91 - 3/113

850

Integrated systems
Review, developing countries, international cooperation, fish production, aquaculture, aquacultural research, marketing, economics, husbandry systems

HUISMAN,E.A.

Aquacultural research as a tool in international assistance.

AMBIO, 19, 1990, pp. 400-403

In this paper the following aspects are be touched on:
- the role of fish (the term "fish" includes finfish, shellfish and crustaceans);
- the role of aquaculture; and
- the role of aquacultural research in international assistance.

The share of fish in the total world food production of animal origin is some 12%.
The production ratio fish to meat is 0.6, since somewhat more than 20 million tons of fish are processed for fish meal/oil and fish-production.
In many developing countries, fish play a much more important role than these figures suggest. Fish protein contributes 25% and 31% of the total animal protein consumption in Africa, and the centrally planned economies of Asia and the Far East, respectively.
Since these regions are inhabitated by roughly half of the world's population, it is obvious that the importance of fish relative to meat can be very high regionally.
Especially in low-income countries, the consumption ratio of fish to meat is much higher than 0.6, emphasizing the fact that fish represents a relatively cheap commodity.
Products of animal origin, including fish, are of major importance as human food commodities due to their relatively high content of essential amino acids. Moreover, a health claim is often attributed to fish consumption in view of fish containing high amounts of polyunsaturated fatty acids relative to the amount found in domestic animals.
Since it is becoming more and more obvious that capture fishery resources are not unlimited, emphasis has been given to enhancement of aquaculture in order to close the increasing gap between demand for and supply of fish.
Total international assistance to the aquacultural sector amounted to some 370 million USD over the period 1978-1984.
Against this background the role of aquacultural research is discussed. It is argued that aquacultural research should not only be production oriented, e.g. related to fish, to fish husbandry systems, and to fish-farming systems, but that research also should be resource oriented and take into account the market, the socioeconomic feasibility and viability, as well as the adequacy of target groups as future producers.

Such research must inevitably reconsider the often cited project objectives like family nutrition and diet improvement as well as the direct target groups of subsistence farmers, recognizing that both these objectives and target groups can be of great importance in forming governmental policy concerning aquaculture development.
Fisheries pave the way for aquaculture. Integration of certain aquacultural operations, like reproduction centers, with existing and accepted forms of fisheries, resulting in so-called "culture based fisheries" could be a more acceptable socioeconomical approach in rural areas than are aquacultural operations.
In summary, aquacultural research as a tool in international assistance should be fashioned to the needs to develop and implement such forms of aquaculture that are socially absorbable, economically feasible, linked to and not competing with present activities of the target groups, and have a high scope for multiplication in the target area, to ensure ultimately autonomous growth of the sector.

91 - 3/114

851

Integrated systems
Asia, Philippines, review, book, proceedings, project workshop, sustainable development, coastal resources utilization, habitat restoration, alternative livelihood, socio-economy, cultural aspects, institutional framework, legal framework, ICLARM

SILVESTRE, G.

Towards sustainable development of the coastal resources of Lingayen Gulf, Philippines.

Proc. of an ASEAN/US Coastal Resources Management Project Workshop Bauang, La Union, Philippines, ISBN 0115-4435,1989, 190 p. + annexes

The coastal waters of Southeast Asian countries have some of the world's richest ecosystems characterized by extensive coral reefs and dense mangrove forests. These waters are further enriched with nutrients from land which enable them to support a wide diversity of marine life.
The coastal zones of most nations in the Association of Southeast Asian Nations (ASEAN) are subjected to increasing population and economic pressures manifested by a variety of coastal activities, notably fishing, coastal aquaculture, waste disposal, salt-making, tin mining, oil drilling, tanker traffic, rural construction and industrialization. This situation is aggravated by the expanding economic activities attempting to uplift the standard of living of coastal people, the majority of whom live below the official poverty line.
The Lingayen Gulf coastal area, located in the northwestern part of Luzon island, illustrates in microcosm the depletion and degradation problems resulting from unplanned and competing resources utilization in the country.
The mix of water-based (e.g., capture fisheries, aquaculture, sea transport, tourism) and land-based (e.g., urban development, farming, logging, mining) economic activities in the area has put considerable stress on the resource systems which are the very basis of the viability of these activities.
Amongst others the following are the conclusions and recommendations stressed during the workshop:
- Alternative livelihood program, social/educational action plan, upland/coastal afforestation, marine park establishment, legal/institutional program and human resources development are priorities based on the criteria of implementability, urgency and potential benefits. Though management of coral reef resources and of commercial and municipal fisheries are primary in terms of urgency and potential benefits, their implementability becomes difficult due to the legal and political problems attached to them.
- During the course of management plan formulation, review and finalization, the direct beneficiaries of the program must be well-informed and enjoined to participate in the decisionmaking

through the conduct of symposia, consultative meetings, and/or public hearings. Participatory planning and implementation must be encouraged to stimulate the enthusiasm of the local communities.
- NGO's must also be mobilized to take on the early implementation of small-scale (but impact) action plans through the assistance of the local communities. This is to address the more serious problems of the gulf residents who cannot wait until the finalization and implementation of the overall management plan.
- The issues affecting Lingayen Gulf and the efforts exerted by the different sectors to bring solutions to these must be popularized. This can be achieved through the conduct of symposia, and the distribution of publications and information materials to improve or stimulate the awareness of the people. For these activities, educational institutions, particularly the Pangasinan State University and the Don Mariano Marcos Memorial State University, must be tapped.

Experience suggests the need for an integrated, interdisciplinary and multisectoral approach in developing plans that provide a course of action usable for daily management of the coastal areas.

852 91 - 3/115

Integrated systems
USA, study, aquaculture, prawns, craw-fish, pond fishing, stocking rate, forage rice, yield, fish rotation

GRANADOS, A.E. et al.

Double-cropping Malaysian prawns, *Macrobrachium rosenbergii*,**and reds wamp crawfish,** *Procambarus clarkii*.

Journal of Appl. Aquaculture, 1, 1991, pp. 65-77

The objectives of this study were:
- to determine the effects of three crawfish stocking densities on survival, growth, and yield of prawns and crawfish cultured in a double-cropping scheme;
- to contrast survival, growth, and yield of prawns cultured with crawfish with those when prawns are cultured in a monoculture system; and
- to compare survival, growth, and yield of prawns fed a commercially formulated diet in the double-cropping system with those of prawns that are cultured in double-cropping systems that receive no formulated feed.

Problems associated with the culture of freshwater prawns in the U.S. include availability and cost of juvenile prawns for stocking, high cost of feeds, wide variation in size at harvest, high labour costs and production requirements, and price competition with marine shrimps. Monoculture of prawns in the 48 contiguous states presently appears to be more appropriate for small-scale recreational activities rather than commercial development.
Development of freshwater prawn production schemes which can be integrated into existing commercial aquacultural enterprises, such as catfish, *Ictalurus punctatus*, crawfish, *Procambarus clarkii*, and golden shiner, *Notemigonus crysoleucas*, could have commercial potential by utilizing existing ponds, facilities, and equipment.
Integration of prawn culture into the current system of crawfish aquaculture may have potential for a 12-month production strategy. Crawfish are typically cultivated from October through May, while prawns must be grown from May through October in the southeastern U.S. because of low water temperatures before and after these dates.
Adjustments in pond management practices of commercial crawfish operations would be required for "double-cropping" freshwater prawns and crawfish.
A major crawfish production scheme is the rotation of rice, *Oryza sativa*, with crawfish. Ponds are planted with rice during April or May; the grain is harvested in August, and ponds are re-flooded in September or October; crawfish are harvested from November through May. Preliminary research demonstrated the potential for double-cropping prawns and crawfish. Rice was planted in May and the pond was gradually filled with water as the rice grew. The deep end of the pond was not planted with rice and served as a harvest pit for

prawns. The pond was re-flooded in October, and 900 kg/ha of market-sized crawfish were harvested from February through May. Summer-fall production of prawns with winter-spring production of crawfish in the same pond could provide the crawfish culturist with economic diversity.
The study demonstrated that prawns and crawfish are compatible in pond production and that one crop of each can be produced annually in the same pond. To achieve this, pond management strategies had to be modified. For example, rice was planted as forage only in the shallow area of the pond, and a deep portion was left open for initial stocking of prawns. While the crawfish yield in ponds was acceptable (1,000 kg/ha), prawn yield was low due to small size at stocking (0.02 g), low stocking rate (17,500/ha), and short grow-out period (93 days).
The ongoing goal of most commercial prawn is to produce a large prawn (30 g+), but when prawns exceed approximately 17 g they begin to segregate into different size groups.
Crawfish are normally not available during summer and early fall, but prawns can be harvested during this period. Moreover, the ideal size of prawns for molting troughs is about 17 g. Thus, prawns could possibly fill both a biological niche (rotation with crawfish in ponds) and a market niche (soft shell).
Preliminary research indicates that prawns can be molted in the same shedding tanks as crawfish, and this could allow year-round production of a soft-shell product. The implementation of this would require new management strategies. Crawfish may have to be cultivated differently by introducing a formulated diet instead of allowing them to feed on rice forage. This management strategy could also produce a larger, more valuable crawfish (33 or less per kg), especially for the European market. Additionally, stocking systems will have to be developed to produce a 17-g prawn during those months when crawfish are normally not available. This study suggests that production of 17-g prawns is possible. Future research should concentrate on stocking dates, stocking sizes, stocking rates per hectare, and length of grow-out period.

91 - 3/116

853

Integrated systems
Review, book, tropics, crops, livestock, fish, integrated farming systems, research framework, education, institutional framework, ICLARM, UNDP

EDWARDS, P. et al.

Research and education for the development of integrated crop-livestock-fish farming systems in the tropics.

Publ. of ICLARM, P.O.B. 1501, Makati, Manila, Philippines, ISBN 971-1022-46-x, 1988, p. 51 p. + appendix

The word integrated is derived from the Latin verb "integrare" which means to make whole, to complete by addition of parts, or to combine parts into a whole. The crop, livestock and fish subsystems may function independently in certain farming systems,and their products be only additive. However, an output from one subsystem in an integrated farming system which otherwise may have been wasted becomes an input to another subsystem resulting in a greater efficiency of output of desired products from the land/water area under a farmer's control. There is synergism in integrated farming since the working together of the subsystems has a greater total effect than the sum of their individual effects.
The main biological feature of an integrated farming system is byproduct recycling; but improved space utilization, in which two subsystems occupy part or all of the space required for one subsystem, may be an important aspect of increased productivity. A major socioeconomic benefit of integrated farming is that inputs to the various subsystems that comprise the farming system tend to be intra-farm, with a diminished reliance on inter-farm or agro-industrial inputs. Integrated farming systems also spread the risks associated with farming because of the increased diversity of produce. They also lead to a more balanced diet for the farming family that chooses to eat some of its own produce.
A schema is presented in this study of the possible evolutionary development of integrated farming systems to set the research framework recommended here in an appropriate context.
Successful integration of aquaculture with agriculture is a complex subject, not least because of the poorly developed research base for aquaculture in comparison with that of agriculture.
An attempt is made in this publication to create a framework for a truly interdisciplinary approach to research and education in integrated farming - a fusion of agricultural and aquaculture sciences. It has been prepared by two aquatic biologists, experienced in integrated farming research and education, and an agriculturist with a special interest in farming systems.
Integration of aquaculture with agriculture is more developed in Asia than in any other region of the world. However, such integrated farming systems are presently used by only a very small

minority of farmers (<1%) in a few countries and have not progressed far in terms of productivity and efficiency from their traditional beginnings.
The integrated farming systems discussed in this study make use of tropical fish, particularly the omnivorous tilapia which has been hailed as the "aquatic chicken" of the future. Tilapias breed and grow year-round in the tropics.
Research for the development of tropical integrated farming systems should mainly be conducted in the tropics unhindered as far as possible by seasonal climatic constraints.
A holistic farming systems approach is taken in this study because the greatest potential for fish culture lies with farmers who are already engaged in the production of crops and livestock. The idea is to bring aquaculture to resource-poor, small-scale farmers who have limited access to the off-farm inputs necessary to exploit modern farming technology. Fish are produced by recycling byproducts of agronomy and animal husbandry into animal protein. Nutrient-rich pond water and mud are potential resources for adjacent crop products. Aquaculture thereby becomes the third partner alongside existing crop and livestock farming subsystems on small-scale farms. The cost of raising fish in such integrated farming systems would be lower than in systems using pond inputs from agro-industry and would be feasible for small-scale farmers.

854 91 - 3/117

Integrated systems
Asia, Philippines, study, integrated farming, goat, fish, resource utilization, food income, goat meat, waste disposal, small-scale aquaculture, feeds, fertilizer

LIBUNAO, L.P.

Goat/fish integrated farming in the Philippines.

AMBIO, 19, 1990, pp. 408-410

This paper presents the findings from the two 120-day fish-culture periods in a 240-day goat rearing cycle.
An integrated farming system offers several potential advantages, i.e. increased productivity, greater income, improved cash flow, fuller employment, a better diet for the farmer and his family and the spread of both biological and economic risks, since two subsystems are involved as opposed to one in a single commodity farming system. This strategy, however, requires more knowledge and management skills.
In Region 1 (Ilocos Region, Philippines), the average farm size per family is only 1.25 ha, a limited area for cultivation and hence there is a need to maximize land utilization to produce more food.
Region 1 is located in the northwestern portion of the Island of Luzon, 300 km north of Manila.
It is predominantly rural. Around 3 043 900 (76.5%) of the total population live in the rural areas.
Results of a survey revealed that the supply of dietary animal protein in the Philippines is inadequate. Raising goats and developing a family-level fish pond for small-scale use could help to decrease protein malnutrition. However, the major constraint for small-scale farmers involved in aquaculture is the shortage and high cost of pond fertilizer and commercial feeds for the fish.
The integration of goat with tilapia production is a means of establishing a sustainable farming system aimed at maximizing productivity and minimizing operational costs. There is great potential for this production as the demand for milk and meat is high.
In the Ilocos Region, Philippines, intensive goat raising is possible due to the high demand for chevron (goat meat) which is the main delicacy of the Ilocanos. However, intensification is greatly limited by the problem of waste disposal. On the other hand, many Ilocanos are engaged in small-scale aquaculture, but operations are hindered by the shortage and high cost of commercial feeds and fertilizer for their fish ponds. A goat/fish production trial is described employing 0, 200, and 300 goats with fish-stocking densities of 10 000 and 20 000 of Nile tilapia (*Oreochromis niloticus)* per ha. The highest individual fish weight (78.05 g), in a 120-day fish-culture period, was recorded for the combination of 300 goats and 10 000 *O. niloticus* per ha, whereas

the lowest gain (45.95 g) was obtained at the stocking density of 20 000 *O. niloticus* per ha without goat manure. However, the highest total fish yield of 1170 kg^{-1} was recorded for a combination of 20 000 *O. niloticus* and 300 goats per ha.
In the two trials conducted, the growth of tilapia increased with the rate of goat manure loading. This indicates that the fish feed produced in the ponds with goat manure is being efficiently utilized by the fish biomass.
If the present trend in some local markets prevails where large fish fetch significantly higher prices than small-size fish, the 300 goat to 10 000 fish per hectare combination would be more profitable. The study continues with increases in the goat populations to 400, 500, and 600 per hectare with the same fish stocking densities.

91 - 3/118

855

Integrated systems
Asia, Thailand, lowlands, study, rice, fish, weed growth, water regime, biological control

PIEPHO, H.P. and J. ALKÄMPER

Effects of integrated rice-cum-fish culture and water regime on weed growth and development in irrigated lowland rice fields of northeast Thailand.

J. Agronomy and Crop Science, 166, 1991, pp. 289-299

Southeast Asia has recently been seeking to introduce more intensive aquacultural practices into existing rice farming systems.
Given controlled water supply and the herbivorous feeding habits of many fish species, intensive rice-cum-fish culture offers the opportunity for biological weed control.
The weed control exerted by the fish is frequently stated as a reason for the average yield increase of the rice.
Many fish species are herbivorous feeders while others uproot weeds in the search for other food and increase water turbidity which in turn inhibits weed photosynthesis.
The major factor governing weed development in rice paddies is water regime. Increasing depth of water usually inhibits growth of most species. A level of 5 cm has been reported to significantly diminish grasses, sedges are usually absent at 15cm. The response of broadleaved weeds to increasing water depth is less pronounced and varies with species.
In the dry season of 1987 a set of field trials was conducted on 8 farms in the Lam Dom Noi Irrigated Area in Ubon Province, Northeast Thailand. Each farmer provided 2 rice-fish-fields and 2 control fields varying in area from 0.1 to 0.5 ha. The rice crops were transplanted within a period of 14 days.
The management was left to the farmers so they could choose fish densities according to their practices. The stocking densities were in the range of 60 to 200 per ha. Species used were *Cyprinus carpio* L. (Common Carp), *Tilapia nilotica* L. (x *mossambica*) (Nile Tilapia), and *Puntius gonionotus* Bleeker (Thai Silver Barb). A mixture of all three species was used on each field.
The water depth varied from field to field according to the irrigation water supply and the water holding capacity.
The weed plots were grouped in classes according to their average water depth, the class width being 2cm. The number of weeds per plot were averaged for each weed group, treatment (rice-fish and control), and class of water depth.
The presence of the fish species *Cyprinus carpio* L., *Tilapia nilotica* L. and *Puntius gonionotus* Bleeker in irrigated paddy fields resulted in a reduction of the numbers of sedges and broadleaved weeds at low water levels around 5 cm. On the contrary, weed growth was enhanced at higher water levels. Similar results were obtained for the percentage area covered and the

species *Marsilea crenata*. At low water levels the number of uprooted weeds in rice-fish fields was markedly increased if compared to control fields. This indicates that fish prefer shallow areas of rice fields with more abundant food supplies as a feeding place. In rice-fish fields the water was turbid on 77.8% of the test plots (1 m²) compared to only 47.4% on the control fields. The findings are explained by the combined action of a 'fertilizing effect' and a 'feeding effect', both of which are due to fish.
It is concluded that, given adequate water supply and sufficient fish densities, there is good scope for biological weed control in integrated rice-cum-fish systems with an additional fertilizing effect on the rice crop.
The results attainable will frequently depend on fish species used, weed species present in the fields, fish stocking densities and water regime. Further research is needed as to the food preferences of different fish species as well as the optimum stocking densities for different species combinations. In addition, further research should be directed towards a better understanding of the mechanisms governing the 'feeding effect' and the 'fertilizing effect' exerted by the fish.

IV CROPPING SYSTEMS

856 91 - 4/102

Cropping systems
Review, developing countries, agricultural sustainability, cash crops, food crops, vegetal cover factors, erosion, control, basic food staples, production figures, economic policy, IIED

BARBIER, E.B.

Cash crops, food crops and agricultural sustainability.

Gatekeeper Series No. SA2; IIED,3 Endsleigh Street, London WC1H ODD, UK, 1990, 11 p.

Recent evidence suggests that the main obstacle to sustainable agricultural development is the failure of any economic policy, whether promoting food crops or exports, to address adequately problems of natural resource management.
Analysing the sustainability of cash versus food crop production shows that distinctions between cash crops and food crops are not clear cut.
A cash crop may be sold at home or abroad and may be either a food or non-food commodity, whereas an export crop is a cash crop that is ultimately exported from the country producing it.
The major non-food cash crops that are exported are cocoa, coffee, fibre crops, rubber, tea and tobacco. In contrast, the term "food crop" usually refers to domestic production of basic staples (cereals, pulses, roots and tubers).
These are the principal subsistence crops, they are also often marketed.
Aggregate evidence suggests that, in most developing countries, expansion of cash cropping for export is not necessarily at the expense of staple food production.
For example, in sub-Saharan Africa, constant or declining per capita food production has been associated with constant or declining shares of land allocated to cash crops.
The amount of land growing both export and food crops in developing market economies has increased in the last ten years due to the bringing into production of "new" land, such as areas under forest or previously considered marginal.
In some regions, government policies deliberately encourage the production of food crops in marginal areas often without simultaneously encouraging proper management techniques and agricultural practices that can reduce environmental and soil erosion problems.
The planned extension of maize, sorghum and millet into dryland areas has tended to exacerbate problems of soil erosion and exhaustion.
The input requirements of increased food and cash crop production may also have important ecological impacts, particularly where

inappropriate use of these inputs is encouraged by government subsidies.
For example in Indonesia subsidies for fertilisers has reached 68% of world prices; as a result, consumption of fertiliser increased by 77% (12.3% per year) over 1980-85.
Inappropriate input subsidies for fertiliser, pesticides and irrigation can impose considerable external costs in terms of agricultural pollution and resources depletion.
Some of these can be considered user costs - in terms of the losses in future agricultural productivity to the cultivator of pesticide resistance, misallocation of input investment or inappropriate use, and any constraints imposed by future scarcity (e.g. water).
Other important external impacts from inappropriate use of agricultural inputs include the effects on human health, fishing activities and biological diversity of pesticide misuse; problems of groundwater contamination and eutrophication of surface water from fertiliser run-off.
Agricultural output and pricing policies that do not take into account the possible environmental impacts and displacement effects of increased production may lead to a less than optimal allocation of natural resources.
This is a common problem not only with policies to promote export crop production but equally with policies to achieve food self-sufficiency.
The environmental implications of agricultural input subsidies are rarely considered in the design of agricultural policies,yet the user and externality costs of these impacts are often quite high.
For marginal lands, the choice of crop must be suitable for the given agro-ecological conditions and economic needs of farming households.
Production-led policies for both food and export crops are designed without sufficient knowledge of these conditions and their economic implications.

857 91 - 4/103

Cropping systems
Review, book, tropics, subtropics, crops, plants, cultivation, economic value, utilization, IAT, CTA

REHM,S. and G. ESPIG

The cultivated plants of the tropics and subtropics.

Verlag Josef Markgraf, Weikersheim in cooperation with CTA, Wageningen; ISBN 3-8236-1169-0, 1991, 552 p.

This book is the translation of the well known original German edition: "Die Kulturpflanzen der Tropen und Subtropen".
The original German edition of this book was based on the lectures of the senior author (S.R.) at Göttingen University and on the documentation on tropical crops collected by G.E.
The number of plants which are cultivated in the tropics and subtropics is very large. About 2,500 species have been named, excluding ornamental and forest plants; this number includes the cultivated plants of the temperate zone, and some close relatives of the species cultivated.
The wealth of plants is far from being fully exploited and harbours genetic resources on a much larger scale than today used. More than 1,000 plants are discussed in this pocket manual.
World trade, the drive for exports, and the transition to rational production procedures are nowadays the causes of rapidly progressing changes in plant cultivation in the tropics and subtropics.
The main concerns of the authors in this book are to comprehend these changes, to exclude obsolete plants, to indicate new developments, and to consider the economic importance of each plant.
With regard to the scientific nomenclature of plants, the authors endeavoured to use the names which are valid according to the International Code. Where plants are still frequently cited in the literature under a name which is no longer valid the most synonym has been given and if necessary, two synonyms.
It seemed desirable to give the common names of plants also in several of the world's most important languages, because the scientific names of the plants are not always given in the foreign literatures.
Botanical particulars (morphology, anatomy, physiology) have been limited to the features which are important for the agronomist.
It has been impossible to present the multitude of agricultural methods and possibilities. The book is limited to emphasizing the most basically important and generally valid aspects.
Detailed advice about fertilizers has been omitted because of the extraordinary differences in soil types found in the tropics and subtropics.
Diseases and pests have been reviewed in as much as they cause severe damage and are of more than regional importance.

The book is organized in the following way:
Each chapter begins with an introduction to the particular properties of the plant group, giving an overview on the economics, production trends, nutritional aspects, chemistry, and technological features. The major crops are treated in detail. With regard to these, the authors sought to cover all essential points: production, botany, breeding, ecophysiology, cultivation practices, diseases and pests, processing and utilization. The numerous minor or only locally important crops were collected in the tables; these give the valid botanical name of each plant, a selection of its vernacular names, and indicate its distribution, economic importance and uses. The drawings help to identify the plants, and depict important morphological peculiarities. The diagrams illustrating the production during the last ten years are intended to offer visual information on the relative importance of a crop and on current trends.
As a key to available information a large number of references to all the species included has been given. In selecting the quotations the authors aimed at covering all aspects of production and utilization, and all regions of the tropics and subtropics.
All information on the plants dealt with in this book is available off-line from a continuously updated data bank for cultivated plants and relevant literature.
The book will be of use to undergraduates, graduates and practioners involved in plant sciences or other looking to extend their general awareness of this exciting area.
Clearly written in a precise form and well illustrated, with an extensive bibliography, this book is an excellent source of information.
The book is therefore highly recommended to all interested in tropical agriculture.

858 91 - 4/104

Cropping systems
Review, crops, marginal environment, agricultural sustainability, seed production, breeding strategies, processing technology, household needs, species mixtures, variety mixtures, pasture environments, IIED, SIDA

JIGGINS, J.

Crop variety mixtures in marginal environments.

Gatekeeper Series No. SA 19; IIED, 3 Endsleigh Street, London, WC1H ODD, UK; 1990, 13 p.

In marginal environments the variability between production sites is high, climatic conditions are erratic within seasons and between years, and infrastructural development is poor. Farmers often respond by enhancing diversity, both of crops and of varieties of crops. Diversity allows versatility; it also contributes to greater household security.
The value of varietal mixtures has largely been ignored in conventional breeding goals.
Here the aims are to select out variability and adaptability in order to exploit the potential of intensive and uniform agriculture. Such strategies are quite inappropriate for marginal environments, and alternatives are urgently required.
In marginal environments, where production conditions vary in time and space, there are four reasons why there is a need to look at new breeding strategies:
- Research capacity is limited
- Marginal environments can be extremely variable
- There is little prospect of modifying the conditions
- Variety mixtures fit the local processing technology and household needs.

Farmers in unstable and variable environments experience two acute pressures: limited sources of power and labour; and, in many cases, limited time within the single short growing season of erratic rainfall. One of the keys to surviving these pressures is the maintenance of versatility in altering labour availability and production opportunities. Mixtures maintain biological diversity. Biological diversity allows versatility in the management of labour and the maintenance of a capacity to respond to inter-annual and inter-seasonal fluctuations in the timing and intensity of rains, and fluctuations in the soil conditions, incidence of pests and diseases, and temperature.
There are three main ways in which farmers can maintain biological diversity: by using mixtures of different species, mixtures of different varieties of the same species, or varieties whose genetic composition is itself variable.
These aspects of creating biological diversity are discussed and examples are given in this paper.
Concluding the implications for breeding strategies the author states, that crop variety mixtures provide farmers in marginal

environments with the capacity to adapt their production to the variable and unstable conditions. Farmers in these environments often have detailed knowledge of the different varieties and the locations and weather patterns to which they are suited. The case for producing mixes of crop varieties is, at present, clearer than the case for retaining unstable varieties within particular blends of crop varieties.
There are few guidelines for researchers who might wish to formulate new variety mixtures, select additions to existing blends, or evaluate the results. A great deal of progress could be made in this direction if researchers were to seek greater farmer participation and help empower farmers to improve their own manipulation of the varieties at their disposal.

91 - 4/105

859

Cropping systems
Review, agricultural sustainability, adaptive research, soil fertility, sustainable cropping, appropriate crops, tillage practices, crop rotation, legumes, crop residues, mulches, organic matter, weed management, fertilizer, soil amendments, IBSRAM, CTA, USAID

PUSHPARAJAH, E.

Adaptive research on sustainable cropping systems.

In: Proc. of a IBSRAM Workshop, Thailand in cooperation with CTA, USAID and other agencies; ISBN 974-7613-20-4, 1989, pp. 59-74

Large areas of Ultisols and Oxisols occur in the humid tropics. These low-fertility soils are often used for cultivation, and their inherently poor chemical properties pose problems for agriculture. With population pressure and the need to produce more food, there is greater demand for land. As a consequence, newer areas are being brought into cultivation, which are often less fertile. In shifting cultivation, productivity is even lower on account of the tendency to reduce the length of the fallow period. Thus there is a need to consider suitable systems for managing the soil, which would enable productivity not only to be sustained but also to be increased.
With the opening of jungle land in the humid tropics, the soils begin to deteriorate rapidly. The loss in productivity of soils is accentuated by traditional farming and/or shifting cultivation. Research has shown that the use of certain practices or inputs would enable sustainable cropping to be established.
The results of trials done in various countries in the humid tropics indicate that sustained cropping both under "low-input" and "high-input" systems are possible. There is, however, a need to pay close attention to:
- the choice of varieties with regard to their adaptation to the soil conditions;
- the need to implement a crop-rotation system incorporating a legume in the sequence - which is useful not only in improving soil fertility but also in preventing a buildup of pests and/or diseases;
- the use of conservation tillage practices;
- adequate weed control and other crop protection measures;
- the need to utilize available crop residues, wastes or mulches, which could include the use of legume shrubs/trees in hedgerows for supplying the crop residue;
- the incorporation initially of the major limiting nutrient, fertilizer (e.g. P, lime etc.) and eventually of all nutrients needed, having regard to the available infrastructure and acceptance by the farmers.

There is an urgent need for adaptive research on sustainable cropping systems which would take these factors into account. Initially, emphasis should be on cultural and management

practices, which should include consideration of the appropriate variety.
In the evaluation of the most appropriate sustainable system, the need for the farmers' acceptance and their ability to implement the system evolved should be considered. The monitoring of any investigation on sustainable systems should consider not only yield and returns, but also include observations on the effect of the system on soil, pests, weeds, and diseases.

860 91 - 4/106

Cropping systems
Review, crop research, developing countries, yield, farming systems, agricultural sustainability, cultivation methods, plant breeding, marginal lands, salinity, new crops

CAESAR, K.

Developments in crop research for the Third World.

AMBIO, 19, No. 8, 1990, pp. 353-357

The opening up of so-far unused land is not only very costly but there are other obstacles involved; these relate to the great ecological risks involved such as erosion, drought, depletion on thin soil layers, etc.. In many regions, the necessity to use even marginal soils raises specific questions relating to how yields should be raised instead of cropping areas extended.
The steady increase in world population as well as necessity to improve food quality in many regions of the world requires enhancement of crop production.
The focus has to be on increases in yields and yield stabilization. To achieve this, all disciplines in crop science have to combine their efforts: Agronomy to improve the cropping systems towards a sustainable land use system which includes mixed cropping up to agroforestry; soil science for better soil management; plant nutrition and fertilizer use to improve nutrient efficiency with regard to mineral uptake and their role in the plant metabolism; plant physiology to clarify further the mechanism of biomass production with minimum losses due to respiration and increasing the storage capacity of plant organs; plant breeding in making use of the physiological findings to "construct" more efficient plants with high yield and adaptability to stress factors as well as climatic conditions influencing growth; implementation of integrated pest control in order to protect the plants from unfavorable hazards to stabilize the yields, to promote environmental protection and health; irrigation management to make use of additional inputs; to avoid erosion and salinization.
In this paper typical examples are given for most of the fields in order to show the progress already made or the prospects envisioned for the future.
The role of so called new crops is discussed as well.
In general, the very often expressed hope to broaden the rather narrow spectrum of cultivated plants has usually resulted in disappointment. The discovery of miracle plants, such as jojoba (*Simmondsia chinensis*) to replace whale oil, or Guayule (*Parthenium argentatum*) to substitute for Hevea rubber were rapidly forgotten by both mass media and unfortunately also by crop scientists for whom nutritional and cash crops hold the foremost place.
In some rare cases, the improvement of regionally important crops like teff (*Eragrostis teff*) in Ethiopia or quinoa (*Chenopodium*

quinoa) in the Andes was undertaken with some success but the only real breakthrough in the last decades was with Triticale, i.e. a hybrid between wheat (*Triticum*) and rye (*Secale*). This new plant has been successfully cultivated on marginal land, but does not compete with the production of other staple foods. Its potential cropping area is described as very promising. In spite of this outlook much research is still necessary to improve this plant for sustainable cropping.
Finally the author concludes that almost all the problems discussed in this paper relate to both plant physiology and plant breeding. All the factors involved, including plant reactions to stress and the mode of adaptation, utilized by the plant, to obtain higher yields must be put forward as clearly defined criteria from which the breeder can select. In many cases, improvements in cropping systems can be achieved by means of technical or management methods. But sustainable improvement will be possible only with improved plants. Therefore, for the low latitudes and in developing countries plant breeding is an indispensable discipline for food security. Furthermore, scientists in industrialized countries can help with basic research relating to single factors, e.g. controlled conditions that can often produce better results than do studies under natural and more complex conditions.

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Cropping systems
Review, cropping systems, plant interactions, mechanisms, mutualisms

GLIESSMAN, S.R.

Plant interactions in multiple cropping systems.

In: Multiple Cropping Systems, Francis, C.A. 1986, 83-95, McMillan, Tabasco, Mexico

Most of the knowledge about the ecological basis for plant interactions comes from the study of natural ecosystems and plant ecology. A great variety of classification schemes has been presented in order to better understand the diversity of types of biotic interactions between species.
When describing the nature of interactions, the focus is on the fact that a plant may influence its neighbours by changing their environment. These changes may be by means of an addition or removal reaction, and there has been much controversy recently as to which is most important. As a guide for such studies, the concept of interference interactions is proposed permitting a mechanistic approach to understanding how the interactions function.
In contrast to purely additive or removal interactions, mutualisms can often combine several components of interference. The benefits gained by each partner link them into mutual, physiological interdependence. When one component species is absent, the others suffer, and in some cases cannot even exist as free-living organisms. It is difficult to separate mutualisms from the benefits found in beneficial intercropping systems. Yield advantages often come about from the avoidance of direct interference through competition for limited resources or production of phytotoxins which eliminate other competitors. It is much more difficult to demonstrate that benefits are directly derived from the interference. Symbiosis is another term that refers to mutualistic interactions.
Symbiotic nitrogen fixation is the most commonly known mutualistic interaction. Legumes with their accompanying *Rhizobium* bacteria have played important roles in agriculture. The benefits of the mixture of legumes with other crops stem from interactions such as the excretion of nitrogen by the legume for use by the nonlegume, stimulation of soil microorganisms, and the return of nitrogen to the soil. Either through legume/nonlegume mixture or legume/nonlegume rotations, many intercropping systems with this mutualism are practiced today.
The much more widespread importance of mutualisms in ecology are currently being discussed. In an evolutionary sense, the benefits gained from mutualisms may tend to be favoured over competitive interactions. For example, success of a plant at low levels of available nutrients may come about more through a mutualistic relationship with other species requiring the nutrients, rather

than by out-competing them. Resources can be partitioned rather than competed for. Mutual defense from predators, herbivores, or disease organisms can become possible. The long-term benefits to be gained from such an approach to multiple cropping important.
The most commonly invoked explanation for yield reduction in mixtures is the removal reaction through competition for a limited resource. Density, the number of plants per unit of area, is the primary component of competition, and agronomists have perfected knowledge of optimal density plantings for sole-crop plantings in order to maximize yields. Very little work has been done on optimizing densities for intercrop systems. In order to accomplish this, the understanding of species proportions and arrangements must be increased. Addition reactions, either through allelopathic interference or mutualisms, alter the crop environment and can be of benefit in crop mixtures. The potential role of such mixtures for weed or pest management needs considerably more research.

91 - 4/108

862

Cropping systems
Australia, tropics, subtropics, study, crop improvement, plant design, crop physiology, climatic constraints, climatic adaptation

LAWN, R.J. and B.C. IMRIE

Crop improvement for tropical and subtropical Australia: designing plants for difficult climates.

Field Crops Research, 26, 1991, pp. 113-139

Emphasis in this paper is placed on the contribution of physiological understanding to breeding to improve genetic potential of crops and to minimize environmental constraints to that potential. The discussion is specifically constrained to the tropics and subtropics of northern Australia, but the principles are equally relevant to comparable environments elsewhere.
As a prelude, the conceptual basis underlying the use of physiological understanding in crop improvement is explored. The general climatic features presently understood to constrain crop production in the tropics and subtropics are also outlined. Throughout, examples are drawn primarily from those grain crops widely recognized as being "tropically adapted" or "summer grown", and for which there has been some local improvement effort. Special emphasis here is placed on soybean (*Glycine max*, an oilseed), mungbean (*Vigna radiata/V. mungo*, a grain legume) and sorghum (*Sorghum bicolor*, a cereal).
These, and most of the summer grain crops being developed in the region, are relatively recent additions to Australian agriculture, and in some cases to the tropics, or to mechanized agriculture in the tropics. Most are strongly sensitive to photoperiod and temperature. A primary aim, therefore, has necessarily been to improve their adaptation to tropical and subtropical environments characterized by generally warm temperatures and relatively short photoperiods. At the same time, constraints imposed by stressful temperature extremes, and frequent water-deficits as a result of limited and highly variable seasonal rainfall, have had to be addressed. The latter constraint has been compounded by soils that often have limited water-storage capacity. Genetic improvement has been confounded by large and often nonsystematic genotype X environment (gXe) interaction, which increases the testing necessary as a basis for selection. The most valuable contribution of physiological understanding has been to assist interpretation of gXe interaction in terms of biological, as opposed to statistical, models. Physiological interpretations have been both qualitative and quantitative in nature, and 'models' range from simple to complex, but nonetheless enable predictive inference to be drawn of the performance of particular genotypes in specific environments. Physiological research is thus being used to identify the key physiological and climatic constraints to productivity confronting crop improvement, to establish strategies for agronomic and breeding research, and to formulate 'dynamic'

ideotypes to assist the breeder to match crop life-cycles to the resources and constraints of target environments. Physiological understanding also offers the potential to exploit traits conferring resistance to specific stresses, but to date that potential remains largely unrealized.
Authors' Abstract, extended.

863 91 - 4/109

Cropping systems
Study, tropics, subtropics, highlands, crop rotation, intercropping, land-use systems, cost-benefit calculations, modern cropping systems, traditional methods

CARLS, J.

Sustainable highland cropping systems.

entwicklung + ländlicher raum, 24, 6, 1990, pp. 22-25

As resources become scarcer in large parts of the tropics and subtropics, use of highland areas (elevation above 100 meters) gains in importance. With increasing elevation, temperatures fall and rainfall often rises; vegetation, soils and land-use possibilities exhibit corresponding gradients. Localized variations in slopes and soils add to the diversity. To pinpoint development potentials, these areas must therefore be subclassified according to carrying capacity, possibilities for agricultural use, population density and distribution, and social, economic and institutional factors. Reference here is primarily to areas lying between the extremes of valley bottoms with more favourable natural conditions and very cool mountain heights which can be used, at best, for only seasonal grazing. In largely marginal highland areas, expansion of cultivation is normally not possible and possibilities of intensification are limited. With chronic lack of capital, most of the smallholders practise capital-extensive but labour-intensive subsistence farming.
The aim is to develop stable and sustainable systems which do justice to ecological potential and socioeconomic necessities. Livestock form an integrated part of these systems. Under such marginal natural conditions, moderate applications of external inputs such as mineral fertilizers cannot be completely dispensed with.
The Luzon region (1500-2500 meters a.s.l.) in the Philippines serves as an example of tropical highland.
The present rotation of potatoes and cabbages, only occasionally interrupted by other crops, needs improvement for both ecological and phytosanitary reasons. A ley-farming system - incorporation of temporary grassland for animal production - is not practised, as the farmers claim that other forage resources are available. To diversify the ration, crops are required which tolerate extreme climatic conditions and low inputs of water and fertilizer, and which can help maintain soil fertility. Plants sown solely for erosion control and soil conservation are not acceptable to the smallholders.
During the height of the wet season with accompanying typhoons, cabbage, chicoree and radish suffer least from such weather. In the dry season (November - February) leguminous species which require little water and fertilizer are most suitable. The danger of transmitting diseases and pests such as clubroot of cabbage and diamond-back moth is lowered by including legumes and potatoes,

and nematode infestation (*Globodera spp*) as well as potato wilt (*Pseudomonas solanacearum*) are reduced to a minimum.
Mixtures of appropriate crops can, by adding organic matter and nitrogen to the soil, help prevent erosion and maintain soil fertility.
A trial in the Cochabamba Valley (3500 meters a.s.l.) of Bolivia demonstrates the positive effects of intercropping. Beans, potatoes and lupins were sown in two patterns: alternating different crops in a row, and alternating rows of different crops. Intercropping increased total yield and, with one exception, resulted in up to 36 percent higher land utilization. The incidence of viral and fungal diseases was also significantly lower in intercropped than sole-cropped potatoes, and the intercropped potatoes stored better.
The ecological conditions in subtropical highland are usually also extreme; generally, the situation described for tropical highland also applies here. The marginality of the subtropical sites is accentuated by lack of water as a constraint to agricultural use.
In the Rif Mountains of Morocco, cereal-based rotations and sheep-keeping are the main components of land use. Trials were carried out with traditional and modern production techniques.
Legumes were included to reduce the disadvantages of too frequent cereal cropping. Legumes are excellent partners in rotation with cereals. The root systems of the two crop types differ, the diseases and pests of the one seldom attack the other, and the positive effect of legumes on the soil can be fully exploited by the cereals. The traditional and modern cropping methods are compared.
The major implications of the trial results are:
- in years with at least 300 millimeters rain, use of modern inputs is justified, but as this much rain was not received in 30 percent of the years recorded, farmers using these inputs run high risks;
- the high productivity of the oats/vetch mixture for mutton production underscorces the great economic importance of integrating livestock-keeping and crop production;

Concluding it is stated that development efforts in highland areas should grow out of their natural potentials:
Exceeding the natural carrying capacity of highland areas by inappropriate land-use systems eventually destroys the environment and the basis for life in the mountains as well as at lower levels through water deficits and floods. In highlands where this danger is acute, development of resource-conserving land-use systems offers a great challenge. The conservation aspects must often be given precedence over yield maximization, so that the ecological carrying capacity of the highland areas can be maintained.

864 91 - 4/110

Cropping systems
Australia, study, rice cropping systems, management strategies, stubble management, nitrogen application, yield variance

BACON, P.E.

Management strategies for maintaining rice yield within rice-based cropping systems.

Field Crops Research, 26, 1991, pp. 315-326

The experiments reported here were designed to assist in the development of a management package for annual drill-sown rice-cropping. This paper examines the effects of various management inputs on yield and yield components in rice crops grown in soil with declining fertility.
Australian rice grown within a one-year-rice/four-year-legume-based pasture rotation can yield over 10 t ha^{-1}. Recently, increased economic pressure has encouraged more-intensive annual rice cropping. However, farmers who use traditional agricultural practices, such as the use of relatively small quantities of nitrogen fertilizer, have had difficulty in maintaining adequate yield. Consequently, there is an urgent need to develop management strategies to maintain productivity.
A five-year study was undertaken to develop management strategies for maintaining yield of consecutive annual rice (*Oryza sativa* L.) crops. Stubble management technique, N application rate and N application time were all important determinants of yield; together they accounted for up to 80% of yield variance.
Incorporating stubble, rather than burning it, had little initial effect on yield but, from the third crop onwards, stubble-incorporation plots out-yielded stubble-burn plots by an average 0.35 t ha^{-1} per crop. The higher yield was due to an average 11% increase in panicle number.
Yield of unfertilized rice fell from 9 t ha^{-1} to 3.7 between the first and fifth crops, with much of the fall occuring between the first two crops. The highest-yielding treatment in the fourth crop (which received 105 kg N ha^{-1} at permanent flood (PF) plus 105 kg N ha^{-1} at panicle initiation (PI) did not achieve the yield of the first rice crop receiving 50 kg N ha^{-1} at PF (8.3 t ha^{-1} compared with 9.6). This suggests that N application in excess of 200 kg N ha^{-1} were necessary to maintain yield.
Fertilizing at sowing had little effect on yield. However, fertilization with a five-year average of 94 kg N ha^{-1} prior to PF resulted in higher average yield (6.8 t ha^{-1}) than that obtained from plots receiving all their fertilizer at PI (6.1 t ha^{-1}). The difference between PF- and PI-fertilized plots became greater with increasing number of crops and was because of increased floret sterility in crops receiving all their N at PI.
The experiments above clearly demonstrate the beneficial effects that stubble incorporation plus increasingly heavy N applications just prior to PF have on the yield of annual rice crops.

Stubble incorporation rather than stubble burning near rice sowing never reduced yield and, from the third crop onwards, incorporation increased yield.
Summarizing the studies demonstrate the need to adjust N-management strategies for changing soil-fertility levels. These strategies should aim to supply sufficient N during the vegetative phase for good vegetative growth to provide a crop capable of achieving high yield under favourable grain-development conditions.

865 91 - 4/111

Cropping systems
Asia, Philippines, organic farming systems, sugarcane, trash farming, legumes, intercropping, sugarcane planting, IFOAM

MENDOZA, T.C.

Development of organic farming practices for sugarcane based farms.

In: Proc. of the Seventh IFOAM Int. Sc. Conference Ouagadougou, Burkina Faso, 1989, pp. 189-202

In view of the detrimental effects of burning sugarcane to the soil organic matter and the atmosphere, and the financial/ecological drawback of fertilization practices centered on inorganic sources, series of related studies were undertaken to gradually reduce or eliminate the need for inorganic fertilizer in sugarcane production.
Sugarcane (*Saccharum officinarum*) possesses a genetic and physio-biochemical potential capable of producing large amounts of biomass. These potentials explain its high responsiveness to applied inputs, i.e. fertilizer, water, weeding.
Translated to actual figures, yields of about 30 tons dry biomass per 100 tons per ha fresh millable canes are easily realizable.
The exploitation of this genetic and physio-biochemical potential find congruence with the large amount of fertilizer applied per unit time and per unit area basis. About 1,0-1,5 ton of fertilizer per ha per crop/year is applied in some sugarcane farms in the Philippines. This practice resulted to alarmingly low pH (below 5,5) among soils devoted to sugarcane culture. As a consequence, fertilization rates had to be increased further to sustain normal yield levels.
Another dominant practice that contributes to soil fertility decline which would directly explain the need for higher fertilizer rate is burning of canes. Pre- and post-harvest cane burning have been a widespread practice.
Tremendous amount of biomass could be decomposed in situ if this practice of burning canes could be minimized if not totally avoided. It is estimated that in a hectare of field, about 10,0-15,0 t/ha of dry trash + tops are burnt. Per nitrogen content analysis, this will be equivalent to 75-100 kg per ha.
As shown in the studies, fertilizer application for sugarcane can be reduced to as much as 50% without sacrifying sugar yield. This can be done by intercropping/green manuring.
It was previously recognized that "organic farming" can be best implemented in small and medium-sized owner-operated farms. Large farms are highly business-oriented. Profit motivation dictates the use of technologies which will bring about maximum profit in the short run. Hence, when the price of sugar is high, large-commercial farms will apply all the fertilizers to the point of optimum returns. On the other hand, small sugarcane farms in the Philippines are tenanted. So, the controls or decisions are still

being made by the landlord. The tenants do not find the practice of building/restoring the soil fertility attractive because (1) the benefits do not occur to them and (2) their feeling of insecurity masks any intention whose gain can be realized in the long run.
The future work is to diversify the utilization of the sugarcane plant at the farm level.

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Cropping systems
Latin America, Colombia, highlands, smallholder, fruit trees, maize, potatoes, grain legumes, vegetable, barley, alley cropping, economic comparison, land productivity, labour inputs, GTZ, BMZ, CEC

MÜLLER-SÄMANN, K.M.

Multiple cropping with deciduous fruit trees in the cold tropical highlands of Colombia.

In: Ecofarming Practices for Tropical Smallholdings, Ed. J. Kotschi, Verlag J. Markgraf, Weikersheim, 1990, pp. 107-126

This paper is based on results of a development project in the highlands of Colombia.
The aim of the Colombian-German development project is to promote smallholder fruit-growing through seedling production and agricultural extension and credit.
In the study area (Boyaca Department) particularly smallholders face serious ecological and economic problems.
The dominant form of land use is extensive cattle-keeping by smallholders, greatly favoured by the spontaneous spread of Kikuyu grass (*Pennisetum clandestinum*) which now covers 50-70% of the agricultural area. Intensive forms of dairy husbandry can be found in the valleys, where night frosts and seasonally high water tables render cropping difficult.
In the project area suitable experimental areas were selected in existing pear and peach plantations and directly adjacent open fields, and simply designed trials were laid out.
In this paper the results of Trials I (1986 and 1986/87) and III (1986/87) are discussed.
In the search for suitable perennial crops, fruit trees offer the best possibilities. They can already be found in many smallholdings, where they are grown on small areas with undersown food crops. This cropping system is considered to be relatively erosion-safe, land-intensive and low-risk. Whereas the undersown crops (potatoes, beans, maize, etc.) secure subsistence, the fruits can be sold and provide cash income. Apples, pears, peaches and plums command high prices and the domestic market.
Summarizing the results, it can be said that in most cases, the yields of field crops under trees were reduced (7-32%) in comparison with yields in the open field. This is due primarily to the reduction in crop area. Insufficient light led to lower yields only in the case of potatoes, which were grown while the trees were in full foliage. Competition for nutrients between trees and field crops was evident only at the upper edges of the terraces and was negligible relative to total yield. Large differences were evident in water supply but other than expected. Both water utilization and water supply appeared to be better under the pear trees and enhanced yields. The arable crops scarcely competed with

the trees for water, as they were no longer in the field at the time when the water requirements of the trees were greatest.
Consideration of the individual yield components reveals that the pear yields in sole and mixed stands were almost identical, whereas the yields of the field crops were reduced in mixed stands, primarily because less area was available for cropping under the trees. The high contribution of the pears to the total gross margin means that, with increasing intensification of the fruit-growing component, the LER value falls, i.e. arable cropping under pear trees becomes less profitable. Under these conditions, the value of the intercropping system can be seen above all in the possibility of securing subsistence via arable cropping and simultaneously gaining cash income via pear production. This combination of subsistence and cash cropping with high land productivity on very small areas is attractive for the smallholder, particularly because production risks are kept low. From the viewpoint of profitability, intercropping is especially interesting for farms which, because of scarce capital, must do without external production inputs such as mineral fertilizers and plant protectants.