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ASSESSMENT OF PRE AND POST HARVEST LOSSES OF RICE AND RED GRAM IN KARNATAKA

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The present study was entrusted by the Plant Protection Division, Ministry of Agriculture to Agro-Economic Research Centres/Units to estimate crop losses caused by the pest and diseases through farmers' field survey. The reference crops included were paddy, wheat, tur and soybean. This report provides the estimates of pre and post harvest physical loss of paddy and red gram in Karnataka. The study received immense support from the officials of the Ministry of Agriculture, Government of India and Department of Agriculture, Government of Karnataka. We sincerely thank all of them for their kind support and cooperation. We would also like to thank the Director, ISEC for unstinted support and encouragement for carrying out this study.

Authors

CHAPTER I
INTRODUCTION

Indian agriculture has undergone considerable transformations over time. These transformations are seen in the form of changes in agrarian structure, technological interventions, cropping pattern, enterprise mix and marketing system. During 1960s and 1970s, much emphasis was placed on increasing agricultural production through adoption of high yielding varieties along with use of chemical fertilisers and pesticides. This had led to intensive use of land and agricultural inputs particularly in the regions endowed with irrigation facilities. The periods of 1980s and 1990s had witnessed crop diversification and emergence of allied enterprises like dairying and animal husbandry. The commodity specific programmes like technology mission on oilseeds were launched during this period.

During 2000s, the nature of demand for agricultural commodities has changed for both the domestic and foreign requirements. The food consumption pattern has shifted from cereals to high value commodities like fruits, vegetables and livestock products. Trade liberalisation has led to production of such commodities which have export demand in the world market. These developments in a way have altered a multi commodity production system to a specialised system in different parts of the country. In the process, many traditionally cultivated crops (e.g. coarse cereals and small millets) either have lost their area or gone out of cultivation. But, these developments have entailed increased building up of pest and diseases, and consequent use of higher amount of pesticides to raise the crop productivity. The increased use of pesticides has also resulted in developing resistance by insects and disease, which further led to reduction in crop yield.

1.1. Status of Agricultural Economy in Karnataka

Karnataka economy has undergone a significant structural transformation since the introduction of new economic policies in the 1990s. Karnataka is considered as one of the most liberalised and industrialised states in India (Government of India, 2007). The State government has been providing favourable policy environment, which helps to attract both private and foreign investment. Despite structural changes towards to the service sector, agriculture continues to play an important role influencing overall growth of the state economy. According to 2011 Population Census, agriculture supported 13.74 million workers, which constituted about 49.28 per cent of the total workforce in the state. In rural areas, dependence of population on agriculture for livelihood is still higher at 70.68 per cent.

At the macro level, share of agriculture and allied sector has declined from 38.55 per cent in 1980s to 30.29 per cent in 1990s and then to 17.58 per cent in 2000s. The reduction in the share of agriculture is on the anticipated direction with the economy reaching higher growth trajectory over time. However, ideally such growth pattern takes place through transition of agrarian economy to modern industrialised economy and then to development of service sector. But, in India and also in most states including Karnataka the agrarian economic transition has bypassed the development of industrial sector and instead has largely shifted to modern service sector. This is evident from almost stagnant share of industry and burgeoning share of service sector in the last two and an half decades. As per the Economic Survey of Karnataka 2012-13, share of industry stood at 28.4 per cent and that of service sector was 56.2 per cent in TE 2011-12.

The growth performance of agricultural sector is varied and marked with wide fluctuations. There were concerns on stagnation in production and productivity of crops during 1980-81 to 1989-90. An Expert Committee constituted by the State Government in 1993 had concluded that investments made in agriculture during 1980s had not been optimally

utilised to sustain the growth momentum witnessed during seventies. While analysing the impediments to agricultural growth, Deshpande (2004) contended that both public and private investments have not adequately been made in the lagging regions particularly in un-irrigated plateau zone of Northern Karnataka and that of Southern Karnataka to spur the growth process.

However, during the recent years agricultural sector has seen turnaround in growth performance due to introduction of various developmental programmes. Agricultural and allied sector registered the trend growth rate of 4.86 per cent during 2001-02 to 2011-12 as against the all India growth rate of 3.24 per cent during the same period. In fact, Karnataka is the first state to introduce exclusive Agriculture Budget since 2011-12 with enhanced allocation of financial resources for the comprehensive development of agricultural and allied sector. The Government of Karnataka is also conducting Global Agribusiness and Food Processing Summit every year to attract private investment for creating market infrastructures, processing and storage facilities. In 2011 summit, 64 Memorandum of Understandings (MOUs) were signed by the state government with private companies. Out of this, 13 projects are in the advanced stage of completion with the investment of Rs. 22,434 crore (Government of Karnataka, 2013).

As observed at the national level, Karnataka's agrarian structure is also characterised by marginal and small holdings, which accounted for about 75 per cent of total operational holdings in 2005. But, these farmers group have operational area of only 37 per cent and the rest are operated by medium farmers and large farmers, who constitute only 25 per cent of the total operational holdings. Further, average size of holdings has decreased progressively from 2.73 ha in 1980-81 to 1.95 ha in 1995-96 and then to 1.63 ha in 2005-06 due to fragmentation and sub division of land.

In Karnataka, agricultural production is undertaken in varying agro-climatic conditions ranging from dry zone to high rainfall regions. The average annual rainfall ranges from 455 mm to 4694 mm. Karnataka is one of the states in India with the lowest level of area under irrigation. The gross irrigated area to gross cropped area was only 31.8 per cent against the national average of 45.3 per cent in 2009-10. The State Government has undertaken several irrigation development programs particularly in the northern part of Karnataka to augment irrigation potential. The public investment in irrigation has increased dramatically from Rs. 717.40 crore in 1993-94 to Rs. 4157.80 crore in 2009-10. The cumulative irrigation potential increased from 24.07 lakh hectares in 199-394 to 34.43 lakh hectares in 2009-10. Out of total potential created, major and medium irrigation project accounted for 71 per cent and the rest by minor irrigation projects (Government of Karnataka 2013). Notwithstanding, there exists huge gap between potential created and actual utilisation of irrigation facilities.

There is competing demand for land for various non-agricultural purposes like residential building, industrial establishments and public use like roads. Increase in level of urbanisation and rise in per capita income put pressure on existing stock of land, which results in increasing diversion of agricultural land for non-agricultural purposes. Land use classification statistics published by the Directorate of Economics and Statistics (DES), Government of India, captures the dimensions of land utilisation in the state of Karnataka. According to this source, land put to non-agricultural use has increased from 8.12 lakh hectares in 1960-61 to 14.30 lakh hectares in 2010-11 with an addition of 6.18 lakh hectares. A careful analysis of land use statistics reveal that increase in non-agricultural land may have come from the reduction in area under barren and uncultivated land, cultivable waste land and permanent pastures and other grazing land. Further, the net sown area remained more or less constant at 104 lakh hectares over time. Given the problems in the reporting of land use data by patwari agency,

these findings from the DES data need be validated through ground truthing. According to DES, the gross cropped area has increased from 105.9 lakh hectares in 1960-61 to 117.6 lakh hectares in 1990-91 and then to 130.6 lakh hectares in 2010-11. The cropping intensity for these corresponding years stood at 103.5 per cent, 113.3 per cent and 124.1 per cent.

The green revolution technology introduced in late 1960s in the form of new seeds cum chemical fertilisers had helped to increase crop production in the State. This was made possible with higher public investment in agricultural research, education and training, irrigation and other infrastructures. However, the technological gains could not spread evenly across the regions and crops in the state due to diverse agro-climatic conditions and varying natural resources endowments. In fact, spread of high yielding varieties in coarse cereals, which occupy considerable area, remained low over time (Kannan, 2010). Use of improved inputs like fertilisers and pesticides also remains low when compared to agriculturally progressive states like Punjab and Haryana.

1.2. Background of Pre and Post Harvest Losses

1.2.1. Pre Harvest Losses

The estimation of crop loss due to pests and diseases is a complex subject. It is in fact, difficult to assess the loss caused by the individual pest as a particular crop may be infested by the pest complex in the farmers' field conditions. Further, extent of crop loss either physical or financial depends on the type of variety, stage of crop growth, pest population and weather conditions. Nevertheless, crop loss estimates have been made and updated regularly at global level. The worldwide yield loss due to various types of pest was estimated at as: 37.4 per cent in rice, 28.2 per cent in wheat, 31.2 per cent in maize and 26.3 per cent in soybean (Oerke, 2007). At all India level, crop loss estimates due to insect pests have been provided by Dhaliwal *et al* (2010). According to this source, the crop loss was estimated at 25 per cent

in rice and maize, 5 per cent in wheat, 15 per cent in pulses and 50 per cent in cotton. The crop loss has increased during post-green revolution period when compared to pre-green revolution period. The severity of pest problems has reportedly been changing with the developments in agricultural technology and modifications of agricultural practices. The damage caused by major inspect-pests in various crops has also been compiled and reported in Reddy and Zehr (2004). Further, a number of studies have established the strong relationship between pest infestation and yield loss in various crops in India (Nair, 1975; Dhaliwal and Arora, 1994; Muralidharan, 2003; Rajeswari *et al*, 2004; Muralidharan and Pasalu, 2006; Rajeswari and Muralidharan, 2006).

Generally, crop loss is estimated as the difference between potential (attainable) yield and the actual yield. The potential yield is the yield that would have been obtained in the absence of pest under consideration. By multiplying the area with the estimated yield loss, total loss is obtained. To estimate the crop loss, most of the existing studies have adopted experimental treatment approach (with or without pest attack through artificial infestation) or fields with natural infestation wherein half of the field is protected against the pest while the other half is not. But, the results obtained from artificial infestation or natural infestation in the selected plots/fields will not be appropriate for extrapolation over a geographical area (Groote, 2002). It is for the reason that the estimated crop losses under these conditions may not represent the actual field conditions of farmers. Alternatively, loss estimates collected directly from the farmers through sample survey may be reliable and could be used for extrapolation in similar geographical settings. However, the farmers' estimates are likely to be subjective and these should be validated with expert estimates of the state department of agriculture and agricultural research stations.

1.2.2. Post Harvest Losses

Production in agriculture is seasonal and exposed to natural environment, but post-production operations play an important role in providing stability in the food supply chain. According to a World Bank (1999) study post harvest losses of foodgrains in India are 7-10 percent of the total production from farm to market level and 4-5 percent at market and distribution level. Given the total production of around 240 million tonnes at present, the total losses work out around 15-25 million tonnes. With the given per capita cereal consumption requirement in India, the above grains lost would be sufficient to feed more than 10 crore people. Losses in food crops occur during harvesting, threshing, drying, storage, transportation, processing and marketing. In the field and during storage, the products are damaged by insects, rodents, birds and other pests. Moreover, the product may be spoiled by infection from fungi, yeasts or bacteria. Food grain stocks suffer qualitative and quantitative losses while in storage. The quantitative losses are generally caused by factors, such as incidence of insect infestation, rodents, birds and also due to physical changes in temperature, moisture content, etc. The qualitative loss is caused by reduction in nutritive value due to factors, such as attack of insect pest, physical changes in the grain and chemical changes in the fats, carbohydrates, protein and also by contamination of myco toxins, besides, residue, etc. The storage loss/gain is a very sensitive issue as it depends upon agro climatic conditions. In order to minimize the losses during storage it is important to know the optimum environment conditions for storage of the product, as well as the conditions under which insects/pests damage the produce.

According to FAO, about 70 percent of the farm produce is stored by farmers for their own consumption, seed, feed and other purposes in India. Farmers store grain in bulk using different types of storage structures made from locally available materials. For the better storage it is necessary to clean and dry the grain to increase its life during storage. In addition, storage structure, design and its construction also play a vital role in reducing or

increasing the losses during storage. With the scientifically constructed storage, it is also essential that the grain being stored is also of good quality. At the village, generally harvesting is done at high moisture content and therefore before storing the same, it is necessary to obtain the desired moisture for safe post storage of grains. There are small storage structures at the farmer level and also bulk storage of foodgrains. The major construction material for storage structures in rural areas at the farmer level are mud, bamboo, stone and plant materials. Generally, they are neither rodent proof, nor secure from fungal and insect attack. On average, out of total 6 percent loss of foodgrains in such storage structures, about half is due to rodents and rest half is due to insects and fungi. The bulk storage of foodgrains is done mainly by traders, cooperatives and government agencies like FCI, CWC, SWC and grain marketing cooperatives. There are many kinds of storage systems followed depending on the length of storage and the product to be stored. Some examples are cover and plinth storage, community storage structures, rural godowns and scientific warehouses.

1.3. Importance of Selected Crops in the State

For the present study, rice and red gram have been selected to assess their yield loss due to pest and diseases, and also post harvest losses. Here, the importance of these selected crops is analysed through area share in total cropped area and value share in total value of agricultural output. It can be observed from the Table 1.1 that foodgrains dominate the cropping pattern accounting for about two-third of total gross cropped area (GCA) in Karnataka. Among food grains, coarse cereals occupy prominent place in the cropping pattern. Nevertheless, per cent area under food grains has declined from 71.9 per cent in triennium ending 1962-63 to 62.1 per cent in triennium ending 2010-11. The decline in area under foodgrains is offset by relative increase in area under oilseeds and other crops (which include coconut, arecanut, chillies and coffee). The share of area under vegetables has increased to 3.5 per cent in 2010-11 from a meagre 1.0 per cent in

1992-93. However, area under fruits and nuts remain more or less constant during the recent years.

Table 1.1. Cropping Pattern in Karnataka

Crop	1962-63	1972-73	1982-83	1992-93	2000-01	2010-11
Rice	9.9	10.7	10.3	10.3	11.9	11.91
Jowar	28	21.8	19.2	18	15.4	10.48
Bajra	4.8	4.6	5.4	3.3	2.6	2.31
Maize	0.1	0.7	1.4	2.3	4.9	9.44
Ragi	9.6	9.8	9.8	8.8	8.1	6.28
Wheat	2.9	2.9	3	1.7	2.2	2.12
Small Millets	4.2	4.1	3.2	1.1	0.6	0.22
Cereals	59.7	55.4	52.4	45.5	46.6	42.76
Arhar	2.7	2.5	3.3	3.9	4.3	5.49
Gram	2.5	1.4	1.3	1.7	2.8	6.97
Pulses	11.9	11	13.2	13.8	15.8	19.31
Foodgrains	71.9	68.3	66.6	59.4	62.4	62.06
Groundnut	8.4	9.2	7.6	10.5	9.3	6.60
Sunflower	-	-	1	8.6	4.9	5.78
Oilseeds	9.7	11	12.2	22.7	17.3	15.23
Cotton	9.3	10.2	9	5	4.7	3.70
Sugarcane	0.7	1	1.6	2.2	3.1	2.73
Tobacco	0.4	0.3	0.5	0.4	0.6	0.80
Fruits & nuts	-	-	-	1.2	2.6	2.10
Vegetables	-	-	-	1.0	2.8	3.50
Others*	0.7	1.3	4.6	4.8	6.7	9.88
GCA	100	100	100	100	100	100.00

Note: * include coconut, arecanut, chillies and coffee; figures are in three years average
Source: Directorate of Economics and Statistics, Government of Karnataka

In 2010-11, rice and jowar have occupied predominant positions in the cropping pattern followed by sunflower and maize. Despite occupying relatively high share, area under jowar has declined drastically since early sixties. Similar pattern could be noticed with respect to other coarse cereals like bajra, ragi and small millets. However, crops like maize, arhar (pigeon pea) and gram have gained in their relative area since early 1990s. Maize occupied only 0.1 per cent of GCA in 1962-63, which has increased steadily to reach 1.4 per cent in 1982-83 and then to 9.4 per cent in 2010-11. Similarly, per cent area under arhar in total cropped area has increased

from 2.5 per cent in 1972-73 to 5.5 per cent in 2010-11. The share of area under gram decelerated during seventies and early eighties, but started picking up since nineties and has occupied about 7.0 of the gross cropped area.

Groundnut is one of the traditional crops grown in Karnataka. It is cultivated both under irrigated and rain fed conditions. The per cent area under this crop has declined sharply since 2000 due to persistent drought like conditions in the major growing areas of the state. However, share of area under sunflower has registered sharp increase from 1.0 per cent in 1982-83 to 8.6 per cent in 1992-93. But, it has showed declining trend during the recent years. Among cash crops, area under cotton has declined drastically over time. However, sugarcane area has increased considerably from 1960s to 2000s, but has showed declining trend since 2001-02. It emerges from the analysis that there is marked shift in area from cereals to pulses, oilseeds and high value crops like vegetables and plantation crops.

Table 1.2. Contribution of Various Crops in Total Value of Agricultural Output at 2004-05 prices

Particulars	TE 2002-03	TE 2005-06	TE 2008-09
Rice	9.66	12.11	11.56
Red gram	1.09	1.69	1.68
Total Cereal	18.50	22.98	21.83
Total Pulses	3.64	4.07	4.67
Total Oilseed	8.91	10.77	8.72
Total Sugar	14.15	7.04	8.88
Total Fibres	1.70	1.61	2.01
Indigo, Dyes & Tanning Materials	0.00	0.00	0.00
Total Drugs & Narcotics	6.85	7.70	6.10
Total Condiments & Spices	7.06	7.70	9.77
Total Fruits & Vegetables	31.08	28.88	30.02
Total Other Crops	2.56	2.97	2.47
Total By Products	4.77	5.50	4.88
Kitchen garden	0.78	0.79	0.67
Total Value of Output	100.00	100.00	100.00

Source: CSO, Ministry of Statistics and Programme Implementation, Government of India

The share of output of major crops in total value of agricultural output is given in Table 1.2. Among the crop and crop groups, rice accounted for about 12 per cent of the total value of agricultural output since mid-2000s. The value share of red gram remained more or less constant. In terms of crop groups, fruits and vegetables constituted the highest share of 30.02 per cent. In fact, food price inflation, which emerged during 2007-08, has largely been attributed to increase in price of fruits and vegetables. The second highest share in total value of agricultural output was contributed by cereals, within which rice accounted for the major proportion. While condiments and spices contributed about 9.77 per cent, sugars and oilseeds accounted for 8.88 per cent and 8.72 per cent, respectively. The value share of pulses increased marginally from 4.06 per cent in 2005-06 to 4.67 per cent in 2008-09. It is clear from the above analysis that rice still contributes substantial proportion of total value of agricultural output and the contribution of red gram remains more or less constant.

1.4. Need for the Study

As per the available data (Oerke, 2006; Dhaliwal et al, 2010), crop losses caused by pests and diseases are huge. But, the knowledge on the subject of 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 the selected crops. The study estimates yield losses due to pest and diseases in the crops viz., rice and tur (pigeon pea). For the pre harvest losses, generally animal pests (insects, mites, rodents, snails and birds), plant pathogens (bacteria, fungi, virus and nematodes) and weeds are collectively called as 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 made to estimate such losses based on the farmers' estimates.

1.5. Objectives of the Study

Keeping in view of importance of the subject, objectives of the presented research are given below:

1. To estimate the physical losses caused by pests and diseases in rice and tur at farm level
2. To examine 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 tur 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 in order to increase national productivity

1.6. Database and Methodology

The present study is based on the farm level data collected from the major districts growing rice and red gram in Karnataka. The crop production constraints particularly infestation by pests and diseases, and losses caused by them has 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 were also collected from the farmers. The post harvest losses during the process of harvesting, collection and threshing, transportation and storage were quantified based on the estimates provided by the farmers.

To collect the primary data, a sample survey was conducted in two districts for each selected crop for the reference period 2011-12. For the present study, Mysore and Shimoga were selected for conducting of survey of paddy farmers. Gulbarga and Bidar were selected to conduct survey of tur farmers. These districts were selected based on high area share in the state total. From each district, one taluk was selected based on again the highest share of area under reference crops within the district. The districts and taluks were chosen in such a way that they represent major growing areas of the rice and red gram and they fall in different agro climatic zones. In fact, for rice, Mysore and Shimoga districts fall under Southern Dry Zone and Southern Transition Zone, respectively. For red gram, while Gulbarga falls under North-Eastern Dry Zone, Bidar comes under North-Eastern Transition Zone. From each taluk/district, two villages with one nearby the market/mandi centre and one far off from the market centre were selected for canvassing the household interview schedule. In total, four villages per district for each crop were chosen for survey. A random sample of 40 farmers were selected from each village and thus constituted a total sample of 160 farmers for each crop.

Table 1.3. Distribution of Sample Households

Particulars	Marginal (<2.5 acres)	Small (2.51 to 5.00 acres)	Medium (5.01 to 10.0 acres)	Large (>10.01acres)	Total
	Paddy				
Mysore	44 (55.0)	18 (22.5)	14 (17.5)	4 (5.0)	80 (100.0)
Shimoga	40 (50.0)	22 (27.5)	14 (17.5)	4 (5.0)	80 (100.0)
Total	84 (52.5)	40 (25.0)	28 (17.5)	8 (5.0)	160 (100.0)
	Red gram				
Bidar	27 (33.8)	23 (28.8)	15 (18.8)	15 (18.8)	80 (100.0)
Gulbarga	12 (15.0)	22 (27.5)	17 (21.3)	29 (36.3)	80 (100.0)
Total	39 (24.4)	45 (28.1)	32 (20.0)	44 (27.5)	160 (100.0)

Note: Figures in parentheses are percentage to total

The distribution of sample farmers is given in **Table 1.3**. For paddy, marginal and small farmers constituted for about 77 per cent and for red gram, medium and large farmers accounted for relatively high proportion as red gram growing areas largely fell under dry areas where average land holding size is high as compared to the paddy growing areas. Large farmer households constituted only 5.0 per cent in Mysore and Shimoga.

1.7. Organisation of the Report

The report is organised in six chapters. With discussion of background comprising importance of selected crops and need for the present study in Chapter I, performance of selected crops of rice and red gram in the state of Karnataka is provided in Chapter II. Changes in input cost structure and profitability of rice and red gram are also discussed. Chapter III presents some important socio-economic characteristics of the selected households, cropping pattern, crop productivity and marketing. Estimates of the pre harvest and post harvest losses of rice and red gram are presented in Chapter IV and Chapter V, respectively. Final chapter presents summary and conclusions of the study.

CHAPTER II
AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED CROPS IN KARNATAKA

The present chapter discusses the growth performance of the selected crops viz., paddy and red gram in the state of Karnataka. The analysis of growth performance helps to understand the relative importance of these crops in the crop economy and it also reflects the policy thrust given by the state government to increase their production. Growth in area, production and yield of paddy and red gram has been carried out at state and district level. Data provided by the Directorate of Economics and Statistics, Government of Karnataka were utilised for this purpose. Further, cost and profitability of these selected crops has also been worked out for the recent years. For this analysis, data published by the Farm Management Division, Department of Agriculture, Government of Karnataka were used. In fact, detailed structure of inputs use and output data are collected annually by the state government at the agro climatic zone level. For the present study, analysis of change in input cost structure and profitability has been worked out at constant prices for paddy and red gram at the state level only. Cost A2 has been utilised for estimating the farm business income of paddy and red gram.

This chapter is organised four sections. After the discussion of trend and growth in area, production and yield of paddy and red gram in the first section, changes in costs and profitability are provided in the second section. Since the present study focuses on the crop losses due to pests and diseases, some secondary estimates available in the published literature are discussed in the third section. The summary of the chapter is provided in the final section.

2.1. Trend and Growth in Area, Production and Yield of Paddy and Red gram in Karnataka

Trend growth in area, production and yield of important crops grown in Karnataka is provided in Table 2.1. For analytical purpose, growth rate of important crops was calculated for different decadal periods. It can be observed that during 1971-72 to 1980-81, growth in area and yield of rice was positive, which resulted in the annual production growth of 1.63 per cent. But, growth rate was not statistically significant. In case of tur/red gram, growth in area was impressive with 3.36 per cent and was also statistically significant. Correspondingly, growth in yield of tur was high at 2.19 per cent. A high growth in area and yield has resulted in appreciable growth (5.54 per cent) in production of tur.

Overall growth in the production of foodgrains during 1971-72 to 1980-81 was 1.65 per cent, which was contributed by positive growth in area and yield. However, growth in production of oilseeds was negative during this period. Interestingly, annual growth in production of sugarcane was impressive at 3.77 per cent, which was mainly contributed by growth in area. Trend growth in production of condiments and spices, and drugs and narcotics was statistically significant.

During 1981-82 to 1990-91, growth in area under tur, oilseeds and sugarcane registered a statistically significant growth rates. However, only oilseeds, condiments and spices, and sugarcane registered positive and statistically significant growth in production. Growth in production of oilseeds and sugarcane was mainly contributed by growth in area. Growth in yield of oilseeds was negative and that of sugarcane was negligible. Similarly, growth in yield of tur was negative and significant, which had led to fall in growth of its production. As compared to previous period, growth in yield of rice has also decelerated resulting in lower growth in output.

Table 2.1. Trend Annual Growth Rate of Area, Production and Yield for Karnataka

(Per cent)

Item	1971-72 to 1980-81			1981-82 to 1990-91			1991-92 to 2000-01			2001-02 to 2010-11			1971-72 to 2010-11		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Rice	0.15	1.63	1.48	0.22	0.61	0.39	1.50***	2.97***	1.48***	2.66**	4.24	1.57	0.83***	2.02***	1.20***
Arhar/Tur	3.36*	5.54	2.19	3.33***	-0.22	-3.54**	2.79	8.23**	5.43	4.73***	9.69***	4.96*	2.19***	2.14***	-0.05
Total Cereals	0.09	2.08	1.19*	-0.54	-0.13	0.41	0.44	2.79***	2.34***	0.72	6.14***	5.42**	-0.17**	1.74***	1.92***
Total Pulses	2.25	-0.60	-2.85	0.50**	-0.96	-1.46	0.16	3.67**	3.52	1.31	5.58***	4.27**	1.50***	1.88***	0.38
Foodgrains	0.53	1.65	1.13	-0.31	-0.19	0.12	0.34	2.85***	2.51***	0.90**	6.08**	5.18**	0.22***	1.75***	1.52
Total Oilseeds	-0.38	-0.02	0.36	7.32***	2.86***	-1.42	-4.91***	-3.36**	1.53	-1.13	2.52	3.65**	1.59***	1.99***	0.39*
Condiments & Spices	4.05***	4.74***	0.69	-0.45	13.60***	4.77***	-3.37	5.37***	8.75*	0.82	1.85	0.84	1.46***	4.22***	2.73***
Fruits & Vegetables	-	-			-	-	-	-	-	4.06***	7.26***	3.20***	-	-	-
Sugarcane	4.70***	3.77***	-0.93	5.22***	5.28***	0.06	3.68***	5.81***	2.13**	1.31	3.24	1.94*	3.00***	3.48***	0.47***
Drugs & Narcotics	2.95***	27.87***	24.91***	-0.97	2.34	3.31	3.62***	-16.52***	-20.14***	5.20***	5.61	0.41	3.01***	0.90	-2.12*

Source: directorate of economics and statistics, Govt of India and Indian Horticulture Database 2006,2008,2009,2011

Note: ***Significant at 1% level,** Significant at 5% level and * Significant at 10% level

However, during 1991-92 to 2000-01 most crops had registered positive and statistically significant growth in production. Trend growth in yield was highly impressive during this period, which had actually led to high growth in crop production. However, exceptions were oilseeds, and drugs and narcotics. Trend growth in area and yield of rice was highly significant and positive with 1.50 per cent and 1.48 per cent, respectively. These had contributed to rice output growth of 2.97 per cent. The growth in tur production was 8.23 per cent, which was mainly contributed by growth in yield. However, area under tur registered positive growth rate as compared to the previous period.

The overall growth momentum, which was observed in the 1990s also continued during 2001-02 to 2010-11. All the crops under study had registered positive and relatively high growth rates during 2001-02 to 2010-11. Trend growth in production of tur was the highest at 9.69 per cent followed by followed by fruits and vegetables (7.26 per cent). High and significant growth in area and yield of tur had contributed to higher growth in production. A similar growth pattern can also be observed for fruits and vegetables. Trend growth in rice production was 4.24 per cent, which was mainly contributed by area while growth in yield was not significant as compared to the previous period. For the entire period of analysis, 1971-72 to 2010-11, trend growth in production of rice and tur was respectable at 2.02 per cent and 2.14 per cent, respectively. It is, therefore clear from the above analysis, both area growth and yield growth has significantly contributed to increase in production of rice and tur during 1990s and 2000s. However, growth in area under rice was highly significant during recent period, while growth in yield was not significantly contributing to output growth. In case of red gram, both area growth and yield had significantly contributed to output growth.

Table 2.2. District wise Share of Rice in Total Area and Production: 1998-99 to 2009-10

(Per cent)

District	Area		Production	
	TE 2000-01	TE 2009-10	TE 2000-01	TE 2009-10
Raichur	9.3	11.4	11.6	12.5
Shimoga	10.9	8.9	10.1	8.2
Mysore	7.6	8.4	8.7	9.5
Bellary	5.3	8.2	6.7	10.5
Davangere	8.1	7.8	10.8	10.1
Gulbarga	1.7	6.0	1.3	5.3
Mandya	5.4	5.8	6.5	7.0
Uttara Kannada	6.2	5.5	4.1	3.7
Koppal	5.0	5.1	6.7	6.7
Belgaum	4.4	4.8	3.0	2.4
Udupi	4.7	4.1	3.4	3.6
Dakshin Kannada	4.5	3.8	3.6	3.3
Hassan	4.6	3.5	4.5	3.3
Haveri	3.8	3.2	2.6	2.0
Chickmagalur	3.5	2.9	3.3	2.8
Kodagu (Coorg)	2.6	2.4	2.3	2.3
Tumkur	3.3	2.4	3.5	2.4
Dharwad	2.7	1.9	1.2	0.9
Chamrajnagar	1.2	1.3	1.4	1.3
Chitradurga	0.9	0.6	0.9	0.5
Ramanagara	0.0	0.5	0.0	0.5
Bidar	0.7	0.4	0.2	0.1
Chikkaballapur	0.0	0.4	0.0	0.4
Kolar	1.4	0.4	1.4	0.2
Bangalore (U)	0.5	0.1	0.5	0.2
Bangalore (R)	1.5	0.1	1.6	0.2
Gadag	0.1	0.1	0.1	0.1
Karnataka	100.0	100.0	100.0	100.0

Source: Directorate of Economics and Statistics, Government of Karnataka

Attempt has also been made to analyse the growth in area, production and yield of rice and red gram across districts in Karnataka for the period 1998-99 to 2009-10. Before analysing the growth rates, share of area and production of the selected crops at the state level is discussed to understand the relative importance of the reference crops grown in different districts. The per cent share of area and production of rice is presented in Table 2.2. Among the rice growing districts, Raichur accounted for 9.3 per of the total

area in TE 2000-01, which increased to 11.4 per cent in TE 2009-10. Raichur, therefore, has emerged to be dominant district growing rice in the state of Karnataka. The other important districts occupying considerable area under rice cultivation during TE 2009-10 are Shimoga (8.9 per cent), Mysore (8.4 per cent), Bellary (8.2 per cent) and Davangere (7.8 per cent).

With respect to production of rice, Raichur again emerged to be an important district occupying the first position at the state level. The share of production of rice was 11.6 per cent in TE 2000-01, which increased to 12.5 per cent in TE 2009-10. The second and third positions were occupied by Bellary (10.5 per cent) and Davangere (10.1 per cent). Mysore and Shimoga accounted for 9.5 per cent and 8.2 per cent of total production, respectively. In fact, these five districts accounted for about 45 per cent of total area and 51 per cent of total production.

In case of red gram, Gulbarga district alone occupied about 61 per cent of area under tur in Karnataka (Table 2.3). This area share remained more or less constant in the last one decade. The other important districts growing tur are Bijapur (12.3 per cent) and Bidar (10.4 per cent). These three districts had accounted for about 84 per cent of the total area under tur during TE 2009-10. Tumkur and Raichur have each occupied about 2.4 per cent of the area. As far as tur production is concerned, Gulbarga accounted for about 61.6 per cent of the total production in the state. Bidar occupied the second position with14.3 per cent followed by Bijapur (8.1 per cent). These three districts taken together produced about 84 per cent of the total tur production in Karnataka. The production share of Tumkur was 3.1 per cent. Overall, Gulbarga has the highest area and it also accounts for the highest production of tur.

Table 2.3. District wise Share of Red gram in Total Area & Production from 1998-99 to 2009-10

(Per cent)

	Area		Production	
Districts	TE 2000-01	TE 2009-10	TE 2000-01	TE 2009-10
Gulbarga	60.8	60.9	60.7	61.6
Bijapur	4.2	12.3	4.4	8.1
Bidar	11.1	10.4	14.2	14.3
Tumkur	2.6	2.4	2.1	3.1
Raichur	3.3	2.4	1.1	1.3
Koppal	2.5	1.6	1.4	1.1
Bellary	1.6	1.5	1.2	1.3
Chitradurga	1.5	1.3	1.5	1.3
Chikkaballapur	0.0	1.0	0.0	0.8
Belgaum	1.7	0.8	1.5	0.5
Davangere	1.4	0.7	1.8	1.4
Ramanagara	0.0	0.6	0.0	0.8
Bagalkot	1.0	0.5	1.3	0.6
Mysore	1.2	0.5	0.9	0.4
Dharwad	0.4	0.5	0.5	0.7
Kolar	1.9	0.4	3.1	0.6
Haveri	1.4	0.4	1.5	0.4
Gadag	0.5	0.4	0.2	0.2
Chamrajnagar	0.4	0.3	0.2	0.4
Hassan	0.6	0.3	0.3	0.2
Bangalore R	1.0	0.2	1.2	0.3
Mandya	0.3	0.2	0.3	0.2
Chickmagalur	0.2	0.1	0.2	0.1
Bangalore (U)	0.2	0.1	0.2	0.1
Shimoga	0.1	0.1	0.1	0.1
Karnataka	100.0	100.0	100.0	100.0

Source: Directorate of Economics and Statistics, Government of Karnataka

Trend growth in area, production and yield of rice across districts in Karnataka is provided in Table 2.4. Among the districts, Gulbarga registered the highest and a significant growth rate of 14.29 per cent in rice area during 1998-99 to 2009-10. The next highest growth rate was registered in Gadag with 7.64 per cent followed by Bellary with 5.20 per cent. However, some districts showed a sharp decline in growth of area under rice during the recent period. In fact, Bangalore (Rural), Bangalore (Urban), Kolar and

Bidar have showed drastic reduction in rice area. For the state as a whole, rice area registered the growth of 0.49 per cent.

Table 2.4. District wise Trend Annual Growth rate of Rice from 1998-2009-10 in Karnataka

(Per cent)

Districts	Area	Prod	Yield
Bagalkot	-5.50*	0.94	6.44***
Bangalore (R)	-22.67***	-19.93***	2.74
Bangalore (U)	-13.12***	-11.04***	2.08
Belgaum	1.21***	0.62	-0.60
Bellary	5.20***	5.72***	0.52
Bidar	-6.77***	-7.57***	-0.80
Bijapur	-21.89*	-14.45	7.44
Chamrajnagar	0.83	-0.11	-0.94
Chickmagalur	-1.53***	-0.76	0.77
Chitradurga	-3.23	-4.82	-1.60
Dakshin Kannada	-1.87***	-0.52	1.34*
Davangere	0.90	1.36	0.46
Dharwad	-4.40***	2.01	6.41
Gadag	7.64***	5.72	-1.92
Gulbarga	14.29***	16.81***	2.52
Hassan	-2.68**	-2.10	0.58
Haveri	-2.60	0.46	3.06
Kodagu (Coorg)	-0.74**	0.44	1.18*
Kolar	-12.16***	-15.15**	-2.99
Koppal	1.22	1.00	-0.22
Mandya	1.45	2.13	0.69
Mysore	1.62	1.74	0.12
Raichur	3.28	2.17	-1.12
Shimoga	-2.00***	-0.60	1.39
Tumkur	-2.50	-2.69	-0.18
Udupi	-1.43***	1.45**	2.88***
Uttara Kannada	-1.15***	0.91	2.06
Karnataka	0.49	1.37	0.89

Note: ***Significant at 1% level,** Significant at 5% level and * Significant at 10% level
Source: Directorate of Economics and Statistics, Government of Karnataka

As far as growth in rice production is concerned, Gulbarga registered the highest growth rate (16.81 per cent) followed by Bellary (5.72 per cent). High growth in rice production in Gulbarga was mainly contributed by growth in area, but growth in yield was not statistically significant. Growth in yield of rice was significant only in Bagalkot, Dakshina Kannada, Kodagu and Udupi. As a result, many districts showed negative growth in rice production during 1998-99 to 2009-10. Bangalore (Rural), Kolar, Bangalore (Urban) and

Bidar have registered sharp decline in rice production as observed in area. Although yield of rice remained more or less stagnant, reduction in area led to fall in growth of production in these districts.

Table 2.5. District wise Trend Annual Growth rate of Red gram from 1998-2009-10 in Karnataka

(Per cent)

Dist	Area	Production	Yield
Bagalkot	-4.33	-7.27	-2.94
Bangalore (R)	-12.88***	-7.87**	5.01*
Bangalore (U)	-3.47	-1.67	1.79
Belgaum	-4.84	-5.53	-0.69
Bellary	2.36	5.53*	3.17*
Bidar	1.41**	3.91*	2.50
Bijapur	16.08***	13.99***	-2.09
Chamrajnagar	-1.58	11.37*	12.96**
Chickmagalur	-0.83	0.97	1.80
Chitradurga	0.84	2.82	1.98
Davangere	-5.49***	-0.71	4.78*
Dharwad	2.91***	14.23*	11.31
Gadag	0.29	5.60	5.31
Gulbarga	2.27***	4.27	2.00
Hassan	-4.50***	1.92	6.41**
Haveri	-11.12***	-6.33	4.80
Kolar	-11.13***	-10.41*	0.72
Koppal	-1.71	1.54	3.25
Mandya	-1.61	5.47	1.80
Mysore	-5.80***	-2.77	3.03
Raichur	-1.31	5.47	6.78**
Shimoga	-3.89	-2.09	1.81
Tumkur	0.97	6.59	5.62*
Uttara Kannada	-12.11**	-10.25***	1.86
Karnataka	2.36***	4.16*	1.80

Note: ***Significant at 1% level,** Significant at 5% level and * Significant at 10% level
Source: Directorate of Economics and Statistics, Government of Karnataka

For red gram, only four districts showed statistically significant growth in area during 1998-99 to 2009-10 (Table 2.5). These districts included Bijapur, Dharwad, Gulbarga and Bidar. Bijapur registered the highest trend growth rate of 16.08 per cent followed by Dharwad (2.91 per cent) and Gulbarga (2.27 per cent). However, some major districts showed negative and insignificant growth in tur area. For the state as a whole, trend annual growth in tur area was 2.36 per cent, which helped to register growth in production of 4.16 per cent during the period under study. Among the

districts, Bijapur recorded the highest growth in production (13.99 per cent), which was mainly contributed by growth in area. The other districts showing significant growth in production were Dharwad, Chamrajnagar, Bidar and Bellary. However, in major tur growing districts of Gulbarga, Bidar and Bijapur, growth in yield was either negative or insignificant. At the state level, growth in tur yield was not significant. The stagnant growth in yield in major tur producing areas is a major concern, which needs to be addressed through concerted efforts of agricultural research institutes/university, extension officials and farmers.

2.2. Changes in Costs and Profitability of Selected Crops

For the purpose of analysis of input cost structure, paid out cost (Cost A2 as per the CACP cost concepts) has been worked out at 1999-00 prices for rice and red gram in Karnataka. The inputs considered include human labour, bullock labour, seed, fertiliser, insecticides, irrigation, interest on working capital, rent paid for leased-in land, land revenue, cesses and taxes and depreciation on implements and farm buildings. While agricultural labour wages were deflated by consumer price index for agricultural labourers, material inputs and other items were deflated by respective wholesale price indices. Various crop outputs were also deflated by using respective wholesale price indices. A weighted state level income series was constructed by using area share of crops in total cropped area as weight.

Table 2.6. Share of different costs in Rice Cultivation

(Per cent)

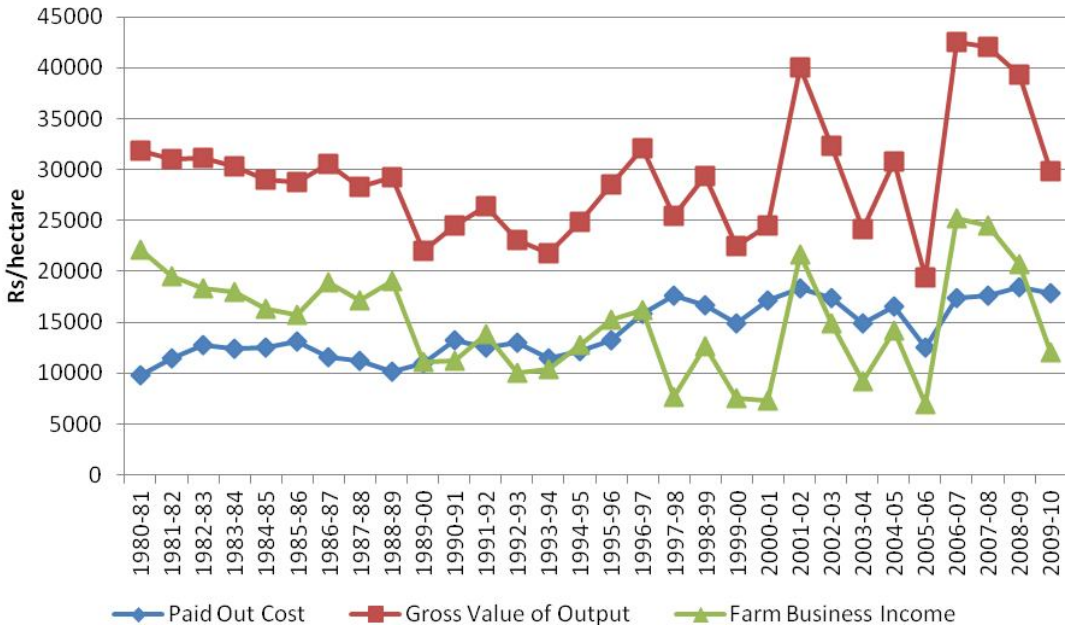
Particulars	Human Labour	Animal Labour	Seed	Manure & Fertiliser	Pesticide	Irrigation	Depreciation	Other Cost	Paid Out Cost
TE 1985-86	45.9	13.6	5.5	20.0	1.3	3.2	2.1	8.4	100.0
TE 1990-91	43.8	13.6	6.2	23.1	1.4	3.0	1.4	7.5	100.0
TE 1995-96	47.3	16.8	4.9	19.6	1.5	1.3	0.7	8.0	100.0
TE 2000-01	44.3	15.8	4.4	22.0	4.2	0.6	0.6	8.0	100.0
TE 2005-06	32.8	18.0	5.8	23.5	6.0	0.4	1.0	12.5	100.0
TE 2009-10	31.0	10.7	4.2	22.7	6.9	1.1	1.2	22.3	100.0

Source: Cost of Cultivation Surveys (various years), Government of India

The per cent cost share of different inputs used in the cultivation of rice is provided in Table 2.6. Among different inputs, human labour accounted for

the highest proportion of paid out cost during TE 1985-86 to TE 2009-10. However, share of human labour cost has showed declining trend over time with 45.9 per cent in TE 1985-86 to 44.3 per cent in TE 2005-06 and then to 31.0 per cent in TE 2009-10. Manure and fertilisers have constituted the second highest proportion in paid cost followed by animal labour cost. Other costs, whose composition is dominated by the interest paid on working capital, have accounted for higher proportion in paid out cost during the recent years. Similarly, it can be observed that cost share of pesticides has increased from 4.2 per cent in TE 2000-01 to 6.9 per cent in TE 2009-10.

Figure 2.1. Trend in Paid Out Cost, Gross Value of Output and FBI of Paddy (at 1999-00 Prices)



Trend in paid out cost, gross value of output and farm business income of rice is presented in Figure 2.1. Farm business income is calculated as the difference between gross value of output and paid out cost. Trend in farm business income has fallen continuously from 1980-81 to 1992-93 and thereafter it improved till1996-97 but to decline again in the subsequent years. The fall in income was quite sharp and remained volatile since 1998-99. The fall in farm business income can be attributed to high fluctuations in gross value output during the period. In fact, trend in farm business

income closely follows the movement in the gross value of output. At the same it can also be noted that paid out cost more or less has been increasing gradually over time. Therefore, fall in value of output and gradual increase in input costs have led to decline in farm business income of rice.

Table 2.7. Share of different costs in Red gram Cultivation

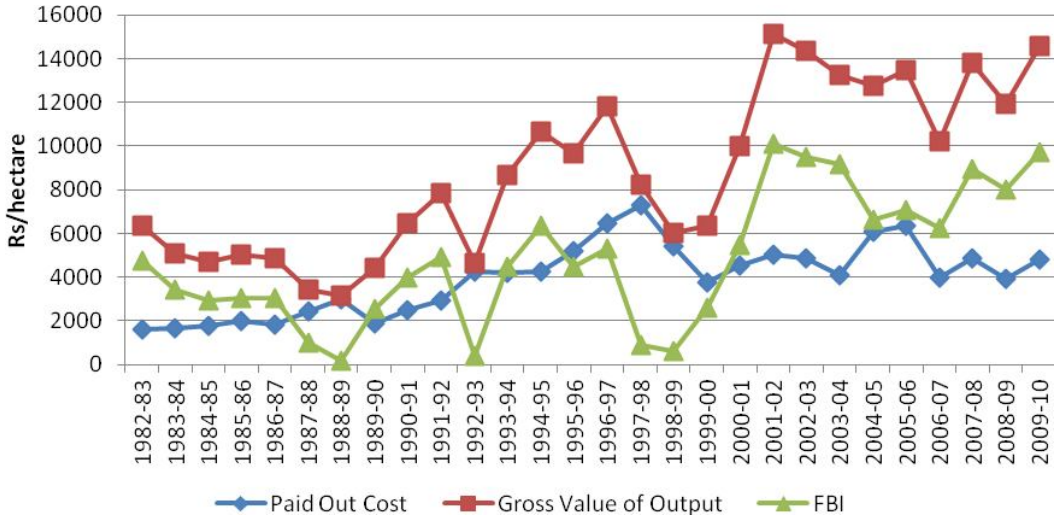
(Per cent)

Particulars	Human Labour	Animal Labour	Seed	Manure & Fertiliser	Pesticide	Irrigation	Depreciation	Other Cost	Paid Out Cost
TE 1987-88	40.2	1.0	9.2	10.8	22.3	0.0	3.1	13.4	100.0
TE 1990-91	28.8	0.8	8.1	19.3	30.6	0.0	2.0	10.4	100.0
TE 1995-96	35.6	0.2	5.6	12.1	32.5	0.0	1.5	12.4	100.0
TE 2000-01	35.6	0.2	5.6	12.1	32.5	0.0	1.5	12.4	100.0
TE 2005-06	29.6	0.2	7.2	27.4	16.9	0.0	2.5	16.1	100.0
TE 2009-10	23.2	0.1	8.8	24.6	19.1	0.0	3.0	21.1	100.0

Source: Cost of Cultivation Surveys (various years), Government of India

The input cost structure for red gram revealed that human labour constituted the highest proportion of paid out cost during the period under study (Table 2.7). But, trend in share of human labour cost has declined from 40.2 per cent in TE 1987-88 to 35.6 per cent in TE 2000-01 and then to 23.2 per cent in TE 2009-10. Use of animal labour remained more or less constant over time. Cost of manure and fertilisers has accounted for the second highest proportion with 24.6 per cent in TE 2009-10. In fact, cost of manures and fertilisers has increased considerably over time. Similarly, cost share of pesticide has increased substantially from 22.3 per cent during TE 1987-88 to 32.5 per cent in TE 2000-01. However, it showed declining trend during the recent years. The cost share of seed and other costs also found to have increased since mid-2000s. The 'other costs' showed increasing trend from 10.4 per cent in TE 1990-91 to 16.1 per cent in TE 2005-06 and to 21.1 per cent in TE 2009-10.

Figure 2.2. Trend in Paid Out Cost, Gross Value of Output and FBI of Red gram (at 1999-00 Prices)



Trend in paid out cost, gross value of output and farm business income of red gram is given in Figure 2.2. It can be observed that there is no definite trend in farm business income of red gram during period under analysis. Both the gross value of output and farm business income showed wide fluctuations from 1988-89 onwards. However, from 1999-00 onwards farm business income showed upward trend and remained in the band of Rs. 6258/hectare and Rs. 10,100/hectare. Unlike paddy, trend in paid out cost increased continuously from 1982-83 to 1997-98 and thereafter it showed declining trend. It is therefore, clear from the analysis that increase in value of gross output has led to increase in farm business income since early 2000s.

2.3. Secondary Estimates of Losses Caused by Pests and Diseases of Selected Crops: A Review

In this section, attempt has been made to review the crop loss estimates available from different published sources. Extensive review of literature revealed that very little information on farmers' survey based empirical evidences on crop losses are available in India. International Rice Research Institute (IRRI) made an attempt to bring scholars working on crop loss assessment together and share technical knowledge on the subject through

an International Workshop organised in 1987. The workshop was the first of its kind to discuss theoretical and empirical methods of assessment of crop loss, its drawbacks and technology for crop loss management in rice. All the papers presented in workshop were brought in a book published in 1990 forms an important source of knowledge for the researchers working on crop loss assessment.

At the global level Oerke (2006) estimated crop losses due to pathogens, viruses, animal pests and weeds for six food and non-food crops during 2001-03. Among the crops, total potential loss is estimated to be the highest for cotton with 82.0 per cent followed by rice (77.0 per cent), potatoes (74.9 per cent), maize (68.5 per cent), soybean (60.0 per cent) and wheat (49.8 per cent). The potential loss estimates vary by pest types for different crops. In fact, weeds found to be causing high potential loss, which varied from 23.0 per cent in wheat to 40.3 per cent in maize. Potential loss due to animal pests is high at 36.8 per cent in cotton and low at 8.7 per cent in wheat. Pathogens and virus also cause considerable production loss in different crops. The potential loss due to pathogens and viruses is estimated to be high in potatoes. The loss ranged from 20-23 per cent and 7-10 per cent by pathogens and viruses, respectively. Overall, weeds caused the highest potential loss of 34 per cent, and animal pests and pathogens produced loss of 18 per cent and 16 per cent, respectively. Oerke also estimated the actual loss for different crops. The total actual loss due to all pests has been estimated high for potato (24-59 per cent) and rice (22-51 per cent).

Rola and Pingali (1993) has complied different estimates of yield losses in rice across the Asian countries from various published sources. Yield loss in rice due to aggregate damage of pests in India was about 35 per cent. Yield loss has varied by insect types like stem borer, leafhoppers and plant hoppers, rice bugs and gall midge, blast, bacterial blight and sheath blight. Among these insects, stem borers caused the highest loss of 3-95 per cent followed by leafhoppers and plant hoppers with 1.1-32.5 per cent. However,

these estimates were outdated and pertained to late sixties and early seventies.

Reddy and Zehr (2004) stated that pest and diseases occur in a complex way and hence it is challenging to distinguish the loss due to individual insect pest from the whole pest complex. They compiled yield loss estimates from various sources and reported the highest of 25 per cent in fruits followed by 18 per cent in cotton. The estimated yield loss in rice and sugarcane was 10 per cent, and for maize, sorghum and millets as 5 per cent. But, these estimates were also pertained to early sixties.

Among the diseases occurring in paddy, Muralidharan et al (2003) found that tungro virus disease occur frequently in different parts of the country and cause considerable amount of loss in production. Depending up on the degree of outbreak, tungro virus disease could cause a maximum production loss of 53 per cent in a district, 23 per cent in a state and about 2 per cent in the country. Historical analysis of data by the authors revealed that estimated loss due to incidence of tungro disease has been more or less increasing in Andhra Pradesh, Uttar Pradesh and West Bengal.

Dhaliwal et al (2010) have stated that dynamics of insect pest problems is changing due to technological intensification of India's agricultural production. Along with technological intensification, changes in ecosystems and habitats lead to higher proportion of not only insects but also non-insect pest population. Crop losses have been estimated for nine crops and crop groups. Authors showed that crop losses have increased during the post-green revolution period as compared to the pre-green revolution period; from 7.2 per cent in early 1960s to 23.3 per cent in early 2000s with an increase of about 16.1 per cent. As per the estimates of Dhaliwal et al, loss due to insect pests was the highest for cotton (50.0 per cent) followed by sorghum and millets (30.0 per cent) during early 2000s. Production loss in rice, maize and other oilseeds excluding groundnut was 25 per cent.

Increase in loss between pre-green revolution and post-green revolution was observed maximum for cotton, sorghum and millets, maize and other oilseeds.

2.4. Summary of the Chapter

Analysis of trend growth rates revealed that production of rice and red gram registered impressive growth during 1990s and 2000s. Annual trend growth in area and yield of rice was 1.50 per cent and 1.48 per cent, respectively, which resulted in production growth of 2.97 per cent during 1991-92 to 2000-01. Similarly growth in production of tur was remarkable at 8.23 per cent, which was mainly contributed by growth in yield. During 2001-02 to 2010-11 also, growth momentum in production continued to register 9.69 per cent in tur and 4.24 per cent in rice.

Among districts growing rice in Karnataka, Raichur emerged to be an important district in terms of area and productions share. The other major districts growing rice are Shimoga and Mysore. In case of red gram, Gulbarga alone accounted for about 61 per cent of area under tur and 62 per cent of production during TE 2009-10. Bijapur and Bidar also occupy significant proportion of area under tur. However, there are variations in annual trend growth rates in area, production and yield registered across districts in Karnataka.

With respect to input cost structure of paddy cultivation, human labour accounted for the highest proportion of 31.0 per cent in TE 2009-10. However, share of human labour cost has showed declining trend over time. Manure and fertilisers have accounted for the second highest proportion of total paid out cost followed by animal labour cost. Trend analysis showed that fall in value of gross value of output and gradual increase in input costs resulted in decline of farm business income of rice. For red gram also, human labour cost accounted for a high proportion of paid out cost followed by manure and fertilisers. Trend in paid out cost of red gram showed

increasing trend from 1982-83 to 1997-98 and thereafter it declined. Farm business income of red gram showed more or less increasing trend since early 2000s and this increasing trend has actually been led by significant increase in value of output.

Attempts were also made to review the secondary estimates on crop loss caused by pests and diseases from various published sources. A careful review showed that very little information on crop loss estimates obtained based on the farmers' field survey are available in India. Further, whatever estimates available from the controlled experimental plots are widely varied and outdated.

CHAPTER III
HOUSEHOLD CHARACTERISTICS, CROPPING PATTERN AND PRODUCTION STRUCTURE

The present chapter discusses some important socio-economic characteristics of the selected sample households, their land holding pattern, cropping pattern and marketing of crop output. For the purpose of analysis, sample farmers growing paddy and red gram have been pooled together, and the relevant estimates are worked out for better understating the characteristics of the entire sample households studied in Karnataka. The analysis of household characteristics and crop production structure helps in assessing the farmers' capacity to identify the pest and diseases that cause crop losses-pre and post harvest stages-and to undertake control measures either through physical, chemical or biological methods. Details of various characteristics of the sample households are provided in the following sections.

3.1 Socio-Economic Characteristics of the Selected Farmers

Table 3.1 provides demographic profile and other important characteristics of the sample households. Of the total sample households, marginal famers accounted for the highest proportion (38.4 per cent) followed by small farmers (26.6 per cent), medium farmers (18.8 per cent) and large farmers (16.3 per cent). The average household size (number of family members) of entire sample was about 7.0 with the highest of about 8.0 members have been recorded among large farmer households. Similarly, number of income earning family members was also found to be relatively high for large farmers as compared to other farmer groups.

The demographic structure of the sample households provides an interesting picture of the composition of adult members and children across the farm size groups. While the proportion of children was lower among the marginal farmers category than that of small, medium and large farmer

categories, the share of adult male and female members was relatively high with 45.8 per cent and 35.2 per cent, respectively for the marginal farmer households. The educational status of the family members has varied with farm size groups. A relatively high percentage of household members with graduate and above were found among the large farmer and medium farmer categories. However, it can be observed that about 60 per cent of the households across the farm size groups reported having their family members completed education of secondary and higher secondary level.

Table 3.1. Demographic profile of the selected farmers (% of households)

Characteristics		Marginal	Small	Medium	Large	Total
No of HH		123	85	60	52	320
Household size (numbers)		5.48	6.89	6.60	8.40	6.54
Average numbers of earners		2.00	2.38	2.28	3.10	2.33
Proportion of Male/Female/Children (%)	Male >15	45.8	38.7	41.4	40.0	41.8
	Female >15	35.2	33.3	35.1	31.8	33.9
	Children <15	19.0	28.0	23.5	28.1	24.3
	Total	100.0	100.0	100.0	100.0	100.0
Average age of the respondent (% households)	Less than 25	10.6	8.2	11.7	11.5	10.3
	Between 25 to 40	24.4	35.3	30.0	42.3	31.3
	Above 40	65.0	56.5	58.3	46.2	58.4
	Total	100.0	100.0	100.0	100.0	100.0
Highest Education status of a family member (% households)	Illiterate	10.57	8.24	6.67	5.77	8.44
	Up to primary	13.82	10.59	13.33	9.62	12.19
	Up to secondary	43.09	51.76	45.00	46.15	46.25
	Higher secondary	20.33	16.47	16.67	15.38	17.81
	Graduate & above	12.20	12.94	18.33	23.08	15.31
	Total	100.00	100.00	100.00	100.00	100.00
Caste (% households)	SC	21.14	15.29	6.67	13.46	15.63
	ST	28.46	22.35	18.33	3.85	20.94
	OBC	12.20	10.59	21.67	17.31	14.38
	General	38.21	51.76	53.33	65.38	49.06
	Total	100.00	100.00	100.00	100.00	100.00
Distance from the main market (km)		12.28	19.28	13.73	25.08	16.48
Annual family income (Rs)		24528	39811	68532	81806	46146

Generally, in empirical studies age of respondent is used as proxy for the years of experience in farming. It can be argued that longer the experience, better the management of crop production activities including the pre and post harvest losses caused by the pest and diseases. For the entire sample, about 58 per cent of the households reported the average age of the respondent above 40 years. In fact, a high percentage of households across farm size categories too, have reported the average of respondent above 40 years with the highest being registered among marginal farmers. The caste composition of sample households has also varied across the farm size groups. Over 50 per cent of the sample households of small, medium and large farmers belonged to general category, whereas the marginal farmers came under SC and ST categories. As far as the family income from all sources concerned it was the highest for large farmers followed by medium farmers and small farmers.

3.2. Characteristics of Operational Holdings

The structure of the operational holdings of the sample households is presented in Table 3.2. It can be observed that the tenancy cultivation of land is common across the farm size groups even though it is not legally allowed in the state of Karnataka. Large farmer households leased in relatively a high amount of land as compared to other farmer categories, whereas medium farmers leased out a high amount of 0.16 acre per household. As far as the land ownership is concerned, it is skewed towards medium and large farmers with 7.06 acre and 16.51 acre per household, respectively. Actually, two of the study districts viz., Gulbarga and Bidar are predominantly rainfed and have large size of average land holdings. As a result, average net operated area was the highest for large farmers (21.01 acre) followed by medium farmers (7.36 acre). Further, gross cropped area was also found to be high for these farmer categories.

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

Farm size	Owned land	Un cultivated land	Leased-in	Leased - out	Net operated area	Net Irrigated area	GCA	Cropping intensity
Marginal	1.68	0.07	0.08	0.02	1.66	1.01	2.47	1.484
Small	3.74	0.10	0.34	0.06	3.92	2.04	5.09	1.299
Medium	7.06	0.11	0.57	0.16	7.36	3.73	9.01	1.224
Large	16.51	0.17	4.67	0.00	21.01	4.47	22.22	1.058
Total	5.65	0.10	0.98	0.05	6.47	2.36	7.60	1.174

For the entire sample, average net operated area was 6.47 acre and the net irrigated area was only 2.36 acre. Interestingly, per cent net irrigated area was relatively high for marginal and small farmers as compared to medium and large farmers. As a result, the cropping intensity also worked out to be higher for marginal and small farmers indicating that these farmers practice intensive cultivation of short duration crops for raising their income from farming. Overall cropping intensity for the entire sample was 1.174 as against 1.484 for marginal farmers and 1.299 for small farmers.

3.3. Structure of Tenancy

As per the Karnataka Land Reforms (Amendment) Act 1974, leasing of land has been prohibited in the state. Although it is not legally permitted to create land tenancy, yet it is widely practiced across the different parts of the state. It can be observed from the Table 3.3 that the incidence of tenancy (land leased as per cent of net operated area) is 15.20 per cent for leasing-in and 0.83 per cent for leasing-out for the entire sample. While large farmers are the major lessee with 22.24 per cent of net operated area, medium farmers emerged to be important lessor with 2.11 per cent of the net operated area. Small farmers have also leased-in land to the extent of 8.56 per cent for cultivation and the same for marginal farmers was 4.55 per cent of the net operated area. The crop sharing is the dominant mode of tenancy arrangement for leasing-in land among the sample farmers.

Table 3.3. Nature of tenancy in leasing-in/leasing-out land (% households)

Farm size	Crop sharing	Fixed rent in cash	Total	% share of tenancy in NOA
Leasing-in				
Marginal	42.86	57.14	100.00	4.55
Small	80.00	20.00	100.00	8.56
Medium	50.00	50.00	100.00	7.70
Large	56.25	43.75	100.00	22.24
Total	58.14	41.86	100.00	15.20
Leasing-out				
Marginal	33.33	66.67	100.00	1.37
Small	100.00	0.00	100.00	1.50
Medium	33.33	66.67	100.00	2.11
Large	-	-	-	-
Total	42.86	57.14	100.00	0.83

3.4. Sources of Irrigation

Different sources of irrigation by per cent net irrigated area are provided in Table 3.4. In the study area, three important sources of irrigation viz., canal, tube well and open well have been used by the farmers. Canal irrigation accounted for the highest proportion of 81.23 per cent of the net irrigated area followed by the tube well (electric and diesel) and open well irrigation. Interestingly, area irrigated through canal water was relatively high for marginal farmers (95.18 per cent), whereas for large farmers it was only 64.69 per cent indicating that resource poor marginal farmers have access to government controlled canal water.

Table 3.4. Sources of irrigation

(% of net irrigated area)

Farm size	Canal	Tube well (diesel)	Tube well (Electric)	Open well	Other	Total
Marginal	95.18	-	3.21	1.61	-	100.00
Small	86.73	0.58	6.92	-	5.77	100.00
Medium	86.37	3.13	4.47	2.91	3.13	100.00
Large	64.69	18.08	9.47	7.75	-	100.00
Total	81.23	6.63	6.37	3.52	2.26	100.00

However, large farmers have access to capital intensive tube well technology irrigating about 28 per cent of the net cropped area. On the whole, canal water was the major source of irrigation across the farm size groups as the study area largely covered the irrigated area, which was dictated by the choice of sample crops like paddy. Tanks were one of the traditional water bodies used for irrigation have now become defunct and encroached upon by local people for various activities.

3.5. Cropping Pattern

Cropping pattern provides information about different crops grown by the farmers in the study area during the reference period. Paddy and red gram are the sample crops selected for the present study to assess the pre and post-harvest loss caused by the pests and diseases. These two crops accounted for about three-fourth of the gross cropped area (GCA); paddy with 34.61 per cent and red gram with 40.23 per cent (Table 3.5). Among the farm size groups, marginal and small farmers allocated relatively high proportion of area for the cultivation of paddy mainly to meet the household food security requirements. In fact, paddy occupied about 72.78 per cent of the area under marginal farmer holdings and 53.66 per cent under small farmer holdings. In case of red gram, large farmers allocated about 52.34 per cent and small farmers about 35.5 per cent of the gross cropped area.

Table 3.5. Cropping pattern of selected farmers (% of GCA)

Crop	Marginal	Small	Medium	Large	Total
Paddy	72.78	53.66	46.75	11.77	34.61
Other cereals	2.55	3.56	8.08	14.86	9.81
Red gram	21.51	35.50	28.64	52.34	40.23
Other Pulses	0.91	1.39	4.44	9.20	5.72
Oilseeds	0.68	1.39	1.43	3.89	2.50
Coconut	0.33	1.33	2.79	0.35	1.06
Areca nut	0.91	1.33	2.31	0.17	0.95
Sugarcane	0.33	-	1.94	0.69	0.80
Others	-	1.85	3.61	6.73	4.33
GCA	100.00	100.00	100.00	100.00	100.00

Note: Other cereals-maize, bajra, jowar and wheat; other pulses- black gram, green gram and horse gram; oilseeds- sunflower, soybean and sesamum; others- onion, beans, brinjal, mango and eucalyptus

In the study area, famers have also cultivated other cereals like jowar, bajra, maize and wheat, which altogether constituted about 9.81 per cent. Similarly, apart from red gram, sample farmers have grown other pulses like black gram, green gram and horse gram accounting for 5.72 per cent of the total cropped area. The allocation of area under other cereals and other pulses was higher for large farmers than that of the other farmer groups. A similar pattern can also be observed for oilseeds and other crops. It can be, therefore, argued that large farm household have diversified the crop cultivation with higher allocation of area under non-food crops. For marginal and small farmers, food security remains an important concern in the backdrop of imperfect food markets and high volatility of food prices. As a result, they tend to allocate more area under food grains than commercial crops.

3.6. Area under HYV of Important Crops

Table 3.6. Area under HYV of Important Crops

(% of cropped area)

Crop	Marginal	Small	Medium	Large	Total
Paddy	99.09	100.00	100.00	100.00	99.76
Jowar	62.96	62.62	53.08	81.59	73.56
Red gram	34.20	29.97	24.13	22.65	24.80
Bengal gram	33.33	100.00	43.18	72.41	65.70
Cotton	-	100.00	100.00	100.00	100.00
Sugarcane	100.00	-	100.00	100.00	100.00
Coconut	100.00	100.00	100.00	100.00	100.00
Areca nut	100.00	100.00	100.00	100.00	100.00

The proportion of area under the high yielding variety of different crops indicates extent of the spread of technology, which responds better to use of improved inputs like fertiliser and irrigation. The per cent area under high yielding varieties (HYV) of important crops grown by the sample farmers is given in Table3.6. Among various crops, spread of HYV for coarse cereals and pulses remains low. The area under HYV for jowar was only 73.56 per cent of the total cropped area. There is scope to increase the production of jowar by increasing the area under HYV with required supply of inputs. For

red gram, area under HYV was much lower at 24.8 per cent of total cropped area. Despite introduction of large number of improved varieties of red gram by various agricultural research institutions/universities, the spread of yield improving technology is still low. However, for commercial crops like sugarcane, cotton, coconut and arecanut, spread of HYV technology was 100 per cent across the farm size groups in the study area.

3.7. Crop Productivity, Marketed Surplus and Value of Output

The average yield of major crops cultivated by the sample farmers is provided in Table 3.7. It can be observed that average yield of crops grown in kharif was, generally high for small farmers as compared to other farmer groups. Medium farmer category has registered more or less the second highest yield level for all kharif crops after the small farmers. In fact, overall average yield of kharif paddy was 19.42 quintal per acre with the highest being recorded among the small farmers (20.09 quintal). Similarly, small farmers have registered the average yield of red gram with 3.22 quintal against overall average yield of 2.78 quintal; jowar with 5.24 quintal against overall average of 3.79 quintal; and cotton with 11.67 quintal against overall average of 9.72 quintal.

However, average yield of rabi paddy was relatively high among large famers as compared to other farm categories. In case of bengal gram, average yield was higher for small farmers. Coconut and arecanut have also found place in the cropping pattern of sample farmers. Some sample farmers have also grown sugarcane and black gram during kharif. Overall, these results broadly indicate that small farmers are more productive (in terms of crop yield) than the other farmer categories due to adoption of better agronomic practices and supervision.

Table 3.7. Average yield of major crops grown by the selected households

(Quintal/ acre)

Crop	Marginal	Small	Medium	Large	Total
	Kharif				
Paddy	19.25	20.09	19.26	18.36	19.42
Jowar	3.23	5.24	4.23	3.14	3.79
Red gram	2.83	3.22	2.81	2.29	2.78
Black gram	-	3.00	-	1.60	1.83
Cotton	-	11.67	7.87	10.16	9.72
Sugarcane	10.00	-	27.29	17.17	21.92
	Rabi				
Paddy	18.45	19.60	20.11	22.95	19.23
Bengal gram	2.67	2.97	2.28	1.22	1.97
	Perennial				
Coconut (00' nuts)	16.60	20.63	48.10	8.34	35.16
Areca nut	23.33	27.41	3.04	5.00	14.94

Crop productivity determines the total output produced and quantity available for marketing by the farm households. The output marketed by the sample households are presented in Table 3.8. Rice and jowar were predominantly used for household consumption and for payment of wages in kind in the study area. As a result, average quantity of kharif paddy and kharif jowar marketed by the sample households stood at 85.38 per cent and 66.55 per cent of total production, respectively. There are variations across the farm size groups. Except jowar for small farmer households, quantity of paddy and jowar marketed was relatively high among medium and large farmers. In case of rabi paddy also, amount marketed was higher for large and medium farmers.

A similar pattern of marketing can also be observed for red gram. However, in case of bengal gram, its quantity marketed was higher for small and medium farmers. It was observed in the field that small farmers sell pulses immediately after harvesting due to high open market prices, even though they mostly end up selling at lower prices to traders, for meeting cash requirements. But, later they are forced to buy from market for meeting family consumption at much higher prices. The state government makes

efforts every season to procure pulses at minimum support price, but such operations are often limited to regulated markets, which still remains beyond the reach of marginal and small producers due to small marketable surplus and long distance from villages.

Table 3.8. Percentage of output marketed by the selected households

Particulars	Marginal	Small	Medium	Large	Total
Kharif					
Paddy	81.45	83.83	88.42	87.90	85.38
Jowar	27.78	72.05	55.64	72.56	66.55
Red gram	78.15	89.16	86.91	92.53	89.88
Black gram	-	100	-	97.14	97.26
Cotton	-	100	100	100	100
Sugarcane	100	-	100	100	100
Rabi					
Paddy	84.57	86.33	89.76	93.68	88.24
Bengal gram	75.00	90.24	88.42	77.70	82.56
Perennial					
Coconut	100	36.51	42.84	100	44.71
Areca nut	100	100	100	100	100

Aggregate value of output and value of marketed surplus by farm size groups are given in Table 3.9. It can be observed that value of aggregate output (main and by-product) per household increase with increase in farm size. However, in terms of output per acre, it increased with increase in farm size to a particular level and then it has tapered off. That is, average value of output per acre of marginal holdings was Rs. 13,901, which increased to Rs. 14,469 per acre of small holdings, to Rs. 15,038 per acre of medium holdings and then decreased to Rs. 9,450 per acre of large holdings. These results broadly suggest that there exists a direct relationship between land productivity and farm size up to particular level only.

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

Farm Size	Value of output (main + by-product)		Value of marketed surplus		% of output marketed
	Rs Per household	Rs Per acre	Rs Per household	Rs Per acre	
Marginal	35141	13901	32620	13209	82.57
Small	86070	14469	70216	13800	84.49
Medium	156051	15038	128403	14246	82.90
Large	283128	9450	192529	8663	90.89
Total	101431	12150	86431	11369	85.25

With respect to aggregate value of marketed surplus, a similar pattern as observed in the distribution of aggregate value of output by farm size groups can also be noted. The value of marketed surplus increased from marginal size holdings to medium size holdings and then decreased for large size holdings. The overall marketed surplus for entire sample farm households was Rs. 11,369 per acre. However, there was no distinct pattern evident for per cent output marketed across the farm size categories.

3.8. Summary of the Chapter

Analysis of the socio-economic characteristics of the sample households revealed that large farm holdings have relatively high average household size and more number of income earning family members. A high proportion of large and medium farmer households have family members with educational qualification of graduation and above as compared to marginal and small farmer households. About 36 per cent of the sample households belonged to SC and ST category and a high proportion of them have marginal and small holdings.

The distribution of operational holdings is skewed towards medium and large farmers. The medium farmers and large farmers owned about 7.06 acres and 16.51 acres per household, respectively. Large farmers leased in relatively a high amount of land as compared to other farmer categories. However, per cent net irrigated area was higher for marginal and small

holdings than medium and large farm holdings. As a result, cropping intensity is worked out higher for marginal and small farm households.

Among farm size groups, marginal and small farmers had allocated relatively a high proportion of area for the cultivation of paddy. For red gram, per cent area allocation was high among large farmers followed by small farmers. However, in terms of spread of high yielding varieties, it was low at 24.8 per cent of the cropped area. Average yield of major crops grown by the sample farmers has varied by farm size groups. Nevertheless, yield of major crops was more or less high among small farmers as compared to other groups. Further, relationship between farm size and land productivity is not very clear among the farm size categories.

CHAPTER IV
ASSESSMENT OF PRE HARVEST LOSSES OF REFERENCE CROPS

An important focus of the present study is to assess the pre harvest losses caused by the pests and diseases that affect crop productivity through damaging various parts of crops at different stages of growth. The ill effects of pest infestation on crop performance can be seen in the form of stunted growth, wilting, curling of leaves, damaged stems, reduction in number of ears, low grain filling and discoloration. Pre harvest losses are encountered from planting of crop to maturity for harvest. Assessment of crop losses through a systematic method helps different stakeholders like farmers, extension officials and policy planners to take necessary steps for controlling pests and to prevent economic loss to the country.

It has been often stated that reliable estimates on crop losses caused by pests are not available for effective management and control of pests (Chiarappa et al, 1972; Walker, 1983; IRRI, 1990). In fact, the available estimates are based on the controlled experiments that are conducted at the agricultural research stations through artificial infestation in demarcated plots. These estimates do not reflect the actual field conditions and the intensity of natural infestations in farmers' fields. Therefore, crop loss estimates that are obtained from artificial infestation in controlled experiments cannot be extrapolated over a geographical area (IRRI, 1990; Groote, 2002). On the other hand, estimates obtained directly from the farmers through a systematic survey may reflect the actual field conditions. Although farmers' estimates or perceptions about the yield loss may be subjective, yet they are representative of actual field conditions and hence can be extrapolated over a geographical area. The present chapter discusses the production losses caused by animal pests, pathogens and weeds (collectively called as pests) to selected crops viz., paddy and red gram in the state of Karnataka.

4.1. Constraints Faced in the Cultivation of Paddy and Red Gram

Crop losses are caused by biotic and abiotic factors that constrain the growth of crops and ultimately result in yield loss. While biotic factors include all pests, abiotic factors constitute water, temperature, radiation and nutrients. Excess or lack of abiotic factors and incidence of pests pose constraints to the farmers in achieving higher crop output. In the field survey, farmers were asked to mention the constraints faced in the cultivation of paddy and red gram. Accordingly, five constraints were identified by the sample farmers for the reference crops. These constraints included poor seed quality, water deficiency, pest and disease incidence, high cost of inputs and low output/market price. After identifying the constraints, farmers were asked to rank them in the order of most important, important and least important with a view to understand the severity of constraints faced by them.

Table 4.1. Constraints faced in cultivation of reference crop

(% households)

S. No	Particulars	Paddy				Red gram			
		Most imp	Important	Least imp	Total	Most imp	Important	Least imp	Total
1	Poor seed quality	5.00	6.25	19.38	30.63	1.25	1.88	4.38	7.50
2	Water deficiency	6.25	5.63	13.13	25.00	68.13	10.63	8.75	87.50
3	Pest and disease problems	54.38	28.75	12.50	95.63	20.00	38.75	30.63	89.38
4	High cost of inputs	30.63	45.00	14.38	90.00	8.75	38.13	40.00	86.88
5	Low output price	4.38	13.75	31.25	49.38	0.63	8.13	8.13	16.88

Generally, farmers face more than one constraint in the cultivation of a particular crop. For paddy cultivation, incidence of pests and diseases emerged to be a serious problem with a reporting of 95.63 per cent of the total paddy growing farmers (160) followed by high cost of inputs, which was reported by 90.0 per cent of the total farmers (Table 4.1). While a quarter of the sample farmers reported water deficiency as the constraint, less than a one third of farmers reported poor seed quality affecting the performance of the paddy. In terms of severity of the problem, 54.38 per cent of the farmers reported pest and diseases problems as most important and 28.75 per cent

as important. Similarly, about 30.63 per cent of the farmers reported high cost of inputs as most important constraint in the growing of paddy.

In the cultivation of red gram also, pest and diseases incidence emerged to be a serious problem in the study area. A high proportion of red gram farmers (89.38 per cent) have reported pest and diseases problems as a major constraint affecting the production of red gram. Water deficiency has been reported (87.5 per cent) as the second most serious problem followed by high cost of inputs (86.88 per cent). However, in terms of severity of the constraints, about 68.13 per cent of the sample farmers considered water deficiency as the most important constraint followed by pest and diseases.

4.2. Assessment of Incidence of Pests and Diseases and Crop Losses

Since the present study focuses on pest and disease problem in the cultivation of paddy and red gram, detailed information on occurrence of different pests and diseases, their severity and consequent production losses were collected from the sample farmers. For effective pest control, it is important that farmers should be able to identify and distinguish the symptoms of insect pests and plant pathogens. Although they are collectively called as pests, but nature of infestations of insects (like eating leaves, tunnelling of stems etc) are different from plant pathogens (like discolouration, rotting etc) and hence control methods. Therefore, sample farmers were asked whether they distinguish the symptoms of insect pest attack and plant pathogens. Interestingly, about 97.5 per cent of paddy farmers and 91.9 per cent of red gram could distinguish symptoms of pest and disease attack (Table 4.2). In the farmers' field, severity of pest attack can be assessed by two methods viz., quantitative and qualitative. While quantitative method of pest assessment includes counting insect eggs on plant parts, number of leaves infested etc., qualitative method encompasses visual observation of damage. It can be noted that over three-fourth of the sample farmers growing paddy and red gram used both the quantitative and qualitative methods to assess the severity of attack.

Table 4.2. Identification of pests and disease attack

(% of households)

Description		Paddy	Red gram
HH able to distinguish pests and disease attack		97.5	91.9
Assessment about the severity of the attack	Quantitative assessment	0.0	0.0
	Qualitative assessment	18.1	15.0
	Both	79.4	76.9

Generally, a particular crop is affected by the complex of pests and diseases; that is, more than one insect or disease affect crop and some diseases tend to develop after the infestation by certain insects. The assessment of yield loss should take into account the incidence of all pests and diseases rather than a single pest or disease, which will give rise to underestimate of crop loss. The error in loss occurs due to failure to take account of interactions of pest/disease components that takes place either directly or indirectly leading to change in the population dynamics of insects or pathogens (Kranz, 2005). Further, severity of pest damage varies by variety, season, agronomic practices and stage of crop growth.

In the present study, yield loss due to pests and diseases is estimated as the difference between actual yield and potential yield. Potential yield, also called as attainable yield, is one that can be obtained in the absence of any pests or a no loss scenario. Actual yield is one that is obtained with the application of pest control methods. This definition for the estimation of crop loss caused by the pests has been widely used by the researchers (Walker, 1983; Rola and Pingali, 1993; Groote, 2002; Oerke**,** 2006). To assess the yield/production loss, farmers were first asked to list all the major insect pests, diseases and weeds that affect the performance of paddy and red gram. The production loss, as mentioned by the farmers based on the severity of attack, was recorded in the scale of <5%, 5-10%, 10-25%, 25-50% and >50% against each insect pest, disease and weed. Further, farmers were also asked to indicate actual yield of paddy and red gram by season of cultivation, and then their normal yield that could be obtained in the

absence of major insect pests, diseases and weeds as mentioned by the sample farmers. The sample farmers were also asked to mention the frequency of attack; every season, once in two seasons and once in three seasons by each of these broadly called pests. The type of variety (local or high yielding) of paddy and red gram was also taken into consideration while estimating the crop loss.

Details of severity of attack, frequency of occurrence and production loss due to insect pests, diseases and weeds in paddy cultivation is provided in Table 4.3. It was observed that sample farmers grew mostly high yielding varieties (HYV) of paddy and hence production loss estimates pertained to HYVs only. Farmers have mentioned many insect pests, diseases and weeds that affect the cultivation of paddy in the study area. Among the insect pests, incidence of yellow stem borer was ranked very severe followed by green leaf hopper. In fact, 74.84 per cent of sample farmers considered yellow stem borer as the major pest causing yield loss in paddy followed by green leaf hopper, leaf roller and case worm. Frequency of attack by these insects is also high; they infest paddy every season, kharif and rabi. Consequently, production loss is estimated to be high for these insect pests. Yellow stem borer is the most dreadful insect causing higher level of production loss. About 30 per cent of the sample farmers have reported that this insect cause production loss of over 25 per cent. Green leaf hopper and case worm also cause considerable loss of paddy yield. Other important insect pests that cause considerable yield loss are white fly and gross hopper.

Table 4.3. Incidence of major pests and disease (percentage of households) – paddy

Name of the pest / disease / weed	Rank of severity*				Frequency of attack**			Production loss***				
	1	2	3	Total	1	2	3	1	2	3	4	5
Major Pests - HYV variety												
Yellow Stem Borer	45.28	20.13	9.43	74.84	48.43	25.79	0.63	8.81	15.72	18.87	15.72	15.72
Green Leaf Hopper	19.50	20.75	22.64	62.89	45.91	16.98	0.00	15.09	10.06	16.98	8.81	8.81
Case Worm	9.43	5.03	5.66	20.13	11.95	6.92	0.63	4.40	5.03	2.52	3.77	3.77
Leaf Roller	5.03	11.95	21.38	38.36	20.75	15.09	2.52	8.81	2.52	12.58	6.92	1.89
Grasshopper	1.26	10.06	7.55	18.87	13.21	5.03	0.63	9.43	1.26	1.89	1.26	1.89
Rice Earhead Bug	5.03	5.03	6.29	16.35	9.43	6.29	0.63	3.77	5.03	3.77	0.00	1.26
Shoot Fly	3.14	5.03	4.40	12.58	5.03	6.92	1.26	3.77	0.63	3.14	3.77	1.26
White Fly	4.40	4.40	1.89	10.69	3.14	6.92	0.63	3.14	1.89	1.89	1.26	2.52
Army Worm	1.89	1.89	5.66	9.43	4.40	5.03	0.00	1.26	0.00	2.52	1.89	1.89
Major Diseases – HYV variety												
Blast Disease	60.38	19.50	13.21	93.08	62.89	29.56	0.00	16.35	13.84	18.87	10.06	30.19
Udbatta Disease	8.18	22.01	24.53	54.72	27.67	25.79	1.89	15.72	8.18	10.69	10.06	3.77
Sheath Blight	11.95	10.06	11.95	33.96	18.24	13.84	2.52	6.29	5.66	8.18	5.66	3.14
Brown Leaf spot	2.52	11.32	8.18	22.01	13.84	5.03	3.14	3.14	3.14	5.03	5.66	2.52
Ganaka Roga	3.77	1.89	3.14	8.81	6.29	1.89	0.63	1.26	2.52	1.89	0.00	2.52
Stack Burn Disease	1.26	2.52	5.03	8.81	6.29	2.52	0.00	2.52	0.63	2.52	1.89	0.63
Shoot Rot	0.00	5.03	1.26	6.29	3.14	3.14	0.00	1.26	0.63	2.52	1.26	0.00
Major Weeds – HYV variety												
Water spinach (*soppu)*	20.13	32.08	15.72	67.92	45.28	20.75	1.26	24.53	3.14	6.92	5.03	6.29
Barga	9.43	7.55	4.40	21.38	9.43	9.43	1.89	7.55	1.89	0.63	5.03	2.52
Amaranthus	11.95	4.40	3.77	20.13	10.69	9.43	0.00	8.18	0.00	2.52	0.63	2.52
Pairu	10.06	5.03	1.89	16.98	10.69	5.03	0.00	4.40	1.26	2.52	1.89	2.52
Cynodon	3.14	6.92	6.29	16.35	9.43	4.40	0.63	5.66	0.63	2.52	1.89	0.00
Menthya	3.77	7.55	2.52	13.84	9.43	2.52	0.00	1.89	0.00	1.26	0.63	2.52
Sunti Grass	6.92	3.77	1.89	12.58	2.52	10.06	0.00	1.26	1.89	0.63	2.52	5.03
Kanije	3.77	3.14	5.03	11.95	5.66	5.03	0.63	5.03	0.63	2.52	1.89	0.63
Kayadhada	3.77	5.03	0.63	9.43	8.18	1.26	0.00	3.14	1.89	1.89	0.63	1.89
Jataka	3.77	0.00	3.14	6.92	5.66	1.26	0.00	1.89	0.63	1.26	0.63	1.26
Zed	2.52	1.26	2.52	6.29	4.40	1.89	0.00	1.26	0.00	1.89	0.63	1.26

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

** Every season=1; Once in two seasons=2; Once in three seasons=3

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

As far as paddy diseases are concerned, 93.08 per cent of the sample farmers reported blast as the most serious disease followed by udbatta disease and sheath blight. In terms of severity of attack, about 60.38 per cent farmers considered blast disease as very severe and 19.50 per cent as severe. Although udbatta disease in general, is treated as a minor disease, about 22.01 per cent of the farmers reported it as severe in the study area. Further, a high proportion of sample farmers reported these diseases affecting performance of paddy every season and cause considerable production loss. In fact, over 40 per cent of the sample farmers mentioned that blast disease cause the yield loss of over 25 per cent and as high as 30 per cent of the farmers have indicated over 50 per cent loss. The other diseases that cause considerable yield losses are udbatta disease, sheath blight, brown leaf spot and ganaka disease.

The sample farmers have reported many weeds causing yield loss in paddy. However, extent of yield loss due to weed infestation appears to be low as compared to insect pests and diseases. This may be due to periodical removal of weeds by employing manual labours by the sample farmers. Among the weed species, water spinach (*soppu)* appears to be predominant weed infesting paddy field followed by barga (a broad leaf weed) and amaranthus. A majority of sample farmers reported that water spinach comes up every season in the paddy field causing considerable yield loss.

Detailed information about incidence and frequency of attack, and production loss caused by pests in the cultivation of red gram is provided in Table 4.4. As discussed in Chapter III, only a quarter of total area under red gram occupied high yielding varieties (HYV) and the rest by traditional varieties. Type of variety influences the extent of infestation and damage loss. Local varieties are more susceptible to pests and diseases than HYV. Although local varieties are low yielders, they are hardy and can withstand dry conditions.

Table 4.4. Incidence of major pests and disease (percentage of households) – Red gram

Name of the pest/disease/weed	Rank of severity*				Frequency of attack**			Production loss***				
	1	2	3	Total	1	2	3	1	2	3	4	5
Major Pests – Local variety												
Black headed caterpillar	22.5	26.3	16.3	65.0	52.5	11.3	0.0	1.9	7.5	18.1	17.5	11.3
Green leaf hopper	21.9	8.1	10.6	40.6	38.1	1.9	0.0	1.9	4.4	12.5	6.9	12.5
Red headed caterpillar	0.6	10.0	11.3	21.9	15.0	5.6	0.0	1.3	2.5	8.8	5.0	1.3
Stem borer	4.4	3.8	4.4	12.5	3.8	6.3	1.9	0.6	0.6	1.9	3.1	1.9
Plume Moth	5.0	1.9	5.0	11.9	5.0	6.3	0.6	0.0	1.9	3.1	3.1	1.9
Leaf hopper	1.9	5.6	2.5	10.0	2.5	7.5	0.0	1.9	3.1	3.1	0.0	1.3
Major Pests - HYV												
Black headed caterpillar	2.5	14.4	5.6	22.5	18.8	3.8	0.0	1.3	1.9	7.5	5.0	3.1
Green leaf hopper	13.8	1.3	3.8	18.8	15.6	3.1	0.0	0.6	3.1	5.6	5.0	2.5
Stem borer	6.3	3.1	3.8	13.1	6.3	6.9	0.0	0.6	3.1	3.1	1.3	1.9
Leaf hopper	2.5	4.4	1.9	8.8	0.6	8.1	0.0	0.6	3.1	0.6	0.6	1.3
Major Diseases – Local												
Sterility Mosaic	38.1	25.0	8.8	71.9	55.6	15.6	0.6	3.1	7.5	22.5	9.4	21.3
Wilt	11.3	15.0	11.9	38.1	25.6	11.9	0.6	1.9	3.1	6.3	7.5	10.6
Stem rot	9.4	13.1	17.5	40.0	23.8	14.4	1.3	1.9	7.5	9.4	8.8	5.6
Brown leaf spot	4.4	2.5	1.9	8.8	6.3	1.9	0.0	0.6	1.3	1.9	1.9	1.3
Yellow mosaic disease	1.3	3.8	1.9	6.9	5.6	1.3	0.0	0.6	0.6	1.9	0.6	2.5
Major Diseases – HYV												
Sterility Mosaic	16.3	13.1	5.6	35.0	26.9	8.1	0.0	0.6	5.0	13.8	6.9	4.4
Wilt	5.6	8.8	5.0	19.4	15.6	3.8	0.0	1.3	1.9	5.0	5.0	1.3
Stem rot	1.9	2.5	6.3	10.6	4.4	6.3	0.0	0.0	1.3	3.8	1.3	0.0
Brown leaf spot	4.4	1.9	1.3	7.5	1.3	6.3	0.0	0.6	2.5	1.3	0.6	1.3
Major Weeds – Local variety												
Karige	31.9	16.9	11.3	60.0	30.0	28.1	0.0	1.9	1.3	8.1	6.3	11.9
Simpige	15.6	15.6	8.1	39.4	21.9	16.9	0.6	4.4	0.6	7.5	5.0	1.3
Honi kukka	3.8	9.4	10.0	23.1	13.8	9.4	0.0	2.5	1.9	7.5	1.3	0.6
Egali	5.0	8.1	8.8	21.9	9.4	11.3	0.0	1.9	1.3	5.6	5.0	3.1
Congress grass	1.3	3.8	3.8	8.8	3.1	5.6	0.0	0.0	0.0	3.1	2.5	0.6
Kaighesh	3.1	1.3	4.4	8.8	6.3	2.5	0.0	0.0	0.0	3.8	0.0	0.0
Major Weeds – HYV												
Karige	10.6	6.3	6.9	23.8	13.8	8.8	0.0	0.6	1.9	1.9	0.6	2.5
Simpige	10.6	5.0	1.9	17.5	10.0	7.5	0.0	0.6	0.0	3.8	0.0	1.3
Egali	4.4	5.0	4.4	13.8	5.6	7.5	0.6	0.0	0.6	1.9	1.3	1.3

Note: As above in Table 4.3

The HYVs are characterised by short duration and resistance to certain pests and diseases, whereas traditional/local varieties are of long duration and susceptible to pests and diseases. This in fact, can be observed that farmers reporting occurrence of more number of insects and diseases in the cultivation of local variety than that of HYV of red gram. In the cultivation of local variety, infestation by black headed caterpillar is found to be very serious affecting the yield followed by green leaf hopper and red headed caterpillar. Stem borer is also found to be affecting the yield performance in both local and HYVs of red gram.

In terms of severity of attack, about 22.5 per cent and 21.9 per cent of sample farmers reported black headed caterpillar and green leaf hopper as very severe, respectively. A high proportion of sample farmers have also reported that these insects occur every season causing considerable yield loss. About 28.8 per cent of farmers reported that black headed caterpillar cause yield loss of over 25 per cent. In the cultivation of HYV of red gram also, black headed caterpillar and green leaf hopper are reported to be serious pests affecting its production performance.

With respect to incidence of diseases in local varieties, about 71.9 per cent of the sample farmers mentioned sterility mosaic as a serious problem followed by stem rot and wilt. Among these diseases, severity of sterility mosaic is very high with reporting of 34.4 per cent farmers. This disease also occurs every season in the farmers' field causing considerable yield loss. About 21.3 per cent of the sample farmers mentioned that sterility mosaic causes red gram yield loss of over 50 per cent. The other diseases that cause substantial yield loss are wilt and stem rot. In the cultivation of HYVs, similar diseases that infest local varieties have affected its yield performance. However, extent of yield loss caused by these diseases is found to be lower in HYVs than in local varieties.

Apart from diseases, weeds are also found to be causing considerable yield losses in the cultivation of red gram. Weeds compete with main crop for sharing various inputs/resources like water, nutrients, sunlight and space. The extent of crop loss has varied by local and high yielding varieties with a reported higher loss in the former category. Some of the serious weeds that infest the red gram field are *karige, sampige* and *egali.* Among these weeds, a high proportion of sample farmers reported *karige* causing higher yield loss.

Table 4.5. Magnitude of crop loss due to pests, disease and weed infestation- Paddy

Description	Marginal	Small	Medium	Large	Total
Actual production with attack (quintal/acre)	18.3	19.5	20.1	20.3	19.5
Normal production without attack (quintal/acre)	22.9	22.8	23.3	24.6	23.3
Loss of output (quintal/acre)	4.6	3.3	3.2	4.3	3.8
Percentage loss over actual production	25.0	16.8	16.0	21.1	19.3
Percentage loss over normal production	20.0	14.4	13.8	17.4	16.2

The yield loss reported by the farmers has been converted into aggregate physical loss for better understating the magnitude of loss caused by all pests taken together in the cultivation of reference crops. Table 4.5 provides physical loss of paddy due to pests, diseases and weeds by farm size groups. As discussed elsewhere, production loss has been estimated as the difference between actual yield and normal/potential yield (no loss scenario) expressed as percentage of normal yield. It can be noted that paddy yield loss due to all pests ranged from 13.8 per cent among medium farmers to 20.0 per cent among marginal farmers. Surprisingly, yield loss among marginal farmers is higher even though these farms are supposedly better managed than other farm categories. It has been found through field survey that marginal farmers find difficult to control pests effectively through chemical method due to high cost of pesticides and lack of adequate finance. The overall paddy yield loss is estimated to be 16.2 per cent. However, in terms of actual production, physical loss has been worked out at 19.3 per cent.

Table 4.6. Magnitude of crop loss due to pests, disease and weed infestation- Red gram

Particulars	Marginal	Small	Medium	Large	Total
Local variety					
Actual production with attack (quintal/acre)	2.7	3.1	2.2	2.0	2.2
Normal production without attack (quintal/acre)	4.7	5.2	3.7	3.7	4.0
Loss of output (quintal/acre)	2.1	2.2	1.5	1.7	1.8
Percentage loss over actual production	76.9	70.7	66.5	89.0	80.8
Percentage loss over normal production	43.5	41.4	40.0	47.1	44.7
HYV					
Actual production with attack (quintal/acre)	2.5	3.1	3.0	2.8	2.9
Normal production without attack (quintal/acre)	5.5	4.6	6.1	5.0	5.1
Loss of output (quintal/acre)	3.1	1.4	3.1	2.1	2.2
Percentage loss over actual production	125.1	45.7	103.8	76.4	78.3
Percentage loss over normal production	55.6	31.3	50.9	43.3	43.9

Similarly, aggregate yield loss in red gram due to all pests by variety type and farm size groups was estimated and presented in Table 4.6. As expected, per cent production loss was higher for local varieties than for high yielding varieties of red gram. In fact, yield loss as percentage of normal production was 44.7 for local varieties and 43.9 for high yielding varieties. There are variations in production loss across the farm size groups. For local varieties, per cent loss was higher among large farmers and for HYVs it was higher among the marginal farmers. In terms of actual production, production loss has been estimated as high as 80.8 per cent in local varieties and 78.3 per cent in HYVs. In general, red gram is cultivated in dry lands and marginal lands with little irrigation facilities. The cultivation of red gram is the important source of livelihood of people in dry land areas. Therefore, concerted efforts by scientists, administrators and extension specialists to reduce yield loss will considerably increase the income of the dry land farmers.

4.3. Methods of Pests and Diseases Control Adopted by the Sample Households

Assessment of yield loss due to pests and diseases helps to design appropriate pest control strategies. At the field level, farmers adopt different methods viz., chemical, mechanical and biological methods either individually or in combination to control pests. Among these methods, chemical method has been predominantly used by the sample farmers. The particulars of chemical method used by the farmers to control weeds, insect pests and diseases are provided in Table 4.7.

Table 4.7. Cost of Chemical methods adopted for pests and disease control (Rs/acre)-Paddy

Particulars	Marginal	Small	Medium	Large	Total
% HH adopted control measures	100.00	100.00	100.00	100.00	100.00
Weedicide					
Av. number of Sprays	1.42	1.17	1.26	1.00	1.32
No. of sprays/acre	0.67	0.21	0.15	0.05	0.29
Cost of chemicals	211.20	172.31	236.47	101.10	190.28
Labour charges	186.73	71.66	68.24	42.65	96.14
Total Cost	397.94	243.97	304.71	143.75	286.43
Insecticide					
Av. number of Sprays	1.69	1.88	1.84	2.00	1.78
No. of sprays/acre	0.81	0.41	0.27	0.15	0.43
Cost of chemicals	346.72	262.29	370.17	380.88	336.01
Labour charges	222.61	161.53	105.02	83.82	148.03
Total Cost	569.33	423.82	475.20	464.71	484.05
Fungicide					
Av. number of Sprays	1.58	1.80	2.00	3.00	1.79
No. of sprays/acre	0.31	0.23	0.13	0.09	0.20
Cost of chemicals	134.15	154.74	163.49	124.49	147.08
Labour charges	65.64	85.34	66.85	23.53	64.63
Total Cost	199.79	240.09	230.34	148.01	211.71

Generally, farmers prefer to manually remove weeds in the paddy field as they feel that use of chemicals/weedicide is not effective beyond certain stage of paddy vegetative growth. However, some farmers applied weedicide before transplanting of seedlings in the main field. The average number of spays was about one per farmer household and in terms of per acre, it was

negligible. The cost of chemicals used was relatively high among medium farmers followed by marginal farmers and small farmers. Due to imputation of family labour cost, total cost of weedicide application worked out to be high among the marginal farmers.

Similarly, total cost of application of insecticide to control insects also estimated to be high for marginal farmers, due to high labour cost, followed by medium and large farmers. However, cost of insecticide used was relatively high for large and medium farmers. The overall cost of application of insecticide was Rs. 484.05/acre, which was higher than that of weedicide (Rs. 286.43/acre) and fungicide (Rs. 211.71/acre). Although average number of sprays of insecticide and fungicide per household was more or less equal, high cost of insecticide-chemical has resulted in high cost of its application. Further, infestation of different insects is more frequent in paddy and hence warrants regular spray of insecticide.

Table 4.8. Cost of Chemical methods adopted for pests and disease control (Rs/acre) - Red gram

Particulars	Marginal	Small	Medium	Large	Total
% HH adopted control measures	100.00	100.00	100.00	100.00	100.00
Weedicide					
Av. number of Sprays	1.50	2.33	2.57	2.67	2.12
No. of sprays/acre	0.23	0.09	0.12	0.01	0.06
Cost of chemical	172.02	68.68	148.13	37.50	68.89
Labour charges	58.10	31.25	26.99	2.71	14.73
Total Cost	230.12	99.93	175.11	40.21	83.63
Insecticide					
Av. number of Sprays	2.07	3.06	2.50	2.99	2.71
No. of sprays/acre	1.93	1.32	0.84	0.46	0.76
Cost of chemical	864.37	850.29	856.80	763.60	798.69
Labour charges	562.84	389.84	360.39	162.12	256.02
Total Cost	1427.22	1240.14	1217.19	925.72	1054.71
Fungicide					
Av. number of Sprays	2.27	1.90	2.86	3.00	2.49
No. of sprays/acre	0.38	0.12	0.13	0.05	0.10
Cost of chemical	223.24	140.43	160.75	85.65	115.33
Labour charges	102.45	38.15	21.95	23.40	30.77
Total Cost	325.69	178.58	182.70	109.04	146.09

Details of chemical methods used to control pests and disease in red gram are provided in Table 4.8. It can be observed that all the sample farmers applied chemical method for pest control in red gram. The average number of sprays per household was relatively high for insecticide application as compared to weedicide and fungicide. Further, there is no systematic relationship between cost of chemicals used and farm size groups. Nevertheless, it has been found that cost of chemical and total cost of application including labour charges was high among the marginal farmers when compared to other farm size groups. In fact, total cost of application of weedicide was Rs. 230.12/acre for marginal farmers and the same for small, medium and large farmers were Rs. 99.93/acre, Rs. 175.11/acre and Rs. 40.21/acre, respectively. Similarly, total cost of application of insecticide by the marginal farmers was Rs. 1427.22/acre and for the application of fungicide it was Rs. 325.69/acre. The cost incurred by the marginal farmers to control pests was much higher than the cost incurred by other farm size groups. High cost of chemicals incurred by the marginal farmers may be attributed to input market discrimination and low bargaining power.

Table 4.9. Details of biological methods adopted for pests and disease control

Item		Paddy		Red gram	
		% of HH adopted this method	Details about the method	% of HH adopted this method	Details about the method
Biological methods		18.75	Neem leaf spray and cow dung spray	31.25	Cow dung spray
Other Control measures	Yes	4.375		1.875	
	No	95.625		98.125	

The sample farmers were also asked, apart from chemical method, any other methods of pest control they have followed in the field. About 18.75 per cent of the paddy sample farmers and 31.25 per cent of the red gram farmers have mentioned adopting biological methods of pest control (Table 4.9). Under biological methods, farmers have used bio-pesticides like cow dung spray and neem leaf spray to control pests and diseases in paddy and red

gram. Some farmers have also reported use of mechanical method of cut and destroy the infected plants.

4.4. Sources of Information for Pests and Diseases Control Adopted by the Sample Households

The effectiveness of any method used to control pests and diseases depends on scientific way of applying it; method of application of chemicals- foliar spray or dusting, appropriate placing of chemicals, time of application and dosage of chemicals. Such scientific knowledge should be disseminated to farmers through periodical training and education by extension specialists and development agencies. Therefore, it is important to understand the current sources of knowledge that the sample farmers have access to and ability to use them for effective control of all pests. It is interesting to observe that almost all the sample farmers sought advice from some source for management of pests and diseases in paddy and red gram (Table 4.10).

Table 4.10. Extension services for pests and disease control management

(% households)

Sources of advice	Most important	Important	Least important	Total
Paddy				
Government extension agent	40.6	21.3	25.6	87.5
Private input dealer	26.3	33.1	18.8	78.1
Fellow farmers	26.9	33.8	15.6	76.3
TV/Radio service/Newspaper	3.8	5.6	23.8	33.1
Agricultural University/KVK	1.9	1.3	0.6	3.8
Red gram				
Government extension agent	27.5	17.5	20.6	65.6
Private input dealer	29.4	30.6	20.0	80.0
Fellow farmers	34.4	37.5	11.3	83.1
TV/Radio service/Newspaper	8.8	13.1	25.6	47.5
Agricultural University/KVK	0.0	0.0	1.3	1.3
Percentage of HH seeking advice	Paddy: 99.37		Red gram: 100.0	

In case of paddy, a high proportion of sample farmers (87.5 per cent) relied on government extension agents for seeking advice on controlling pests and diseases. Among them, 40.63 per cent considered extension agents as most important and 21.25 per cent as important source of information. The

second major source of information is the private input dealers, who in the recent years assumed important role in lending credit and in providing technical knowledge to farmers. The fellow farmers emerged as the third major source of information among the sample farmers. About a quarter of sample farmers mentioned private input dealers and fellow farmers as the most important source of advice for pest and disease management in paddy.

For red gram growers, fellow farmers are the major source of information about controlling pest and disease. Among these growers, 34.38 per cent considered the fellow farmers as the most important source and 37.50 per cent as the important source. The private input dealers have emerged as the second major source of advice followed by government extension agents in the third place. Only about 65.63 per cent of sample farmers consulted government extension agents for advice on pest and disease management. Among these farmers, 27.5 per cent considered it as most important and 17.5 as important source of information.

4.5. Household Suggestions to Minimize Pre Harvest Losses

The sample farmer households were solicited suggestions for minimizing the pre harvest losses. Since the loss estimates were worked out based on the estimates provided by the farmers, it was appropriate to ask for suggestions to reduce the losses. Suggestions provided by the farmers are given in Table 4.11. For paddy, sample famers have mostly suggested to use of organic fertilisers and pesticides to control the pests and diseases. Timely identification of incidence of pests helps better management through biological, chemical and mechanical methods. Timely sowing and harvesting of crop has also been suggested to escape from the pest attack. Similar suggestions were given by the red gram growers also. The moisture management in soil emerged to be an important suggestion by the farmers. The sample farmers also mentioned use of organic fertilisers like cow dung and neem spray for controlling pests.

Table 4.11. Household Suggestions to Minimize Pre Harvest Losses

Paddy	Red gram
Use of natural and organic fertilizers and pesticides	Timely use of pesticides and insecticides to control the attack of pests and diseases.
Adequate level of water should be provided for the germination of the crop	There should be a good communication network between Grama panchayat and farmers.
Timely check should be carried out to identify the diseases	More care to be taken with respect to pod borer disease to save the crop.
Cow dung, organic and homemade fertilisers should be used	Provision of water facility should be improved as nearly 75% of land of under red gram gets insufficient rain
Government agents should organise training programme for the farmers to educate them	Subsidy should be given on fertilisers, and the price of these should be controlled
More of bio-products should be used to enhance production.	Timely sowing and harvesting of crop
Usage of natural agricultural manures like neem oil sprays etc. to prevent diseases.	Pest control measures should be taken up timely and good quality seeds and fertilisers should be used
Levelling of land & regular soil testing should be done to enhance the fertility of the soil.	Fertilisers and powders should be used during tilling the land
Proper dosage of fertilisers and pesticides should be taken up in the last 15 days of crop maturity	Rain water harvesting should be done on a large scale to prevent the scarcity of water for cultivation
Provision of good quality weedicides by the Government on subsidised basis	Regular soil testing should be carried out along with changing the cropping pattern in the soil to enhance the nutrient contents of the soil
Timely sowing and harvesting of crop	Usage of DAP, cow dung, organic and natural manures, homemade fertilisers etc.
Timely spray should be given to prevent the crops from the attack of pests and diseases.	Scarcity of labourers and timely availability of fertilisers should be dealt with
Increase the credit availability	Loan facility should be improved

4.6. Summary of the Chapter

Of the constraints faced by the sample famers in the cultivation of paddy, about 96 per cent of them mentioned pest and diseases as the serious problem followed by high cost of inputs and low output price. In terms of severity of the problem, 54.38 per cent reported pest and diseases as most important and 28.75 per cent as important. For red gram, about 89.38 per cent of the sample farmers reported pest and disease incidence as the major

constraint followed by water deficiency (87.5 per cent) and high cost of inputs (86.88 per cent). But, in terms of severity of the problem, a high proportion of the sample farmers considered water deficiency as the most important constraint in the cultivation of red gram followed by pest and diseases.

Among the insect pests that affect paddy, majority of sample farmers ranked incidence of yellow stem very severe followed by green leaf hopper, leaf roller and case worm. These insects affect the crop every season. Yellow stem borer is the most dreadful insect causing yield loss of over 25 per cent as reported by about 30 per cent of the paddy farmers. With respect to paddy diseases, most farmers reported blast as the most serious problem followed by udbatta disease and sheath blight. However, yield loss due to weed infestation is estimated low as compared to insect pests and diseases.

In the cultivation of red gram, infestation by black headed caterpillar is found to be a serious problem affecting its yield followed by green leaf hopper and red headed caterpillar. Stem borer is also seen as an important insect pest affecting the performance of both local and HYV. With respect to disease, most sample farmers reported sterility mosaic as serious problem followed by stem rot and wilt. Infestation by weeds also causes considerable yield loss in red gram. Among different weeds, most farmers reported karige weed causing higher yield loss.

Yield loss reported by insect pest, disease and weeds was converted into aggregate physical loss of production of paddy and red gram. The per cent loss of paddy over actual production was estimated at 19.3 per cent and loss over normal production at 16.2 per cent. For red gram, production loss was estimated at 80.8 per cent in local variety and 78.3 per cent in HYVs. The assessment yield loss helps to design appropriate strategies for controlling insect pests, diseases and weeds. The sample farmers have mostly used chemical method to control the pest damage.

CHAPTER V
ASSESSMENT OF POST HARVEST LOSSES OF REFERENCE CROPS

In the previous Chapter, quantum of pre harvest crop losses due to incidence of different pests and diseases were presented for paddy and red gram. The issues related to cost of pest control and other pest management practices were also discussed. Besides pre harvest losses, farmers also encounter significant proportion of post harvest losses caused by various factors like excess moisture, improper harvesting time, unsuitable harvesting methods, poor mode of transport and unscientific storage practices. Empirically, post harvest losses are estimated from the point of harvesting to marketing of crop produce. It also encompasses the losses occurring during the intermediate processes like threshing, cleaning, packing, transportation and storage. For a holistic understanding the magnitude of crop losses, it is better take into account both the pre harvest and post harvest losses for appropriate policy interventions.

In this chapter, quantity of crop produce lost/wasted has been estimated at different stages of its movement from the point of harvesting in the field to final disposal by the farmers. More specifically, in the present study post harvest crop loss is estimated for harvesting, threshing, winnowing, transportation, handling and storage. The amount of crop loss estimated at all these stages has been added to arrive at the total post harvest loss for paddy and red gram.

5.1. Production Loss during Harvest

Depending up on the availability of resources like irrigation water, labour, financial capital and also weather conditions and market prices, farmers adjust the time of harvesting of the crops. Varietal characteristics also determine the time of crop planting and harvesting, which help to protect against avoidable losses. Accordingly, three different time periods of harvesting of paddy and red gram were captured in the field survey. These

included early harvest (timely harvest), mid harvest (delayed harvest) and late harvest. It has been observed that harvesting loss is varied by different time of harvesting which is generally carried out after the maturity of grains of the standing crops. Another important dimension of causes of harvesting loss is the method of harvesting; manual or mechanical. Harvesting loss by time of harvest and method has been ranked high, medium and low. Quantity of harvesting loss by these dimensions has also been estimated for the reference crops.

Table 5.1. Quantity lost at different stages of harvest: Paddy

Stages of harvest and variety		Early	Mid	Late	Total
Area harvested per household (acres)		5.49	5.32	3.60	5.28
Percentage area harvested (early, mid and late)		10.5	87.4	2.1	100.0
Area manually harvested (%)		17.2	82.8	0.0	100.0
Area mechanically harvested (%)		9.1	88.3	2.6	100.0
Rank of loss (% households)	High	0.0	1.5	0.0	1.3
	Medium	62.5	11.7	0.0	16.4
	Low	37.5	86.9	100.0	82.4
	Total	100.0	100.0	100.0	100.0
Quantity lost during harvest	Kg per acre of harvest	33.2	37.4	41.4	37.1
	Kg per quintal of harvest	1.74	1.92	1.86	1.90
	Loss % of harvest amount	1.74	1.92	1.86	1.90

Quantity of grains lost during harvesting of paddy is presented in Table 5.1. It can be observed that about 87.4 per cent of the sample area under paddy has been harvested during mid period, which is also considered as delayed harvesting. Consequently, grains lost because of delayed harvesting are likely to be high. With regard to method of harvesting, mechanical harvesting through combine harvester is emerging as an important mode during recent years. For the entire sample, about 83 per cent of the total paddy area was harvested through combine harvesting and the rest by manual harvesting. About 82.2 per cent of the manually harvested area and 88.3 per cent of mechanically harvested area fell under mid-period harvesting. The sample sample farmers (1.5 per cent) reported high loss and

86.9 per cent low loss of grains during mid-period harvesting, while 62.5 per cent reported medium loss during early harvesting.

However, quantity of loss across different periods of harvesting assumes importance. It has been estimated a high quantity of grains loss per acre during late harvesting followed by mid harvesting and early harvesting. In fact, amount of grains lost because of late harvesting of paddy has been estimated at 41.4 Kg/acre followed by 37.4 Kg/acre for mid harvesting and 33.2 Kg/acre for early harvesting. In terms of total quantity harvested, harvesting loss was found to be the highest at 1.92 per cent for mid-harvest and lowest at 1.74 per cent for early harvest. These results imply that farmers suffer considerable amount of paddy gains loss due to delayed harvesting, which can be avoided by making them available adequate support facilities like harvesting machines and threshing machines on custom hiring basis.

Table 5.2. Quantity lost at different stages of harvest: Red gram

Stages of harvest and variety		Local				HYV			
		Early	Mid	Late	Total	Early	Mid	Late	Total
Area harvested per household (acres)		12.7	6.7	5.1	6.8	1.3	5.1	3.3	4.7
Percentage area harvested (early, mid and late)		15.6	67.0	17.5	100.0	0.5	86.0	13.5	100.0
Area manually harvested (%)		15.6	67.0	17.5	100.0	0.5	86.0	13.5	100.0
Rank of loss (% households)	High	-	-	-	-	-	-	-	-
	Medium	11.1	1.4	36.0	10.2	0.0	0.0	10.0	1.9
	Low	88.9	98.6	64.0	89.8	100.0	100.0	90.0	98.1
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Quantity lost during harvest	Kg per acre of harvest	9.5	6.8	16.1	8.8	4.8	8.2	11.3	8.8
	Kg per quintal of harvest	4.3	3.0	8.3	4.0	5.5	2.7	6.6	3.1
	Loss % of harvest amount	4.3	3.0	8.3	4.0	5.5	2.7	6.6	3.1

The estimated quantity of red gram lost during harvesting is presented in Table 5.2. The crop loss is provided by variety type; local and high yielding varieties (HYV) and time periods of harvesting. For both the local and HYVs of red gram, a high proportion of area (67 per cent for local and 86 per cent for HYV) has been harvested during the mid period. In the study area,

manual harvesting of red gram was found to be a common practice. Further, none of the sample households ranked high loss by periods of harvesting. However, 36.0 per cent of the sample farmers ranked medium loss for late harvesting of local variety and 10.0 per cent for late harvesting of HYV.

In terms of average quantity of red gram lost, it was estimated almost the same level of 8.8 Kg/acre for local variety and HYV. Similarly, quantity lost during the late harvesting was relatively high for both the types with 16.1 Kg and 11.3 Kg, respectively. The per cent loss in terms of total quantity harvested also worked out high for late harvesting. It was 8.3 per cent for local variety and 6.6 per cent for HYV. Unlike paddy, per cent loss has been estimated low for mid harvesting of local and HYV of red gram in the study area.

5.2. Production Loss during Threshing and Winnowing

After harvesting, threshing and winnowing of grains are important operations. While threshing involves separation of grains from plant, winnowing removes extraneous and other unwanted materials from the threshed grains. The quantity of paddy grains lost during threshing and winnowing is provided in Table 5.3. Under the mechanical harvesting method, three operations namely cutting, threshing and winnowing are combined. The sample farmers were able to provide some estimates of loss separately for these operations carried out under combine harvesting. It can be observed that about 91.30 per cent of the paddy farmers mentioned low loss of grains under mechanical threshing as compared to manual threshing. However, average loss per acre has been estimated slightly higher for mechanical threshing than manual threshing. But, in terms of quantity threshed the average loss is estimated at 1.16 Kg/quintal for mechanical threshing as compared to 1.24 Kg/quintal for manual threshing.

Table 5.3. Quantity lost during threshing and winnowing: Paddy

Stages of harvest and variety		Manual	Mechanical
Area/quantity threshed (% household)		4.02	2.91
Rank of loss (% households)	High	16.67	4.35
	Medium	44.44	4.35
	Low	38.89	91.30
Quantity lost during threshing	Average loss (Kg per acre)	21.92	25.37
	Average loss (Kg per qtl)	1.24	1.16
	Loss % of threshed amount	-	-
Area/quantity manually winnowed (% household)		100.00	100.00
Rank of loss (% household)	High	11.76	
	Medium	35.29	
	Low	52.94	100.00
Quantity lost during winnowing	Average loss (Kg per acre)	20.21	8.33
	Loss % of winnowed amount	1.14	0.46

Similarly, manual winnowing of paddy grains lead to more loss than mechanical winnowing. About 11.76 per cent and 35.29 per cent of the sample farmers ranked high and medium of loss of grains, respectively under manual winnowing. Low loss has been reported under mechanical method. The average amount of grains lost was 20.21 Kg/acre for manual winnowing and 8.33 Kg/acre for mechanical winnowing. In terms of quantity winnowed, respective quantity lost was 1.14 per cent and 0.46 per cent.

For red gram, quantity of grains lost under different methods of threshing and winnowing is provided by variety type in Table 5.4. The estimated quantum of crop loss has varied under manual and mechanical methods for local variety and HYV of red gram. For local variety, mechanical methods used for threshing lead to more loss of grains than manual methods. In contrast, for HYV of red gram, quantity of loss of grains was low under mechanical method as compared to manual method. It is

because of reported high breakage of local variety of red gram under mechanical method of threshing by the farmers.

Table 5.4. Quantity lost during threshing and winnowing: Red gram

Stages of harvest and variety		Local		HYV	
		Manual	Mechanical	Manual	Mechanical
Area/quantity threshed (% household)		6.54	12.53	4.57	7.00
Rank of loss (% households)	High	2.91	0.00	2.00	0.00
	Medium	19.42	40.00	4.00	0.00
	Low	77.67	60.00	94.00	100.00
Quantity lost during threshing	Average loss (Kg per acre)	4.92	5.59	4.42	1.07
	Average loss (Kg per qtl)	2.16	3.59	1.54	0.37
	Loss % of threshed amount	2.16	3.59	1.54	0.37
Area/quantity Mechanically winnowed (% household)		28.00	75.00	17.00	33.00
Rank of loss (% households)	High	10.71	0.00	5.88	0.00
	Medium	7.14	20.00	23.53	6.06
	Low	82.14	80.00	70.59	93.94
Quantity lost during winnowing	Average loss (Kg per acre)	2.76	2.74	4.74	3.17
	Loss % of winnowed amount	1.20	1.25	2.28	1.04

It can be observed from the Table 5.4 that about 40 per cent of the sample farmers have ranked medium of loss of grains under the mechanical method of threshing of local variety. The average loss has been estimated at 2.16 per cent for manual threshing and 3.59 per cent for mechanical threshing. In case of HYV of red gram, average loss of gram is worked out at 1.54 per cent for manual threshing and 0.37 per cent for mechanical threshing. After threshing which involves removal of grains from dried pods, grains are winnowed to remove the unwanted materials. For both the variety types, mechanical winnowing more or less appears to be more efficient than manual winnowing. The average quantity lost under manual and mechanical winnowing was 1.20 per cent and 1.25 per cent, respectively for local variety. The respective figures for HYV were 2.28 per cent and 1.04 per

cent. It is clear from the above analysis that varietal characteristics matter when adopting a particular technology for threshing and winnowing. Therefore, development of suitable technology and making them available at affordable cost will help to reduce crop loss considerably.

5.3. Production Loss during Transportation and Handling

Table 5.5. Quantity lost during transportation and handling: Paddy

Mode of transportation		Head load	Bullock cart	Trolley	Truck	Total
Average quantity transported (qtl per hh)		11.33	32.97	74.67	58.81	53.99
Average distance covered (kms)		2.67	4.14	7.63	9.56	6.06
Transportation cost (Rs per quintal)		22.67	61.11	154.96	142.67	110.09
Rank of loss (% of household)	High	0.00	0.96	0.93	-	0.87
	Medium	0.00	0.96	0.93	23.53	2.60
	Low	100.00	98.08	98.13	76.47	96.54
	Total	100.00	100.00	100.00	100.00	100.00
Quantity lost during transport	Average loss (Kg per qtl of amount transported)	0.38	0.62	0.64	0.80	0.64
	% of amount transported	0.38	0.62	0.64	0.80	0.64
Quantity lost during handling	Average loss (Kg per qtl of amount handled)	0.41	0.31	0.29	0.53	0.31
	% of amount handled	0.41	0.31	0.29	0.53	0.31

Handling and transportation are the important stages, which involve packing and moving of the produce from field to farmers' home or market. Improper handling and bad transportation facilities may lead to considerable loss of grains produced. The sample farmers used five modes of transport viz., head load, bullock cart, trolley, tempo and truck for transporting the produce. Table 5.5 provide details of transportation and handling of paddy. Among other particulars, only distance travelled is reported and not the destination. Among the modes of transportation, average quantity of paddy transported through tractor trolley was relatively high at 74.67 quintal by the sample farmers. The next important mode of transportation was the truck followed by the bullock cart. The sample

farmers have used truck and tractor trolley to carry the produce for longer distance. However, the average cost of transportation was worked out at Rs. 154.96 per quintal for trolley and Rs. 142.67 per quintal for truck.

The reported rank of loss of grains has varied across the modes of transportation by the sample farmers. Some farmers have reported that transportation of paddy grains through bullock cart and trolley leads to high loss. About 23.53 per cent of the sample farmers mentioned medium loss of grains when grains are transported through truck. It is also evident from relatively a high quantity of loss of grains (0.80 Kg/quintal) when trucks are used for transport as compared to other modes of transport. The transportation loss for trolley is estimated at 0.64 Kg and for bullock cart 0.62 Kg. Similarly, handling loss has been worked out high for using truck when compared to other modes of transport.

Table 5.6. Quantity lost during transportation and handling: Red gram

Mode of transportation		Head load	Bullock cart	Trolley	Tempo	Truck	Total
Average quantity transported (qtl per hh)		2.24	5.47	13.26	2.14	3.80	9.85
Average distance covered (kms)		2.32	3.85	8.50	11.43	1.38	6.74
Transportation cost (Rs per quintal)		25.90	33.87	34.89	46.67	21.05	34.60
Rank of loss (% hh)	High	-	-	-	-	-	-
	Medium	9.09	2.86	1.47	0.00	0.00	2.19
	Low	90.91	97.14	98.53	100.00	100.00	97.81
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Quantity lost during transport	Average loss (Kg per qtl of amount transported)		-	-	-	-	-
	% of amount transported	1.99	1.57	0.99	1.20	2.24	1.11
Quantity lost during handling	Average loss (Kg per qtl of amount handled)		-	-	-	-	-
	% of amount handled	1.38	0.71	0.64	0.73	0.95	0.66

For red gram, tractor trolley emerges to be a predominant mode of transportation among the sample farmers (Table 5.6). However, for transporting to long distance especially to government regulated markets

tempo has been widely used by the farmers. The average cost of transport has been worked out high for tempo (Rs. 46.67/quintal) followed by trolley (Rs. 34.89/quintal) and bullock cart (Rs. 33.87/quintal). Interestingly, none of the sample farmers reported high loss of grains across these modes of transport and most of them have mentioned only low loss. However, in terms of average quantity lost through transport, it has been estimated high for truck (2.24 Kg) followed by head load (1.99 Kg) and bullock cart (1.57 Kg). Further, average quantity of red gram lost during handling was high for head load. It can be understood from the above analysis that farmers suffer considerable amount of transportation loss, which can be minimised through provision of better road facilities and construction of markets close to the villages.

5.4. Production Loss during Storage

Generally, farmers store agricultural produce to create time utility. Farmers store the harvested produce for future sale in order to get better price and also for family consumption in case of foodgrains. However, mode of storage and materials used for storing affects the quality and quantity of the produce stored. It can be seen from the Table 5.7 that the sample farmers have used three types of storage structures viz., open space, gunny/plastic bags and kothi/bin (kutcha or pucca) and three types of places or locations viz., kutcha house, pucca house and scientific warehouse for storing of paddy and red gram. In case of paddy, both in kutcha and pucca houses, sample farmers preferred to store in gunny/plastic bags. In fact, out of the total amount of paddy stored in kutcha house and pucca huose, almost 100 per cent and 96.36 per cent of them were stored in gunny/plastic bags, respectively. In pucca house, some farmers stored paddy in open space also. However, in godown about 68.18 per cent of total amount of paddy was stored in kothi/bin and 31.82 per cent in gunny/plastic bags.

Table 5.7. Quantity lost during storage: Paddy

Place of storage		Kutcha	Pucca	Godown
Mode of storage (% of amount stored)	Open	0.00	3.64	0.00
	Gunny/plastic bag	100.00	96.36	31.82
	Kothi/bin kuchha, Pucca	0.00	0.00	68.18
	Steel drums	0.00	0.00	0.00
	Others	0.00	0.00	0.00
	Total	100.00	100.00	100.00
Amount stored (Qtl per hh)		15.54	23.03	55.00
Percentage of hh who dried before storing		4.38	92.50	2.50
Average number of days stored (per hh)		164.00	176.00	17.00
Rank of loss in storage	High	0.00	3.40	0.00
	Medium	28.57	21.77	0.00
	Low	71.43	74.83	100.00
Quantity lost during storage (kg per quintal of storage)	Due to weight loss	0.97	1.31	1.36
	Due to rodents	4.32	1.43	0.91
	Due to fungus	0.37	0.29	0.00
Storage cost Rs. per quintal		66.01	58.66	48.57

Average number of days paddy stored has varied across the places of storage. The sample farmers stored for longer duration of 176 days in pucca house than in kutcha house (164 days) and in godown (17 days). For storing in scientific godown, farmers have to pay some nominal amount. However, storage loss of grains in scientific godown has been ranked low. Some farmers have reported high loss only in pucca house and medium loss in both kutcha house and pucca house. The quantum of storage loss of paddy has been captured as loss due to reduction in weight, loss due to rodent damage and loss due to pathogens (fungus). Storage loss due to reduction in weight has been estimated high in scientific godown as compared to other places of storage. But, storage loss of paddy due to rodents and fungus was relatively high at 4.32 Kg and 0.37 Kg in kutcha house and pucca house, respectively. The storage cost, which comprises cost of handling and chemicals used, has also been worked out high for kutcha house.

Table 5.8. Quantity lost during storage: Red gram

Place of storage		Kutcha	Pucca	Godown
Mode of storage (% of amount stored)	Open	23.91	0.00	0.00
	Gunny/plastic bag	76.09	100.00	100.00
	Kothi/bin kuchha, Pucca	0.00	0.00	0.00
	Steel drums	0.00	0.00	0.00
	Others	0.00	0.00	0.00
	Total	100.00	100.00	100.00
Amount stored (Qtl per hh)		5.00	7.08	1.25
Percentage of hh who dried before storing		3.60	96.40	
Average number of days stored (per hh)		282.14	181.50	291.67
Rank of loss in storage	High	0.00	1.06	0.00
	Medium	0.00	12.70	33.33
	Low	100.00	86.24	66.67
Quantity lost during storage (kg per quintal of storage)	Due to weight loss	3.71	1.49	1.87
	Due to rodents	0.29	0.71	2.40
	Due to fungus	0.20	0.18	0.00
Storage cost Rs. per quintal		58.86	62.73	54.67

In case of red gram, out of total amount stored in kutcha house about 76.09 per cent was kept in gunny/plastic bags and 23.91 per cent in open spaces (Table 5.8). But, in pucca house and in godown, the entire amount was stored in gunny/plastic bags. It has been found that godowns located in regulated markets have been used to store red gram for longer duration of 292 days than kutcha house (282 days) and pucca house (182 days). But, about one-third of the sample farmers ranked medium loss of red gram stored in scientific godown. The estimated storage loss by type has varied across the places of storage. The storage loss due to reduction in weight was high at 3.71Kg in kutcha house followed by godown (1.87 Kg) and pucca house (1.49 Kg). Surprisingly, storage loss due to rodents was estimated to be relatively high in godown. These results broadly suggest that a high proportion of farmers store their produce mostly in home without proper facilities leading considerable amount of loss. It is necessary that scientific storage structures need to be constructed nearby villages and farmers, irrespective size groups should be able to access them at affordable costs.

5.5. Capacity Utilisation of Storage Structures by the Sample Households

Table 5.9. Capacity utilization of storage by the households: Paddy

Mode of storage	Capacity (qtl)	Actual storage (qtl)	Capacity utilization (%)
Kutcha house	53.3	15.7	29.5
Pucca house	85.3	23.1	25.4
Scientific godown	212.5	55.0	25.9
Other			
Total	85.5	23.2	25.5

Capacity utilisation refers to the extent to which the store houses or places are efficiently used by the farmers to store agricultural produce. The capacity utilisation of three types of storage places viz., kutcha house, pucca house and scientific godown has been discussed here. As far as storing of paddy is concerned, while the utilisation of kutcha house has been estimated at 29.5 per cent, capacity utilisation of pucca house and scientific godown was only about 25 per cent (Table 5.9). In case of red gram, capacity utilisation of pucca house by the sample farmers was relatively high at 20 per cent and low for scientific godown (6.3 per cent) and kutcha house (9.0 per cent). The overall capacity utilisation of all storage locations was only 19.3 per cent (Table 5.10).

Table 5.10. Capacity utilization of storage by the households: Red gram

Mode of storage	Capacity (qtls)	Actual storage (qtls)	Capacity utilization (%)
Kutcha house	55.8	5.0	9.0
Pucca house	35.4	7.1	20.0
Scientific godown	19.9	1.3	6.3
Other			
Total	35.9	6.9	19.3

Total harvest and post harvest losses per quintal of paddy and red gram by farm size groups is presented in Table 5.11. Except storage loss, all other type of post harvest losses of paddy has been found high for the marginal farmers. In fact, losses of grains by different types of operations encountered

by marginal farmers are harvesting loss (2.32 Kg), threshing loss (0.48 Kg), winnowing loss (0.16 Kg), transport loss (0.84 Kg) and handling loss (0.42 Kg). Among the farm size groups, post harvest losses are worked out low for large farmers. Unlike marginal farmers, the large farmers have access to improved technology for harvesting, threshing, winnowing and storage, and also to finance for different operations. As a result, different types of post harvest losses and harvest loss encountered by large farmers are relatively low. Total post harvest loss per acre of paddy was the highest for marginal farmers (103.68 Kg) followed by medium farmers (73.19 Kg), small farmers (66.34 Kg) and large farmers (54.13 Kg).

Table 5.11. Total post harvest losses per quintal of paddy by farm size

Particulars	Marginal	Small	Medium	Large	Total
Quantity lost in harvest (kg/qtl)	2.32	1.80	1.99	1.26	1.90
Quantity lost in threshing (kg/qtl)	0.48	0.17	0.11	0.00	0.20
Quantity lost in winnowing (kg/qtl)	0.16	0.12	0.04	0.00	0.08
Quantity lost in transport (kg/qtl)	0.84	0.39	0.55	0.52	0.57
Quantity lost in handling (kg/qtl)	0.42	0.26	0.25	0.17	0.28
Quantity lost in storage (kg/qtl)	3.89	3.90	4.74	2.73	3.83
Total post harvest loss (kg/qtl)	8.11	6.64	7.69	4.68	6.87
Total post harvest loss (kg/acre)*	103.68	66.34	73.19	54.13	76.22

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

A similar pattern for harvest and post harvest losses of red gram encountered by farm size groups can be observed. The harvest and post harvest losses were high for marginal farmers and small farmers as compared to medium farmers and large farmers (Table 5.12). Among the different type of losses, harvesting loss and storage loss have been found to be very high at 3.72 Kg and 11.15 Kg, respectively for the entire sample farmers. Total post harvest loss is estimated at 24.21 Kg/acre. The post harvest losses can generally be avoided through provisioning of adequate infrastructures in the form of better road, threshing floor, scientific ware

houses and locating output markets closer to the villages. To provide such facilities, increase in both public and private investment and quality of such investments are very important.

Table 5.12. Total post harvest losses per quintal of red gram by farm size

Particulars	Marginal	Small	Medium	Large	Total
Quantity lost in harvest (kg/qtl)	5.85	4.14	3.09	3.46	3.72
Quantity lost in threshing (kg/qtl)	2.99	2.03	1.79	1.95	2.02
Quantity lost in winnowing (kg/qtl)	2.18	1.23	1.25	1.09	1.23
Quantity lost in transport (kg/qtl)	1.90	1.35	1.24	0.89	1.11
Quantity lost in handling (kg/qtl)	1.08	0.74	0.66	0.58	0.66
Quantity lost in storage (kg/qtl)	5.47	3.90	2.59	1.86	2.42
Total post harvest loss (kg/qtl)	19.48	13.40	10.62	9.82	11.15
Total post harvest loss (kg/acre)*	43.08	33.62	23.28	20.02	24.21

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

5.6. Quantitative Aspects of Storage and Pest Control Measures Adopted by the Sample Households

Attempts were made to collect detailed information on storage structures and locations within residential/farm premises used by the farmers to store paddy and red gram. Table 5.13 provides some quantitative aspects of storage structures used by the sample farmers. The quantitative information on storage structure captured includes nature of storage structures, physical conditions, cost of storage, maintenance status and storage pest control measures. With regard to roof of storage house, majority of the sample farmers (71.58 per cent for paddy and 52.20 per cent for red gram) have mentioned that it was made of other materials like stone slabs. About 20.22 per cent of paddy farmers and 18.87 per cent of the red gram farmers used asbestos sheet as the roof. Further, about a quarter of red gram farmers' storage house roof was cemented to protect against the weather events and other incidents. It was observed in the field that while some sample farmers had designated area or rooms within their house for storing

agricultural produce, others had stored within house wherever space is available.

Table 5.13: Some qualitative aspects of storage (% households)

Description		Paddy	Red gram
1. Nature of storage structure			
Roof made of	Grass thatched	0.55	1.26
	Crop by product	-	-
	Plastic cover	-	-
	Metal/cemented	7.65	27.67
	Asbestos sheet	20.22	18.87
	Others	71.58	52.2
Walls made of	Burnt bricks/cemented	72.29	49.06
	Woven basket	0.6	
	Mud	27.11	39.62
	Crib	-	-
	Open wall	-	-
	Others		11.32
Floor made of	Concrete	89.1	58.97
	Earth	7.69	9.62
	Woven basket	-	-
	Wooden	-	-
	Others	3.21	31.41
Percentage of households having platform		81.88	79.61
Height of the platform	Less than 6 inches	84.55	88.19
	6-12 inches	13.01	5.51
	Above 12 inches	1.63	
	Others	0.81	6.3
2. Physical condition of storage			
Roof	Leaking root	13.46	23.42
	Good roof	86.54	76.58
Walls	Damaged wall	17.72	21.02
	Good condition walls	82.28	78.98
Guards	Rat guard installed	45.75	39.33
	No rat guards	54.25	60.67
Floor	Cemented good condition roof	85.71	58.87
	Broken floor, mud coming out	14.29	41.13
3. Cost of storage			
The average age of the storage structure (years per household)		28.96178	29.8
Cost of permanent storage e.g. steel drums etc. (Rs per household)		175000	

Table 5.13: Some qualitative aspects of storage (% households) Contd...

Description		Paddy	Red gram
Cost of kutcha or cemented house for storage (Rs. Per household)		54877.7	44191.0
4. Maintenance status – Frequency of repair of grain storage			
Roof	Every year	13.84	14.65
	Every two years	4.40	6.37
	2-5 Years	20.75	13.38
	No maintenance required	61.01	65.61
Walls	Every year	10.69	13.84
	Every two years	5.03	4.4
	2-5 Years	15.09	8.81
	No maintenance required	69.18	72.96
Rat guards	Every year	69.72	45.28
	Every two years	1.41	0.63
	2-5 Years	4.23	0.63
	No maintenance required	24.65	53.46
5. Storage pests control measures			
Sun drying	Monthly	32.43	6.98
	Quarterly	25	59.69
	By-annual	16.89	27.13
	Annual	2.03	0.78
	Never	23.65	5.43
Removal of infested grain from storage and destroying it	Monthly	10.07	1.57
	Quarterly	29.5	27.56
	By-annual	4.32	7.09
	Annual	5.04	3.94
	Never	51.08	59.84
Admixing with ash and plant materials	Monthly	5.07	1.59
	Quarterly	12.32	3.97
	By-annual	13.04	13.49
	Annual	1.45	5.56
	Never	68.12	75.4
Fumigation	Monthly	2.29	1.61
	Quarterly	1.53	0.81
	By-annual	2.29	1.61
	Annual	3.05	95.97
	Never	90.84	
Others	Monthly	1.90	-
	Quarterly	-	1.14
	Bi-annual	-	-
	Annual	-	-
	Never	98.10	98.86

The walls of storage house were mostly made of bricks or cement and mud. About 72.29 per cent of the paddy farmers and 49.06 per cent red gram farmers had brick or cemented walls. Some resource poor farmers had constructed storage room or house with mud walls. Accordingly, these mud walled storage houses had earthen floor, whereas other structures were made of concrete floor. The per cent storage house/rooms with concrete floor has varied for paddy farmers and red gram farmers. The height of the platforms used for keeping the paddy and red gram has also varied. However, about 82 per cent of the paddy farmers and 80 per cent of the red gram farmers used raised platform for keeping the grains in order to protect from moisture, insects and admixing with extraneous materials.

Information on physical conditions of roof, walls, guards (e.g. rat guards) and floor of storage house/rooms were also collected from the sample farmers. Most farmers reported good condition of roof and good condition of walls with respective reporting of 86.54 per cent and 82.28 per cent of paddy farmers, and 76.58 per cent and 78.98 per cent of red gram farmers. Only a less than 50 per cent of the paddy and red gram farmers considered rats as serious problem damaging stored grains, which actually prompted them to install rat guards in the storage house/room. While majority of paddy farmers reported cemented floor with good condition, substantial proportion of red gram farmers reported having mud floor with broken conditions. In fact, the sample red gram farmers largely fell under dry land areas with poor resources and housing conditions. As a result, loss of grains reported to be relatively high for them.

Age of the house or store room affects frequency and cost of maintenance of roof, walls and rat guards. The reported average age of storage structure was about 29 years. While some sample farmers mentioned requirement of maintenance every year or once in 2-5 years, a high proportion reported non-requirement of maintenance of roof and walls. However, rat guards have

to be changed more frequently as they become obsolete and ineffective quickly.

Apart from poor storage structures, infestation of pests on stored grains leads to considerable storage loss. In order to protect the grains from pest infestation, farmers undertake certain operations periodically. These include sun drying, removal of infested grains and destroying them, admixing with ash and plant materials, and fumigation. The sample paddy farmers reported sun drying of grains every month, whereas the red gram reported doing such operation quarterly. About of a quarter of paddy and red gram farmers have mentioned manual removal of infested grains and destroying them so as to prevent infestation to the whole grain lot. Some farmers have also mixed charcoal ash and plant materials with the grains as repellent to insects and pathogens. Red gram farmers have practiced fumigation of store house or room annually mainly to prevent the rodents and storage insects.

5.7. Households Suggestions to Minimize Post Harvest Losses

Similar to suggestions given for effective management of pre harvest losses, sample farmers were asked to provide suggestions to reduce the post harvest losses. The farmer household suggestions for paddy and red gram are provided in Table 5.14. Most paddy farmers mentioned creation of scientific storage structures in rural areas to facilitate farmers to store the grains after the harvest and also help to avoid distress sale. Use of mechanical method for harvesting, threshing and winnowing were suggested to reduce the post harvest losses.

Farmers have also mentioned using of quality bags and pucca store houses to minimize losses. Presently, government charges farmers for storing of paddy in scientific warehouses, but farmers suggested that these facilities should be made available free of cost. Similar suggestions were also made by the sample farmers for reducing the post harvest losses of red gram. Most farmers mentioned that grains should be well dried before storage. Timely

harvest and threshing helps to reduce the grains loss, but for that sufficient number of machinery should be available within the villages for custom hiring.

Table 5.14. Household Suggestions to Minimize Post Harvest Losses

Paddy	Red gram
The crop should be dried properly before storage to avoid fungus formation	The crop should be dried properly before storage to avoid fungus
Mechanical methods should be used for winnowing and harvesting to reduce the losses	Capital intensive machineries should be used to avoid losses due to manual harvesting
Creation of storage facility in rural areas	Provision of Government subsidy for storage
The crop should be timely harvested	Formation of Farmer Union
Timely availability of machinery should be increased	Better storage facilities should be created, especially in rural areas
The cost of storage must be free and should be provided by the Government	Contract farming could be promoted as an alternative to storage facility
The number of scientific godowns should be increased to ensure better storage facilities	Usage of scientific godowns should be increased to prevent losses
Store grains in pucca storage house to avoid loss	Good quality bags should be used
Manual harvesting and winnowing should be avoided	The problem of middlemen should be tackled to avoid distress sale
Good quality gunny bags like tarpaulin should be used to save stored crops from getting spoiled	The crops should be timely harvested to avoid losses, by using more of machinery and less of manual labour
Rat guards, new machinery etc. should be used to protect the crop from rodents	Rodents and DDT should be used to prevent the crops from rats and ants
Wages should be decent to reduce the shortage of labour	Better transportation facility
Better transportation facility would prevent the losses	Maintenance of storage houses is the main concern
Involvement of Krishikala should be encouraged to create awareness among farmers.	Construction of scientific godowns etc. should be taken up by the Government and the same should be made accessible to all
	Organic sprays and burnt fire should be used to avoid infection in crop

5.8. Summary of the Chapter

In this chapter attempt was made to measure the post harvest losses of paddy and red gram in the state of Karnataka. Analysis of data revealed that most farmers harvested paddy in mid-period of harvesting (delayed harvesting) and as a result grains loss was estimated high at 1.92 per cent.

However, paddy grain loss was estimated to be low at 1.74 per cent for early harvesting. Overall, harvesting loss of paddy was worked out at 1.90 per cent of production. The mechanical method of harvesting of paddy is a predominant practice with the coverage of 83 per cent of paddy area. In case of red gram, a high proportion of area under local variety and HYV was harvested during the mid-period. About 36.0 per cent of the red gram farmers reported medium loss for late harvesting of local variety and 10.0 per cent for late harvesting of HYV. Overall estimated loss during harvesting of red gram was 3.1 per cent with highest being recorded for late harvesting.

The sample paddy farmers have mostly used mechanical threshing to separate the grains. While grains loss due to mechanical threshing has been found out at 1.6 per cent, loss due to manual threshing is worked out at 1.24 per cent. Similarly, manual winnowing of paddy leads to more loss than mechanical winnowing. The respective loss due to winnowing is found to be 1.14 per cent and 0.46 per cent. For local variety of red gram, mechanical threshing methods produce more loss of grains than manual methods. But, for HYV mechanical method is found to be more efficient than manual threshing. For winnowing of red gram, mechanical procedure produces relatively less loss of grains.

Among the modes of transportation, average quantity of paddy transported through tractor trolley was relatively high as compared to other means of transport. However, average cost of transportation was high at Rs. 154.96 per quintal for trolley and Rs. 142.67 per quintal for truck. It has been found that about a less than quarter of sample farmers reported medium loss of grains when grains are transported through truck. Similarly, handling loss has also been found to be high for using truck. Overall, the quantity of paddy lost during transport and handling was 0.64 per cent and 0.31 per cent, respectively. For red gram, tractor trolley emerged to be an important mode of transportation with the average cost of Rs. 34.89 per quintal. However, average quantity of grains lost was relatively high for

truck followed by head load and bullock cart. Further, handling loss was high for head load.

Another important dimension of post harvest loss is the storage loss. Storage loss due to reduction in weight has been estimated high for paddy in scientific godown as compared to kutcha house and pucca house. But, storage loss of paddy due to rodents and fungus was relatively high in kutcha house and puccas house. In case of red gram, estimated storage loss due to reduction in weight was the highest in kutcha house followed by godown and pucca house. Overall, the total post harvest loss for paddy was 6.87 Kg per quintal of paddy produced and for red gram it was 11.15 per cent. The post harvest losses are avoidable losses, which can be achieved through provisioning of better road facilities, threshing floor and scientific ware houses.

CHAPTER VI
SUMMARY AND CONCLUSIONS

6.1. Background

Karnataka economy has undergone a significant structural transformation since the introduction of new economic policies in the 1990s. At the macro level, share of agriculture and allied sector has declined from 38.55 per cent in 1980s to 30.29 per cent in 1990s and then to 17.58 per cent in 2000s. The reduction in the share of agriculture is on the anticipated direction with the economy reaching higher growth trajectory over time. However, ideally such growth pattern takes place through transition of agrarian economy to modern industrialised economy and then to development of service sector. But, in India and also in most states including Karnataka the agrarian economic transition has bypassed the development of industrial sector and instead has largely shifted to modern service sector.

The growth performance of agricultural sector is varied and marked with wide fluctuations. The green revolution technology introduced in the late 1960s in the form of new seeds cum chemical fertilisers had helped to increase crop production in the State. This was made possible with higher public investment in agricultural research, education and training, irrigation and other infrastructures. However, the technological gains could not spread evenly across the regions and crops in the state due to diverse agro-climatic conditions and varying natural resources endowments. Use of improved inputs like fertilisers and pesticides also remains low when compared to agriculturally progressive states like Punjab and Haryana.

There were concerns on stagnation in production and productivity of crops during 1980-81 to 1989-90. Despite various efforts made by the state government, stagnation in productivity continued during 1990s in some crops and hence overall performance of agriculture was not so impressive. However, during the recent years agricultural sector has seen turnaround in

growth performance. Agricultural and allied sector has registered the trend growth rate of 4.86 per cent during 2001-02 to 2011-12 as against the all India growth rate of 3.24 per cent during the same period. However, process of agricultural development witnessed since late 1960s has brought many changes in the commodity production. There is a shift in the multi commodity production system to a specialised system, encompassing use of new technology in cultivation practices, intensive application of fertilisers, pesticides and irrigation water. These developments, among others, have entailed increased building up of pest and diseases, and consequent use of higher amount of pesticides to raise the crop productivity. The increased use of pesticides has also resulted in developing resistance by insects and disease, which further led to reduction in crop yield.

As per the available data, crop losses caused by pests and diseases are huge. But, the knowledge on the subject of crop loss at the farm level is very much limited. In fact, the estimation of crop loss due to pests and diseases is a complex subject and it is difficult to assess the loss caused by the individual pest as a particular crop may be infested by the pest complex in the farmers' field conditions. Further, the extent of crop loss depends on the type of variety, stage of crop growth, pest population and weather conditions. The available crop loss estimates are derived from experimental treatment approach, which do not reflect the actual field conditions. Further, these estimates may not be useful for extrapolation over a geographical area. On the other hand, crop loss estimates collected directly from the farmers through sample survey may be reliable and can be used for extrapolation in similar geographical settings. 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. In India, availability of reliable crop loss estimates at different stages of post harvesting is scanty. Both the quantity and quality losses are encountered during harvest and post harvest stages. The present study has

attempted to estimate the pre and post harvest losses in paddy and red gram in Karnataka.

With the above background, the present study has focused on the following objectives.

1. To estimate the physical losses caused by pests and diseases in rice and tur at farm level
2. To examine 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 tur 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 in order to increase national productivity

This study has mainly relied on the data collected through a primary survey of paddy and red gram farmers conducted during 2011-12 in Karnataka. Two major districts (Mysore and Shimoga for paddy; Gulbarga and Bidar for red gram) were selected for each reference crop based on their area share. From each district, one taluk was selected based on the highest share of area under reference crops within the district. The districts and taluks were chosen in such a way that they fall in different agro climatic zones. For rice, sample districts of Mysore and Shimoga fall under Southern Dry Zone and Southern Transition Zone, respectively. For red gram, while Gulbarga falls under North-Eastern Dry Zone, Bidar comes under North-Eastern Transition Zone. From each taluk/district, two villages with one nearby the market/mandi centre and one far off from the market centre were selected for canvassing the household interview schedule. In total, four villages and from each village random sample of 40 farmers were selected. A total sample of 160 farmers surveyed for each crop.

6.2. Summary of Findings

6.2.1. Area, Production, Productivity and Profitability of Selected Crops in Karnataka

During 1971-72 to 1980-81, growth in area and yield of rice was positive, which resulted in the annual production growth of 1.63 per cent. In case of tur, growth in area was impressive with 3.36 per cent and it was statistically significant. Correspondingly, growth in yield of tur was high at 2.19 per cent. A high growth in area and yield has resulted in appreciable growth (5.54 per cent) in production of tur. However, during 1981-82 to 1990-91, growth in yield of tur was negative and significant, which had led to fall in growth of production. Similarly, growth in yield of rice decelerated during this period, which resulted in lower growth in output.

During 1991-92 to 2000-01, most crops had registered positive and statistically significant growth in production. The trend annual growth in rice production was 2.97 per cent and in tur production it was 8.23 per cent. High growth in production was mainly contributed by high growth in yield. Interestingly, this high growth momentum also continued during 2000s. Trend growth in production of tur was high at 9.69 per cent, which was contributed by significant growth in area and yield. Trend growth in rice production was 4.24 per cent, which was mainly contributed by area. Growth in rice yield was not significant as compared to the previous period.

Among the rice growing districts, Raichur accounted for 11.4 per cent of total area and 12.5 per cent of production in TE 2009-10. Raichur, therefore, has emerged to be dominant district in rice cultivation in Karnataka. The other important districts occupying considerable area under rice cultivation during TE 2009-10 are Shimoga (8.9 per cent), Mysore (8.4 per cent), Bellary (8.2 per cent) and Davangere (7.8 per cent). In case of red gram, Gulbarga district alone occupied about 61 per cent of area under tur in Karnataka. The other important districts growing tur are Bijapur (12.3 per cent) and Bidar (10.4 per cent). These three districts had accounted for

about 84 per cent of the total area under tur during TE 2009-10. As far as tur production is concerned, Gulbarga accounted for about 61.6 per cent of the total production in the state. Bidar occupied the second position with14.3 per cent followed by Bijapur (8.1 per cent).

Analysis of input cost structure of paddy showed that human labour accounted for the highest proportion of paid out cost during TE 1985-86 to TE 2009-10. Manure and fertilisers constituted the second highest proportion of paid cost followed by animal labour. Trend in farm business income of rice has fallen continuously from 1980-81 to 1992-93 and thereafter it improved till1996-97 but declined again in the subsequent years. It has been found out that fall in value of output and gradual increase in input costs have led to decline in farm business income of rice.

For red gram, trend in cost share of human labour has declined from 40.2 per cent in TE 1987-88 to 35.6 per cent in TE 2000-01 and then to 23.2 per cent in TE 2009-10. Cost of manure and fertilisers has accounted for the second highest proportion with 24.6 per cent in TE 2009-10. Cost share of pesticide has also showed increasing trend over time. Both the gross value of output and farm business income showed wide fluctuations from 1988-89 onwards. However, increase in value of gross output has led to increase in farm business income of red gram since early 2000s.

6.2.3. Household Characteristics, Cropping Pattern and Production Structure

Of the total sample households chosen for the study, marginal famers accounted for the highest proportion (38.4 per cent) followed by small farmers (26.6 per cent), medium farmers (18.8 per cent) and large farmers (16.3 per cent). The average sample household size was worked at 7.0. Large farmer households found to have more number of family members and also income earning persons. The educational status of the family members has varied with farm size groups. A relatively high percentage of household

members with graduate and above were found among the large farmer and medium farmer categories. Analysis of caste composition of sample households showed that over 50 per cent of the sample households of small, medium and large farmers belonged to general category, whereas the marginal farmers came under SC and ST categories. As far as the family income from all sources concerned, it was the highest for large farmers followed by medium farmers and small farmers.

The distribution of operational holdings is skewed towards medium and large farmers. The medium farmers and large farmers owned about 7.06 acres and 16.51 acres per household, respectively. Large farmers leased in relatively a high amount of land as compared to other farmer categories. However, per cent net irrigated area was higher for marginal and small holdings than medium and large farm holdings. As a result, cropping intensity is worked out higher for marginal and small farm households. Area irrigated through canal water was relatively high for marginal farmers (95.18 per cent), whereas for large farmers it was only 64.69 per cent indicating that resource poor marginal farmers have access to government controlled canal water. However, large farmers have access to capital intensive tube well technology irrigating about 28 per cent of the net cropped area.

Paddy and red gram are the sample crops selected for the present study. These two crops accounted for about three-fourth of the gross cropped area (GCA) of the sample farmers. Marginal farmers and small farmers had allocated relatively a high proportion of area for the cultivation of paddy with 72.78 per cent and 53.66 per cent, respectively. In case of red gram, large farmers allocated about 52.34 per cent and small farmers about 35.5 per cent of the gross cropped area.

Average yield of major crops grown by the sample farmers has varied by farm size groups. Yield of major crops was more or less high among small farmers as compared to other groups. Further, relationship between farm

size and land productivity is not very clear among the farm size categories. The value of aggregate output per household has increased with increase in farm size. However, in terms of output per acre, it increased with increase in farm size to a particular level and then it has tapered off. Similarly, value of marketed surplus increased from marginal size holdings to medium size holdings and then decreased for large size holdings. These results broadly suggest that there exists a direct relationship between land productivity and farm size up to particular level only.

6.2.4. Pre Harvest Loss of the Reference Crops

Crop losses are caused by biotic and abiotic factors that constrain the growth of crops resulting in loss of yield. Among the constraints identified in the cultivation of paddy, incidence of pests and diseases emerged to be a serious problem with a reporting of 95.63 per cent followed by high cost of inputs, which was reported by 90.0 per cent of the sample farmers. While a quarter of the sample farmers reported water deficiency as the constraint, less than one third of farmers reported poor seed quality affecting the performance of the paddy. In terms of severity, a high proportion of sample farmers identified pests and diseases as the most important problem. In the cultivation of red gram also, incidence of pest and diseases emerged to be a serious problem in the study area. Water deficiency has been reported as the second most serious problem followed by high cost of inputs.

Sample farmers were asked whether they could distinguish the symptoms of insect pest attack and plant pathogens. Interestingly, about 97.5 per cent of paddy farmers and 91.9 per cent of red gram growers could distinguish symptoms of pest and disease attack. Further, about three-fourth of the sample farmers growing paddy and red gram used both the quantitative and qualitative methods to assess the severity of attack.

Among the insect pests of paddy, incidence of yellow stem borer was ranked very severe followed by green leaf hopper. In fact, 74.84 per cent of sample

farmers considered yellow stem borer as the major pest causing yield loss in paddy followed by green leaf hopper, leaf roller and case worm. About 30 per cent of the sample farmers have reported that yellow stem borer causes production loss of over 25 per cent. Green leaf hopper and case worm also cause considerable loss of yield. With respect to paddy diseases, 93.08 per cent of the sample farmers reported blast as the most serious disease followed by udbatta disease and sheath blight. In terms of severity of attack, about 60.38 per cent of sample farmers considered blast disease as very severe and 19.50 per cent as severe. In fact, over 40 per cent of the sample farmers mentioned that blast disease caused the yield loss of over 25 per cent and as high as 30 per cent of the farmers have indicated over 50 per cent loss. However, the extent of yield loss due to weed infestation appears to be low as compared to insect pests and diseases.

In the cultivation of local variety of red gram, infestation by black headed caterpillar is found to be very serious affecting the yield followed by green leaf hopper and red headed caterpillar. Stem borer is also found to be affecting the yield performance in both local and HYVs of red gram. In terms of severity of attack, about 22.5 per cent and 21.9 per cent of sample farmers reported black headed caterpillar and green leaf hopper as very severe, respectively. About 28.8 per cent of farmers reported that black headed caterpillar caused yield loss of over 25 per cent. In the cultivation of HYV of red gram also, black headed caterpillar and green leaf hopper reported to be serious pests. On diseases of red gram, about 71.9 per cent of the sample farmers mentioned sterility mosaic as a serious problem followed by stem rot and wilt. A high proportion of sample farmers mentioned that sterility mosaic causes yield loss of over 50 per cent.

Among farm size groups, yield loss of paddy for marginal farmers is found to be high. The overall paddy yield loss is estimated at 16.2 per cent of normal production. However, in terms of actual production, physical loss has been worked out at 19.3 per cent. For red gram, aggregate yield loss of local

varieties was higher than that of high yielding varieties. Yield loss as percentage of normal production was 44.7 for local varieties and 43.9 for high yielding varieties. In terms of actual production, production loss has been estimated as high as 80.8 per cent in local varieties and 78.3 per cent in HYVs.

Among various methods of pest control, chemical method has been predominantly used by the sample farmers. Use of weedicide in paddy field is found to be low with average number of one spray per farmer household and in terms of per acre, it is negligible. The average number of sprays of insecticide and fungicide was about two per household. The total cost of application of chemicals has varied across farm size groups.

The effectiveness of any method used to control pests and diseases depends on scientific way of applying it. In case of paddy, a high proportion of sample farmers (87.5 per cent) relied on government extension agents for seeking advice on controlling pests and diseases. The second major source of information was the private input dealers, who in the recent years assumed important role in lending credit and in providing technical knowledge to farmers. The fellow farmers emerged as the third major source of information among the sample farmers. For red gram growers, fellow farmers are the major source of information about controlling pest and disease. The private input dealers have emerged as the second major source of advice followed by government extension agents in the third place. Analysis shown that the sample farmers largely relied on the informal sources of information for controlling pests and diseases in paddy and red gram.

6.2.5. Post Harvest Losses of the Reference Crops

Post harvest loss is captured through loss during harvesting, threshing, winnowing, transportation and storage. Time of harvest after the crop reaches the maturity affects quantum of loss of grains at different stages of post harvest operations. About 87.4 per cent of the sample area under paddy has been harvested during mid period, which is also considered as delayed harvesting. It has been estimated a high quantity of loss of grains per acre during late harvesting followed by mid harvesting and early harvesting. In terms of total quantity harvested, harvesting loss was found to be the highest at 1.92 per cent for mid-harvest and lowest at 1.74 per cent for early harvest.

For red gram, per cent loss in terms of total quantity harvested was worked out high for late harvesting. For both the local and HYVs of red gram, a high proportion of area has been harvested during the mid period. The per cent loss in terms of total quantity harvested has been estimated high for late harvesting with 8.3 per cent for local variety and 6.6 per cent for HYV.

Under the mechanical harvesting of paddy mainly through combine harvester, three operations namely cutting, threshing and winnowing are combined. About 91.30 per cent of the paddy farmers mentioned low loss of grains under mechanical threshing as compared to manual threshing. In terms of quantity threshed the average loss is estimated at 1.16 Kg/quintal for mechanical threshing as compared to 1.24 Kg/quintal for manual threshing. Similarly, manual winnowing of paddy grains is found to be causing more loss than mechanical winnowing.

For local variety of red gram, mechanical threshing methods produce more loss of grains than manual methods. But, for HYV mechanical threshing is found to be more efficient than manual threshing. The average loss has been estimated at 2.16 per cent for manual threshing and 3.59 per cent for mechanical threshing. In case of HYV of red gram, average loss of gram is

worked out at 1.54 per cent for manual threshing and 0.37 per cent for mechanical threshing. For winnowing of both local variety and HYV of red gram, mechanical procedure produces relatively less loss of grains.

Among the modes of transportation of paddy, average quantity transported through tractor trolley was relatively high followed by truck and bullock cart. The transportation loss for truck has been estimated high at 0.80 Kg/quintal and for trolley it is 0.64 Kg and for bullock cart 0.62 Kg. Similarly, handling loss has been worked out high for using truck when compared to other modes of transport.

For red gram, tractor trolley emerges was a predominant mode of transportation among the sample farmers. In terms of average quantity lost through transport, it has been estimated high for truck (2.24 Kg) followed by head load (1.99 Kg) and bullock cart (1.57 Kg). Further, average quantity of red gram lost during handling was high when transported through head load.

The type of storage structures and location of storage used has varied by farm size groups and crops. Out of the total amount of paddy stored in kutcha house and pucca huose, almost 100 per cent and 96.36 per cent of them were stored in gunny/plastic bags, respectively. In godown about 68.18 per cent of total amount of paddy was stored in kothi/bin and 31.82 per cent in gunny/plastic bags. Storage loss due to reduction in weight has been estimated high in scientific godown as compared to other places of storage. But, storage loss of paddy due to rodents and fungus was relatively high at 4.32 Kg and 0.37 Kg in kutcha house and pucca house, respectively.

In case of red gram, out of total amount stored in kutcha house about 76.09 per cent was kept in gunny/plastic bags and 23.91 per cent in open spaces. But, in pucca house and in godown, the entire amount was stored in gunny/plastic bags. The storage loss due to reduction in weight was high at

3.71Kg in kutcha house followed by godown (1.87 Kg) and pucca house (1.49 Kg). Surprisingly, storage loss due to rodents was estimated relatively high in godown as compared to other storage types. It was found through field survey that farmers store red gram in godowns located in regulated markets, where these godowns were reportedly not maintained well. For the entire sample of paddy farmers, total post harvest loss is estimated at 6.87 Kg/quintal of production. For red gram, total post harvest is worked out at 11.15 Kg/quintal of production.

6.3. Conclusions

Based on the analysis of data and summary of findings, the following conclusions have been drawn.

(i). Among the constraints faced in the cultivation of paddy, about 54.38 per cent and 30.63 per cent of the sample farmers reported incidence of pest and diseases, and high cost of inputs, respectively as the most important problem affecting yield performance. In the cultivation of red gram, 89.38 per cent reported incidence of pests and diseases, and 87.5 per cent considered water deficiency as the major constraints.

(ii). Most sample farmers ranked incidence of yellow stem borer in paddy as very severe followed by green leaf hopper. About 30 per cent of the farmers reported that yellow stem borer caused production loss of over 25 per cent. In case of disease, 93.08 per cent of the sample farmers reported blast as the most serious problem followed by udbatta disease and sheath blight. In fact, over 40 per cent of the sample farmers mentioned that blast disease cause the yield loss of over 25 per cent and as high as 30 per cent of the farmers have indicated over 50 per cent loss. However, extent of yield loss due to weed infestation is low.

(iii). In the cultivation of local varieties of red gram, about 22.5 per cent and 21.9 per cent of sample farmers reported severe infestation by black headed

caterpillar and green leaf hopper, respectively. About 28.8 per cent of farmers reported that black headed caterpillar cause yield loss of over 25 per cent. For HYV, black headed caterpillar and green leaf hopper are reported to be serious pests. On diseases of red gram, about 71.9 per cent of the sample farmers mentioned sterility mosaic as a serious problem followed by stem rot and wilt. Sterility mosaic causes yield loss of over 50 per cent.

(iv). Overall yield loss of paddy due to all pests, diseases and weeds is estimated at 16.2 per cent of normal production. Yield loss appears to be high among marginal farmers. For red gram, overall yield loss of local variety is 44.7 per cent and that of HYV is 43.9 per cent.

(v). Among different sources of information, 87.5 per cent of paddy sample farmers relied on government extension agents followed by private input dealers (78.1 per cent) for seeking advice on controlling pests and diseases. For red gram growers, fellow farmers (83.1 per cent) emerged to be a major source of information followed by private input dealers (80.0 per cent).

(vi). Overall harvesting loss of paddy is estimated at 1.9 per cent, which is found to be relatively high among the marginal farmers (2.32 per cent). Grain loss during threshing and winnowing is worked out at 0.28 per cent. Loss of paddy during transportation and handling is found to be high among the marginal farmers. The respective overall loss is 0.57 per cent and 0.28 per cent. The storage loss is estimated at 3.83 per cent, which is relatively high for medium farmers.

(vii). Total post harvest loss of paddy is estimated at 6.87 per cent, which can potentially be avoided through efficient management. Post harvest loss is found be the highest for marginal farmers with 8.11 per cent followed by medium farmers (7.69 per cent) and small farmers (6.64 per cent).

(viii). Harvesting loss of red gram is found to be 3.72 per cent, which is much higher at 5.85 per cent for marginal farmers. Loss during threshing, winnowing, transport, handling and storage is also found to be high for marginal farmers. Next to harvesting loss (3.72 per cent), a significant proportion of red gram is wasted during threshing and storage with 2.02 per cent and 2.42 per cent, respectively.

(ix). Overall post harvest loss of red gram is estimated at 11.15 per cent, which is relatively high among the marginal farmers with 19.48 per cent. Post harvest loss for small farmers has been worked out at 13.40 per cent, for medium farmers at 10.62 per cent and for large farmers at 9.82 per cent.

6.4. Policy Recommendations

(i). Amount of pre and post harvest losses caused by biotic and abiotic factors is found to be substantial. These are avoidable losses, which actually amounts to the quantity of grains saved for the economy. In order to reduce these losses, scientific knowledge on cultivation practices and post harvest operations need to be imparted to the farmers. For this, advantages of information and communication technology (ICT) should be tapped to provide practical advice for control of insect pests, diseases and weeds.

(ii). Pests and diseases occur in a complex way affecting the crop yield performance. Infestation of weeds along with insect pests and diseases compounds further the pest control strategy. However, evidences show that adoption of integrated pest and disease management practices is promising for control of pests. Therefore, an integrated approach, which at present is lacking, needs to be promoted for effective control of pests.

(iii). Rural infrastructure will play an important role in reducing avoidable post harvest losses. However, most surveyed villages lacked basic agricultural infrastructure facilities like threshing floor, drying yard, proper

roads and warehouses. Government regulated markets are located far away from villages, which ranged from 12 Km to 25 Km in the study areas. Therefore, there is a need to step up not only the amount of public and private investment in building rural agricultural infrastructure, but also quality of such investments.

(iv). Mechanisation of different agricultural operations is progressing faster for timely completion of works and also for overcoming the labour shortages. But, timely availability of agricultural machineries and implements is crucial to avoid delay in operations and also reduce losses of grains at post harvest stages. Therefore, local bodies like grama panchayats should be facilitated to own and hire out the machineries to the village farmers.

(v). Reliable database on crop loss estimates helps to make proper planning for monitoring and controlling of pests in different crops. Therefore, it is necessary that all the available published estimates should be compiled and published regularly for use by different stakeholders.

REFERENCES

Deshpande, R. S (2004). "Agricultural Development of Karnataka: Promises to Keep", *Research Report,* Agricultural Development and Rural Transformation Centre (ADRTC), ISEC, Bangalore.

Dhaliwal, G.S. and Ramesh Arora (1994). *Trends in Agricultural Insect Pest Management,* Commonwealth Publishers, New Delhi.

Dhaliwal, G.S., Vikas Jindal and A. K. Dhawan (2010). "Insect Pest Problems and Crop Losses: Changing Trends", *Indian Journal of Ecology,* 37(1): 1-7.

FAO, Food and Agricultural Organisation (FAO), Research and development issues in grain postharvest problems in Asia; www.fao.org/wairdocs/x5002e/X5002e02.htm

Government of India (2007). *Karnataka Development Report,* Planning Commission, Government of India, Academic Foundation, New Delhi.

Government of Karnataka (2013). *Economic Survey-2012-13i,* Planning, Programme Monitoring and Statistics Department, Government of Karnataka, Bangalore.

Groote, Hugo De (2002). "Maize Yield Losses from Stemborers in Kenya", *Insect Science and its Application,* 22(2): 89-96.

IRRI (1990). *Crop Loss Assessment in Rice,* International Rice Research Institute (IRRI), Philippines.

Kannan, Elumalai (2010). "Determinants of Stagnation in Productivity of Important Crops in Karnataka", *Research Report: IX/ADRTC/127*, Agricultural Development and Rural Transformation Centre (ADRTC), Institute for Social and Economic Change (ISEC), Bangalore.

Kranz, J (2005). "Interactions in Pest Complexes and Their Effects on Yield", *Journal of Plant Diseases and Protection,* 112(4): 366-385.

Muralidharan, K and I. C. Pasalu (2006). "Assessments of Crop Losses in Rice Ecosystems due to Stem Borer Damage (Lepidoptera: Pyralidae)", *Crop Protection,* 25: 409-417.

Muralidharan, K., D. Krishnaveni, N.V.L. Rajeswari and A. S. R. Prasad (2003). "Tungro Epidemics and Yield Losses in Paddy Fields in India", *Current Science,* 85(8): 1143-1147.

Nair, M. R. G. K. (1975). *Insects and Mites of Crops in India,* Indian Council of Agricultural Research, New Delhi.

Oerke, E C (2006). "Crop Losses to Pests", *Journal of Agricultural Science,* 144: 31-43.

Oerke, E C (2007). "Crop Losses to Animal Pests, Plant Pathogens, and Weeds", In: David Pimental (ed.), *Encyclopaedia of Pest Management,* 116-120, CRC Press, USA.

Rajarajeswari, N. V.L. and K. Muralidharan (2006). "Estimates of Farm Yield Yields and District Production Loss from Blast Epidemics", *Journal of Mycology and Plant Pathology,* 36(2): 115-124.

Rajarajeswari, N. V.L., C. Dinaker and K. Muralidharan (2004). "Assessing Injury to Grain Filling and Yield Losses from Tungro Virus Epidemics", *Indian Journal of Plant Protection,* 32(1): 73-79.

Reddy, K.V.S and Usha B. Zehr (2001). "Novel Strategies for Overcoming Pests and Diseases in India" In: *New Directions for a Diverse Planet*, proceedings of the 4th International Crop Science Congress, 26-1October 2004, Brisbane, Australia.

Rola, Agnes C and P L Pingali (1993). *Pesticides, Rice Productivity and Farmers' Health: An Economic Assessment*, International Rice Research Institute (IRRI), Philippines and World Resources Institute, USA.

Shukla, B.D. and R.T. Patil (1999). 'Overview of grain drying and storage problems in India' in World Bank Report, "Post-harvest Management, Fight Hunger with FAO, India Grains", March 2002, 4(3).

Siddiq, E.A., "Bridging the Rice Yield Gap in India", Food and Agriculture Organisation,

Walker, P T (1983). "Crop Losses: The Need to Quantify the Effects of Pests, Diseases and Weeds on Agricultural Production", *Agriculture, Ecosystems and Environment*, 9: 119-158.