack has been found to be 0.92 quintal per acre. The overall normal production without attack is 6.04 quintal per acre. However, the percentage loss over normal production is less (15.29 per cent) than that of percentage loss over actual production.

In rice cultivation cent per cent of the farmers use weedicide except marginal farms. Even the use of weedicides is very high (57.17 per cent) in marginal farm also. The cost due to application of weedicides per acre in small (Rs. 160.55/-) and marginal farms (Rs.107.09/-) is very high than that of medium (Rs. 68.45/-) and large farms (Rs. 44.81/-). Interestingly, the cost due to application of insecticides per acre is also high in small (Rs.269.42/-) and marginal farms (Rs. 164.64/-) than that of medium (Rs. 134.42/-) and large farms (Rs. 103.49/-). Surprisingly, the use of fungicides is restricted to medium and large farms only and the cost due to use of fungicides varies from Rs.27.46/- to 36.93/- per acre.

In general, the attack of pest and diseases in wheat is low than that of rice. However, it has been found that cent per cent use of weedicide is restricted to small and medium farms in wheat cultivation. Similarly, use of weedicides is also extended to majority (82.50 per cent) of the marginal farms. The cost due to application of weedicides per acre in marginal farm is very high (Rs. 188.81/-) than that of small (Rs. 137.67/-) and medium farms (Rs. 114.09/-). Interestingly, the cost due to application of insecticides is restricted to small and medium farms only. Per acre cost for insecticides varies from Rs. 120.85/- in medium farms to Rs. 33.99/- in small farms. However, there is no evidence in use of fungicides in wheat cultivation.

It has been found that both rice and wheat farmers mostly depend on private input dealers and fellow farmers in controlling pests and diseases in crop cultivation. Surprisingly as perceived by the farmers, agricultural universities and Krishi Vigyan Kendras have no role in disseminating extension services especially in case of pests and disease control management. In general and according to the suggestions of the respondents, provision of pest and disease resistant quality seeds along with technical know-how, soil testing facility etc. are call for the day to minimize the losses at pre-harvesting stage of rice and wheat. Similarly, provision of infrastructural facilities including ware houses, marketing infrastructure and good condition of road can restrict the losses at the post-harvest stage of rice and wheat.

It has been observed that the quantity lost in harvest is 0.78 kg in rice and 1.26 kg in wheat. Quantities losses during threshing in rice and wheat are 0.32 kg and 0.26 kg, respectively. Similarly, 0.55 kg and 0.83 kg

are lost during winnowing of rice and wheat. The transport lost varies from 0.55 kg in rice to 0.83 kg in wheat. Quantity losses in handling are 0.31 kg in rice and 0.63 kg in wheat and quantity lost during storage is 1.78 kg in case of rice and 3.93 kg in case of wheat. The total post harvest loss in rice has been found to be 76.84 kg per acre, whereas it is 30.59 kg per acre in case of wheat. It is worthwhile to note that the total post harvest loss increases with the increase in farm size. Therefore, it has been observed that post-harvest handling has led to considerable loss in rice and wheat. The share of storage loss has been found to be maximum than that of other losses. The improvement in storage facilities required immediate attention of the policy makers for reducing post-harvest loss in rice and wheat. It has been observed that most of the cases crop by-product is used by the farmers as roof of the storage structure and a very less percentage (31.67 per cent) of farmers use burnt brick/cemented wall in storage structure. Most of the households (82 per cent) having platform in storage of 6 to 12 inches high and they use to make expenditure for maintaining the storage every year. Sun drying is done annually by every farmer and the walls of the storage are maintained every alternative year. Removal of infested grain from storage and destroying operation is done annually by 100 per cent farmers. Smoking is also done to disinfect the storage space. However, it has been observed that there is still significant scope to boost for improvement in storage structure in the study area. There is a need to impart training to the farmers, traders and extension officials at the block level on the practical aspects of storage and preservation of food grains. It is also essential to popularise scientific techniques of storage amongst farmers, etc through demonstrations and wide publicity and to develop selected villages to serve as model villages. There is also need to arrange facilities for farmers for purchase of improved types of storage structures and to maintain liaison with State Governments and to arrange steady supply of storage structures and pesticides to the users.

6.5 Conclusions and Policy Suggestions

Pre and post-harvest losses present one of the main problems not only in rice and wheat but also in all crops. Losses can occur in rice and wheat during harvesting, threshing, winnowing, drying, storage, transportation etc. It has been estimated that the total post harvest loss in rice is 76.84 kg while in wheat it is 30.59 kg per acre. Similarly, it has been found that pre harvest losses due to pest and diseases vary according to crop to crop. It has been observed that BPH is very important pest in HYV rice, occurring every season and causing a perceptible damage to rice. In rice, the other identified pests are BPH, GLH, LF, GH, REHB. These identified pests are also occurring every season and loss of production varies from farms to farms. Among diseases, SB is very important and occurring every season and causing crop loss. Other diseases viz., B, BLB, SR and BS are also very common in rice. Among weeds, Lh is important. Other weeds of rice are Fl, Ai, Lp, Mq and Ec. The level of crop loss due to these weeds varies from 0.49 per cent to 1.59 per cent.

Aphid is very important pest in wheat, occurring every season and causing crop loss. Other identified pests in wheat are Aw and SB. Among diseases, LB is very important. Similarly other diseases viz., LR, SR and YER are also occurring every season and causing crop loss. Among weeds, go, ca, af, and sf are very important. The level of crop loss due to these weeds also varies. It is worthwhile to mention that among pests and diseases, rodent is very severe and causing maximum loss in wheat cultivation.

In view of the above, it can be concluded that if pre and post harvest losses are reduced, the farm income can be increased substantially without cultivating additional acres of land or increasing any additional expenditure on seed, fertilizer, irrigation and plant protection measure to grow the crops. Based on the findings of the study, the following policy prescriptions have been made to control the pre and post harvest losses. However, it has been observed that there is still significant scope to boost for improvement in storage structure in the study area.

1. Provision of rural godowns with sufficient infrastructure of marketing facilities may control the pre and post harvest losses in a fruitful manner (**Attn**: Directorate of Marketing, Government of India).

2. Integrated Pest Management (IPM) and Integrated Nutrient Management (INM) practices can be popularised to control the pests and diseases during the stage of pre-harvest of crops (**Attn**: Directorate of Plant Protection, Government of India).

3. There is a need to impart training to the farmers, traders and extension officials at the block level on the practical aspects of storage and preservation of food grains (**Attn**: Agricultural Universities, Extension Wing, Department of Agriculture, Government of West Bengal).

4. It is also essential to popularise scientific techniques of storage amongst farmers, etc through demonstrations and wide publicity and to develop selected villages to serve as model villages (**Attn**: Agricultural Universities, Extension Wing, Department of Agriculture, Government of West Bengal).

5. There is also need to arrange facilities for farmers for purchase of improved types of storage structures and to maintain liaison with State Governments and to arrange steady supply of storage structures and pesticides to the users (**Attn**: Financial Institutions, Department of Agriculture, Government of West Bengal).

6 Winnowing is one of the post harvest operations that incur high amount of loss. These losses were attributed to improper handling and inefficient machine. Care should be taken to properly handle the machine during winnowing.

References

Abdullahi, A. and Haile, A. 1991. Research on the control of insect and rodent pests of wheat in Ethiopia. In *Wheat research in Ethiopia: a historical perspective*. Addis Ababa, IAR/CIMMYT.

Acharya, S. S. 1997. "Agricultural Price Policy and Development: Some Facts and Emerging Issues", *Indian Journal of Agricultural Economics*, 52 (1): 1-47.

Anderson, D.R., D.J. Sweeney and T.A. Williams, 2008. Statistics for Business and Economics. 10th Edn., Wadsworth/Thomson Learning, Belmont, CA.

Boyce, J.K., 1987. Agrarian Impasse in Bengal: Institutional Constraints to Technological Change. Oxford University Press, Oxford and New York.

Chander Subhash, Aggarwal P.K., Kalra Naveen, Swaruparani D.N. 2003. Changes in Pest Profiles in Rice-Wheat Cropping System in Indo-Gangetic Plains. Annals of Plant Protection Sciences. Volume : 11 (2).

Chand, Ramesh. 2010. "Understanding the Nature and Causes of Food Inflation", *Economic and Political Weekly*, 44 (9): 10-13.

Chattopadhyay, A.K and P.S. Das, 2000. Estimation of growth rate: A critical analysis with reference to West Bengal agriculture. Indian Journal of Agricultural Economics, 55: 116-135.

Dantwala, M. L. 1986. "Technology, Growth and Equity in Agriculture", in John W Mellor and Gunvant M Desai (eds) *Agricultural Change and Rural Poverty*, (Delhi: Oxford University Press).

De, U.K., 2002. Economics of Crop Diversification. Akansha Publishing House, New Delhi.

Dev, S Mahendra and Ajit Ranade. 1998. "Rising Food Prices and Rural Poverty: Going Beyond Correlations", *Economic and Political Weekly*, 33 (39): 2529-2536.

Dev, S Mahendra and C Ravi. 2007. "Poverty and Inequality: All India and States, 1983-2005", *Economic and Political Weekly*, 42 (6): 509-521.

Directorate of Rice Research, 2007-08. Progress Reports, 2006-07. Volume 2. Crop Protection (Entomology and Pathology). All India Coordinated Rice improvement Programme (ICAR), DRR, Hyd-30.

Ghosh, B.K. and P.K. Kuri, 2005. Changes in cropping pattern in West Bengal during 1970-71 to 2000-01. IASSI Q., 24: 39-56.

Ghosh, B.K. and P.K. Kuri, 2007. Agricultural growth in West Bengal from 1970-71 to 2003-04: A decomposition analysis. ICFAI J. Agric. Econ., 4: 30-46.

Harris, J., 1992. What is happening in rural West Bengal: Agrarian reforms, growth and distribution. Economic and Political Weekly, 28: 1237-1247.

Hazarika , L.K., Kalita, S., Bhuyan, M., DekaR.L., Sharma,K and Burman, B.2009. Integrated pest management in the north eastern region: technological advances to combat global climate change. In: IPM Strategies to combat Emerging pests in the current Scenario of climate change (Eds Ramamurthy, V.V. Gupta G.P & Puri S.N) Proceedings of the national symposium on IPM strategies to combat Emerging pests in the current Scenario of climate change held at College of Agriculture and Forestry, Central agricultural University, Pasighat 791002 Arunachal Pradesh, January 28-30, 2009 (Invited lectures) pp 277-289.

Herdt, R.W. 1991. Research priorities for Rice Biotechnology. In Rice Biotechnology (ed. Khush G.S and Toenniessen G H). International Rice Research Institute. Los Banos, Phillipines.

Jaswant Singh, G. S. Dhaliwal, Joginder Singh and P. S. Shera 2002. Changing scenario of rice insect pests in Punjab and their management strategies. Indian Journal of Ecology Vol. 29(2).

Kirtani, 2005. Predicting impacts of global warming on population dynamics and distribution of Arthropods in Japan. Population Ecology.3:153-159.

Krishnaji, N (1990): "Agricultural Price Policy: A Survey with Reference to Indian Foodgrain Economy", *Economic and Political Weekly*, 25 (26): A-54-A-63.

Krishnaiah K, Reddy P.C and Subba Rao C. 1986. Integrated Pest Control in rice in Krishna Delta area of Andhra Pradesh. Indian Journal of Plant Protection 14 (2): 1-12.

Krishnaiah, K. 1993. Changing scenario in rice insect pest problems. In :H. C. Sharma and M. Veerabadra Rao (eds.) Pests and pest management in India – The changing scenario. Plant Protection Association of India., Hyderabad. Pp:11 – 18.

Mangal Sain and Prakash A 2008. Major insect pests of rice and their changing scenario. AZRA 2008 RPM Book. Rice Pest Management pp 7-24.

McFarlane, J.A. 1989. *Guidelines for pest management research to reduce stored food losses caused by insects and mites*. Overseas Development and Natural Resources Institute Bulletin No. 22. Chatham, Kent, UK.

Mukherji, B. and S. Mukhopadhyay, 1995. Impact of institutional change on productivity in a small-farm economy: Case of Rural West Bengal. Economic and Political Weekly, 30: 2134-2137.

NRC (National Research Council). 1996. *Lost crops of Africa*, vol.1. Washington, DC, National Academy Press.

Parikh, Kirit S, A Ganesh-Kumar and Gangadhar Darbha (2003): "Growth and Welfare Consequences of Rise in MSP", *Economic and Political Weekly,* 38 (9): 891-895.

Raghavan, M. 2008. "Changing Pattern of Input Use and Cost of Cultivation", *Economic and Political Weekly,* 43 (26&27): 123-129.

Rao, N Chandrasekhara. 2004. "Aggregate Agricultural Supply Response in Andhra Pradesh", *Indian Journal of Agricultural Economics,* 59 (1): 91-104.

_____ (2006): "Agrarian Crisis in Andhra Pradesh" *Journal of Indian School of Political Economy,* 18 (1&2): 35-75.

Rao, C H Hanumantha. 1994. *Agricultural Growth, Rural Poverty and Environmental Degradation in India,* (New Delhi: Oxford University Press).

Rao, V. M. 2001. "The Making of Agricultural Price Policy: A Review of C A C P Reports", *Journal of Indian School of Political Weekly,* 13 (1): 1-28.

Rao (ed) *#ew Challenges Facing Indian Agriculture,* (Hyderabad: Visalandhra Publishing House).

____ (2001): "A Whole Crop of Uncertainties", *Frontline,* 18 (2): 8-10.

____ and M S Bhatia (2004): *Cost of Cultivation and Farm Income in India*, Department of agriculture and Cooperation, Ministry of Agriculture, (New Delhi, Academic Foundation).

Saha, A. and M. Swaminathan, 1994. Agricultural growth in West Bengal in the 1980s: A disaggregation by districts and crops. Economic and Political Weekly, 29: A-8-A-8.

Sanyal, M.K., P.K. Biswas and S. Bardhan, 1998. Institutional change and output growth in West Bengal agriculture: End of impasse. Economic and Political Weekly, 33: 2979-2986.

Schiff, M and C E Montenegro (1997), "Aggregate Agricultural Supply Response in Developing Countries: A Survey of Selected Issues", *Economic Development and Cultural Change,* 45 (2): 393-410.

Sen, Abhijit. 1999. "Agricultural Price Policy: Achievements and the Emerging Problems", in Y V Krishna

Singh, Manmohan. 1995. "Inaugural Address at the 54th Annual Conference of the Indian Society of Agricultural Economics", *Indian Journal of Agricultural Economics,* 50 (1): 1-6.

Tyler, P.S. and Boxall, R.A. 1984. Post-harvest loss reduction programmes: a decade of activities: what consequences? *Trop. Stored Prod. Info.*, 23: 13-28.

Yadava, R.L and Subba Rao, A.V.M. 2001. Atlas of cropping systems in India. PDCSR Bulletin No 2001-2, pp 96, Project Directorate for Cropping Systems Research, Modipuram, Meerut-250110.

Annexure-I

Tables Based on Primary Survey Data

Definition of operational holdings based on net operated area (NOA)

Marginal = Operational holdings (NOA) < 2.50 Acres

Small = Operational holdings (NOA) 2.51 to 5.00 Acres

Medium = Operational holdings (NOA) 5.01 to 10.00 Acres

Large = Operational holdings (NOA) > 10.01 Acres

Annexure –II

Coordinator's Comments on the Draft Report

Assessment of Pre and Post Harvest Losses in Rice and Wheat in West Bengal.

(i) The estimation of growth rates of area, production and yield of important corps by using Boyce's kinked exponential model is methodologically sound and it reveals growth pattern in different periods very clearly. But, the presentation of results in Tables 2.1, 2.2 and 2.3 needs to be improved. Authors should provide some information on break periods; first break and second break in these tables. Figures in parenthesis should be clearly mentioned below the each table. Units of the numbers should be mentioned in all the tables including Tale 2.4 and Table 2.5. The level of significance of the growth rates in Table 2.5 (t values) need to be provided.

(ii) For the values given in constant prices in Table 2.5, the deflator used and its base year should be provided. The numbers given in Table 2.6 are highly confusing and their units are not clear. It is better to compare the efficiency of production based on the unit cost of production; Rs/quintal or Rs/ acre.

(iii) In Chapter III, Table 3.2: the NOA =Owned land – uncultivated land + leased in – leased out land. Thus the total NOA is given as 2.57 but our calculations show that it should be 2.98. Please make the correction. How GCA is calculated is not known. GCA indicates gross cropped area and it implies numbers of crops grown per acre. If the cropping intensity which is nothing but GCA/NSA*100 is correct as given in the table then GCA should be the following:

Marginal	2.74
Small	5.15
Medium	10.75
Large	20.21
Total	4.04

(iv) In Table 3.4: Source of irrigation; the last column presents net irrigated area in acres. Instead the authors should present net irrigated area acres per household. Authors have mentioned vegetable under perennial crops in most of the tables. It needs to be corrected and the name of major vegetable crops shall be provided in a note below the tables.

(v) In Chapter IV, Table 4.1 should be modified. From the current results given in Table 4.1, it is not possible to state the proportion of the sample famers out of the total sample farmers that have faced a particular constraint in the study region and how each of the constraints has been ranked by these farmers. Therefore to obtain appropriate results, estimate the percentage of households by each rank out of total sample households (i.e., 120 households) rather than the sum of households falling within each constraint.

(vi) Table 4.3 and Table 4.4 should be modified completely in line with the table format shared by the ADRTC. As per the survey schedule and table plan, there are only three constraints. But, these tables unfortunately contain four constraints. This need to be corrected carefully. Further, production loss should be reported as percentage households reporting the loss of 5 per cent, 5-10 per cent and so on. But, it appears that the actual per cent loss collected from the field is reported in Tables. Kindly also refer to comment (iv) to estimate the per cent figures out of the total sample farmers for these tables also.

(vii) Unfortunately, the report is missing the most import table on 'magnitude of crop loss due to pests, diseases and weed infestations' for the sample crops. The table format is reproduced below for necessary action.

Table. The magnitude of crop loss due to pests, disease and weed infestation- Crop I and Crop II

Description	Marginal		Small		Medium		Large		Total	
	Local	HYV	Local	HYV	Local	HYV	Local	HYV	Local	HYV
Actual production with attack (quintal/acre)										
Normal production without attack (quintal/acre)										
Loss of output (quintal/acre)										
Percentage loss over actual production										
Percentage loss over normal production										

(viii) Table 4.5 may be removed as it contains only zero values.

(ix) In Table 4.8, provide the results for the percentage of the households seeking advice. Further, workout the percentage out of the total sample farmers as explained in comment (iv).

(x) In Table 5.7, workout the percentages by column, i.e. storage structures like kutcha house, pucca house and so on.

Annexure –III

Action Taken Report

Assessment of Pre and Post Harvest Losses in Rice and Wheat in West Bengal.

1. First trend break and second trend break measure the differential value of estimated slopes and their significance at to break points respectively, with t values in parenthesis. Thus the trend breaks provide us with the estimated values of the change in the decadal growth rates of production, area and yield rate respectively of the crops concerned.

Figures in parenthesis present the t values corresponding to each of the estimated growth rates.

The corresponding *'s signify the level of significance of the estimates decadal growth rates and that of the differential growth rates at the trend breaks. Units of the numbers in all the tables are given.

2. As estimates the level of significance of the growth rates in Table- 2.5 (t values) are given.

In Table-2.5 Regression analysis is done newly with STATA - 8 where the deflator used and corresponding t values of co-efficient are being provided.

In Table- 2.6 data are given from the report of CACP, Government of India.

3. In Chapter –III, Table -3.2: the NOA and GCA has been corrected properly.

4. In Table -3.4: Net irrigated area acres per households has been done instead of net irrigated area in acres. The explanation behind the mentioning vegetables as perinial crops in most of the tables are given below the tables concerned.

5. In Table-4.1: The percentage of households by each rank out of total samples households (i.e. 120 households in case of rice and 120 households in case of wheat) has been estimated.

a. So far as table 4.1 is concerned it is to be noted that all the sample farmers have identified all the constraints as relevant/ effective. Consequently 100% of to sample farmers have faced all the constraints (mentioned in report)

b. Given the questionnaire (Item 5, Page 3) it is not possible to directly determine how each of the constraint has been ranked by each of the farmers. This is because, as per column 3 of item 5 of page 3 of the questionnaire. Each farmer is clearly asked to choose one of the three restricted options (most imp/imp/least imp) against each of the constraints and they are not given the options to rank through 1 to 5.

c. However, given the questionnaire we have tried to rank indirectly the relative importance of the constraints. The methodology is as follows:

We have summed the total rank values by adding the options (most important=1, important=2, least important=3) against each constraint and designated that constraint as most important which has generated least total value. In case of tie between two rank sums we cannot judge the relative importance of the corresponding constraint. These ranks are itself waightage difference between households.

Table 4.1b: Rank Sum values for the constraints faced by the farmers

Constraints	Rice	Wheat
Poor seed quality	288	177
Water deficiency	175	156
Pest & disease problems	183	169
High cost of inputs	135	120
Low output price	120	120

6. In Table-4.4: we gave Rodent as 4th constraints in case of wheat as it is a most important constraints faced by the wheat cultivators in West Bengal. However, we may keep it in the first constraint that is Major Pests.

7. The Table on magnitude of crop loss due to pest, diseases and weed infestation for the sample crops which was missing in draft report, has already been given in revised draft report sent to you in soft copy.

8. As instructed Table-4.5: is removed as it contains only zero values.

9. In Table-4.10(4.8 mentioned earlier in draft report) the same arguments can be given as in Table-4.1. However, given the questionnaire we have tried to rank indirectly the relative importance of the sources of advice seeking by the farmers.

Table 4.10b: Rank Sum values for the sources of advice seeking by the farmers

Sources of advice	Rice	Wheat
Government extension agent	294	238
Private input dealer	240	240
Fellow farmers	172	172
TV/Radio service/Newspaper	360	360
Agricultural University/KVK	360	360
Any other	-	-

10. In Table-5.7: percentages by column that is storage structure like kutcha house, Pucca house and so on has been worked out.