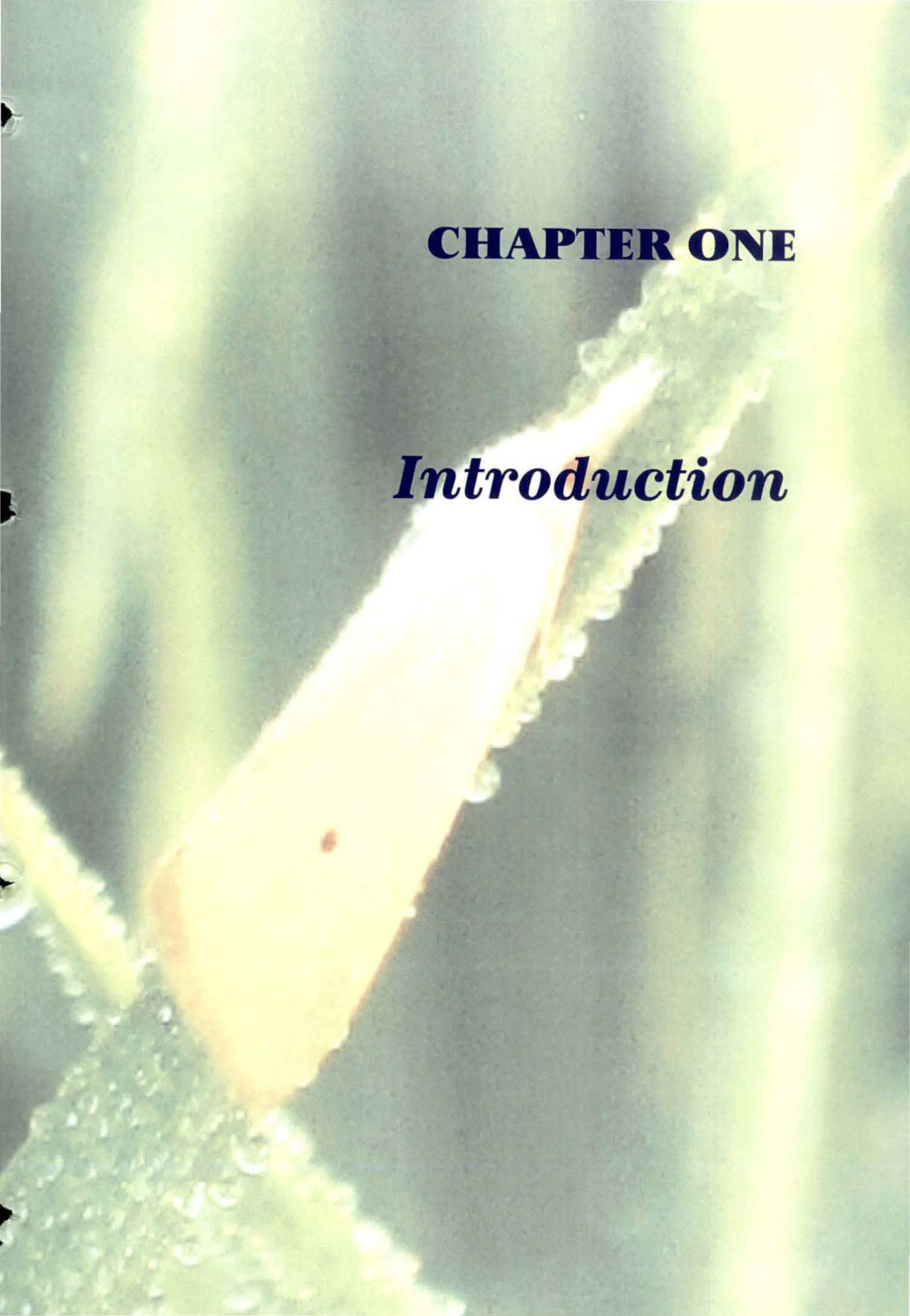


CHAPTER ONE

Introduction

Agriculture occupies a pride of place in the Indian economy contributing a little less than 34 % of national income. About 64.3 % of the working people depend upon agriculture and share 50% of India's export. Food crops constitute a major part in Indian agriculture covering an area of about 75 % of the total cropped area and contribute to about 50 % of the total value of agricultural production. India is the second largest producer of paddy. It has about 28 % of the world's area under paddy cultivation which covers 37 % of the cultivated area in consideration of all kinds of cereals in India (Lenka 1998).

The green revolution has been ascribed as chain reaction (Over 1979), accelerating technological innovations and thereby introducing unforeseen problems (Havens *et al.* 1973). Such intensification is defined as "an increase in resources devoted to rice cultivation" (Loevinsohn 1987). Production increase came from more area planted with rice (32%), from irrigation and double cropping (25%), from fertilizers (22%), and from the inherent higher yielding quality of modern varieties (21%) (Pingali and Garpacio 1997). Increased use of machinery and pesticides are other contributing factors for improved rice productivity.

Intensive rice monoculture systems popularized by the green revolution have created an environment that is conducive to insect pest growth (Pingali and Garpacio 1997). Promoting the widespread and indiscriminate use of insecticides and introducing a limited number of rice varieties for use on a very large scale and replacing the diverse array of varieties grown previously are the major factors responsible for the rapid multiplication of rice pests and diseases. **The deep realization of such situation was evoked by the declaration of the 'International Rice Year 2004' for 'sustainable bio-friendly grain production' by improved cultural practices.**

The rice (paddy), *Oryza spp*, of the grassy family Gramineae, is extensively cultivated in humid and warmer climates, especially in the Eastern part of Asia. The word *'Ouliz'* of the *'Ningpo'* dialect of old Chinese language became '*Oruz*' in Arabic and '*Oryza*' in Greek languages, and became

'*Ritz*' and subsequently rice (Grist 1965, Oka 1988). Some are of the opinion that the word rice is a derived offshoot from the Tamil word '*Arisi*'.

The genus *Oryza* contains about 23 species, out of which two species are domesticated, namely, *Oryza sativa* native to Asia and *Oryza glaberima* native to Africa (Vaughan 1994). Oryza *sativa* has evolved into three races, *Indica, Japonica* and *Javanica* having a wider adaptability and grows from North Korea to South America and from sea level to the elevation of about 2,600 meter. (Jumla, Nepal)(Takahashi 1984, Scott *et al.* 2003).

Presently the two major rice varieties grown world wide are *Oryza sativa indica* and *Oryza sativa japonica.* The beginning of rice domestication in India is not yet definitely known, and hence remains a matter of conjecture. It seems to have appeared around 1400 B.C. in southern parts of India after its full domestication in the northern plains of Indian subcontinent in around 2000 B.C. (Yoshida 1981, Morishima 2003).

Rice provides about 80% and 33% caloric intake of two billion Asians and one billion people of Africa and Latin America respectively (Chang 1984). Asia leads the world in paddy production accounting 90% of worlds' paddy supply. Among the Asian countries, China tops the list accounting 36% of the worlds' production and India ranked second producing about 20% (Misra 2004). The share of other countries are Indonesia 6%, Bangladesh 5%, Japan 5%, Thailand 4%, Vietnam 3%, Burma 3%, Brazil 2%, South Korea 2%, Philippines 2%, USA 1% and Pakistan 1%. Considering productivity, China (4407 Kg/ha) is next to USA (6788 Kg/ha) which is far above the world average rate (3033 Kg / ha). India ranks 7th (1986 Kg /ha) (Gulati *et al.* 1990) (Fig.1.1).

The prominent zone of paddy cultivation is particularly restricted to the south East Asia. The world wide production of rice is 596.5 million tones with an average productivity level of 3.8 ton/ ha (FAO data base 2000). About 95% of the world's total rice is produced in developing countries and 92% of it is in Asia with productivity level of 3.9 ton/ha. Of the 147.5 million hectare of land devoted to rice cultivation world wide, Asia accounts for 90% (132.1 million hectare) (Fig.1.2).

Among the prominent five agro ecological zones (AEZ) of India, rice is mainly cultivated under AEZ1 (worm and semiarid), AEZ2 (warm sub humid) and AEZ6 (warm sub humid with summer rainfall). Rice as prime cereal food grain of this country and constitutes 44.87% of the total cereal production and is grown in about 44.6 million hectares of which 24.6 m.ha comes rain-fed land having a diversified moisture regimes and different ecological situations, like rain fed upland (7.1 m.ha) favourable low land (10.0 m.ha) unfavorable low land (6.0 m.ha) and deep water ecosystem. The productivity in the irrigated ecosystem ranges from 2.3 ton / ha to 3.5 ton / ha, while rain-fed ecologies of shallow lowland, deep water and upland register average productivities of 1.6, 1.0, and 0.5 ton / ha respectively and require high doses of pesticidal protection (Agricultural Statistics at a glance, 2000. Agricultural Statistic Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India).

West Bengal leads top among the states of India both in production (15.26 mt) and productivity (2414 kg/ha) which is increasing rapidly (Figs.1.3a and b).The next states are Uttar Pradesh (2120 kg/ha) and Andhra Pradesh (2978 kg/ ha). West Bengal contributes to 15% of the country's total production having only 2.7% of India's geographical area. In West Bengal rice is grown in diverse agro-ecological situations. There are three distinct rice growing season, viz, *aus* / autumn rice (March to July in Northern parts of Bengal and May to October in South parts of Bengal), *amon* / winter rice (June to December) and *boro* / summer rice (December to May). (Statistical Hand Book of Agriculture, Bureau of Applied Economics and Statistics, Govt. of West Bengal).

Studies by Saha and Swaminathamn (1994) and Rawal and Swaminatham (1998) are the opinion that the rapid growth of paddy cultivation in West Bengal brought about primarily by an expansion in the irrigated *boro* (Summer) crop, extensive use of HYV's of seeds, adoption of new cultivation techniques, application of both newly evolved chemical pesticides and fertilizers.

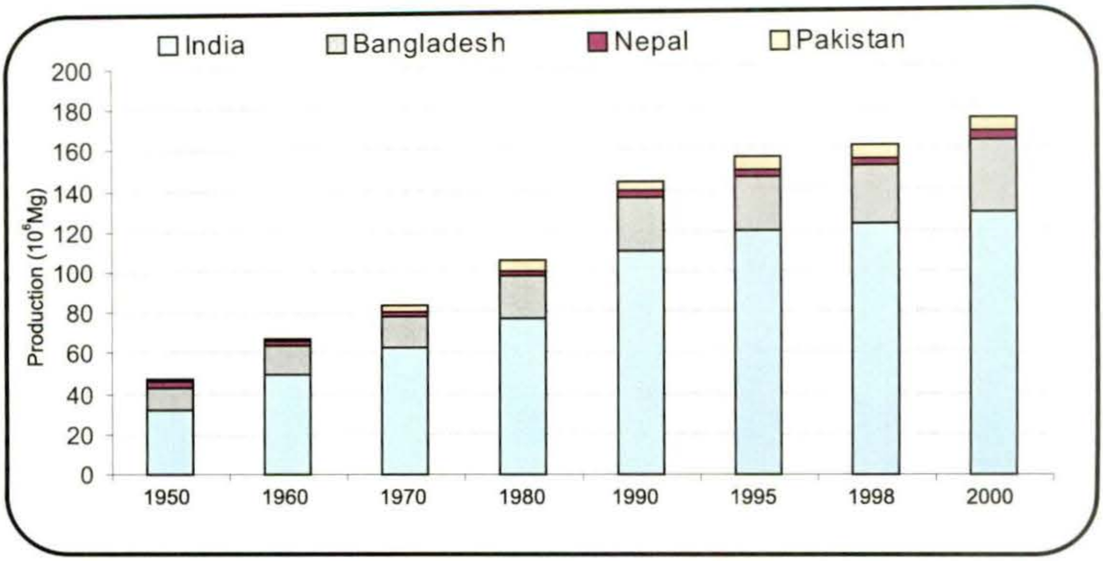


Fig. 1.1: Trends in rice production in South Asia (1950-2000). (Based on data from Pingali *et al.* 1999).

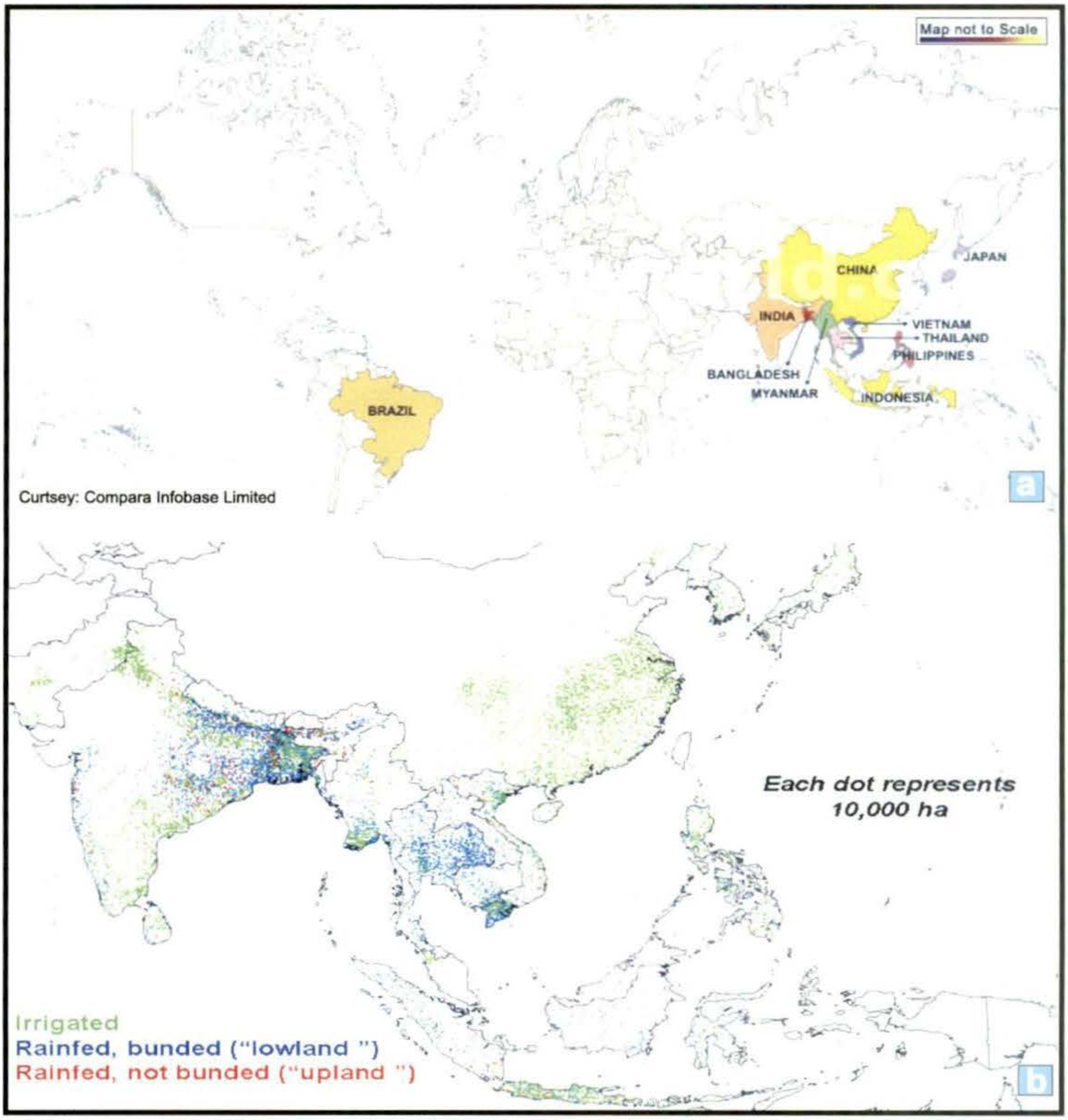
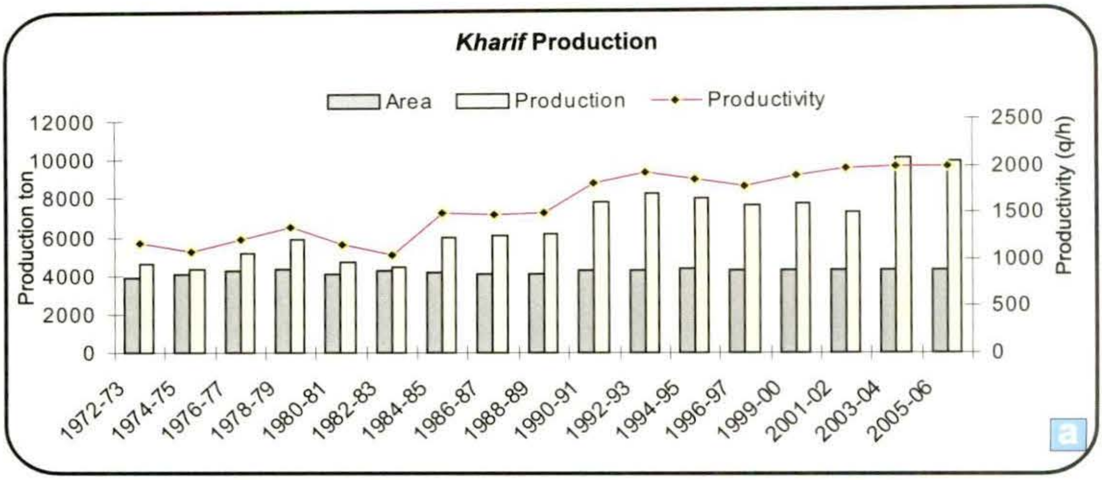


Fig. 1.2: Major paddy producing areas of the a: world and b: India.



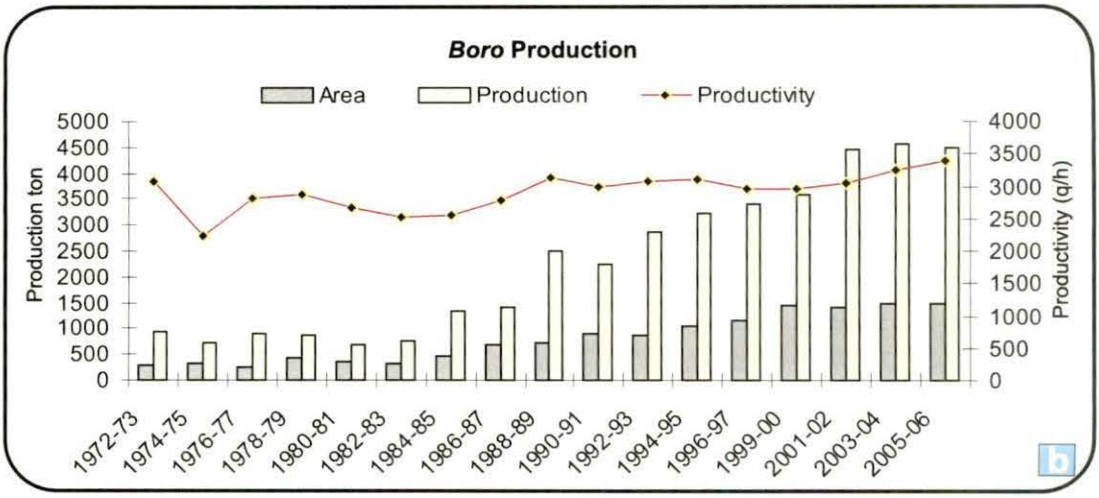
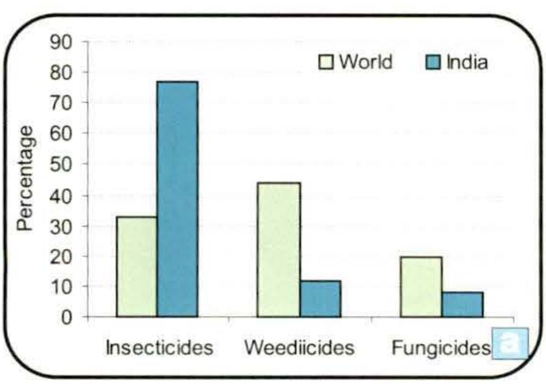


Fig. 1.3: Trends in rice production in West Bengal. Best on data from statistical Hand Book of Agriculture, Bureau of Applied Economic and Statistics, Govt. of West Bengal 2004. Annual progress report: Eastern India Rain-fed Shuttle Breeding progamme, RRI Chinsurah, W.B. 2002.



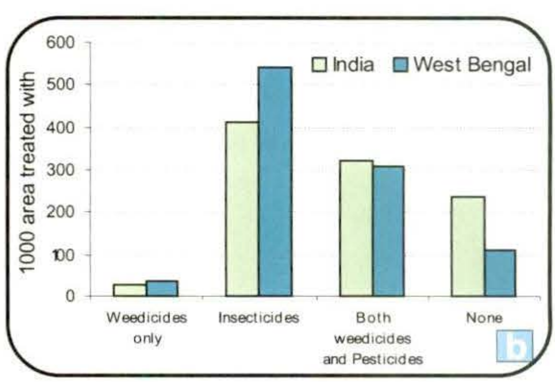


Fig. 1.4: Relative application of different types of pesticides in paddy field. a: Application of pesticide in agriculture fields in the World and India (based on FAO report 2002), b: In India and West Bengal during *kharif* season (based on data of National Survey Organization, Department of Statistics and Pogramme Implementation, Govt. Of India 2002).

Mukherjee *et al.* (1996) and Pillai *et al.* (2001) also share the same opinion. It is found that the farmers have an ever increasing trends in the adoption of HYV's during 1986-1987 (52% in *amon* and 24% *boro* season) to 1991 - 1992 (62% in *amom* and 72% in *boro* season). Such activities necessitates the requirement of newer brands of pesticides and fertilizers making a dynamic change in the insect pest complexities (Bramble 1989).

Observation on the relative application of different types of pesticides throughout the world by David (1992) shows a higher tendency of application of insecticides in India than the average value of the world in general. Study on the proportional application of different types of pesticides in paddy field throughout the country shows that in West Bengal, insecticide application was far above the national level. Rate of application is much higher in *kharif* season than in the *boro* season. Such observation is also supported by the contemporary reports published by Govt. of India (Figs.1.4a and b).

Statistically, in West Bengal the District Uttar Dinajpur ranks 13th in terms of rice production having an average productivity of 1995 kg / ha. Among the nine administrative blocks of this District the three adjoining blocks namely Raiganj, Hemtabad and Itahar offer a diversified cropping zones, both irrigated and rain fed, high and low lands with varied agro-ecological conditions for both local and high yielding varieties (HYV's) production (Figs.1.5a and b) (Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal, 2001).

The agro ecological situation (humidity 64.30 - 98.31% and maximum and minimum temperature 19.7 and 27.9 respectively) and socio-economic background (36% small farmer and 58% marginal farmers) of this region constitute a congenial environment for paddy cultivation on a commercial scale. In view of the improving irrigation technology, a declining rate of cultivation of autumn rice in lieu of HYV's and jute cultivation was noticed in the northern districts of West Bengal inclusive of the District of Uttar Dinajpur (Pal *et al.*1980).

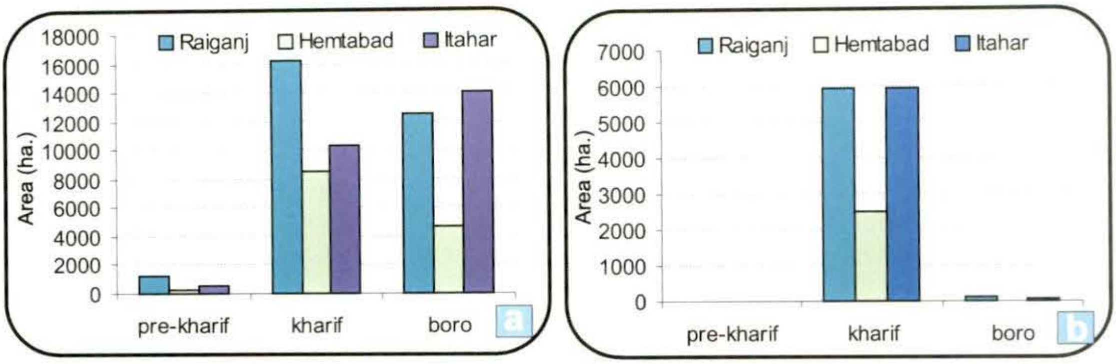


Fig. 1.5: Relative adoption of varieties in the three block in three seasons a: High yielding, b: Local.

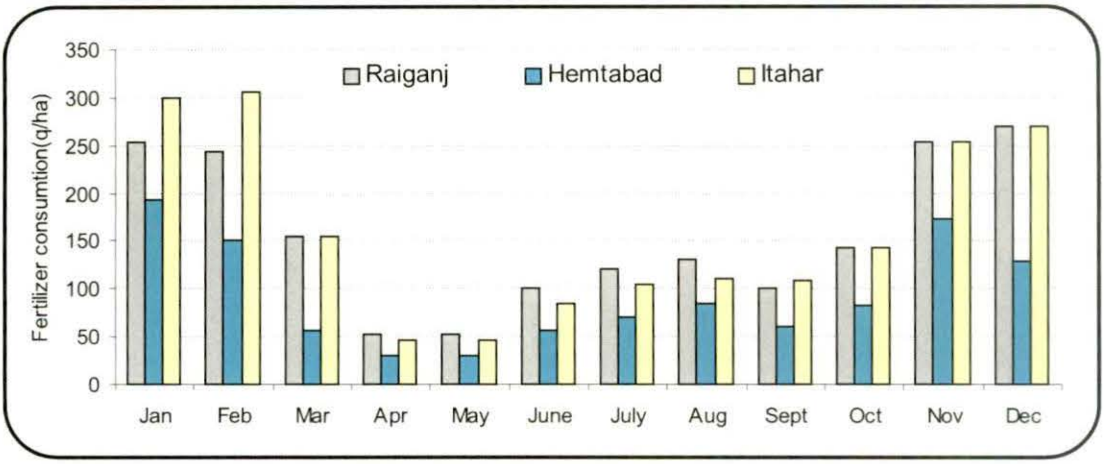


Fig. 1.6: Quantity of inorganic N fertilizer used round the year in the three blocks of study, Raiganj, Hemtabad and Itahar (based on the Annual Reports of District Agriculture Hand Book 2003-05).

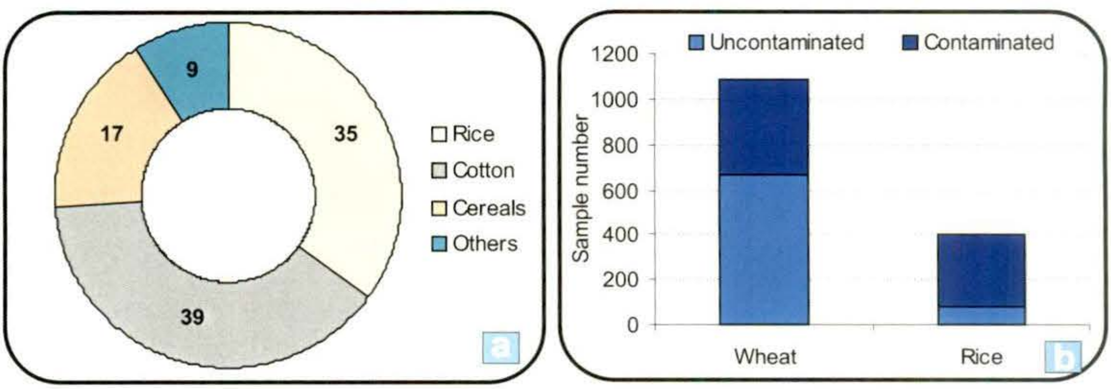


Fig. 1.7: Pesticides in food stuff a: Proportional application of pesticides in different crop-ecosystems in India (based on David and Murthy 1993), b: Relative contamination of pesticides in rice and wheat (based on data from Kathpal and Kumari 2000).

Prolonged continuous cropping, monoculture, technically sound irrigation, newer brands of pesticides and fertilizers, adoption of HYV's with a cropping intensity more than 189% often increase the vulnerability of the crops to insect pest attack and favour multiplication and carry over of the insect pests (District Annual Plan on Agriculture, Uttar Dinajpur, 2004-2005). Available average data of four consecutive years indicate that the use pattern of inorganic fertilizer differs considerably throughout the year in the three blocks namely Raiganj, Hemtabad and Itahar in the district of Uttar Dinajpur; accordingly the status of pest infestation differs indicating that the fertilizer itself has a relation to the pest structure (Fig.1.6).

The adoption of variety for cultivation in the three blocks showed heterogeneity. High yielding varieties were cultivated with priority in the blocks Raiganj and Itahar while in Hemtabad; very little preference of HYVs is given for summer and winter crops. Cultivation of HYV's in the autumn season is restricted to all the three blocks. Local varieties are mainly cultivated in the winter season in all the blocks (Fig.1.9).

In order to overcome the problems of hazardous effects of the toxic residues of broad spectrum synthetic pesticides on the perishable crop like paddy, it is necessary to evolve a safe pest management strategy particularly in the District of Uttar Dinajpur of West Bengal where no investigation, even of preliminary nature, has yet been carried out and little attention is given to the recommended common IPM practices. Therefore, a thorough study on incidence of insect pests and their natural enemies in relation to prevailing weather conditions, quantification of loss, suggestive application of insecticides, judicious proportional use of inorganic and organic fertilizers, calculation of cost effectivity are essentially required to consider in compatible with other holistic approach so that an IPM strategy can be evolved which should be specific for this region.

Gunathilangaraj and Kumar (1997) listed 537 pests of rice from India which includes 385 species of insects. Panwar (2002) reported 80 insect species having major economic significance in rice in India. Prakasha Rao (2004) observed that about two dozens of insects have been found as the key 'biotic stresses' on rice in different agro-ecological situation through out India.

In the area of experimentation, paddy is attacked by a number of insect pests (District Agricultural Hand Book, Uttar Dinajpur 2004). Estimation by the Regional Rice Research Institute, Chinsurah, West Bengal depicted a list of nearly 15 major insect pests of regional importance having potentiality of damage depending on agro-ecological conditions through out West Bengal. Variations in the population status and their magnitude of damage depend on the adopted cultivation procedure and field crop management methodology (Eastern India Rain fed Low Land Shuttle Breeding Programme: Annual Progress Report, 2002, RRI, Chinsurah).

Cramer (1967) observed a very high paddy grain loss in Asia (>50%) moderate loss in Africa (34%) and relatively low in Oceania (13%), America (25%) and Europe (15%), while Oerke *et al.* (1994) estimated more than 50% loss in Asia, Africa, America and slightly less loss in Europe and Oceania. Savary *et al.* (2000) attempted to evaluate the loss of field paddy grain and deterioration due to the insect pest and found nearly similar result. Pest induced yield loss in tropical countries has been estimated to vary from 35-40 %, 30 % in India and 16-30 % in Philippines (Teng *et al.* 1993). The extent of loss is intensified up to 25 % under modern agricultural situation with the adoption of HYV's amounting to an annual loss of rupees 94680 millions (Dhaliwal and Arora,1996). Kenmore (1987) observed that crop losses were comparatively low under irrigated pest control programme. Bhattacharyya *et al.* (2007) attempted to formulate a more realistic model to evaluate the pest induced loss and found the pattern of loss is season dependent.

Investigations on the food web studies of paddy crop ecosystem (Roger *et al.*1991, Heong *et al.*1998), predator and parasitoid biology, ecology and impact (Shepard *et al.*1987, Kamal *et al.*1990) have highlighted the high potential biodiversity of paddy field fauna, including natural enemy richness (Dale, 1994, Schoenly *et al.* 1998, Kaur 2001). Injudicious use of pesticides and chemical fertilizer disturb the balance due to the effect imparted on the natural enemy population and other beneficial organisms (Kumar *et al.* 2000, Lawler 2001), calling to formulate a more reliable cropping system approach called Integrated Crop Management (ICM).

Synthetic or inorganic fertilizers may catapult short term increase in paddy cultivation (Agnihotri 2000), but exerts ill effects on environment and all living beings (Ciftcioglu *et al.* 2006, Gamlin *et al.* 2007). Chemical pesticides and biocides are well known hazardous toxicants with cumulative and long range impacts causing a real threat to ecological security (Bull 1982, Berg 2001, Dash *et al.* 2003) Agrochemicals of broad spectrums are highly potent and agile to enter into the food chain (Knight *et al.* 2005). Their concentration increases with every successive trophic levels in paddy agro-ecosystem leading to bio-concentration, biological magnification or biological amplification (Senapati *et al.* 1988, Sontakke 1998). Rampant application of the agrochemicals leads to the gradual increase in the resistant insect species throughout the world (Figs.1.7a and b).

Basically, the conceptual origin of the IPM for crop protection lies in the background of such over dependence and excessive use of corrosive chemical pesticides following world war II and their subsequent unfavourable consequences (Greene *et al.* 2002). Often the target pest species have become tolerant to pesticides and no longer can be controlled economically with chemicals due to pesticide resistance (Fleischer *et al.* 1999). Further with the removal of the predator and parasites, many of the species returned at much higher number causing pest resurgence or 'flareback' (Kalode 1976, Jayaraj 1987). Brown plant hopper resurgence has been well documented in India (Chelliah *et al.* 1980, Raman *et al.*1983, Krishnaiah *et al.*2006, Bhavani 2006) and in other Asian countries. Following the repeated applications of pesticides to push back the population otherwise results in 'pesticide treadmill effect' (Altieri 1995). Often the population of non target insect species may increase in number to damaging level following pesticide treatment and attain the status of serious pests collectively called secondary pest outbreak (Kiritani 1972, Pathak 1977).

Furthermore, insecticidal suppression of biocontrol agents such as parasitoids and predators leads to pest resurgence and secondary pest outbreak.

Therefore, the strategy of IPM should be based on safe pesticidal application and low inorganic fertilizer input without any compromise to the yield as far as practicable.

Stern *et al.* (1959) coined the concept of integrated control in which the beneficial actions of biological control agents were supplemented with pesticides. In short, Geier and Clerk (1961) have called this concept of pest control as protective management of noxious species of pest, a management in which all available techniques are evaluated and considered into a unified programme to manage the pest population. The concepts of *protective population management* later shortened to *pest management* (Geier 1966) gained considerable exposure at Twelfth International Congress of Entomology, London (Waterhouse 1965). Perkings (1982) forwarded the view of the *total pest management* (TPM) conducted on the large geographic areas coordinated by organizations rather than by individual farmers. National Research Council Board of Agriculture, USA proposed a new paradigm termed *ecologically based pest management* (EBPM) replacing IPM for long term sustainability and without adverse environmental consequences (Gazzoni 1994). Pimbert (1993) viewed the role of IPM practitioners as catalysts and advisers, searcher and suppliers, supporters and consultants, facilitators and removers of the hindrance of the production.

The agendum 21 of the United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro in June, 1992 identified IPM as a controlling measure required for promoting the sustainable agriculture and rural development.

The first reference to the use of cultural control practices by the adoption of age old cultivation methodology in India is found in the book *The Agricultural Pests of Eastern and Southern Asia* by Balfour (1887) advocating the use of crop rotation involving cereals and pulses and clean farming for minimizing the damage by insect pests. Ayyar (1938) in *Hand Book of*

Economic Entomology of South India narrated a list of prophylactic practices and put stress upon the cultural practices for pest control.

Utility of modern IPM in rice cropping system has emerged as a multi-factorial cropping system approach known as *component technology* of rice production. The evident advantages of this approach are marked by the reduction in the use of chemical pesticides, with measurable benefits to the environment, households save on cash, while crop yields tend to increase owing to better crop management (Jiggins 1996).

Taking the philosophy of such technology, a number of successful integrated pest control programmes have been initiated in India (Premchand 1984, Tripathy *et al.*1999, Rao *et al.* 1999), Bangladesh (Nurzaman *et al.* 2000, Islam *et al.* 2004), The Phillippines (Marciano *et al.* 1981), China (Hu *et al.*1997), Pakistan (Quddus *et al* .2004) and Indonesia (Pincus 1994, Karimuna 2004).

The Indonesian rice IPM model, became the role model for the countries participating in FAO-IPC for IPM in Asia (Va de Fliert 1993). At the first phase of the FAO programme (1980-86) the model was tested to focus on developing the technical aspects of the IPM concept in its seven participating countries: India, Bangladesh, Indonesia, Malaysia, Philippines, Sri Lanka and Thailand. The key success of the programme in Indonesia was the banning of 57 broad spectrum organophosphate, pyrethroid and chlorinated hydrocarbon insecticides (Kenmore *et al.* 1985).

Major emphasis of Philippine's IPM programmes has centered on the use of resistant varieties (Pathak *et al.*1982). But the insect resistant genes could spread into wild or weedy races enhancing there invasiveness (Song *et al.* 2003) and thus challenges the safety and sustainability (Rao *et al.* 1995). Furthermore, the consistent use of the newer resistant varieties causes resistance breakdown, particularly against Brown Plant Hopper (BPH), *Nilaparvata lugens* (Stal.) (Heinrichs *et al.* 1985, Kenmore 1996). In China IPM is based on pest forecasting, cultural control practices and limited use of Industrial chemicals.

In India, the first IPM programme in rice was started at Cuttack, Orissa in 1975 covering an area of about 1000 ha in 10 villages (Brader 1979). Subsequently an operational research project (ORP) was instituted on integrated control of rice pests at 6 locations in 5 provinces (Krishnaiah *et al.* 1985).

In 1980, food and agricultural organization of United Nation (FAO) initiated on inter-country programme for IPM in paddy production. India, being one of the seven countries involved with such programme, showed an intensification of IPM promotional activities in installed 26 IPM centers and by the establishment of Farmers Field School (FFS) (Pincus 1994, Eveleens *et al* .2000). The field schools are designed to build up farmers' understanding the agro-ecological relationships and to improve their capacities to systematically observe, document and interpret these. From 1994-95, Farmers' Field Schools (FFSs) have been started in Andhra Pradesh, Karnataka, Maharashtra, Punjab, Uttar Pradesh and several other states.

In India, IPM programmers are being led by the Directorate of Plant Protection, Quarantine and Storage, Government of India, Ministry of Agriculture for the developmental activities, Indian Council of Agricultural Research and State Agricultural Universities for Research, Education and Training Activities and State Department of Agriculture for Extension Works. Based on the experiences gained through the bio control programme during Vth and VIth 5-year plans, survey and surveillance of insect pests and natural enemies during VIth and VIIth 5-year plan, and IPM demonstration at farmers' field during VIth 5-year plan, IPM was adopted as core plan protection activities during the VIIth 5-year plan.

Execution of the generated knowledge requires a thoughtful scientific attitude of farmers and their perception to mobilize it (Bandyopadhyay *et al.* 2000, Dalvi *et al.* 2004). Farmer's innovations are the only source of improvements in crop production and protection technology (Harverskort *et al.* 1991). *Local Ideas* can then be further developed in a creative participation process that integrates the *dynamics of indigenous and formal scientific knowledge* (Singh *et al.*1994)

Placing the farmers at the centre of development process is wholly consistent with the present IPM goal of making the farmer a confident manager and decision maker, free from dependence on a constant stream of pest control instructions from outside. A number of terms have been proposed for the new approach like: *Farmer-first-and-last*, *farmer participatory research*, *people-centered technology development* (PCTD) and *participatory technology development* (PTD) (Chambers *et al.* 1991).

In order to achieve this goal, strengthening the dynamics of indigenous knowledge of the farmers along with formal science requires a *promoting local innovation* (PROLINNOVA), in global partnership. PROLINNOVA builds on and seeks to scale farmer based R & D approaches that start with discovering how farmers carry out informal experimentation to develop and test new ideas for improved use of natural resources and relies on the *Conventional Cultural Methods* and *Low Input Sustainable Agriculture* (LISA). The philosophy of PROLINNOVA is carried out by different institutions throughout the world such as by International Centre of Insect Physiology and Ecology, Kenya (ICIPE), International Pest Management Working Group (IPMWG) and Cooperative Research Centre for Tropical Pest management, Australia (CRCTPM).

The International Workshop held in Leipzig, Germany in 2003 formulated a platform for *Knowledge Assessment and Sharing on Sustainable Agriculture* (KASSA). The ideology of KASSA is presently in practice in rice-wheat consortium of Indo-Gagetic plains which requires *local information*. The parametrical evaluation of the Knowledge, Attitude and Perception (KAP) is required to evolve for better application strategy. Sehgal *et al.* (2001) have found that the dynamics and severity of pest attack in the Indo-Gangetic Plains (IGP) have shifted with the adoption and spread of the rice-wheat crop rotation in the last three decades.

At national level for the effective cooperation and execution of the generated view of KAP, several institutions with effective programmers are active like All India Coordinated Crop Improvement Programmers, National

Remote Sensing Agencies, National Information Centre Network, National Horticulture Board and Development of Plant Protection.

Under a minimum input of pesticides and a low inorganic fertilizer management as evoked in the *component technology* of rice production, the primary objective is to replace *the external inputs* with *the locally available knowledge*, adaptive modification of the existing management skills, effective utilization of *the natural products* which recalls *the ancient Indian farming practices, the organic farming* (Lal *et al.* 1985). Organic farming is a connotation to the hypothesis of *the natural green farming* and is completely relies on *natural products* which are used scientifically at right time in right proportion.

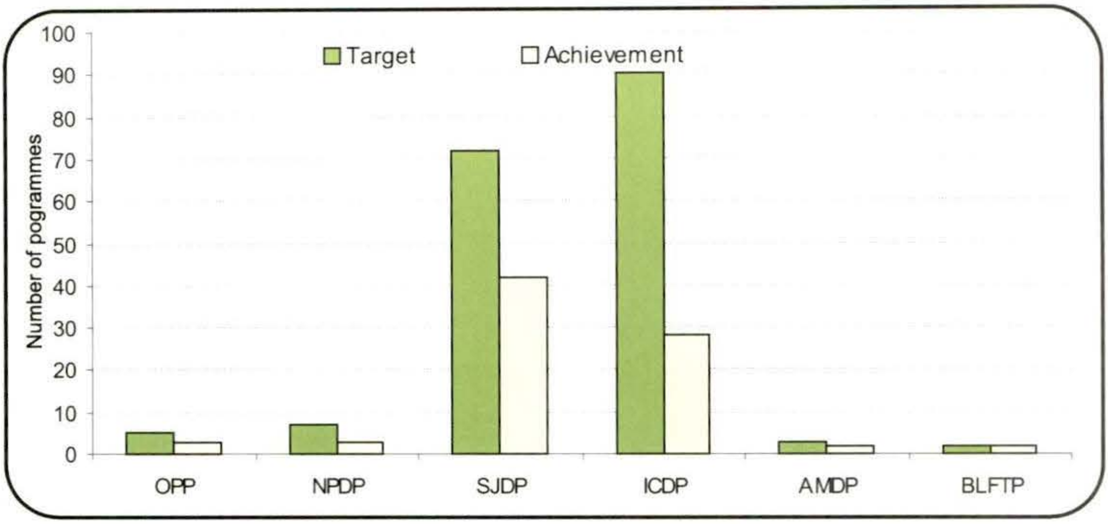
The cultural control of insect pests is the tactical use of regular farm practices to delay or reduce insect pest attack (Lawani 1982). Cultural measures involve the manipulation of the agro ecosystem to make it unfavorable for insect pests and more suitable for crop growth and natural enemies of the pests. Cultural practices have potential components of IPM for farmers in the tropics because they are simple, effective, convenient, environmentally safe and socially acceptable, economically feasible, and do not require any limitation posted by pesticides to the environment, human health and development of pest resistance.

In order to meet the food requirements of the fast-growing human population, a 65% production increase would have to be met with, within the next 30 years, without much expansion of the actual cultivated area (Roger *et al.* 1991). But if the issue of organic farming is a mandate, there will be 20% decrease in fields, a 50% loss due to global shortage of organic N fertilizer (Winter 2000). The phenomenon thus is likely to result in food shortages aggravating due to a constant rise in population. Global monitoring has shown that withdrawing chemical pesticides makes losses significantly worst. Knutson *et al.* (1990) claimed that in USA the yield of crops grown without pesticides was reduced by 24 % for wheat, 32 % for corn, 37% for soybean, 39 % for cotton, 57 % for rice and 78 % for groundnut.

Sensing the reality, it is more time appropriate to initiate an integrated use of organic and inorganic fertilizer and minimum application of toxic agro chemicals with a better utilization of cultural practices. Very restricted success of IPM programme is achieved in the district Uttar Dinajpur (Fig.1.8).

In consideration of the perspectives delineated above, programmes have been drawn accordingly and the present investigation has been carried out in three adjoining blocks namely Raiganj, Hemtabad and Itahar of the District of Uttar Dinajpur during the period from 2003 to 2006 in a holistic approach as follows :

1. Study of the incidence and abundance of the major insect pest population and interaction with the biotic and abiotic environmental factors, with a view to identify favourable weather parameters, peak period of pest infestation and vulnerable stages of crop growth with an ultimate objective to formulate a cultivation schedule considering the prevailing paddy cultivation practices.
2. Study of bio-ecology of major pests namely yellow stem borer (YSB), brown plant hopper (YSB), gall midge (GM), paddy bug (PB) and natural enemies in relation to the plant yield attributes with an objective to assess the pest and natural enemy structure at different cultivation practices, environmental conditions and the agro ecological factors.
3. Quantification of the crop losses, by a single pest or by pest complexes, categorization of villages in domains, determination of the pest threshold level with an objective to take appropriate decision on protection measures.
4. Tabulation of suggestive time specific control measures and major key pests. Side by side, computation of the probable effects of each control measures on each concurrent major pest in respect of their ETL levels.



OPP - Oil seed production programme NPDP - National pulse development project, SJDP - Special jute development programme, ICDP- Integrated cereal development pogramme, AMDP - Accelerated maize development pogramme, BLFTP - Block level farm training pogramme.

Fig. 1.8: Comparative diagram showing the number of different IPM pogrammes and their relative successes (based on data of District Agrticultural Hand Book, 2004, Uttar Dinajpur).

Fig. 1.9: Cultivation of paddy in stretches of continuity.

Emphasizing all the above mentioned objectives, cultural management of four major pests (yellow stem borer, brown plant hopper, gall midge and paddy bug), were investigated in the widely adopted high yielding variety *Swarna Mashuri*-MTU 7029, a derivative of *Mashuri* covering nearly 12% of India's rice-land. The cultural management broadly involved suitable proportion of chemical and organic fertilizers, limited application of pesticides, adoption of suitable tillage methods, frequency of hand weeding, proper water stress management, selection of proper number of seedling/hill and appropriate hill distances. Furthermore, biology of the pests was considered in relation to the crop phenology.

Collectively, the basic philosophy of the present investigation is **to initiate and develop a local system with data generation, fine-tuning of the system to produce-profitable, stable and sustainable yields, to refine and verify ETLs, to test the tactics, to replace gradually anti-IPM practices by pro-IPM practices and to conduct research work designed for farmer managed adoptive trial.**

It is expected further that the generated knowledge and the adoptable outcome of the present investigation will lead to cohort a paddy insect pest management strategy with the generation of a simulated model applicable for the three blocks of the District Uttar Dinajpur, West Bengal, which is environmentally sound, technically feasible, economically viable, ready-hand practicable and also safe to the farmers health. Such management protocol will be built up on **'5P'as its core basic: Population, Productivity, Price, Pollution, Pest and Pesticides**. The strategy can be followed in toto or with partial modifications in other regions even on other cereal crops having similar pest infestation problems.