MULTIPLE CROPPING IN THE CHIANG MAI VALLEY.

The complex relationships between components in a multiple cropping system. Multiple Cropping Project, Faculty of Agriculture, Chiang Mai University.

This paper rather than dealing with component research in any detail will attempt to illustrate by drawing on examples from MCP research, how the components in a multiple cropping system interact with each other and in many cases confer important properties on the whole system which are often not apparent when the components are studied individually.

Any system can most usefully be defined as a set of components that interact with one another in such a way that, in many important respects, they behave as a whole entity. Each component has its characteristic behaviour but the pattern of interaction between the components, the topology of the system, is such that the behaviourof the whole system is more than a mere summation of the behaviourof its components. For example the yield response of a field of rice to fertilizer application or to drought is not the simple summation of the yield response of individual plants treated and measured in isolation. Rice plants compete with one another for nutrients and water and this affects the final yield of rice in a complex manner.

Multiple cropping research deals with systems, namely agro-ecosystems. Agro-ecosystems are very diverse and extremely complex and will thus probably never be completely understood. However it is not usually essential to fully understand any system in order to be able to manage it efficiently for the desired purpose. The depth of understanding required depends on the purpose for which the system is being managed. For instance a motor car is also a system, the manager being the driver. For the purpose of getting from A to B the drive must be able to manupulate the accelerator, clutch, brake and steering-wheel to make the car go and must have a knowledge of the roads and conditions between A and B; he need not however have)any knowledge of the working components and subsystems within the engine.

The approach presented in an earlier paper is based on the assumption that the performance of agro-ecosystems is also largely determined by a limited number of important or 'key' processes and that improvements can be brought about by a limited number of 'key' management decisions that impinge on these 'key' processes (Walker et al., 1978). The experimence gained from recent MCP work suggests that system properties play a vital role in determining the nature of these key processes which are thus usually multi-faceted and therefore initially not always amenable to component oriented research.

Thus as a prerequisite to key process oriented research it is necessary to define the system in which we are interested, its boundary and the purpose for which it is being operated as well as defining the subsystems and components which are operating within it.

Agro-ecosystems tend to occur in a hierarchical arrangement of subsystems. For instance a multiple cropping system is composed of a number of component crops which themselves can also be considered as systems exhibiting system properties caused by the interactions between individual plants, the soil, nutrients, water, etc. Similarly going up the hierarchy a multiple cropping system is part of the entire farm system which may include a number of different cropping systems along with various livestock enterprises which all interact with one another in a complex manner bringing about properties that may only be apparent at the level of the higher system namely the farm.

Thus as a prerequisite to systems research the hierarchical arrangement of the systems must be defined. In the case of the agro-ecosystem of the Chiang Mai Valley the major levels of organisation which exhibit important system properties are shown in Figure 1.

Once the system has been defined and the various subsystems identified the next stage is on which aspects of its behaviour are important. Firstly the productivity (the average net return to the investments of land labour, capital and skill) is obviously important. Secondly the stability (the variability about the mean productivity over both space and time) is obviously an important consideration especially for the riskaverse smallholder common throughout South East Asia.

Stability will depend on the inherent characteristics of the system (system resilience) and on the constancy of the external environment (the likeliehood of perturbation or stress). Thirdly the durability (the long term potential productivity) must be considered if the system is to be practiced for a number of years. Any long term downward trend in productivity means that the system is not sustainable at the level of productivity initially envisaged.

Productivity, stability and durability shouldbe assessed in a number of ways rather than in merely biological (yield) terms. The economic performance (profit) is obviously a very important consideration for non-subsistence crops. However farmers operate farms in the way they do for a number of other more abstract objectives besides maximising food and cash production (Gasson, 1973). Cultural institutions such as exchange work groups, village land rental patterns, traditional water users associations, etc. are obviously important in increasing economic and biological productivity and maintaining agro-ecosystem stability and durability; they also, however, exhibit a type of social productivity in terms of meeting the more abstract goals and values of the farmers such as prestige, enjoyment of the work, social acceptance, etc. (Potter, 1976; Ireson, 1976; Suthasupa, 1977). Thus in some cases it may be just as important to stabilise and sustain these social structures to avoid a social collapse of the agro-ecosystem which may in turn lead to economic and biological collapse. Thus a biological or economic viewpoint of productivity, stability and durability is not always sufficient.

By way of an example, it was quickly recognised by the MCP that in order to increase cropping intensity an earlier maturing rice variety was essential to allow early planting of the second crop. Profitability was the main criterion used and the varieties chosen for testing were the short duration, high-yielding, non glutinous R.D. varieties. Although these varieties allowed increased cropping intensity and compared very favourably economically with the traditional, long duration varieties such as Sanpatong they were, in general, not adopted by the farmers who preferred glutinous rice as their staple diet. Indeed the majority of farmers who wish to plant an early second crop use local, short duration, glutinous varieties such as khaw saam duan which yield somewhat less than Sanpatong but mature earlier. Thus in this case it was not sufficient to consider only profitability criterionwith no regard for traditional cultural values such as the social unacceptability of a farmer not having a rice barn full of glutinous rice even if cash is available to meet subsistence requirements.

The field of theoretical ecology has been concerned with the productivity, stability and durability of ecosystems. However, most of the work to date has been on relatively unintensively managed systems such as fishery or forestry systems(Holling, 1973 and 1979; Conway, 1977). Although the concepts developed in theoretical ecology may be able to be profitably used when considering more intensively managed ecosystems such as multiple cropping systems the concepte will have to be modified and refined in the light of the special problems peculiar to agricultural systems.

However, even an initial analysis of multiple cropping systems reveal some important inter actions between productivity, stability and durability. For example a highly unstable system with highly fluctuating annual performance may be undurable economically for a small farmer who cannot accept large fluctuations in his income from year to year or within years even though the average income levels may be quite high (Figures 2a,2b.). Conversely, there is anecdotal evidence from the Chiang Mai Valley that the soil salinity problems that are beginning to appear in some intensively cropped areas may be overcome by flooding which occurs naturally every few years. In this instance an instability in the system (periodic - flooding) may enhance the durability of the system (reduce salinity - problems) (Figures 2c,2d.).

Durability problems are beginning to emerge in some multiple cropping systems in the Chiang Mai Valley. A soil problem resulting in reduced yields of some crops is beginning to emerge on the MCP experimental plots which have been intensively cropped for the last 10 years. Trends in the wet season rice yields are shown in Figure 3. After an initial increase yields peaked at about 6.5 tons per hectare in 1971 since which time yields have been steadily declining to the present 4 to 5 tons per hectare. There is also evidence to suggest that some dry season crops in particular mungbean, wheat, french bean, broad bean and peas are also affected. Symptoms on most crops are similar: plants are stunted, yellow patches developed on the leaves with scorching on older leaves and reproductive was affected at almost all stages. (Rerkasem, 1979).

The problem also appears to be emerging in farmer's fields in some intensively cropped of the valley although as yet it has not been quantitatively assessed. The actual problem has yet to be specifically identified but it appears to be related to a number of interacting factors including decline in pH, manganese toxicity, ferrolysis, salinity and trace element deficiency. No single factor is at a level sufficient to be critical in itself rather, the interactions between the various factors appear to be synergistic giving an effect which is greater than a mere summation of the component effects taken in isolation. Thus component research on any one factor studied in isolation may not be very useful in overcoming the problem. For instance in the case of pH decline although liming raises the pH to adequate levels it does not reduce the problem to any noticeable extent.

Traditional agricultural research has concentrated on improving productivity within certain stability limits often with very little refard paid to long term durability which has been assumed not to be a problem. As Figure 4 shows, however, as agricultural systems have developed from the 'hunter-gatherer' system to the more highly productive systems the interactions become more complex and often include time-lags giving rise to the possibility of unforseen system effects which may show themselves in the early years but may later reduce potential productivity of the system. Unless a systematic approach capable of incorporating these longer term effects is adopted in the research phase then these initially unforseen effects such as the soil problem in the Chiang Mai Valley may occur after large scale farmer adoption when the effects will be widespread and serious.

Traditional agricultural development strategies have concentrated on increasing production in two dimensions namely by expanding the area planted and increasing the yield of the crops planted. The potential for multiple cropping to increase productivity in a third dimension namely time is readily obvious, however, it also represents an increase in ecological diversity in the time dimension. Diversity can be very important in reducing risk from both biological and economic factors thus increasing stability.

However if managed appropriately, diversity also has the potential to maintain long term durability. Although theoretical ecologists are beginning to question the previously accepted fact that diversity confers durability per se (May, 1973) by utilising diversity based on an understanding of the key interactions involved the potential exists to enhance durability. For example, some farmers in the Chiang Mai Valley say they have no need to crop all of their land intensively to meet cash or subsistence requirements. However, rather than leave some of their land fallow in some years they prefer to plant a crop of rice in the rainy season each year. The reason they give is that cropping the land suppresses the weeds which would otherwise reduce prouctivity when they do wish to plant a crop. In this instance by increasing cropping intensity (and thus diversity) long term durability is enhanced.

Thus although the increase in complexity associated with multiple cropping probably increases the problems facing agricultural research workers, the increase in temporal diversity gives the potential to increase productivity, stability and durability. Research must, however, be based on an understanding of the key processes of the agro-ecosystem so that the component research required to bring about these improvements is relevant in terms of its effect on the behaviour of the entire system.

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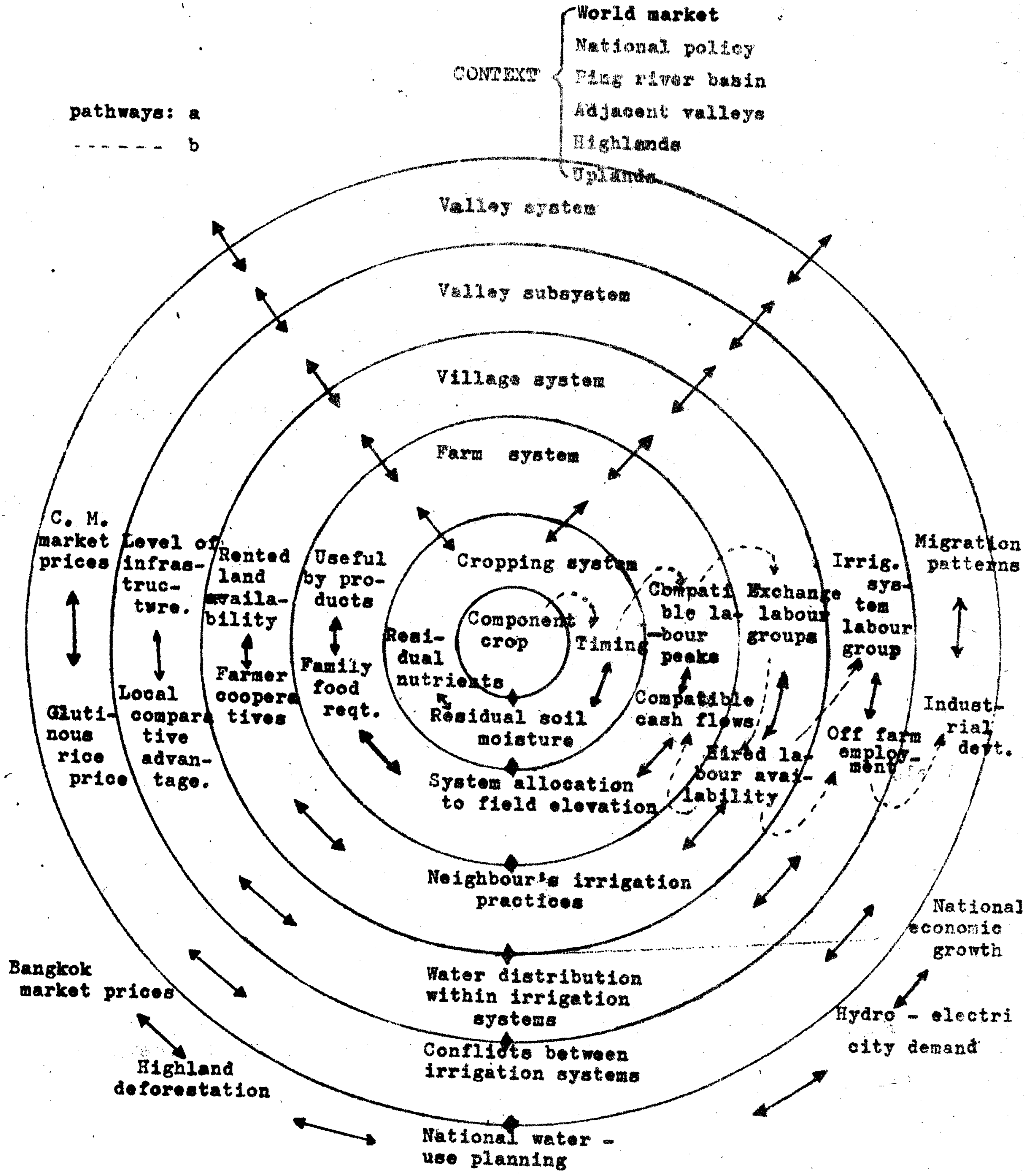

Figure 1. Hierarchical arrangement of subsystems for the Chiang Mai Valley.

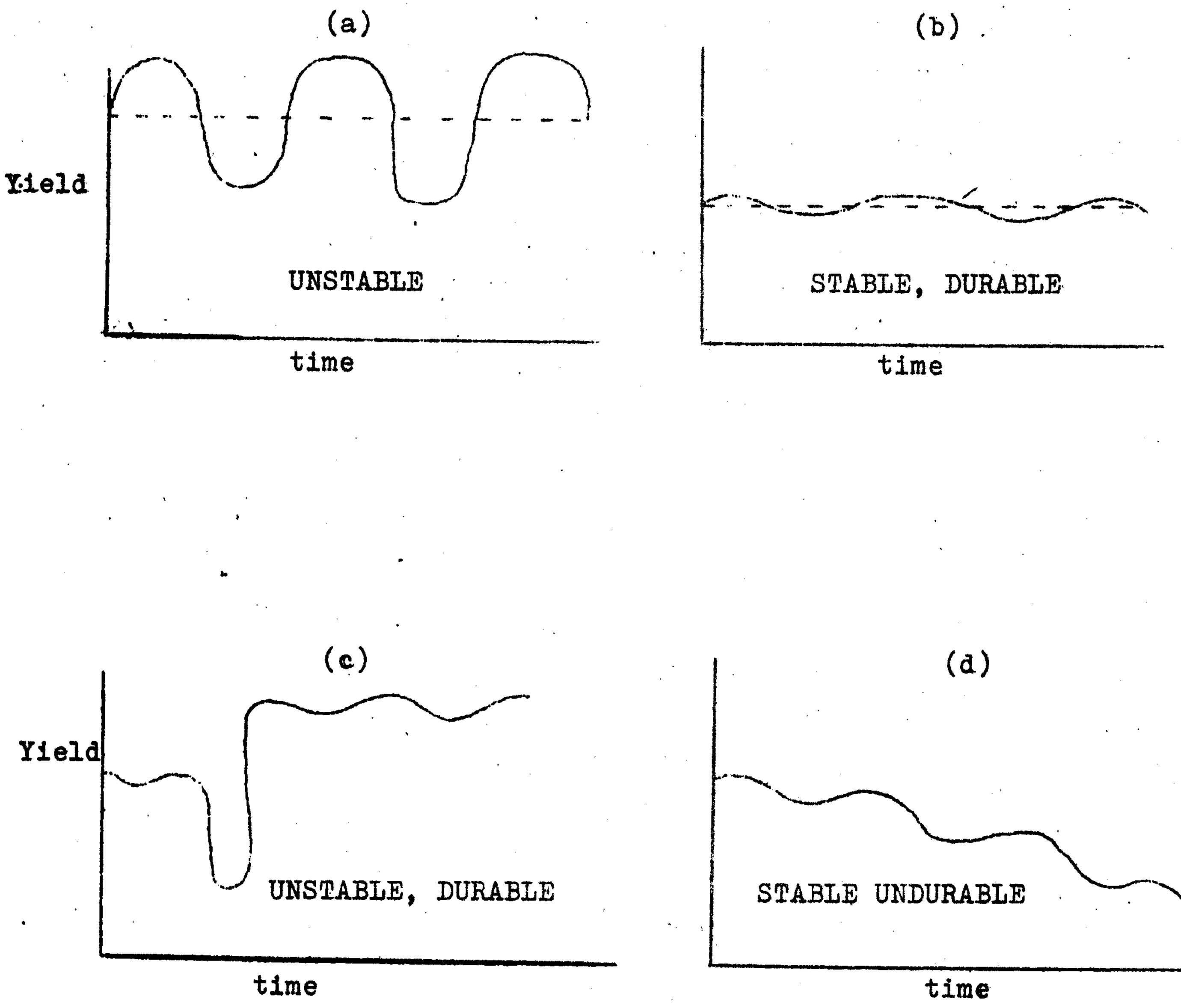

Figure 2. Hypothetical modes of behaviour of agro-ecosystems.

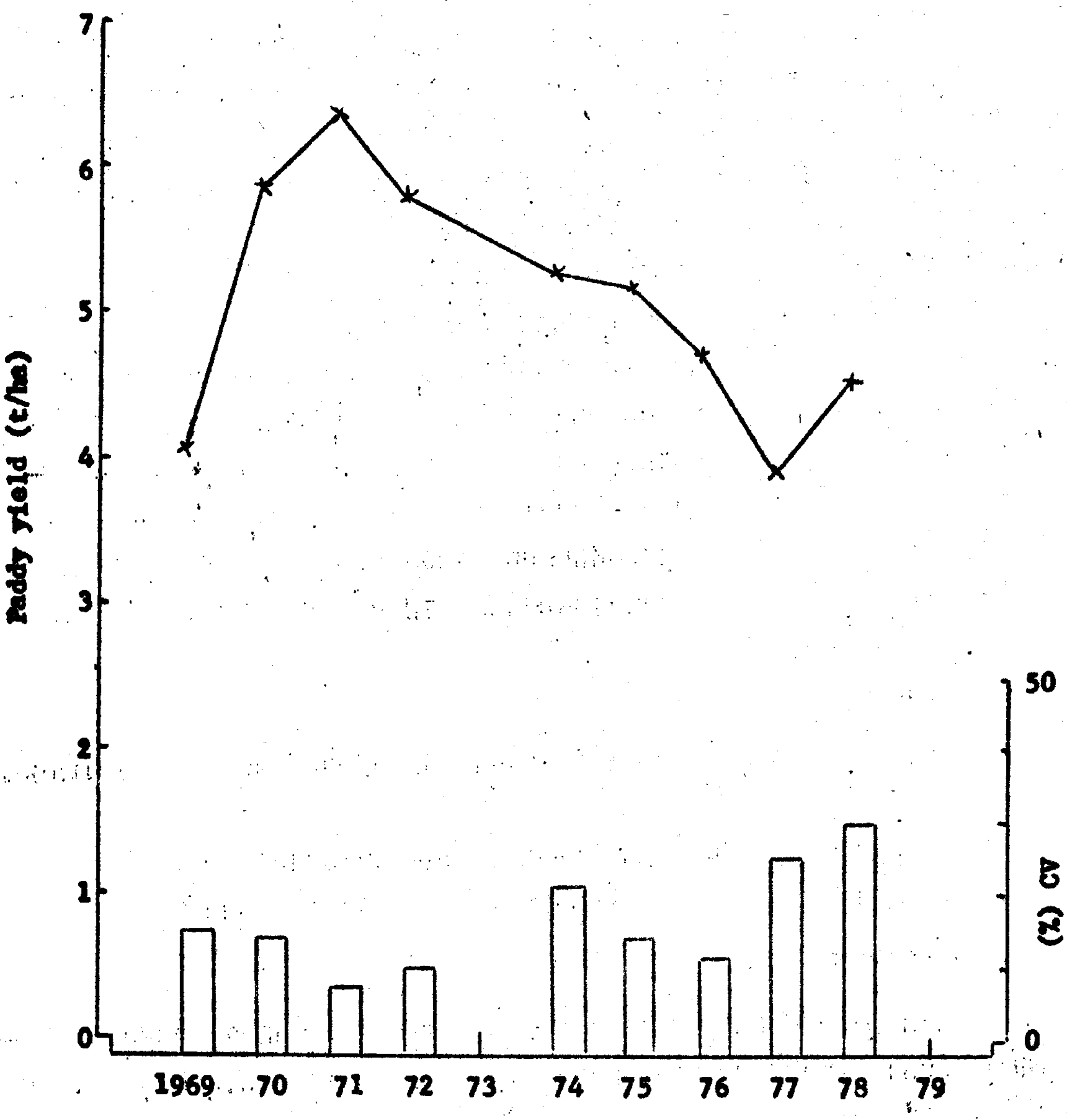

Figure 1. Rice yield in intensive cropping systems, each point mean from 16 plots.