The Diagnostic Survey as a Tool for Developing a Relevant Research Program: A Study from the Terai of Nepal

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Abstract

A diagnostic survey approach was used to describe farmer practices and problems in the rice-wheat cropping systems of Rupendehi District in the Terai of Nepal. The survey participants were senior researchers from Nepal, IRRI and CIMMYT.

The objectives were : 1. To understand local farming systems, the local rice-wheat pattern, interactions between rice and wheat and interactions between the rice-wheat subsystem and other sub-systems; 2. define near-term and longer term (sustainability) problems and understand their causes; and 3. Identify further research needs.

Semi-structured guidelines rather than formal questionnaires were used to guide discussions with farmers and other respondents. These guidelines were redefined daily after thorough discussion. The survey was done in the rice and wheat seasons.

Several short and long term problems and causes were identified and are presented in the paper and diagrammed using problem-cause flowcharts. For wheat, late planting, waterlogging, poor stands, nutrient deficiencies and late season moisture stress were short term problems and soil fertility and pest and disease problems more long term. For rice, drought, low fertility, soil depleting cropping patterns and pests were major causes of low and declining rice yields. The intricate nature of the interactions that cause these problems are discussed with future research strategies suggested for developing solutions for this important South Asian cropping system. Evidence is presented of declining wheat and rice yields in the District even when recommended levels of inputs are used. The issue of sustainability is addressed with reference to the role of the diagnostic survey in this type of research.

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INTRODUCTION

The last decade or so has seen an enormous increase in cropping systems, farming systems and on-farm research and the application of methodologies to address these topics. In general, each of these approaches to systems research has developed a research model similar to that found in Figure 1 (Harrington et al., 1989) implemented in specific sites. The reason for this site specificity is that systems are complex and unique to the biological, physical, edaphic, climatic and socio-economic situations at selected locations.

A major challenge for FSR practitioners in the near future is to adapt FSR procedures to examine and solve problems associated with sustainability, in all its various forms. This paper will describe how diagnostic surveys were used by a Nepal-CIMMYT-IRRI team to generate information on longer term problems (sustainability), as well as near term problems in a rice and wheat based farming system in one District in the Southern Terai area of Nepal.

SURVEY OBJECTIVES

The objectives were : 1. To understand local farming systems, the local rice-wheat pattern, interactions between rice and wheat and interactions between the rice-wheat subsystem and other subsystems; 2. To define near-term and longer-term (sustainability) problems and understand their causes; and 3. To identify further research needs.

METHODOLOGY

The two surveys, one in the wheat and one in the rice season, could equally have been called an "informal" or "exploratory survey", a "rapid rural appraisal", "sondeo" or "joint trek". Semi-structured guidelines rather than formal questionnaires were used to guide discussions with farmers and other respondents. The survey team was multidisciplinary in nature and included rice and wheat researchers from agronomy, anthropology, economics, extension, pathology and plant breeding from Nepal, CIMMYT and IRRI. Participants were divided into groups for field interviews. Survey guidelines were redefined as information was obtained and new questions arose from the daily afternoon debriefing sessions. Over time, a consensus was obtained on farming system attributes and problems for rice and wheat in the District. In addition, secondary data (climatic, soil, experimental and other survey data) supplemented the information obtained by interview. Attempts were made to listen closely to the respondents, and to present their views rather than those of the scientists. When a sufficient overall consensus was formed, the team divided into groups to write specific portions of the report. This allowed a report to be available soon after the survey finished.

The data collected were mostly qualitative in nature since the methodology was not designed to obtain quantitative data. The latter type of data can be collected more efficiently by using formal surveys that focus on issues of high priority identified by the diagnostic survey.

SITE DESCRIPTION

Rupandehi District in Nepal's Terai (Figure 2), a part of the Gangetic flood plain, was selected for study because it represents 14% of Nepal's total land area, 42% of the country's cultivated land and is a major rice-wheat area. Farming systems based on the rice-wheat cropping system are of great interest to CIMMYT, IRRI and several South Asian NARS. Rice-wheat is grown on 9m ha in S. Asia (Hobbs et al., 1988). Considering that much of it is irrigated and fertilized with moderately high levels of chemical fertilizers, especially nitrogen, the productivity of this system (less than 2t/ha) is low. Any improvement in the yield of these two major staples in the region would likely be beneficial.

Rupandehi District has a sub-tropical climate influenced by the SW monsoon. Average annual rainfall is around 1600 mm and increases from south to north. More than 85% of the rain comes in the period from mid-June to the end of September. There is a distinct cool season from October to April when wheat is grown. Mean monthly temperatures are 15C in January. There are frequent strong, hot, dry Westerly windstorms in April and May that significantly effect the grain filling of late planted wheat.

Farmers were found to use landtype classes that correspond closely to technical classifications (APROSC, 1986). These classes were based on interrelated variation in soil, topography and hydrology. Two major classes are evident :

- lower river terraces (locally called *Khala*) are characterized by heavy soils, poor drainage and high water tables. They are commonly used for production of a single, long duration, traditional rice crop. Wheat is not commonly grown after rice harvest on these lands.

- Upper terraces (*Danda*) are characterized by lighter soils with fewer drainage problems. This class embraces fields where water supplies are relatively secure and rice is transplanted; and fields that are more drought prone and that are usually direct seeded with local short maturing rice varieties. Rice-wheat is the major pattern on the upper terrace soils with wheat often mixed with *Brassica sp.* and rice with sunnhemp, pidgeonpea and millet. Seedbeds for the lower terraces are placed on the upper terraces and are followed by black gram, mustard and vegetables.

The survey data described below are from cropping systems on upper terraces where rice-wheat is the major pattern:

CROP MANAGEMENT

A full description of crop management for rice and wheat obtained from the survey can be found in Fujisaka and Harrington, 1989 and Fujisaka, 1989.

Wheat

Turnaround time from rice to wheat varies from 15-35 days because of soil physical conditions and farmer implements that are limited in effectiveness. December planting is normal

with some fields planted in January. The optimal dates for wheat planting are mid-November with later dates resulting in linear yield declines. Land preparation accounts for a large proportion of wheat production costs. Planting is done by broadcasting seed and ploughing the soil for incorporation. All farmers use improved Mexican type varieties, with RR21 (Sonalika) and UP262 the predominant varieties. Most of the wheat is partially irrigated (one or two supplemental irrigations). Water stress can be a problem in low rainfall years while waterlogging can also be a problem because of poor irrigation management. Many farmers apply chemical fertilizers on wheat, but on the order of 25-50 kg nutrients/ha, well below recommended levels. Only a few farmers apply FYM on wheat and none were found to use green manures. Mixed cropping with *Brassica* is common especially in rainfed and partially irrigated areas. *Brassica* is harvested for home oil use. District level wheat yields are about 1.5t/ha.

Rice

The stale seedbed method (*jotai*) is practiced with land preparation spanning 30-60 days. Farmers first direct seed local, short maturity rice varieties on the drought prone *danda* upper terraces, and then transplant modern varieties on their more water-secure fields. Dates of planting vary within small areas. Individual farmers plant several varieties over a staggered period. The early direct seeded varieties are sown in June and harvested from mid-September to mid-October. Yields from 0.7 to 3.2t/ha, averaging 1.8t/ha were reported.

Direct seeding is mostly (75%) wet seeding of pre-germinated seed (*lewa*) but if rains are poor dry seeding is done. Traditional varieties are direct seeded, while improved varieties are not because of less drought tolerance and longer maturity. More weeding is done in direct seeded rice (45 person days/ha) than transplanted (25 pd/ha) fields.

Some farmers use FYM on rice to maintain soil fertility but most use low levels of inorganic fertilizers (25-50 kg nutrients/ha). Water is mainly supplied by rainfall, but some farmers supplement this with tubewell or canal irrigation.

MAJOR SYSTEM INTERACTIONS

One of the major objectives of the survey was to view the rice and wheat crops in a systems perspective. Several important interactions are highlighted in this section that have important implications for determining the strategy for increasing productivity of rice-wheat in the District.

Interactions between Rice and Wheat

Rice Harvest Date and Wheat Planting Date A major interaction is the competition of farmers' land and labor resources during rice harvest and wheat sowing. This is critical for wheat since experimental data shows a linear decrease (about 1% ha/day) in wheat yields when planting is delayed beyond November 20th. Delays in rice harvest will delay wheat planting.

It was hypothesised that delays in rice harvesting are due to late rice transplanting, in turn due to late nursery

establishment. However, farmers indicated that this is not true. Farmers avoid late transplanting and late seedbed preparation and use direct seeding if rains are late. This is probably because of the high risk of drought stress and possible cold injury during pollination in October (rains often cease abruptly in late September) and poor rice yields when rice is planted late. Farmers already sacrifice some yield by growing lower yield potential short duration varieties.

In some cases farmers must dry their rice in their fields before carrying to their homes and stacking and this delays land preparation for wheat. When the rice is stacked, rat damage is substantial. Other poorer farmers must thresh some rice, in order to obtain food or cash, before preparing wheat fields. Others must earn urgently required cash by working off-farm and preparing land for bigger farmers before ploughing their own lands. Labour shortages, because of alternative employment opportunities and a reluctance on the part of younger workers to do menial agricultural work, creates a serious bottleneck for timely rice harvest and wheat planting at this time of the year.

Effect of Paddy Soil Management on Wheat. The puddling of soils for rice production results in poor soil physical condition for the succeeding wheat crop. This, combined with farmer's land preparation methods (intensive, shallow tillage) and rice residues, results in poor seedbeds, late planting and unfavourable conditions for wheat.

The formation of a sub-surface pan by puddling (important for reducing water percolation in rice) restricts drainage and can cause waterlogging after rain or irrigation and restricted root growth. Poor root growth results in reduced soil moisture availability, as the soils dry, and plant nutrients for wheat. If the pan is broken for wheat, water use in the next rice crop can be excessive unless the pan can be reformed, and can also create problems for physical support of the animals ploughing the soil. Dry-seeded rice or cultivation of rice with reduced puddling reduces the problems for cultivation of the next wheat crop.

Food Security for Resource Poor Farmers. The rice-wheat pattern appears to play an important role in food security of low-income farm households. Both crops provide an important staple food at food scarce times. Also farmers are able to adjust to poor rice harvests by planting more wheat.

Other System Interactions

There are a number of interactions between rice and wheat on the one hand, and fuel, fodder and farm yard manure (FYM) on the other. Large ruminants rely on rice and wheat straw as major sources of fodder. These livestock provide FYM for fertilizer and cooking fuel. Herd size appears to be limited by fodder availability. Fuel demand is increasing and, given the lack of alternatives (ie. depletion of fuel wood resources) more FYM is being used for cooking and less for fertilizer. Dried dung cakes now provide most local fuel

needs and may account for up to 75% of the FYM produced by a farm household's animal herd. Remaining forest groves will suffer from increasing pressure as fuel resources are exploited by the increasing human population. FYM as fertilizer is a major means of sustaining soil fertility and experiments have shown that it is a key element for sustainable yields.

PROBLEMS, CAUSES AND SOLUTIONS

Near Term Problems

A major objective of the diagnostic survey was to develop hypotheses on problems affecting the rice-wheat pattern. Problems include a) factors that directly reduce yields; b) inefficient use of inputs, regardless of effects on yields; c) inefficient cropping pattern or enterprise selection; and d) longer-term factors affecting the sustainability of rice and wheat productivity. Table 1 lists the problems identified for the rice-wheat systems of Rupendehi District.

Most of the problems affecting rice and wheat productivity in the study area were found to be near term in nature. Carryover effects, or issues of resource degradation or irreversibility were less easy to identify. Detailed discussion of these short term problems, including significant system interactions, and causes and possible solutions may be found in Harrington and Fujisaka (1989) or Fujisaka (1989).

In brief, some of the short term problems (listed in Table 1) are direct results of the incompatibility of the management systems used for the rice and wheat crops and the

interactions described earlier. Some of the solutions to these problems require extensive research on strategies such as reduced soil puddling for rice, dry seeded rice, zero or reduced tillage for wheat establishment, drainage and water management systems and breeding of appropriate rice and wheat varieties.

Longer Term Problems

Compared to near-term issues, less progress was made in defining longer term issues of sustainability. This is because the issues are less obvious and because they are masked by confounding other factors. In fact, some farmers indicated that yields of rice and wheat are declining, while others said they are increasing. Part of the reason for this difference is the increasing trend in use of fertilizers, irrigation and improved varieties in the past decade. This can mask any underlying long-term reduction in productivity. It is well known that yield trends are a less reliable indicator of sustainability than trends in total factor productivity or even gross margins (Monteith, n.d.; Lynam and Herdt, 1989).

Evidence from experiments conducted at the Bhairahawa wheat station (Figure 3) clearly show a decline in yield with constant use of recommended inputs. The data in Figure 3 is data for wheat uniform breeder yield trials conducted over the past 10 years with the same level of management and inputs. Similar data are available for rice in a long term rice-rice-wheat cropping pattern trial on the same station (Figure 4)

that has run for the last 12 years. The data is highly variable, but the trends are significantly negative even when the recommended fertilizers (treatment 5) or 10t of FYM per crop are applied (treatment 9). Yields decline even faster (in fact to zero) when phosphorus is not used.

Two longer term sustainability issues were continually discussed by the team during the course of the survey both with farmers and amongst themselves:

Soil fertility issues suggest that deficiencies will increasingly limit yields of both rice and wheat. Field observations during the diagnostic survey suggested that nutrient deficiencies (especially N, P and possibly Zn for rice) were already restricting rice and wheat yields, especially on lighter soils on the upper terraces. This is not surprising considering the farmers low use of fertilizer; and is likely to get worse. Hypothesized causes of nutrient deficiencies are listed in Figure 5. Many of these causes will have cumulative effects over time:

i) Both rice and wheat are exhaustive crops and will reduce soil fertility unless attempts are made to replace the nutrients extracted.

ii) The sub-surface pan restricts the rooting zone of wheat as well as rice, thus upper soil layers are being mined faster than if rooting were deeper.

iii) Farmers apply only low levels of inorganic and organic fertilizer, insufficient to replace nutrients extracted by the crops.

iv) As FYM supplies decline, and as FYM is increasingly used for cooking, farmers will apply less to their crops.

v) Crop residues and weeds are fed to livestock rather than incorporated into the soil.

The above suggests there is an urgent need to put a high priority on research to develope solutions for this serious problem. There are no simple solutions but the following need to be considered:

a) Development of realistic and profitable doses (and forms of application) of inorganic fertilizer, possibly including micronutrients (eg. zinc for rice).

b) Improved FYM management and techniques to combine FYM and inorganic fertilizer, to increase fertilizer efficiency.

c) Development of alternative fuel sources, to enable farmers to use more FYM for fertilizer.

d) Development of alternative fodder sources, to allow an increase in animal herd size, increased production of FYM, and incorporation of more FYM and crop residues into the soil.

e) Study of the role and economics of green manures and legumes in rice-wheat rotations to help supplement costly inorganic fertilizers.

Pest, diseases and weeds will increasingly reduce rice and wheat yields. Farmers' opinions indicated that pests, weeds and diseases especially for rice were important and increasing in severity. Data from soil samples collected during the surveys also indicated that soil borne fungi and

nematodes may also be creating problems. The incidence, frequency and yield loss associated with each of the above could not be determined by the diagnostic survey although they were thoroughly discussed by the team with farmers.

There was concern that the problem will increase over time simply because the more intensive rice-wheat pattern is more likely to allow buildup and shifts of pests, weeds and diseases than the old rice-fallow system. More integrated, indepth research is needed in this area to further describe the problem and identify suitable solutions. More scientists from pest management disciplines should associate with agronomists to achieve this goal.

DIAGNOSTIC SURVEYS AND SUSTAINABILITY RESEARCH

Obviously, diagnostic surveys are not able to provide more than hypotheses for problems and causes of longer term sustainability issues. These longer term issues will require more quantitative activities such as long term trials, monitoring surveys and analysis of historical data sets. Long term trials can provide data on long term trends for specific treatments (Figure 4) but these experiments are very difficult to manage (as noted by the large variability in the data), are expensive and require many years of work before tangible results are available.

Monitoring of specific plots and collection of a series of input/output data and changes in edaphic and biological components overtime would be another way to document trends in

production on a sound statistical basis. This is an approach used more by social than agricultural scientists and interaction between these two groups on appropriate methodologies and ways to analyse data would be useful. This is also a method to evaluate the adoption of new technology by farmers.

The diagnostic survey is an important research tool even where the more complex sustainability issues are studied because:

1. The interacting complexity of the problems of sustainability require, even more, that disciplines and commodities work together in an integrated way. In this Nepal survey all members of the team communicated in a positive manner not only during the survey but also in the followup activities since the survey. The survey developed a sense of trust and confidence within the team essential for promoting cooperation and coordination.

2. The diagnostic survey is very useful in making contacts with extension workers and farmers in the command area which will be a prerequisite for selection of sites for further studies. The survey also allows the stratification of the area into more homogeneous domains for better sampling of variability.

3. Through observations of farmer problems and discussion with farmers and fellow scientists, the more important issues were prioritized and appropriate treatments selected for the more expensive sustainability research work.

In conclusion, the diagnostic survey is an invaluable tool to initiate the work on both short and long term farmer problems within a system and sustainability perspective in a logical and coordinated manner.

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Table 1: A List of near and longer term problems for rice-wheat system of Rupendehi District

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Near Term Problems

WHEAT

1) Late planting
2) Early season waterlogging
3) Inadequate plant stand
4) Late season moisture stress
5) Nutrient deficiencies (especially N and P)
6) Farmers varieties are less productive than alternatives

RICE

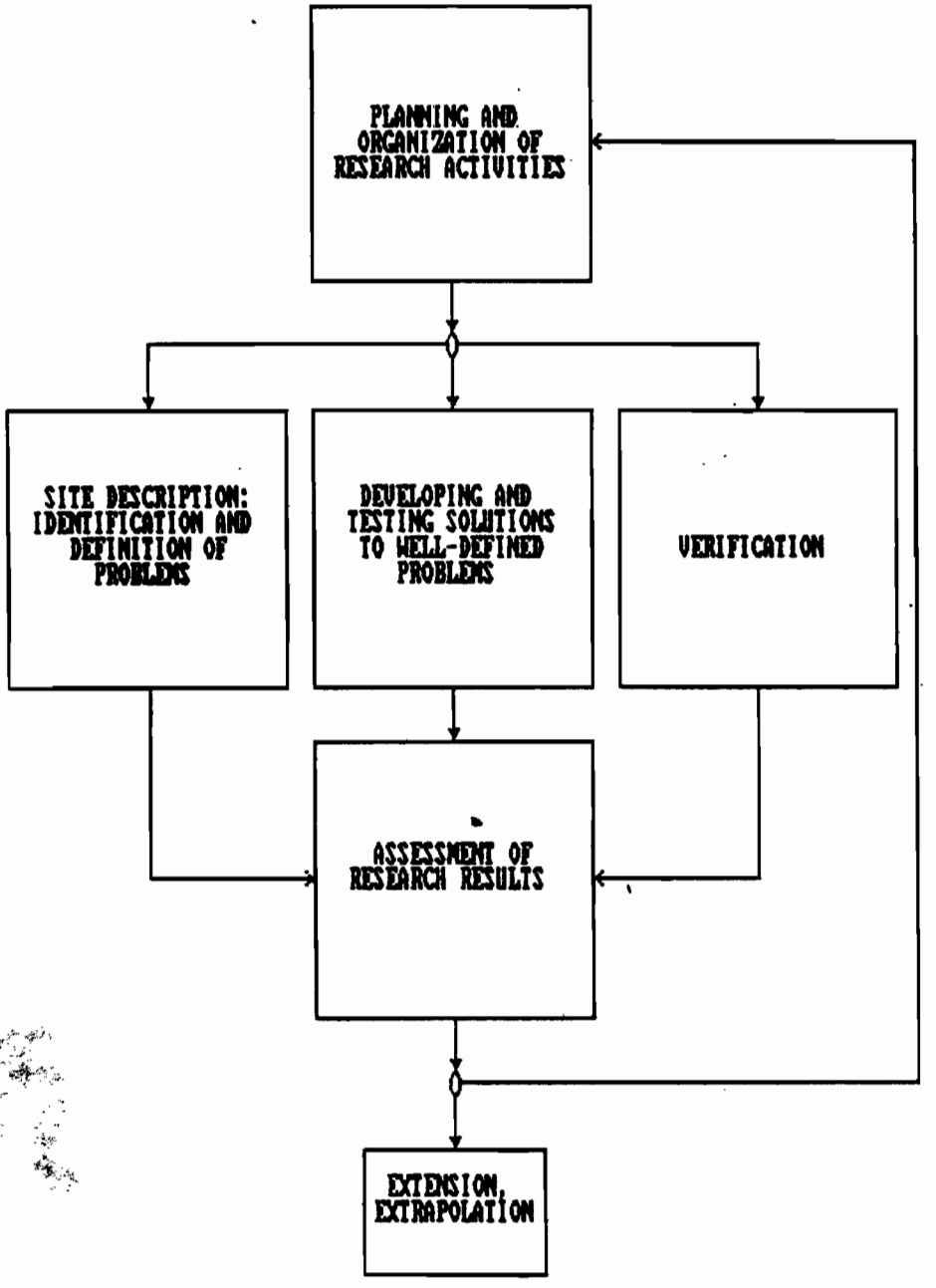
1) Early season drought stress (establishment)
2) Late season drought stress (flowering- grain filling)
2) Pests - insects, weeds and diseases
3) Nutrient deficiencies

Longer Term Problems

WHEAT AND RICE

1) Nutrient deficiencies
2) Pest, diseases and weeds

FIGURE 1: A GENERALIZED APPROACH TO OFCOR.



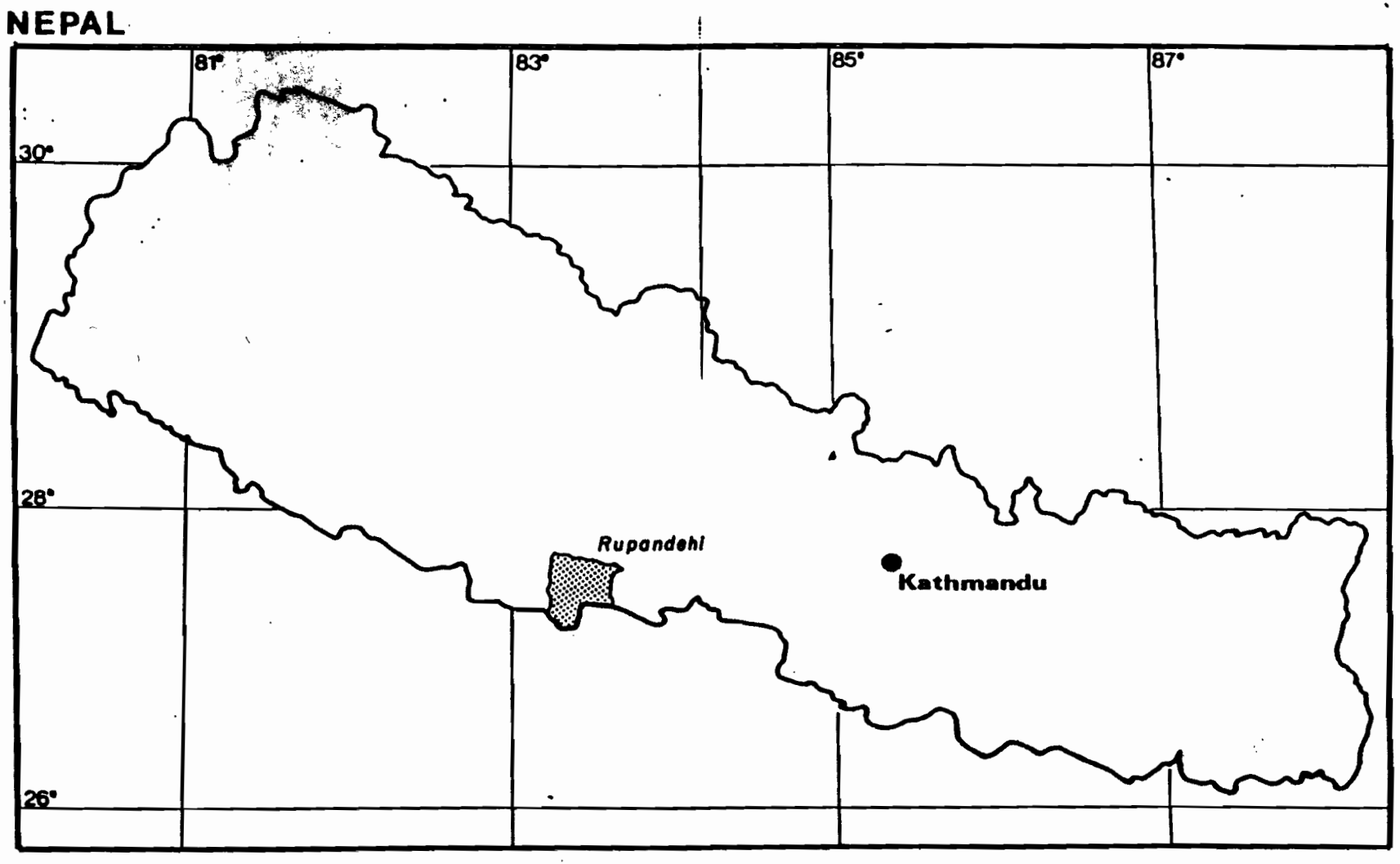


Figure 1. Rupandehi District, Nepal.

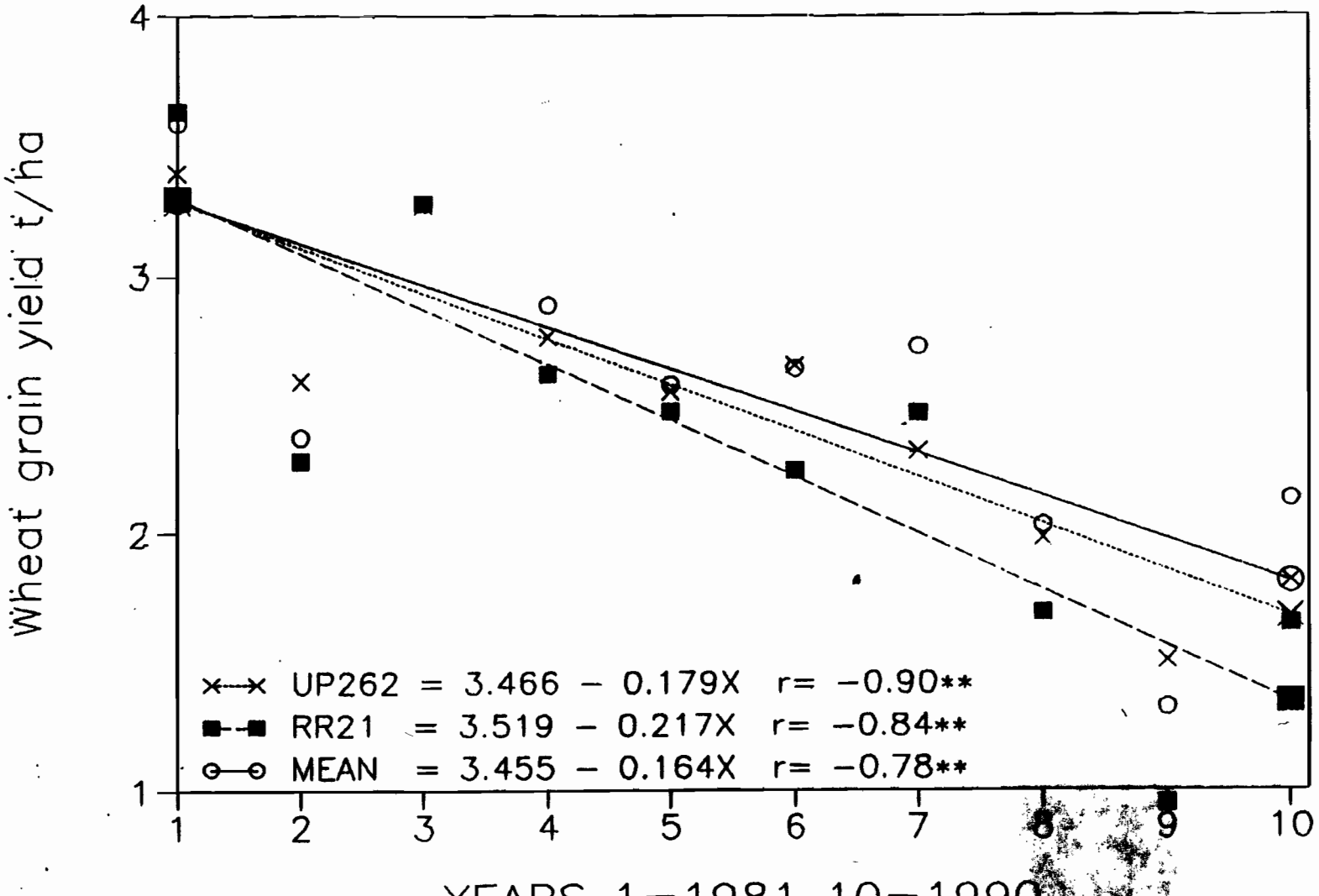


Figure 3: Regression of wheat grain yield by year for the mean, RR21 and UP262 from the Bhairawa CVT normal irrigated experiments.

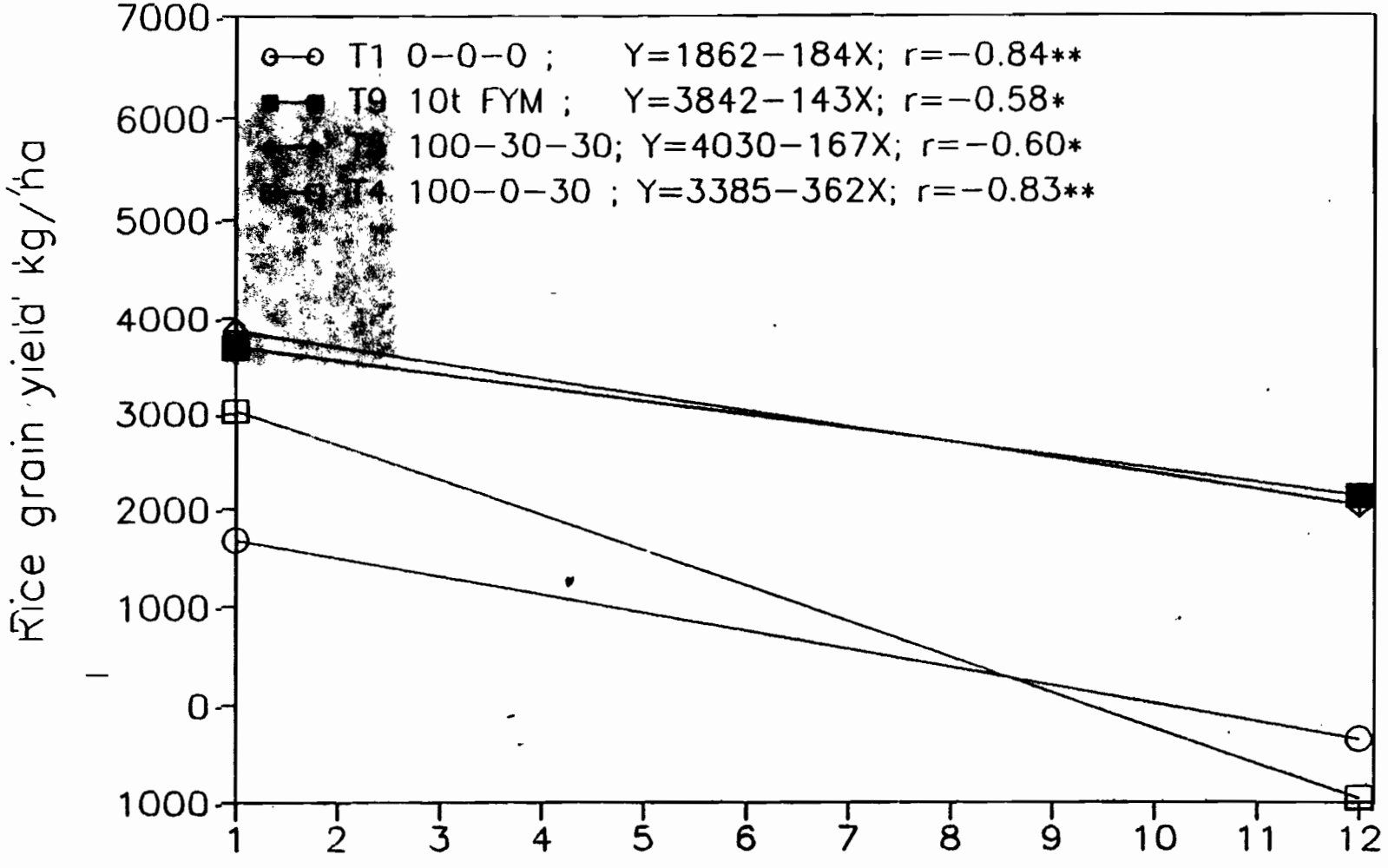


Figure 4 : The effect of various fertilizer levels on the yield of early rice in a rice-rice-wheat cropping pattern at Bhairawa, Nepal over the past 12 years.

FIGURE 5: SOIL FERTILITY — PROBLEMS AND CAUSES