IV CROPPING SYSTEMS

331 89 - 4/34

Cropping systems
North America, USA, experiment, temperate climate zone, cropping system, conventional agriculture, low-input system
LIEBHARDT, W.C. et al.
Crop production during conversion from conventional to low-input methods.

Agron. J. 81, 1989, pp. 150-159

Alternatives to conventional agricultural methods range over a wide spectrum. As used in this paper, the term "low-input" emphasizes the use of international resources generated on-farm rather than purchased resources produced externally. Pest control is achieved mainly through cultural and biological methods, such as mechanical cultivation and crop rotation, and nutrients are supplied primarily by animal and green manures.
A fundamental difference between low-input and conventional systems is the use of more diverse crop rotations in low-input systems. Continuous cropping of corn, or corn and soybeans, cannot be sustained without substantial additions of fertilizer and pesticides. Many studies demonstrate reduced yields in continuous corn compared to corn following hay or small grains.
Another important component of low-input farming systems is the use of animal manures, green manures, and cover crops. These soil amendments provide nutrients and organic matter, the benefits of which have been discussed elsewhere.
Very few replicated experiments have been conducted comparing low-input and conventional systems.
A 5-yr cropping system experiment was initiated in 1981 to study transition from a conventional agricultural system using pesticides and fertilizers to a low-input system. Three 5 yr rotations were compared. A conventional corn (*Zea mays* L.)-soybean [*Glycine max* (L.) Merr.] rotation (designated "conventional") was compared to two low-input rotations which utilized oat (*Avena sativa* L.), red clover (*Trifolium pratense* L.) and winter wheat (*Triticum aestivum* L.), in addition to corn and soybean. One low-input rotation used cattle manure as a nutrient source and produced forage crops in addition to cash crops (designated "low-input/livestock"), while the other used legume crops as a nutrient source and produced a cash crop every year (designated "low-input/cash grain"). Corn grain yields in the low-input systems were 75% of conventional in 1981 to 1984, but yields were not significantly different in 1985. Weed competition and insufficient N limited low-input corn yields during the first 4yrs. Soybean yields in the low-input systems were equal to or greater than conventional all 5 yrs. It is concluded that a favourable transition from input-intensive cropping to low-input systems is feasible, but only if crop rotations are used which include crops that demand less N and are competitive with weeds, such as small grain, soybean, or legume hay. Corn should be avoided for the first 3 to 4 yrs.
A farmer might choose to facilitate the transition by reducing pesticide and fertilizer inputs gradually. Herbicides could be banded in the row at a reduced rate and supplemented by cultivation. If corn must be grown during the first 3 to 4 years, low rates of N fertilizer could be applied to supplement N derived from manure or legumes.
In the conversion from conventional to low-input farming methods, weed and nutrient problems may result if herbicides and fertilizers are withdrawn without designing the system to function without these inputs. Management skills are a key factor in designing systems to make this transition successful. The primary management decisions in this experiment were related to weed control, and the production and availability of N. Future work will concentrate on refining low-input systems to further improve weed control and N availability, as well as to reduce soil erosion and nitrate leaching.

332 89 - 4/35

Cropping systems
Asia, India, experiment, sole cropping, intercropping, rice, mungbean, soybean, peanut, blackgram
MANDAL, B.K.
Effect of intercropping on the yield components of rice, mungbean, soybean, peanut and blackgram.

J. Agr. & Crop Science, 162, 1989, pp. 30-34

Due to the bottleneck of availability of cultivable land, the scope for horizontal expansion for increasing foodgrain production in India is gradually becoming limited, but there is a good scope for vertical expansion through intensified cropping. Intercropping is one of such approaches. Rice (*Oryza sativa* L.) enjoys second position among the cereal crops in the world. The crop is also adapted to diverse agroclimatic conditions. In West Bengal, rice is the predominant crop, being grown in more than 70 per cent of the cultivated land. Pulses are the chief sources of dietary proteins in India. Well equipped with the unique property of fertility restoration, they have been considered to be the backbone of Indian agriculture. Among the pulses mungbean, blackgram and soybean occupy an important position in West Bengal. Among the oilseed crops, groundnut holds a dominant position in India.
An investigation was carried out to study the feasibility of growing different leguminous crops as intercrop with rice.
The soil was alluvial, sandy loam in texture with 0,063% N, 15.88 kg available phosphorus, 80.40 kg available K/ha and a pH of 7.6.
The 14 cropping systems were: sole rice, sole mungbean, sole soybean, sole peanut, sole blackgram, rice + mungbean (4:1), rice + mungbean (2:1), rice + soybean (2:1), rice + soybean 4:1), rice

+ soybean deferred (2:1), rice + peanut (2:1), rice + peanut (4:1), rice + blackgram (4:1) and rice + blackgram (2:1). Sole crop of rice always recorded higher number of effective tillers/m², however, it was observed that legumes had an influence on the number of filled grains per panicle in rice + legume combinations. Among legumes, pure crops of soybean and peanut always gave rise to increased number of yield components in comparison to the other crops grown in association with rice. In case of mungbean, number of pods per plant and thousand kernel weight was higher in pure crops, though number of seeds per pod was more with rice + mungbean combination. Blackgram in association with rice yielded greater number of seeds per pod and thousand kernel weight though sole crop of blackgram significantly produced higher number of pods per plant.

333 89 - 4/36

Cropping systems
Fed. Rep. of Germany, greenhouse trials, sandy soil, missed cropping, sole cropping, wheat, barley, persian clover, salinity, soil water regime, soil temperature, nutrient uptake, protein content

HOSSIEN, Y.K.

Einfluß der Faktoren NaCl-Versalzung, Boden-Wasserregime und Bodentemperatur auf Wachstum, Nährstoffaufnahme und Proteingehalt von Weizen und Gerste in Reinkultur und in Mischkultur mit Perserklee.- (Influence of the factors NaCl salinity, soil water regime and soil temperature on growth, nutrient uptake and protein content of wheat and barley in single cultivation and in mixed cultivation with persian clover).

Göttinger Beiträge zur Land- u. Forstw. i.d. Tropen und Subtropen, 30, 1987, 289 + Annex.

The present experiments were intended to give information on the influence of NaCl salinity, water regime, and soil temperature on growth, nutrient uptake, and protein fractions of different convars or varieties of wheat and barley grown either singly or mixed with Persian clover (*Trifolium resupinatum* L.) on marginal sandy soils. The experiments were carried out in a temperate or an untemperate greenhouse. The results are presented in the following sections according to the four main factors.

NaCl salinity
Salinity has been tested with wheat and barley in single- and mixed cropping in the temperate and in the untemperate greenhouse.
- Low salt content of the soil (o,05% NaCl) had generally no negative but frequently often a positive effect on growth (shoot dry weight) and seed weight.
- Higher salinity reduced shoot and root dry weight and seed weight.
- Barley proved to be more tolerant to salinity stress than wheat.
- The wheat cv. Ralle and the barley cv. Carina showed an average tolerance to salinity compared to some local varieties tested.

- Soil salinity led to a higher TCA-soluble protein fraction in the seeds.
- Mineral uptake was disturbed by soil salinity: uptake of N, P, K, Ca, and Mg was reduced whereas Na and Cl uptake was increased. Hence the Na/K ratio was increased.
- Seeds, in general, had lower content and uptake of Ca, Mg, Na, and Cl.
- High salinity in the soil led to a decrease of total water uptake, whereas relative water uptake (water uptake/dry matter of shoots) was increased.
- Application of gypsum ($CaSO_4 \cdot 2 H_2O$) to salinized soil (0,2% NaCl) caused slightly better growth and slight increases of N, K, Ca and Mg in the plants. Na in this case was reduced only in barley.

Water regime
The water regimes were tested with wheat and barley grown in single- and mixed cropping in the temperate and in the untemperate greenhouse.
- Water regime of 20% led to depressions of growth with both wheat and barley. Already low soil salinity reduced growth additionally under these dry conditions.
- Increase of watering increased growth shoot dry weight, ear weight, number and weight of seeds. Root dry weight was increased as well and also water consumption.
- TCA-soluble protein fractions were decreased when plants were watered at higher levels.
- Higher water regimes reduced the concentrations of N, P, K, Ca, Mg, Na, and Cl in the plants, Na and Cl more than those of the nutrient elements. The total uptake of N, P, K, Ca, and Mg was increased, whereas Na and Cl uptake decreased at higher water levels. Na/K- and Na/Cl ratios were reduced as well.
- Under economical considerations the water regime of 55% showed the best results increasing growth on the one hand and reducing relative water consumption on the other hand.

Soil temperature
Different soil temperatures were applied to wheat and barley only in single cultivation and in the temperate greenhouse.
- Under the given conditions high shoot dry weights were achieved at the soil temperature of 20° C.
- Increase of the soil temperature reduced growth of barley and wheat. Barley showed to be more tolerant than wheat up to a temperature of 30° C.
- High soil temperatures disturbed the nutrient balance of wheat and barley; the concentrations of N, P, K, and Ca were reduced, those Na and Cl were increased. High soil temperature intensified the negative effect of increasing salinity.

Mixed cropping
Wheat and barley were grown alone or in mixed systems with clover either inoculated with *Rhizobium trifolii* or not inoculated in the untemperate greenhouse.
- Wheat and barley in mixed cultivation with uninoculated clover showed a high tolerance ot salinity stress and yielded high shoot dry weights.
- Mixed cropping of wheat and barley with inoculated clover produced low shoot dry weights.

- Clover - both inoculated and uninoculated - had higher shoot dry weights when grown alone than in mixed cultivation with either wheat or barley.
- Generally, wheat and barley had high nutrient concentrations as well as high nutrient uptakes when grown together with uninoculated clover.
- Salinity reduced contents and uptake of N, P, K, Ca, and Mg of clover, whereas it increased these values of Na and Cl.
- Uninoculated clover in mixed cultivation with either wheat or barley as preceding crop had a positive effect on the growth of the following crops, wheat or barley grown singly.
- Single clover as preceding crop improved the growth of single clover as following crop.

Author's summary

334. 89 - 4/37

Cropping systems
Asia, Philippines, IRRI, cropping pattern, small farms, dryland, rice, methodology
GARRITY, D.P. et al.
Determining superior cropping patterns for small farms in a dryland rice environment: test of a methodology.

IRRI Res. Paper Series, 33, 1989, 13 pp.

Strategies for increasing farm productivity that focus on introducing technical changes within a single-crop enterprise are often rejected by farmers because of unforeseen negative effects on productivity or resource utilization. Cropping systems research approaches this problem by determining the effects of potential technical changes on the entire system. This paper discusses the methodology for cropping systems research for dryland rice-based systems in the Philippines. Test patterns are grown on a portion of each cooperating farm under joint farmer-research team management. This methodology involves the farmer actively in the research process, thus facilitating early detection of some of the constraints to adoption at the farm level. The potential for increased crop productivity was tested in the Batanga region where the predominant cropping pattern involves dryland rice followed by field corn. Alternative cropping was tested, including: following rice with alternative field crops that may offer advantages over corn; following rice with two crops to extend cropping further into the dry season; and following rice with intercrop patterns to replace monoculture corn. Alternative crops included soybean, peanut, mungbean, and cowpea. After 3 years of testing, it was found that adoption of an improved corn variety could increase productivity in the dryland rice-corn system studied. Soybean and sorghum appeared to be outstanding alternative crops. However, because neither is currently grown in the area, their acceptation would represent a substantial change in the system. New infrastructural support, markets, and threshers would be required. Intercropping of corn shows the potential of substantially raising land productivity, but lack of labour appears to be a potential constraint. Cropping patterns with three crops per year were shown to be feasible and profitable.

89 - 4/38

335

Cropping systems
Australia, high altitude, experiment, soybean, cassava, yield, intercropping, sowing time
TSAY, J.S. et al.
Effects of relative sowing time of soybean on growth and yield of cassava in cassava/soybean intercropping.

Field Crops Res., 19, 1988, pp. 227-239

Cassava *(Manihot esculenta* Crantz.) is a major root crop in the wet tropics and subtropics. There is a widespread practice of cassava intercropping in these regions using many different species. Grain legumes are among the crops most often used, this combination providing a better-balanced human diet in respect of protein and carbohydrate. Legumes may also help to minimize the decline of soil fertility, which is a serious problem under continuous cropping with sole cassava. A previous study showed that quick-maturing, short-statured soybean appears to be suitable as an intercrop in the subtropical regions where the growing season is limited to 9 months by low temperature in winter. When intercropped with soybean at 0,9 or 2,7 m row spacings of cassava, there was a large reduction in total biomass production, but tuber yield was not affected, because the harvest index increased.
In intercropping, the relative times of planting of the component crops have both biological and practical implications because they change the relative competitive ability and hence the yield of component crops and the combined yield. It is known that a small difference in relative planting times can cause a large difference in final economic yield, as for example shown for a maize/cowpea intercrop.
A study was made of the development of yield in cassava/soybean intercrops to examine physiological reasons for high harvest index of cassava in intercropping and to identify the optimum time for sowing soybeans. This paper describes the performance of the cassava component, while another paper described that of the soybean component and of sole-soybean crops.
The development of yield in cassava, either as a sole crop or intercropped with quick-maturing soybean sown 1,5 or 9 weeks after cassava planting, or a succession of two soybean sowings 14 weeks after planting, was followed at a high latitude (27°S) where the cassava growing season is limited to 9 months by winter temperatures. Competition, at least largely for nitrogen, restricted the growth of cassava. After soybean harvest, leaf-area increased in such a way that there was little difference in interception of radiation among crops. Consequently growth rates and amounts of assimilates potentially available for tuber growth were similar. Competition from earlier-sown-soybean greatly

reduced branching by cassava. The reduced number of branches were sufficient to provide adequate leaf-area index, but were a reduced sink for assimilates during the main period of tuber growth. The slightly reduced assimilate supply available in early intercropped cassava was offset by the increased partitioning to tubers. As a result, soybean intercropping did not reduce tuber yield, except slightly in the case of double-intercropped cassava, but provided an additional yield of grain. Land equivalent ratio was particularly high at about 1,6 when soybean was sown within 5 weeks of cassava planting. When soybean was sown 9 weeks after cassava planting, land equivalent ratio was reduced to about 1,3 as a result of lower soybean yield.

336 89 - 4/39

Cropping systems
Australia, experiments, subtropical region, cassava, soybean, cultivars, intercropping, evaluation
TSAY, J.S. et al.
Intercropping cassava with soybean cultivars of varying maturities.

Field Crops Res., 19, 1988, pp. 211-225

Short-statured, early maturing soybean (85 days to mature) is suitable as an intercrop with cassava (*Manihot esculenta* Crantz) in the subtropical regions where the growing season of cassava is limited to 9 months by low temperature in winter. It was observed that competition restricted the growth of cassava, but after soybean harvest there was sufficient time for cassava to attain full light interception and to produce high total biomass. Distribution of assimilates to tubers was increased, as a result of reduced branching of cassava and hence competition for assimilates. In consequence, tuber yield was not reduced by the soybean intercrop. Nevertheless, total biomass and grain yield of the soybean were low. Increased crop duration with the use of a late-maturing cultivar may provide higher grain yield but, commonly, cassava tuber yield is adversely affected by long-duration legum crops.
As the duration of a legume crop increases, competition for light becomes more severe. When other environmental and soil factors are not limiting, light becomes the factor determining the productivity of intercrops. Dry-matter growth of an intercrop can be studied in terms of total light interception (LI) and efficiency of conversion (EC) of the intercepted light to plant dry matter. Crop yield then can be expressed as LI x EC x HI, where HI is harvest index. Such an analysis for a sorghum/pigeonpea intercrop indicated slight advantages of the intercrop in all these terms. This type of analysis was adopted for the work reported here in which the effects of soybean cultivars of differing maturity on the growth and economic yield of each component crop were examined in cassava/soybean intercropping. The objective of this study was to identify the

most suitable maturity type of soybean in cassava/soybean intercropping, and to examine which term(s) in the above analysis contributed to the superior productivity of the intercrop.
All soybean cultivars dominated intercropped cassava, and their dry-matter growth and seed yield were not affected by competition with cassava. Growth of cassava was, on the other hand, severely restricted by intercropped soybean, particularly by late-maturing types. After removal of early-maturing soybean, cassava recovered quickly to produce high leaf-area and effectively intercepted solar radiation. Consequential high total dry-matter production, combined with high assimilate allocation to tubers, resulted in tuber yield at the final harvest similar to that in sole cassava. After the removal of late-maturing soybean, however, recovery was poor, and with a short growing season remaining, tuber yields were only 50-60% of that of sole cassava.
In addition to their adverse effect on cassave growth, late-maturing cultivars were not suitable as an intercrop because of low harvest indices and low light-conversion efficiency (dry matter produced per unit intercepted radiation), although total light interception during the whole growth of cassava/soybean intercrop was similar to that of sole cassava. The low overall light-conversion efficiency in intercropping with late-maturing cultivars was due to very low dry-matter production of soybean during pod-filling when light interception was still high.

337 89 4/40

Cropping systems
Asia, IRRI, experiments, cropping systems, subsistence farmers, multidisciplinary approach
HOQUE, M.Z. et al.
Need for long-term cropping systems experiments.

Report (11th) of the Cropping Systems Working Group Meeting, IRRI, 1981, pp. 327-331;

Crop intensification may be necessary to the survival of subsistence farmers in Asia. Because the validity of intensive multiple cropping systems (i.e., effects on the soil, labour utilization) is still being questioned, the authors of this report suggest that long-term trials be designed and implemented before the farmers' situation worsens. The objectives of long-term trials include identifying soil and crop management methods which can be used to ensure high crop yields while protecting the environment and developing a data base for future guidance and research programs. A list of recommendations for planning and implementing long-term cropping systems trials is provided; these include, inter alia, conducting the trials on experiment stations rather than in farmers' fields, focusing the purpose of the trials on the generation of component technology over time, and using a multidisciplinary approach. Attention is briefly given to the types of experiments to be conducted, experimental design, and the

types of data which should be collected and analyzed. An implementation plan for the proposed programm is suggested.
(Abstract from FSR)

338 89 -4/41

Cropping systems
Australia, experiment, cassava, soybean, intercropping, nitrogen
TSAY, J.S. et al.
Growth and yield of cassava as influenced by intercropped soybean and by nitrogen application.

Field Crops Res., 21, 1989, 83-94

In sole cropping, application of N at planting enhanced leaf area and dry-matter production during early stages of growth, but the effects did not persist until the final harvest. Dry-matter partitioning to tubers was reduced, and in consequence tuber yield tended to be less in this treatment than in the no-N control, although not significantly. N-application at day 85 had negligible effects on dry-matter production and partitioning.
The adverse effect of soybean on the growth and morphology of intercropped cassava was similar, but more severe than that of the no-N application in sole crop. Total dry-matter of intercropped cassava was always less than that of sole cassava in any N treatment. Lateral branch production and leaf turnover were reduced by the presence of soybean, and the consequent reduction in shoot demand for assimilates resulted in an increased proportion of assimilates transferred to tubers. When N was applied at planting, harvest index was higher in intercropped than in sole cassava, and tuber yield was similar in the two crops.
Intercropping under no N-application made only a slight improvement in harvest-index over the corresponding sole cassava, while severely reducing total dry-matter production. It appears, therefore, that the tuber yield advantage of cassava/soybean intercropping is likely to be small under low availability of soil N.

339 89 - 4/42

Cropping systems
USA, study, humid tropics, ecosystems, CATIE, plant communities, leaf area, light transmission, roots, damage
GLIESSMAN, S. et al.
Leaf area, light transmission, roots and leaf damage in nine tropical plant communities.

Agro-Ecosystem, 7, 1982, 305-326

The efficiency of resource utilization and resistance to pest attack are two key issues in agriculture, especially as fertilizers and pesticides increase in cost. This is particularly

true in the humid tropics, where year-round growth permits rapid pest and disease build-ups, high rainfall promotes nutrient leaching, and weeds invade agressively. Structurally, diverse multiple-crop tropical agroecosystems might reduce these problems more than the monocultures now often used.
To find out if structurally complex ecosystems make better use of resources and experience less herbivory than do simple systems, nine varied agricultural and successional ecosystems were studied, ranging from simple to diverse, herbaceous to woody, short to tall, and young to old. The study concentrated on a few study areas to reduce variation due solely to geographic variables. Measurements included: leaf area index (LAI) by height and by species and optical density of the canopy, both indicators of a system's light-capture ability; root biomass by depth and diameter class, an indicator of ability to exploit root-zone resources; and leaf damage (caused primarily by herbivorous insects) by species, and indicator of resistance to pest attack.
Six of the nine ecosystems were on the grounds of the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica.
The other three study sites were in the state of Tabasco, Mexico.
Leaf area index ranged from 1,0 in young maize to 5,1 in natural succesion and the gmelina plantation. The vertical distribution of leaves was most uniform in diverse ecosystems, and most clumped in species ecosystems. Light transmission was impoverished inversely proportional to leaf area, and two dense-canopied monocultures (sweet potato and gmelina) were nearly as effective at light capture as were some of the more diverse ecosystems. Optical density of the canopy ranged from <0,5 (35% transmission) in the young maize to >2,0(<1% transmission) in the natural succession.
Large roots (>5 mm diameter) accounted for most root biomass in the older ecosystems at soil depth of 5-25 cm, and fine roots (< 5 mm diameter) were most important in the surface 5 cm in all ecosystems. The range of values for root biomass (39 to 422 g m^{-2} to a depth of 25 cm) were similar to the range of values for leaf biomass (33 to 345 g m^{-2}) and, with the exception of two monocultures, ecosystems with high leaf biomass also had high root biomass. The surface area of the fine roots was lower than leaf area, abd ranged from 0,5 to > 2,0 m^2 m^{-2} of ground. Total root surface area increased with age and diversity, and the monocultures - even those effective at light capture - had low root surface area.
Herbivore damage on leaves of 35 species ranged from <2 to > 16% of leaf area. Heavily damaged species contributed less to total ecosystem leaf area than did species damaged less than average. Ecosystem-level damage was not well correlated with age or diversity. Leaf damage in all ecosystems ranged from about 2 to 10% of leaf area, or <2 to > 25 gm^{-2} of ecosystem.
Young monocultures do not necessarily capture less light, provide less soil cover, and experience more herbivory than older, more diverse ecosystems. However, root surface area (and therefore possible nutrient-capture ability) is high only in ecosystems that are diverse or old, and this is an important design consideration for agroecosystems appropriate for the humid tropical lowlands.

340 89 4/43

Cropping systems
Africa, Nigeria, study, IITA, humid tropics, cassava, maize, okra, egusi melon, plant mixtures, intercropping, productivity
IKEORGU, J.E.G. et al.
Productivity of species in cassava/maize, okra/egusi melon complex mixtures in Nigeria.

Field Crops Res., 21, 1989, 1-7

In Nigeria, cassava (*Manihot esculenta* Crantz) and maize (*Zea mays* L) are dominant components of many traditional complex mixtures. The cassava/maize package developed to small-scale farmers was not readily adopted because of the non-inclusion of minor crops which, in traditional mixed-cropping systems, are as important as the base crops. Some of the minor crops frequently grown with cassava and maize are egusi melon (*Citrullus lanatus* Thunb.) okra (*Abelmoschus esculentus* Moench) and fluted pumpkin (*Telfairia occidentalis* L). It is now being realised that small-scale farmers will not adopt any technology that excludes these essential minor crops. Apart from preliminary work on cassava/egusi melon and cassava/okra mixtures at IITA, little attempt has been made to determine the productivity of major root-crop-based complex mixtures. The study was carried out to determine whether, under technologically improved conditions, the inclusion of egusi melon and/or okra in cassava/maize intercrops actually improves total productivity. Information from this work will reveal the strengths and weaknesses of the cassava/maize recommendation.
The crop combinations investigated, along with their sole crops, were: (1) cassava/maize/okra/egusi melon; (2) cassava/maize/okra; (3) cassava/maize/egusi melon; (4) cassava/maize; (5) cassava/okra; (6) cassava/egusi melon; (7) cassava/okra/egusi melon; (8) maize/egusi melon; and (10) maize/okra/egusi melon.
In cassava/okra and cassava/egusi melon mixtures, cassava yield did not differ from that of sole cassava. Maize depressed the yield of cassava by about 28% in cassava/maize mixture, even though the maize population used was only 50% of the optimum for sole maize. Inclusion of either okra or egusi melon or both okra and egusi melon to the cassava/maize intercrops still gave cassava tuber yields comparable to that from cassava/maize. This indicates that the farmer could still produce as much cassava in cassava/maize/vegetables as in cassava/maize alone.
Intercropping did not depress the grain yields of maize. Maize grain-yield in maize/cassava intercrops was 26% more than in sole maize at equivalent populations. Sole maize yield at optimum population (40 000 plants/ha) was 3.6 to/ha.
It was interesting to note that maize yield remained high irrespective of companion crop type.
Intercropping reduced yield of okra by more than 50%. Unlike egusi melon which spreads very fast, okra grows slowly and hence a

slight shading by a higher-canopy crop would reduce fruit yield. It is probable that tall-growing okra varieties may be more suitable for intercropping than dwarf types, though probably at the expense of other components species.
As was observed for okra, intercropping reduced seed yield of egusi melon by more than 50%. Egusi melon appears to be more compatible with cassava/maize intercrops than okra. For example, egusi melon yielded 49% of sole-crop yield in egusi- melon/cassava and egusi-melon/maize intercrops, respectively, while okra yielded only 28% and 14% with the same companion crops. Also, in egusi-melon/cassava/maize intercrops, seed yield of egusi melon was depressed by 76% while in okra/cassava/maize, okra fruit yield was depressed by 90%.
The various LER and calorie yields obtained from intercropping systems involving cassava, maize, okra and egusi melon are shown in a table: The cassava/maize system is highly productive in terms of calorie yield per unit area per unit time. Inclusion of okra and egusi melon into the cassava/maize system did not further improve calorie yields. The four-crop mixture had slightly lower calorie yields but higher LER than cassava/maize intercrops. This means that although okra and egusi melon did not improve the calorie yields of cassava and maize-based complex mixture, they could improve total productivity per unit area of land. The cassava/maize recommendation could have been based on the high-calorie productivity of the cassava/maize intercrops.
The data of this experiment seem to provide an explanation for the persistence of traditional practice. While dietary requirements are better satisfied, the farmer also saves more land by including vegetables in cassava/maize intercrops.

341 89 - 4/44

Cropping systems
Asia, India, experiments, rainy season, loam soil, lowlands, nitrogen fixation, nodulation, yield, soybean, nitrogen-harvest-index, mineral nitrogen equivalent
CHANDEL, A.S. et al.
Symbiotic nitrogen fixation and nitrogen benefits by nodulated soybean (*Glycine* max (L.) Merrill) to interplanted crops in Northern India.

Trop. Agric. (Trinidad), 66, 1, 1989, 73-77

Simultaneous cropping or mixed cropping is important in Indian agriculture. Intercropping is a variant of this system in which crops are planted in rows.
The merits of mixed cropping relative to sole cropping have been evaluated in sorghum (*Sorghum bicolor* (L.) Moench), millet (*Panicum miliaceum* L.), maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* (L.) Walp.). There are many reports on the beneficial effect of grain legumes such as soybean (*Glycine max* (L.) Merrill) by virtue of their ability to fix atmospheric N_2 and leave the soil enriched. There is, however, a dearth of precise information

on how much benefit cereals and legumes derive from mixed cropping in terms of mineral nitrogen equivalents, nitrogen uptake and grain yield. Benefits were quantified by growing *Eleusine coracana* (L.) Gaertn. and non-nodulated soybean as intercrops with nodulated soybean.
Experiments were conducted to study the effect of nodulation of the soybean (*Glycine max* (L.) Merrill) on plant dry matter, grain yield and nitrogen benefits in terms of mineral nitrogen equivalent (MNE), nitrogen uptake and nitrogen-harvest-index (NHE) in interplanted ragi (*Eleusine coracana* (L.) Gaertn. cv. PES-176 and non-nodulated soybean cv. Lee. Symbiotically fixed N_2 by nodulated soybean was also determined. Nodulated soybean significantly increased plant dry matter and grain yield of interplanted crops. The average beneficial effect in terms of mineral-nitrogen-equivalent, was 41.1 and 82.4 kg N ha^{-1} from non-nodulated soybean and 43.2 and 78.6 kg N ha^{-1} for ragi, respectively, associated with one and two rows of nodulated soybean between the intercrops. Average nitrogen benefit in terms of N-uptake was 61.8 and 73.1 N ha^{-1} for non-nodulated soybean and 32.0 and 45.1 kg N ha^{-1} for ragi associated with one and two rows of nodulated soybean, respectively. Application of N at a greater rate than 20 kg ha^{-1} decreased nitrogen-harvest-index in both interplanted crops. Nodulated soybean, however, slightly improved nitrogen-harvest-index. The quantity of symbiotic N_2 fixed by nodulated soybean cv. Shilajeet was estimated to be 128.1 kg N ha^{-1}.

342 89 - 4/45

Cropping systems
USA, experiment, cowpea, forage, planting sequence, nitrogen, intercropping, yield
BRYAN, W.B. and S.A. PEPRAH
Effect of planting sequence and time, and nitrogen on maize legume intercrop yield.

J. Agron. and Crop Sc., 161, 1988, 17-22

Increasing costs of land and energy have stimulated renewed interest in intercropping since growing two or more crops simultaneously may enhance land productivity compared to monocropping. Intercropping reduces risk of crop failure, increases availability of N when a legume is one of the intercrop components, and may increase crop nutritive value. Major difficulties with intercropping include mechanization of cultural practices, and fertilizer and herbicide applications.
Maize (Zea mays L.) and bean (*Phaseolus spp.*) and cowpea (*Vigna unguiculata* (L.) Walp.) are widely intercropped in the tropics for grain production. Some work has also been carried out on the use of the intercrops for forage. Little research has been carried out on maize/legume intercrops for forage in temperate areas. The effects of planting sequence and time on yields are unclear. Thus, an experiment was conduced to compare forage and grain production

of maize/polebean and maize/cowpea intercrops planted in different sequences and at different times. Two levels of N fertilization (0 and 160 kg ha^{-1}) were also included in the experiment.
Intercropping (average of all treatments) reduced maize grain and forage yields compared to maize in monoculture but had no effect on total forage production. However, total forage production was greatest when the seeding sequence was maize intercropped at the same time or before cowpea. Cowpea never produced grain, but forage production was almost twice that of polebean. Maize produced most forage when seeded before the legumes, and the legumes produced most forage when seeded before maize. Early planting increased maize production and decreased legume production. Nitrogen increased maize grain, maize forage, and total forage yields but had not effect on legume forage production.
Results of these experiments show that intercropping maize and legumes has promise for increasing forage production in temperate climates. Although intercropping may reduce yield of individual components, total forage yield was not lower than monocropped maize in this experiment. In fact, total forage production tended to be greater where maize and cowpea were intercropped either by seeding on the same date or by seeding cowpea after maize. Cowpea is more promising than polebean as an intercrop with maize. Both legumes affected maize production equally, however, cowpea produced almost twice as much dry matter as polebean.
More research is needed both on production criteria such as intercrop planting times and densities, weed control, planting and harvesting mechanization, and on economic and management aspects of forage production from intercropping.

343 89 - 4/46

Cropping systems
Africa, Sahel, experiments, ICRISAT, cowpea, pearl millet, cultivars, intercropping
NTARE, B.R.
Evaluation of cowpea cultivars for intercropping with pearl millet in the Sahelian zone of West Africa.

Field Crops Res., 20, 1989, 31-40

This study was made to examine the performance of contrasting cowpea cultivars intercropped with millet, to determine the relationship between performance in sole-crop and intercrop. The study also examined the effectiveness of selection for intercropped cowpea.
Field trials were conducted at ICRISAT Sahelian Centre, Niger, to examine the performance of contrasting cowpea cultivars intercropped with pearl millet. Significant effects ($P \leq 0.05$) of cropping system and cultivars were observed for cowpea grain yield. Cultivar X cropping system interaction was significant only for fodder yield. Intercropping reduced cowpea yields significantly but the degree of reduction varied among cultivars.

Early-maturing erect cultivars exhibited greater yield reduction than the indeterminate spreading types and had the least effect on millet yields. Indeterminate spreading cultivars produced greater grain and fodder yield than erect types and caused the greatest millet yield reduction.
The relationship between the yield of cowpea cultivars and millet when intercropped was negative. Linear correlations between yield of cowpea in sole and intercrop were positive and significant ($P < 0.01$) with r values ranging from 0.45 to 0.91. However, a small proportion of the biggest and least-yielding cowpea cultivars in intercropping would have been selected and rejected respectively, on the basis of sole-crop grain-yield. It was concluded that selection of cowpea cultivars for intercropping with millet based on their grain yield in sole-crop may have limited success. Selection based on fodder yield favoured late-maturing cultivars. Selection of cowpea cultivars for intercropping should be based on their intercropped performance, paying special attention to other agronomic factors. An appropriate cowpea cultivar for intercropping with millet would be one that is less competitive with millet and yields both grain and fodder.
Drought-stress is a major concern particularly at the end of the season. Early-maturing cultivars to escape drought would minimize the probability of all components being equally affected. They should not be erect and extraearly, and not too leafy to be too competitive with the millet. An appropriate cowpea cultivar for intercropping with millet would be the one that is less competitive and yields both grain and fodder.
The relationships between cowpea yields in sole and intercropping were positive and significant, indicating that evaluation in sole-crop gave a reasonable prediction of cowpea performance in intercropping. The ranking of cultivars in the two cropping systems revealed that a small proportion of the highest-yielding cultivars in intercrop would have been selected from sole-crop. Similarly, a small porportion of the lowest-yielding cultivars in intercrop would have been rejected based on their sole-crop performance. These results suggest that selection of cowpea cultivars for intercropping with millet based on their grain yield in sole-cropping may have limited success. Since sole and intercropped performance were reasonably related, selection for simply inherited traits such as resistance to diseases and insects, plant type and maturity could be done in segregating populations in sole-crop. The final selection for intercropping should be based on intercropped performance of advanced breeding lines.

344 89 - 4/47

Cropping systems
Australia, semi-arid zone, monsoon climate, field trials, maize, sorghum, pearl millet, yield, productivity
MUCHOW, R.C.
Comparative Productivity of Maize, Sorghum and Pearl Millet in a Semi-Arid Tropical Environment. I. Yield Potential.

Field Crops Res., 20, 1989, pp., 191-205

The primary objective of the work reported here is to analyze the environmental limitations of the productivity of maize, sorghum and millet in the semi-arid tropics as a basis for the selection of appropriate crops for these regions.
Few studies have been conducted in which the yield-determining processes of maize, sorghum and millet have been compared in the same experiment under similar agronomic and environmental conditions. Accordingly, a field study was undertaken in the semi-arid tropics of northern Australia with the objective of comparing the productivity of these cereals under different radiation, temperature and water regimes. This paper examines the potential productivity of high-yielding F_1 hybrids of maize, sorghum and pearl millet grown under the fully irrigated and high-fertility conditions of the experiment. Different sowing-dates were used to assess the impact of varying radiation and temperature regimes on yield.
The varying radiation and temperature regimes sowing during affected biomass at maturity in maize and millet, but not in sorghum. Variation in biomass depending on sowing dates was associated more with differences in the amount of radiation intercepted than in radiation-use efficiency. In contrast, grain yield was relatively stable across sowing dates in maize, but it varied with sowing date in sorghum and millet. Here, differences in grain-yield were related more to variation in harvest index. Overall, variation in grain yield across sowing dates within species was small relative to that among other species.
Average grain yields over the three sowing dates were 9.2 t ha^{-1} for maize, 5.6 t ha^{-1} for sorghum and 2.9 t ha^{-1} for millet. High yield was associated with high biomass production both at maturity and during grain-filling, high harvest index, and an increase in stover weight during grain-filling. High biomass accumulation was associated with long growth duration, especially the duration of grain-filling and thus high cumulative radiation interception, and with high radiation-use efficiency.
It was concluded that crops growing in the semi-arid tropics rarely reach their potential, owing to water shortage, poor nutrition, incidence of pests and diseases and poor crop husbandry. One of these limiting factors, namely the consequences of water shortage, is considered in the companion paper.

345 89 - 4/48

Cropping systems
Australia, semi-arid zone, study, maize, sorghum, pearl millet, water deficit
MUCHOW, R.C.
Comparative Productivity of Maize, Sorghum and Pearl Millet in a Semi-Arid Tropical Environment II. Effect of Water Deficits.

Field Crops Res., 20, 1989, 207-219

This paper is the second in the series examining the effect of water regime on the comparative productivity of maize, sorghum and pearl millet in semi-arid tropical Australia.
This paper examines the productivity of maize, sorghum and pearl millet under both short-term water deficit at different stages of growth and prolonged water deficit during grain-filling. The effect of water deficit on radiation interception (RI) and radiation-use efficiency (RUE) and thus on biomass accumulation, on harvest index (HI) and, therefore, on grain yield in the different cereals, is described. This information is used to define those environments in which maize, sorghum and millet are best suited.
Maize out-yielded sorghum and millet under water deficit where maize grain-yield was at least 6 t ha^{-1}, whereas sorghum yielded more than millet and maize where maize yield ranged from 1 t to 2 t ha^{-1}. Only where maize produced no grain under water deficit did millet yield the same as sorghum. In millet, grain-yield was more stable than biomass in response to water shortage, but in maize and sorghum biomass was more stable. The decrease in biomass in response to water deficit was associated more with a reduction in radiation-use efficiency than with a decrease in radiation interception, except when the water deficit was imposed during early vegetative growth, when the opposite was the case. Mobilization of pre-anthesis assimilate to grain occurred in sorghum and millet but not in maize. Where water shortage occurred, harvest index was more conservative than biomass accumulation; harvest index was reduced only when water deficits severely decreased grain-yield.
This study has highlighted the importance of biomass accumulation in determining grain-yield in these species. Water deficit reduced biomass and grain-yield in several treatments, but did not decrease HI, which decreased only where water deficit severely reduced grain-yield. Given the relatively high temperature in this semi-arid tropical environment and the consequent rapid canopy development, intermittent water deficit is more likely to have a larger impact on RUE than on RI. Further work is required to identify factors contributing to differences in RUE in response to water regime, both among and within species.

346 89 - 4/49

Cropping systems
Asia, India, groundnuts, experiments, split-plot design, Alfisol, plant density, cultivars, yield, ICRISAT, irrigation
RATTUNDE, H.F. et al.
Cultivar Mixtures: a Means of Exploiting Morpho-Developmental Differences among Cultivated Groundnuts.

Field Crops Res., 19, 1988, 201-210

Crop yield is determined by the effectiveness with which the community of crop plants exploits its environmental resources for growth. This suggests crop yields would be maximized by using heterogeneous populations that contain several genotypes whose demands for environmental factors differ in space or time, thus encouraging a complementary and fuller exploitation of available environmental resources.
The objectives of these experiments were to determine (1) whether by sowing groundnut cultivars in mixed stands, synergistic interactions among cultivars could be exploited to increase yield of pods, kernels, or haulms relative to those of the sole crops, and (2) whether certain combinations of growth patterns produce a greater frequency of overcompensatory reactions than do others.
Two genotypes were used from each of four growth-habit classes (Spanish, Valencia, Virginia bunch, and Virginia runner) to form two cultivar (1:1) mixtures representing diverse maturity and growth-habit combinations. The mixtures, 12 in the 1983-1984 dry season, and 28 in the 1984 rainy season, were sown at three and two plant densities, respectively. Land Equivalent Ratios (LER) of mixtures showed that overcompensation was more frequent than undercompensation. The largest LERs were 1.23 for pod yield, 1.29 for kernel yield, and 1.18 for haulm yield average over planting densities in the rainy season. Intersubspecific combinations that gave diversity for both maturity and growth habit exhibited synergistic interactions most frequently. However, this intergenotypic interaction was specific to the genotypes involved. Investigation of cultivar mixtures in groundnuts should focus on stability rather than maximization of yield since no mixture yield surpassed that of the highest-yielding variety.

347 89 - 4/50

Cropping systems
Africa, Nigeria, humid zone, glasshouse experiment, cowpea, luffa, pre-planting, plant density, mixed planting, lateritic soil
OKUSANYA, O.T. et al.
Effects of pre-planting, mixed planting and planting density of *Vigna unguiculata* (L.) Walp. on the growth of *Luffa aegyptiaca* Mill. in humic and red lateritic soils.

Trop. Agric. (Trinidad), 65, 3, 1988, 241-244

Luffa aegyptiaca Mill. (=*L. cylindrica* (L.) Roem.) (Cucurbitaceae) is an annual tendril climber, mainly tropical and subtropical. It is of economic importance in West Africa because of the edibility of the young fruits and the use of the dried fibrous interior as a sponge. This latter use is increasing so that not enough is being harvested from the wild and from back-gardens; the need for large-scale cultivation and high production of the species arises.
In this investigation, two glasshouse experiments were carried out to determine the effects on the growth of *L. aegyptiaca* of (i) planting it in soils which had been pre-planted with a legume and (ii) mixed planting with the legume. At the same time the effect of sowing density was also determined.
For these experiments, *Vigna unguiculata* (L.) Walp. was chosen as legume because, like many other members of the Leguminosae, it is also of economic importance as a cash crop. It is an annual herbaceous erect plant. The Ife-Brown variety, commonly available and a favourite of farmers, was used.
Two soil types, humic and red lateritic, were collected from areas where two populations of *L. aegyptiaca* grow naturally. These two soil types not only have contrasting chemical and physical characteristics but the *L. aegyptiaca* populations growing in them also show marked differences.
The effects of pre-planting, mixed planting and planting density of *Vigna unguiculata* (L.) Walp. on the growth of *Luffa aegyptiaca* Mill. in humic and red lateritic soils were determined in the glasshouse. Pre-planting of *V. unguiculata* in the soils which were subsequently used to grow *L. aegyptiaca* resulted in increased growth.
The results show clearly that the density of sowing of the species is an important factor for growth. Decrease in weight as planting density increased shows the effect of intraspecific competition; space, light and nutrients are likely factors for competition. Individuals of the same species will have the same ecological requirements; if these are in short supply, intraspecific competition would set in and appears to have happened in this experiment.
Competition for nutrients appears to be very important in the lateritic soil as it is poorer in nutrients than the humic soil; consequently, the mean dry weights of either the pre-planted *V. unguiculata* or the *L. aegyptiaca* which was planted after *V. unguiculata*, were lower than those for the humic soils. The effect of the poor nutrient status of red earth becomes more marked in the mixed planting experiment.
The results of the pre-planting experiments, which simulate the system of crop rotation, suggest that pre-planting of *V. unguiculata* in soils to be used for growing *L. aegyptiaca* would enhance the growth of *L. aegyptiaca*, and that the higher the density of *V. unguiculata* pre-planted the better would the growth of L. aegyptiaca be. The pre-planting of a legume appears to be a good method for increasing the productivity of *L. aegyptiaca*, more especially in humic than in red earth soils. This result supports the generally accepted view that legumes improve soil fertility and consequently the productivity of crops grown after them.

The results of mixed planting experiments in humic soil suggest that it would not be agriculturally and ecologically sound to grow the two species in mixed culture; similarly for red earth. When the results of the pre-planting and mixed planting experiments are compared, it is aboundantly clear that for the improved growth of *L. aegyptiaca*, pre-planting with *V. unguiculata* or possibly any legume rather than mixed planting is preferable.

348 89 - 4/51

Cropping systems
Asia, India, highland, monsoon climate, sandy loam soil, randomized block, experiment, legumes, oilseeds, cereal, pigeonpea, intercropping, yield, land-equivalent ratio
RAFFEY, A. and U.K. VERMA
Production potential of legumes, oilseeds and cereal in intercropping system with pigeonpea (*Cajanus cajan*).

Ind. J. of Agr. Sc., <u>58</u>, (2), 1988, pp. 433-436

The upland soils of Bihar plateau are Alfisols, light-textured, with low water-holding capacity. The area is traditionally monocropped with upland rice (*Oryza sativa* Linn.), finger millet or ragi [*Eleusine coracana* (Linn.) Gaertn.], other millets and pulses in the rainy season. Due to low irrigation potential and low water-holding capacity (100-150 mm/m depth), double cropping is not possible. The only way to increase cropping intensity and to improve resource utilization is intercropping system.
The experiment was laid out in randomized block design with 11 treatments replicated thrice. Treatments 7-11 were in additive series. The treatments were (i) 'BR 65' sole pigeonpea, (ii) 'Sunaina' greengram, (iii) 'T 9' blackgram, (iv) 'AK 12-24'groundnut, (v) 'Birsa Soybean 1'soybean, (vi) 'BR 19-23' rice, (vii)pigeonpea + greengram, (viii) pigeonpea + blackgram, (ix) pigeonpea + groundnut, (x) pigeonpea + soybean, and (xi) pigeonpea + rice.
There was annual variation in pigeonpea yield. Yield of pigeonpea both as a sole crop and as intercrop was better in 1983 and 1984 than in 1982 owing to rain in September-October, whereas in 1982 there was practically no rain after 16 September. Irrespective of the intercrop, the yield of pigeonpea was always higher in sole stand than in intercropping system. This might have been due to competition with intercrops.
Yield of all crops decreased under intercropping system compared with their respective sole-crop yield. However, the extent of reduction was less in soybean (300 kg/ha in pooled mean).
All intercropping systems proved efficient with land-equivalent ratios of more than 1. Pigeonpea + soybean gave the highest LER value, because reduction in their yield was lesser than of other intercropping systems, whereas pigeonpea + greengram gave the lowest yield. Pigeonpea + groundnut, pigeonpea + blackgram and pigeonpea + rice gave the same LER values.

Sole groundnut and pigeonpea + groundnut gave the maximum pigeonpea-equivalent yields of 2,187 and 2,253 kg/ha, respectively, and were significantly superior to all other treatments. These 2 treatments were on a par with each other, and sole pigeonpea, pigeonpea + blackgram, pigeonpea + soybean and pigeonpea + rice were also on a par among themselves. Pigeonpea + greengram system gave the lowest pigeonpea-equivalent yield.
Amongst the sole crops, greengram was the least profitable, followed by soybean. Sole pigeonpea was superior to the others, except groundnut.

349 89 - 4/52

Cropping systems
USA, experiment, maize, soybean, leaf removal, randomized block design, yield stability, sole crop, intercropping
KELLEY, T.G. and J.A. JACOBS
Yield stability of sole-crop and intercrop planting systems.

In: Soybean in Trop. and Subtrop. Cropping Systems: Proc. of a Symp., Japan; AVRDC, 1986, pp. 49-56

The objective of the study reported here was to test the "risk-aversion hypothesis," often stated as a primary reason for mixed plantings under subsistence conditions. The hypothesis maintains that mixed plantings, intercrops, or random mixtures are less susceptible to the yield losses that result from adverse climatic or environmental conditions than are corresponding sole-crops. The measure used for testing the stability of a cropping system in this experiment was the ability of a crop to perform or yield well under adverse conditions. By subjecting a mixed crop of maize (*Zea mays*) and soybean (*Glycine max*) and corresponding sole-crops to simulated insect and disease defoliations, a measure of the relative degree of production stability was derived for each system.
The effect of defoliation on maize and soybean grown under both sole-crop and intercrop systems was studied in an experiment. A mid-season maize cultivar, FR 632 x FR 16, and soybean cultivar Williams 80 were each subjected to varying degrees of leaf removal at different times in the season.
A randomized block design consisting of treatments in a factorial combination of five levels of defoliation (0, 25, 50, 75, and 100%) at three dates (25, 45, and 60 days after seeding (DAS)) was used. Within each of the fifteen factorial treatment combinations (Main plots), a split-split plot design was arranged. Subplots consisted of either sole-cropping or intercropping. Each subplot specified the crop to be defoliated. There were three replications.
Under both sole-crop stands of maize and soybean, defoliation treatments depressed grain yields in relation to severity and time of defoliation. The results obtained here are in general agreement with earlier studies on defoliation for both crops. Yield reductions followed a negative linear trend with respect to rate

and time of defoliation. Exceptions were observed for maize defoliated at the earliest date, the 8-leaf stage, and when maize was defoliated at the 25% rate for all dates. In these cases a yield increase of up to 9% was observed.
Yield reductions in defoliated, intercropped maize and soybean were more acute than in the defoliated sole-crops. This was presumably due to the presence of the competing companion crop which was able to increase its yield as a result of the other's injury. This effect was more pronounced under maize-defoliated conditions than under soybean-defoliated conditions. Soybean intercrop yields increased in proportion to the degree and time of maize defoliation. Maize intercrop yields under defoliated-soybean were higher than the control (undefoliated treatment), but did not show increasing trends in proportion to the degree and time of soybean defoliation. The reason for this phenomenon is not clear, but the unavailability of light may have limited yields in the soybean intercrop. Removing (partially or fully) the maize plants allowed more light to reach the soybean canopy and thereby increased yields. Maize, being a taller crop, may not have benefited to the same degree from soybean leaf removal. No light meter readings were taken, however, so this hypothesis cannot be substantiated.
Defoliation, either in maize or soybean, caused greater proportional yield reductions when the defoliated crop was intercropped rather than planted in solid stands. Therefore, in order for an intercrop system to suffer lower losses due to defoliation, yield compensation from the non-defoliated crop must exceed the difference in loss between the intercrop and sole-crop defoliation. There are obvious problems in comparing yield compensation values of one crop to crop yield losses in another. For this analysis an assumption was made in order to equalize the productivity between a hectare of sole-crop maize and the productivity of a hectare of sole-crop soybean, so that a conversion factor of 2.1 t of maize is equivalent to 1.0 t of soybean. Accordingly, after the conversion adjustment, direct comparisons between sole-crop yields and intercrop yields could be made on the basis of total combined grain yields for each of the defoliation treatments. Under normal conditions (undefoliated), an intercropping system, maize + soybean, was 8.7% more productive than the corresponding sole plantings of the same crops. Under maize-defoliated conditions, maize + soybean was an average of 8.1% more productive than the corresponding sole-crop plantings. The value increased under conditions of more severe defoliation, reaching 26.3% at the at the rate of 75% of defoliation on the last date. For the soybean defoliation treatments, intercrops were an average of 4.9% more productive than the maize and soybean sole-crops. There was no trend for either increase or decrease in this value as defoliation severity increased.
In regard to production stability, maize + soybean intercrop provided higher "highest-returns", higher "average-returns," and higher "minimum returns" than corresponding maize and soybean sole-crops. The yield returns for maize- and soybean-defoliated conditions under single sole-cropping, two sole-crops, and intercropping are presented. Under maize-defoliated conditions the

intercrop system had an average return of 7.9 t/ha, with a range of 0.8 t/ha between highest and lowest returns. For the single crop planting, an average value of 7.1 t/ha and a range of 3.6 t/ha between highest and lowest returns were observed. This implies that as the cropping system moved away from diversity (intercropping) and towards homogeneity (sole-cropping), average returns were lower, range of yield values increased, and, most importantly, possibilities for very low returns increased - a concern of top priority for small farmers operating at or near the minimum subsistence level. Hence the data suggest that the risk-aversion principle for intercropping applies to maize-defoliated conditions.

The picture changes for soybean-defoliated treatments. Average grain yield for intercropping, two sole-crop plantings, and single sole-crop planting, were 7.8, 7.4, and 7.1 t/ha, respectively - a much closer margin than that observed unde maize-defoliated conditions. Under soybean-defoliated conditions, which were generally not as sensitive to yield losses as the maize-defoliated treatments, the risk-aversion hypotheses would not be a valid justification for intercropping, since minimum yield returns from the two sole-crop plantings and intercrop plantings were about the same. Justification for intercropping by risk-aversion would require higher minimum returns rather than just comparable minimum returns. Still, average returns and highest returns were higher in the intercrop treatment than in either of the sole-crop systems.

It appears that intercropping does offer a measure of risk aversion based on the treatments tested in this experiment. Lowest grain yield (excluding 100% defoliation) was found in the single sole-crop planting (4.7 t/ha from 75% maize defoliation on last date) followed by the two sole-crop planting system (6.2 t/ha from 75% defoliation on the last date). Lowest grain yield for the intercrop (6.7 t/ha for soybean defoliation on the last date) was over 0.5 t/ha higher than the two sole-crop plantings.

A complete loss in one crop is not uncommon, but because of the alternative for replantings - especially under sole-crop conditions - it is difficult to assess the real advantage of intercrops over sole-crops in this situation. If, however, the assumption is made that a replant situation is not feasible (too late in the growing season or labor shortages early in the season) the intercrop system is markedly superior to sole-cropping. The difference is most dramatic under maize-defoliated conditions. Yields of intercropped soybeans where maize was completely defoliated averaged 87% of sole-cropped soybean yields. The earlier the maize was removed from the intercrop the more soybean yields increased.

350 89 - 4/53

Cropping systems
Africa, Ghana, savannah zone, land-use, experiments, crop rotation, split plot design, maize, groundnut, yam, sorghum

SCHMIDT, G. and E. FREY

Crop Rotation Effects in Savannah Soil.

Nyankpala Agric. Res. Report, 4, 1988, pp. 37, Distr.: Verlag J. Markgraf, FRG, ISBN 3-8236-1159-3, DM 19,--

In crop sequence experiments carried out at the Nyankpala Agricultural Experiment Station (Guinea savannah zone of Northern Ghana) maize proved to be very responsive to preceding crops. Grain legumes (groundnut, cowpea, pigeon pea) and yam were very favourable preceding crops for maize.

Yields were lower where maize followed maize and lowest where maize followed sorghum. Intercropping of maize with various grain legumes (alternating rows of maize and legumes) led to subsequent maize yields which were close to those obtained after sole crop maize.

Maize also responded strongly to nitrogen fertilizer application. This applied to all combinations with previous crops. In a long term crop sequence trial (1981-1986) nitrogen fertilizer efficiency (60 kg N/ha) for maize tended to be highest after yam. In this experiment, protein contents of maize grain and nitrogen contents of maize stover were generally extremely low indicating a very poor plant and soil nitrogen status. The application of 60 kg N/ha brought about only a slight increase in these contents whereas preceding crops had either little or no distinct influence. As a result the quantity of nitrogen contained in grain and stover was mainly determined by crop yields.

The nitrogen uptake of maize varied greatly depending on the weather conditions. In dry seasons the uptake of soil and fertilizer nitrogen was low. The highest recovery of fertilizer nitrogen was observed in two seasons with a favourable rainfall distribution (1984 and 1985). During the same seasons as well as in a third season with high stover yields (1982) the difference between nitrogen uptake after groundnut and after maize, largely attributable to biological N-fixation, was also the highest (27-32 kg N/ha). This difference was minimal in two dry seasons.

Tall local sorghum was less responsive to preceding crops than maize. During the first two years of the long term crop sequence trial no distinct influence of preceding crops could be observed. From the third year groundnut turned out to be the best preceding crop followed by maize-groundnut intercropping and/or yam. Sorghum after maize tended to be less productive and sorghum after sorghum gave the lowest yields. Nitrogen fertilizer (60 kg N/ha) increased sorghum yields during 4 of the 5 test seasons, but sorghum responded less than maize. In two seasons nitrogen fertilizer did not show any appreciable effect on sorghum cultivated after groundnut or maize-groundnut intercropping.

Groundnut yields were little influenced by preceding crops. In three seasons yields tended to be low after groundnut or maize-

groundnut intercropping indicating self-intolerance. However, during extended drought in another season groundnut after groundnut wilted less than groundnut after sorghum. This may have been the reason for higher kernel yields after groundnut or maize-groundnut intercropping than after sorghum. Nitrogen fertilizer mostly depressed groundnut yields.
Yam yields were hardly or not influenced by either preceding crops or nitrogen fertilizer application. A tendency of low yam yield after yam reached the level of significance only once in 5 years. In the last season (1986), previous sole crop groundnut cultivation or maize-groundnut intercropping increased yields as compared with previous cereal or yam cultivation. After groundnut yam did not respond to nitrogen fertilizer or responded less than after other crops, in particular sorghum.
In an ideal rotation, maize which is most responsive to previous crops and fertilizer should be grown after grain legumes. Phosphate fertilizer for a whole rotation is concentrated on this crop, which also has a high nitrogen fertilizer requirement (recommended minimum dose: 60 kg N/ha). Maize is followed by yam or again grain legumes, crops not affected by the N-hunger period during the decomposition of cereal residues of extremely low nitrogen content and ideal preceding crops for sorghum. Sorghum should not be followed by cereals.

351 89 - 4/54

Cropping systems
Asia, Sri Lanka, experiments, humid tropics, Ultisol, mixed cropping, mungbean, annual crops, perennial crops, yield, alley cropping, AVRDC
SANGAKKARA, U.R.
Mungbean as a component of annual mixed cropping system.

In: Mungbean - Proc. of the 2nd Int. Symp., Bangkok, Thailand, AVRDC, Shanhua, Tainan, Taiwan, 1988, pp. 406-411

Grain legume production in Sri Lanka is centered around cowpea (*Vigna unguiculata* (L.) Walp.) and mungbean (*Vigna radiata* (L.) Wilczek), although others are produced on a smaller scale.
The production of food crops in Sri Lanka is based on the smallholder agricultural sector, in which land holdings range between 0.5 and 1 ha. Due to the constraints of land size, mixed cropping is recommended for these small holdings both in the traditional lands and in new settlement schemes opened up under the development programs. Traditional small-holder farms in Sri Lanka produce rice in the lowlands and legumes, cereals, condiments (chilies) or root crops in the highlands. Upland crops are generally mixed, and the combinations consist of a legume with one or two of the other economic species. Studies, both in Sri Lanka and abroad, have shown the versatility of mungbean for mixed cropping in such systems, especially with cereals. In addition mungbean is recommended for dryland cultivation, especially under alley and agroforestry farming systems.

A study was carried out to evaluate the comparative performance of mungbean when planted in binary mixtures with three companion crops which have different crop canopy structures and growth patterns during the rainy season in the midelevation region (1500 to 2000 m above sea level) of Sri Lanka. Another study evaluated the comparative performance of mungbean under two alley crops (*Leucaena* and *Gliricidia*) and in open-farming conditions found in the traditional systems of the dry zone of Sri Lanka. These are primarily intended to test the versatility of mungbean under different conditions found in small-holder farming systems.
The selected main crop treatments were: cassava (*Manihot esculenta* Crantz) variety CARI 555; corn (*Zea mays* L.) variety Thai composite; and sweet potato (*Ipomoea batatas* (L.) Lam.) variety C 26.
These were planted in rows at 1 m spacing. The spacing between plants within rows was 1, 20 and 50 cm for cassava, corn and sweet potato, respectively.
The main crop was intercropped with mungbean variety MI 5 in rows at 25 cm spacing between the main crops and at an interrow spacing of 10 cm. In addition a mungbean monocrop was established at similar spacing.
Annual Mixed Cropping System:
The results show that the plant heights of mungbean are marginally taller when intercropped with a tall companion crop. This could be associated with the available light for mungbean. Corn, and to a lesser extent cassava, intercept a proportion of incident light depriving intercrop of the maximum available radiation. This shading effect can be considered the mechanism of increased plant height of intercropped mungbean compared to its monocult or plants grown with a short companion crop.
No significant differences were observed between mungbean plants in terms of flower and pod set, when intercropped. Thus, shading has minimal effects on the number. of flowers and pods per plant in mungbean. Temperature is reported to have a greater effect on these parameters than light.
Seed development in legumes is generally associated with available radiation. A table shows that the number of seeds per pod and 100-seed weight of mungbean are affected by intercropping. The lowest seed number per pod and 100-seed weight is recorded when mungbean is intercropped with corn, which intercepts a greater percentage of light than the other companion crops tested. Since cassava permits greater light penetration, these seed parameters are affected to a lesser extent. As there is no shading effect when mungbean is associated with sweet potato, these yield components are similar to those of the monocrop.
Per plant and per hectare yields reflect the effects of intercropping on yield components. Corn has the greatest effect on mungbean yields. However, yields of mungbean are depressed when intercropped. The measurements taken in this study indicate the detrimental effect of shading, especially when grown with a taller crop. The mechanisms of yield reduction when mungbean is intercropped with sweet potato, although not elucidated in this study, have been reported as interactions between the root systems for nutrients. This conclusion is based on the availability of

adequate light for mungbean when grown with the shorter crop, and the production of the highest yield among the intercrops under conditions of no competition for light.

Alley-Cropped Trial:

The lopping of branches at the beginning of the wet season allowed ample light penetration into the contours that were intercropped. In addition the prevalent rainfall in this season was conducive to mungbean even under conditions of open farming. Thus, yield components and yield of mungbean within the alley-cropped region and traditional open-farming conditions show no significant differences.

In contrast *Leucaena leucocephala* and, to a lesser extent, *Gliricidia sepium* intercept light during the dry season. Shading has a beneficial effect on the microclimate of the alleys, reducing temperature and increasing water retention when compared with open-farming conditions. The improvement of growth conditions under alley crops in the yala season helps better growth of mungbean when compared to the open-farming conditions. All yield components are increased when mungbean is alley cropped in the yala season. When comparing the alley crops, *L. leucocephala*, due to its dense canopy, appears to have a greater beneficial impact on mungbean than *G. sepium*. Thus, mungbean can be considered a useful component for alley crops, especially in the yala season under rainfed conditions, where no agricultural practices are undertaken in traditional farmer lands.

The results of this study show the feasibility of growing mungbean as an intercrop with both annual and perennial species. Although mungbean yields are significantly reduced when intercropped with taller annual species, as reported in most grain legumes, they have the capacity to increase the productivity of land by producing a crop, from a region hitherto left uncultivated within a short period of time. If associated with a short companion crop and proper culture practices are adopted, yield reduction could be minimal.

The results suggest that competition for light is one of the factors causing yield reduction in the intercropped mungbean. When such competition is absent, yield reductions are low. However, the presence of root competition cannot be ignored and this area warrants further research.

The value of mungbean under alley cropping, especially in the yala season when no successful agriculture is possible due to very low rainfall, is shown in this study. While optimal yields are not obtained, the results reveal that when mungbean is cropped under perennial species, especially *L. leucocephala*, in the yala season its yield can double over that obtained in other conditions. Its value is further enhanced due to its short duration, which enables it to use the available soil moisture efficiently. However, no increase in yield is obtained when mungbean is alley cropped in the maha season, due to the availability of water.

89 - 4/55

352

Cropping systems

Asia, India, experiments, Alfisol, intercropping, mungbean, pigeon pea, sorghum leaf area index, grain yield, dry matter

SUBRAMANIAN, V.B. and D.G. RAO

Intercropping effects on yield components of dryland sorghum, pigeon pea and mung bean.

Trop. Agric. (Trinidad), 65, 2, 1988, pp. 145-149

The present paper reports the results of field experiments on two intercropping systems: sorghum + pigeon pea and sorghum + mung bean. The objective was to compare the effect of intercropping on the three crops to identify intercropping-sensitive yield components.

Two contrasting intercropping systems, sorghum + pigeon pea and sorghum + mung bean, were compared for the effects of intercropping on leaf area index, grain yield, yield components and total dry matter.

Both component crops of the sorghum + pigeon pea system yielded less grain and dry matter than did the respective sole crops. In the sorghum + mung bean system, grain yield and dry matter of the sole and intercrop sorghum were not significantly different but the yields of intercrop mung bean were only some 20% of that of the sole crop. In comparison with the sole crops, harvest index was more than two-fold in pigeon pea, was decreased in mung bean and was not affected in sorghum.

The grain yield components of sole and intercrops of sorghum, pigeon pea and mung bean are compared. Except the intercrop sorghum + mung bean system, all the intercrops had fewer grains m^{-2} than did the respective sole crops. In pigeon pea, the reduction in number of grains was due to reduction in number of pods m^{-2}, whereas in mung bean, both number of pods m^{-2} and number of grains pod^{-1} were affected. Intercropping did not influence the average grain size (1000 grain weight).

Data on dry matter accumulation in plant parts and leaf area index at anthesis of sole and intercrop sorghum are presented. In the sorghum + pigeon pea system, intercropping resulted in reduction in total dry matter production and leaf area index of sorghum. Accumulation of dry matter was relatively less affected in the stem than in leaf and ear. In the sorghum + mung bean system, leaf area index in sole and intercrop sorghum were not significantly different.

Dry matter m^{-2} increased progressively in both the sole and intercrop pigeon pea during the late vegetative and early reproductive stages. After the commencement of flowering, the rate of increase in dry matter accumulation slowed, more so in the steam. The absolute amount of dry matter in the intercrop was only 50% of the sole crop. The reduction due to intercropping in dry matter accumulation was slightly but consistently more in leaves than in stem. The stem of the intercrop pigeon pea was thinner. The height and node number on the main stem at which the first branch was borne was higher in the intercrop than in the sole

crop. The number of nodes and primary branches plant[-1] were also less. At maturity, the reduction due to intercropping in number of secondary branches plant[-1] was more than that of primary branches. In the sorghum + mung bean system, dry matter in the intercrop mung bean at flowering was about 33% of that of the sole crop. As with sorghum and pigeon pea, leaf dry matter accumulation was relatively more affected by intercropping. Both leaf area index and leaf weight ratio were significantly less in the intercrop than in the sole crop.

353 89 - 4/56

Cropping systems
Asia, India, experiment, field trial, sandy loam soil, irrigation, nitrogen, maize, cowpea, intercropping, intercrop competition, fodder crop
AGRARWAL, G.C. and A.S.SIDHU
Effect of irrigation and nitrogen on maize-cowpea fodder intercropping at Ludhiana, India: advantages and intercrop competition.

Field Crops Res., 18, 1988, pp. 177-184

This study was undertaken to examine: (1) the effect of nitrogen and irrigation on maize (*Zea mays* L.) and cowpea (*Vigna sinensis*) fodder intercropping advantages and intercrop competition; (2) the residual effect of such intercropping on a succeeding pearl millet (*Pennisetum americanum* L.) fodder crop; and (3) relationships among different measures used for evaluating intercrop competition.
The effects of three variables, crop system, nitrogen level, and irrigation level, were studied.
For further evaluation of the intercrop system, the residual effect on a following pearl millet crop, sown after harvesting, was also studied. Irrigation treatments became replications for the succeeding pearl millet experiment. Basal doses of 26.2 kg P/ha and 24.9 kg K/ha, but no nitrogen, were applied.
A yield advantage of intercropping over sole cropping was observed at all N and irrigation levels, with LER of 1.09 averaged over all treatments. However, differences in LER values at different levels of N and irrigation were non-significant. Although the relative fodder yield advantage of the intercrop was consistent at all N levels, the relative contribution to yield from maize increased with N level.
Irrigation frequency did not affect LER. This agrees with other findings that moisture availability has no observable effect on LER.
Intercrop competition was affected by both nitrogen and irrigation. LER for cowpea decreased and that for maize increased with increase in nitrogen.
Evaluated in terms of relativ crowding coefficients as well as aggressiveness, cowpea changed from a dominant species at lower N levels to a dominated species at higher N. The behaviour of maize

was the reverse of cowpea. The competitive ability of maize was almost equal to that of cowpea. For quantifying competition between competing crops at different irrigation and nitrogen levels the competitive ratio was computed, as other measures have some limitations. Nitrogen increased the competitive ability of the maize, increasing from 0.80 at zero N to 1.46 at 120 kg N/ha. Since the competitive ratio values of the two crops are the reciprocal they are presented for only one of the crops. The results show that cowpea is more competitive than maize only when grown under N and irrigation constraints.
Sole maize gave the highest fodder yields except at N_0, and sole cowpea the least. Sole cowpea significantly responded to N up to 40 kg N/ha only, whereas increases in yields of sole maize and of the maize-cowpea intercrop were significant up to 120 kg N/ha. However, the contribution of cowpea in intercrop yield decreased with increase in N.
Both the preceding cropping system and applied N at 120 kg/ha had significant effects on the succeeding pearl millet fodder yield. Pearl millet fodder yield was the highest when grown after cowpea. Averaged over all N treatments, pearl millet grown after the intercrop yielded 42% more than after maize.
It was found that N uptake by pearl millet (25.5 kg/ha) following the intercrop was 1.3 times more than after maize.
Yields of cereal-legume intercrops have, generally, been found to be less than those of cereal crops, and the results of this study supports this. Consequently, intercropping has been advocated either for balanced food production or other specific considerations. That approach ignores the beneficial residual effect of intercropping. A rational evaluation of cereal-legume intercropping should be based on crop-sequence yields. The total crop sequence fodder yield of the intercrop system was comparable to yield of the sole-crop sequence. Higher crop-sequence yields from intercropping at low inputs indicate that intercropping is more beneficial under N and irrigation constraints.

354 89 - 4/57

Cropping systems
Africa, Mozambique, experiments, intercropping, groundnut, maize, ICRISAT, IDRC
RAMANAIAH, K.V. et al.
Groundnut/Maize Intercropping in Mozambique.

In: Trop. of the 2nd Reg. Groundnut Workshop for Southern Africa, Harare, Zimbabwe, 1986, pp. 119-123

In Mozambique, groundnut is usually intercropped with cassava, maize, beans, sorghum, etc., depending upon the locality and season. Some combinations have advantages during drought years. This study was conducted on a research station and on farmers' fields to determine the best geometry of planting groundnut/maize intercrops, and to compare the results obtained on research stations with those obtained under farming conditions.

The yield of maize was greatly reduced when intercropped with groundnut . Line planting facilitated easier weeding than the zig-zag- pattern. Line planting took more labour than the zig-zag method at the time of sowing. This is very important for the farmer as he has to plant as much area as possible to capture the available moisture before it escapes from the ground. In some places where rats and birds are a problem, line planting was disadvantageous because they can easily pick up seeds if they are in a line.
Difficulties in achieving standard moisture contents resulted in the omission of some data. The results reflect the variable nature of each farm and the non-uniform rainfall pattern.
In general, intercropping groundnut with maize is not advantageous. The maize crop, when associated with groundnut, was short in height, pale yellow in foliage colour (nitrogen deficiency) and was infected with stem borers. Many of the cooperating farmers were of the opinion that it is better to select crops like cassava, sorghum, and beans rather than maize. Similarly, these farmers are now of the opinion that maize should be grown as a sole crop or intercropped with beans.
Intercropping of groundnut with maize is not always advantageous, especially in a dry year. Maize suffers if it is intercropped with groundnut.
Although farmers are convinced by the results, some still intercrop groundnut with maize because they need both maize and groundnut for consumption. If sufficient land is available they prefer to grow groundnut as a sole crop, but maize is always grown with some other crop such as beans, cassava, etc..

355 89 - 4/58

Cropping systems
Asia, India, experiment, field trial, cocoa, arecanut, mixed cropping, bivariate analysis, spacing, manure, economic evaluation
BHAGAVAN, S. and SHAMA BHAT K.
An Appraisal of a Mixed Cropping Trial on Arecanut and Cocoa.

J. of Plantation Crops <u>17</u>, (1), 1989, pp. 10-17

Increased production and efficient use of resources can best be achieved through mixed cropping systems. It has been outlined how cocoa can effectively be grown in combination with either coconut or arecanut palms to increase the returns per unit area. In such mixed cropping trials, testing the response of crops to treatments imposed is difficult when two or more crops are involved.
There are complex interactions that occur in intercropping, depending on various combinations of the effect of plant species, plant density and spacing, planting patterns, canopy types, root systems, differential demands on environmental factors at different growth stages and so on. There are various functions such as Relative Crowding Coefficient, Competition Index, Aggressiveness, Reciprocity, Land Equivalent Ratio, Land Utilization, Gross Returns, Net Returns, Diversity Index, Multiple

Cropping Index, Harvest Diversity Index, Simultaneous Cropping Index, Cultivated Land Utilization Index and Crop Intensity Index which expresses competitive abilities of components and or yield advantages for a given crop model. Each of these methodologies have advantage of their own in testing predefined objective but none of these can be used satisfactorily for assessing the efficacy of a given cropping model with due consideration to individual crop performance and that too when perennial crops are involved. This is because in perennial crop mixture
- the growth pattern and yield of each crops are highly interdependent;
- the extent of competition and other interactions among the crops vary substantially as the year advances and
- the prices of each crop will be fluctuating over years.

Such an insight of assessing individual crop performance in addition to testing the efficacy of the given crop model can best be made by bivariate/ multivariate analysis after eliminating the interdependency among the crops.
In the present study, data from an arecanut-cocoa mixed cropping experiment was used. Apart from economic evaluation of different spacings based on gross returns per hectare, a bivariate analysis has been attempted in order to evaluate the treatment effects. This method has following advantages:
- it brings out the extent of interdependency existing between two crops
- it considers both the crop yields as two variates instead of combining the two yields as one index and
- it assesses the performance of treatments for the mixed cropping system as a whole.

It was found that yield per plant was higher when arecanut was spaced at 2.7 m x 2,7 and cocoa at 5.4 x 5.4 m. However, when both the crops were planted at a spacing of 2.7 m x 2.7 m, eventhough there was a decrease in yield of individual plants, yield per unit area was significantly higher due to higher population density. The economic evaluation based on gross returns also highlights the efficacy of 2.7 m x 2.7 m spacing for both the crops with average gross returns of Rs. 82.830 per hectare.
In fact any increase in spacing from the recommended spacing for the arecanut, viz,, 2.7 m x 2.7 m gives significantly poorer returns as the major portion (nearly 2/3 rd) of returns is realised from this crop.
From the analysis it is evident that cocoa can effectively be grown in the areca gardens in recommended spacing with cocoa trees spaced at 2.7 m x 2.7 m and if the cost of cultivation of cocoa is found to be high, the next best spacing viz. cocoa spaced at 2.7 x 5.4 m may be preferable for realising good returns.

356 89 - 4/59

Cropping systems
Asia, tropics, developing countries, IRRI, cropping systems research, multiple cropping, small farmers, crop intensification, on-farm research, sustainability, future programes, evaluation
PENDLETON, J.W. and GREENLAND, D.J.
Cropping systems research program of IRRI.

In: Summary Procedings of an Experts Meeting, ICRISAT, India and UNEP, Kenya, 1986, pp. 25-27

The aim of cropping systems research at IRRI is to identify productive ricebased rainfed cropping systems acceptable to small farmers in specific regions. This paper presents the evolution, development, present research areas and achievements, and future challenges in cropping systems research by IRRI.
The six essential components of the methodology are site selection, site description, design of improved cropping systems, site testing, preproduction testing, and the production program. The last one, that is the production program, is the ultimate objective - to provide government decisionmakers with sufficient information to make firm decisions about supporting improved cropping systems programs and technology that will lead to greater food production and better family welfare for small Asian rice farmers. The CSR team helps prepare the recommendations for production programs with extension staff or government policymakers.
The program accomplishments are:
- The development of a methodology for designing, testing, and transferring improved technology for increasing food production.
- The formation of the Asian Cropping Systems Network and its continued growth and development.
- Specialized training at IRRI in cropping systems to trainees from many countries who return to be program leaders.

Future challenges exist primarily in the following areas:
- Variety improvement: Varieties that are tough enough to withstand stresses of too much water or too little water, that is the ability to produce relatively stable yields, are needed. Improvement of dryland crop varieties for rice-based cropping systems has been identified as the long-term objective. It is agreed that both the empirical and the physiological approaches should be utilized. Cultivars with low sensitivity to both temperature and photoperiod are needed.
- Management and tillage: For most soils, the conversion from puddled to well aggregated, well aerated soil conditions is expensive, time-consuming, and wasteful in terms of residual soil moisture. The transition period of as much as 1-2 months can be avoided by seeding the following crop in the uncultivated drained paddy field. Recent trials show promising results from this technique.
- Fertilizers: Maintenance of soil fertility and efficient fertilizer use in intensive cropping systems is beginning to

receive attention. Collaboration in long-term fertility trials and studies on controlled-release nitrogen carriers, to generate more information about tailoring fertilizer practices to fit rice-based cropping systems. Research on systems where organic and inorganic fertilizers are used in a complementary manner. Symbiotic nitrogen fixation must continue to receive attention for all legume types. Trials have shown that a green manure crop before rice can contribute the equivalent of 30 kg ha^{-1} of fertilizer N.
- Environment: Agrometeorological and land capability studies will receive more attention as a means of identifying areas where present cropping systems might be intensified. Basic rice growth modeling for rainfed rice will continue. Better information on the physical environment should assist us in understanding and controlling pest outbreaks. Closer identification of critical soil moisture levels for component crops is needed.
Socioeconomic variables are much harder to measure than physical parameters and simpler, faster methods are needed.
One of the future challenges for IRRI is how best to serve the increasing demands of national programs that have recently evolved from cropping systems programs dealing with only the cropping component of farming systems programs. It remains necessary to integrate livestock, agroforestry, aquaculture, and other components of farmers' production into the system. This will receive increasing collaborative attention.

357 89 - 4/60

Cropping systems
Africa, semi-arid tropics, review,ICRISAT, pearl millet, yield stability, management practices, soil fertility, production systems, plant nutrition, soil management, water-use-efficiency, tillage systems, animal traction, cultivars, cultural practices, crop associations, agroforestry
FUSSELL, L.K. et al.
Practiques de culture visant à augmenter et à stabiliser le rendement en Afrique. (Management Practices to Increase Yield and Yield Stability of Pearl Millet in Africa.).

In: Proc. of the Int. Pearl Millet Workshop, ICRISAT, India, Patancheru, A.P. 502 324, ISBN 92-9066-134-8, 1987, pp. 255-268

Pearl millet (*Pennisetum americanum*) is a staple cereal best adapted to the low fertility soils and frequently drought-prone semi-arid tropics of Africa and India. It is grown on an estimated 27 million ha in these two regions, with 56% of the production in Africa. In Africa, major pearl millet growing areas are in West Africa (83%) and the Sudan (8%), in the Sahelian (300-600 mm annual rainfall) and the Sudanian (600-900 mm) bioclimatic zones. Of the 14 million ha grown in West Africa, Nigeria (28%) is the largest producer, followed by Niger (22%), and Mali (10%). The discussion in this paper is confined to implications for these principal millet-growing regions of Africa.

Of all the regions of Sub-Saharan Africa (SSA), West Africa has shown the slowest growth rate for total food production, mainly due to the very low production rate of the major staples, sorghum and millet, and the decline in the groundnut cash crop production. The small increase in total food production has been almost exclusively due to increases in cultivated area. The new land tends to be in poorer, marginal cropping areas. The technological change has had little impact on food production in general, and millet production in particular. FAO statistics indicate for Africa to meet its food needs in the year 2000, increased production will have to come from increased yield per hectare (51%), rather than from expanded cultivated areas (27%), or from more than one crop per year on the same land (22%).
Millet is traditionally reserved for light, sandy, low fertility soils in areas where rainfall is low and drought common. Few yield-increasing inputs are used. Management strategies, using mainly hand labour, are extensive rather than intensive. The crop is grown with low plant populations, normally in association with other crops, particularly cowpeas (*Vigna unguiculata* [L.] Walp.) and Sorghum bicolor [L.] Moench). Millet grain is used primarily for human consumption, however the straw is important for construction and as standing dry fodder for animal production system.
Improved millet production in the West African semi-arid tropics (WASAT) should rely on management practices that increase yields, when possible, while improving production stability in both good and poor rainfall years. Farmers' production can be stabilized through a reduction in yield variation from year-to-year, and by insuring a carryover of grain from good to poor years.
The principal factors limiting millet yields in WASAT to be, in order of priority: (1) inherent loss of soil fertility, (2) limited and untimely cultural practice, and (3) the frequent occurrence of drought periods. The first two factors are more limiting than moisture in most years. In years when rainfall is inadequate, water-use efficiency and yields can be improved by inputs that address these two factors. The improvement of millet production will rely on management practices that overcome these limitations, while insuring yield stability and maintenance or improvement of the production resource base. Inputs, by necessity, will have to be available to the resource-poor farmer.

358

89 - 4/61

Cropping systems
Asia, India, field trials, intercropping, pigeonpea, plant populations, maize, green gram, sesame, upland rice
MOINBASHA, S. and R.A. SINGH
Land-Equivalent Ratios of Pigeonpea-Based Intercropping Systems at Different Plant Populations.

International Pigeonpea Newsletter (IPN),Nr.7, 1988, pp. 18-20

Field experiments were conducted during the cropping seasons of 1982/83 and 1983/84 at the Agricultural Research Station of Banaras Hindu University, Barkachha-Mirzapur, Uttar Pradesh, to develop compatible intercropping systems with pigeonpea for Ultisols (Vindhyan Red Loams) of eastern Uttar Pradesh, India. The experiments were laid out in randomized-block design with three replications. There were five intercropping plant populations factorially combined with green gram cv T44 (65 days to maturity), maize cv Diara Composite (75 days), sesame cv T12 (85 days), and upland rice cv Akashi (100 days; only in the 2nd year). Plant populations in intercropping were maintained by changing within-row plant to plant distance. Sole-crop treatments of all crops used in the intercropping experiment were grown at their respective optimum populations, i.e.: pigeonpea 50.000 plants ha^{-1}, maize 75.000 plant ha^{-1}, sesame 100.000 plants ha^{-1}, and mungbean 200.000 plants ha^{-1} and upland rice at 80 kg seed ha^{-1}.
Pigeonpea intercropping in additive combinations with either green gram, maize, or sesame was consistently more productive than when grown separately, as total LER values were greater than 1.0 for these treatments. However, the LERs of intercropping systems under replacement populations were close to 1.0 indicating no advantage of intercropping. Upland rice did not show any compatibility with pigonpea even when it was maintained at 150% of sole stand. Perhaps the taller-growing pigeonpeas shaded the rice canopy and reduced dry-matter partitioning to grain.
Intercropping of pigeonpea with low-growing green gram caused pigeonpea yield to be virtually identical to that of the control pigeonpea at each population pressure. The average response of total grain LERs of pigeonpea and green gram intercropping was superior and highly compatible when pigeonpea was alternated with three green gram rows at 30 cm. When intercropped with maize, partial LERs for pigeonpea were less than for pigeonpea grown alone. This indicates suppression of pigeonpea growth by maize. It is interesting to note that in intercropping, both pigeonpea and maize LERs for grain were affected when the maize plant population was increased any more than its sole optimum. Nevertheless, the response to total dry matter LER of maize was considerably higher and it did entail sacrifice in grain yield of pigeonpea. Thus the overall efficiency of the pigeonpea/maize intercropping system was optimum with a maize plant density at the sole maize optimum (75.000 plants ha^{-1}) but a pigeonpea density at 1.5 times (i.e., 75.000 plants ha^{-1}).
In conclusion, it has not been found any compatibility in intercropping upland rice with pigeonpea (at least with the row arrangements tried), but green gram maize and sesame were highly compatible and it would be more profitable to grow them as intercrops with pigeonpea than as sole crops.

359 89 - 4/62

Cropping systems
Africa, savanna, agroecological zones, experiments, cowpeas, varieties, cropping systems, small-scale farmers, potential
IITA
Cowpea varieties for different agro-ecological zones and cropping systems.

IITA Ann. Report and Research Highlights 1987/88, ISSN 03311-4340, 1988, pp. 76-81

Cowpeas - an important food legume produced in several countries around the world - are adapted to a wide array of soils and moisture regime. Because this crop is versatile and fits in with different cropping systems, rotational niches, and marginal lands unsuitable for some of the major crops, it has expansion potential and offers opportunities for small-scale farmers to practice intensive cropping on their farms.
The most limiting constraint is damage by insects because the plant is vulnerable to pests from seedling to harvest stage and in storage. In spite of this and some other constraints, the cowpea production area has maintained a stable position, but any expansion will depend on alleviating the insect pest problems which are more severe in Africa than in Latin America and Asia.
Cowpeas are grown in different agro-ecological zones of sub-Saharan Africa, but primarily in the drier regions of West Africa in mixture with millets and sorghum without any chemical protection. Insecticides are essential for pure or sole crop cowpeas.
IITA-bred varieties are being adopted in several countries of Africa, Central and South America, and Asia. Popularity of the varieties is based on superior performance, maturity, and seed type. For example, VITA-1, VITA-3, and VITA-7, popular in Central and South America, are not in other regions. For example, the preferred seed types in West Africa are large white or brown with a rough seed coat texture, but in Central and South America and East Africa cowpeas are used as a substitute for beans so consumers prefer red and brown seeds with a smooth coat.
Among the varieties TVx-3236 was the first to combine a moderate level of resistance to thrips and to receive wide acceptance in several ecological zones in Africa. It was then used as a parent for further incorporation of resistance to aphids and buchids, resulting in a new cowpea line - IT84S-2246-4. It has a high yield potential and moderate resistance to diseases and to aphids, bruchids, and thrips.
Because of a wide range in maturity and plant types available in cowpea germplasm, scientists developed erect, early-maturing cowpea varieties and evaluated them in maize-based, cassava-based, yam-based, and rice-based cropping systems.
Cowpea varieties adapted to different agroecological zones in various West African countries are listed in this paper.
IITA research on cowpeas in the years ahead will focus on plant resistance to insects and diseases and on breeding varieties especially suited to mixed cropping with sorghum and millet in the moist and dry savanna zones in West and Central Africa. Here the need is for new varieties with stability of yield rather than high yielding cowpeas that require insecticides and fertilizers which small farmers cannot afford.
Pearl millet and cowpeas are grown extensively as intercrops in the dry savanna regions of West Africa.
Spreading and indeterminate types are important factors influencing cowpea yield in both sole and intercrop systems. Therefore, research efforts are aimed at developing spreading plant types suitable for the millet-based systems and having resistance to the various stresses that limit production.

360 89 - 4/63

Cropping systems
Africa, Kenya, semi-arid and arid zones, experiments, ecophysiology, land-use patterns, legumes, tepary bean, bambarra groundnut, drought resistance
HORNETZ, B.
Ökophysiologische Experimente zur Verbesserung der Landnutzung im Trockengrenzbereich SE-Kenyas mit trockenadaptierten Leguminosen (Tepary-Bohnen, Bambarra-Erderbsen). (Ecophysiological Experiments for Improving Land-duse Patterns in the Dryland of Southeast Kenya by Means of Drought Resistant Leguminous Crops (Tepary Beans, Bambarra Groundnuts).

Der Tropenlandwirt, 89, 1988, pp. 107-129

Pressure inducted by increased population of as much as about 4% per year has led to a dramatical shortage of arable land in the smallholder farming areas of Kenya, especially in the so called "high potential areas".
People either have to optimize their agricultural systems in these high potential areas by expensive investments or - as most of them leave their homes and try to settle in uncultivated areas, predominantly marginal agricultural lands of the semi-arid and arid drylands.
Though it can be observed that in the wetter parts of the drylands smallholders have started to cultivate drought resistant leguminous crops like pigeon peas (*Cajanus cajan*) and cowpeas (*Vigna unguiculata*), there is a lack of ecologically adapted crops in the potential cropping areas.
This study deals with potential cultivation of the "minor pulses" of tepary beans (*Phaseolus acutifolius*) and bambarra groundnuts (*Voandzeia/Vigna subterranea*) with special reference to their ecophysiological demand.
The aim of this research is to supplement actual land-use patterns in those areas recently dominated by integrated systems of crop cultivation and livestock production with ecological adapted leguminous crops of high nutritional values. This would subsequently reduce the risk of crop failure, food crises, and soil degradation (mainly by means of nitrogen fixation).

Newly constructed growth containers gave possibilities to stimulate different durations and intensities of water stress under controlled environmental conditions in climatic chamber experiments.
It was observed and recorded that teparies and bambarras possess different mechanisms of morphological and physiological adaptation to high temperature and water stress. This apparently includes the ability of osmotic adjustment. The patterns of adaptation to water stress are combined with defined hydrature periods closely connected with the reduction of soil moisture.
The computations resulted in a spatial differentiation of potential cultivation patterns of tepary beans and bambarra groundnuts. Short-cycle teparies can be cultivated in all areas of the analyzed geographical area. Successful cropping with a probability of about 67% is even confined to the more humid rainy seasons in the drier parts of the agroecological zone.
The tested variety of bambarra groundnuts turned out to need at least 75 days of sufficient water supply during the agrohumid period (AHP) to receive the water requirements for obtaining minimum yields in two out of three years.

V AGROECOLOGY

361 89 - 5/28

Agroecology
Review, environment, agriculture, economics, eco-development, holistic approach, nonmonetary principles, house-keeping, policy
SÖDERBAUM, P.
Agriculture, economics, and eco-development.

In: Proc. of the 6th Int. Sc. Conf., IFOAM, UC, Santa Cruz, California, USA, 1988, pp. 93-102

In this paper it is suggested that the meaning of economics is not necessarily a simple and clearcut one. There may be many kinds of economics, just as there are many kinds of agriculture. And what is more interesting, perhaps, is that there are important similarities with respect to philosophy between some forms of nonconventional economics and organic farming as a case of nonconventional agriculture. In a similar way, the links between conventional economics and conventional farming are worth studying.
When asked about the meaning of economics, many people tend to think primarily of monetary aspects such as the price "mechanism" and the use of money as an instrument in our societies.
Problems related to development and environment are certainly complex in many respects and any desire to simplify things is perfectly understandable. Some simplification is also necessary. But the process of reducing complex development and environmental phenomena to one-dimensional terms involves losses in relevance which make the whole approach dubious. It is oversimplification.
Economics has to be understood in an broad sense, in which a parallel study of nonmonetary and monetary processes as impacts is recommended. Management of health resources or natural resources like ecosystems will seldom be made any wiser by attempts to put monetary prices on everything. On the contrary, there is a risk that our understanding of the nonmonetary processes involved will diminish.
The tendency among economists and others to think of economics as mainly related to monetary resources and monetary aspects of other resources should be counteracted.
In addition to the holistic and multidimensional idea of economics and resources and positional thinking, positional analysis is characterized by systems thinking, i.e., an effort to identify all the diverse systems that will be affected differently, depending upon the alternative chosen in a specific decision situation. This is essentially a way of broadening the analysis from one-sector thinking to multi-sector analyses.
The first part of the word economics comes from oikos, meaning house. Economics, therefore, could be seen as dealing with housekeeping in a broad sense. The "holistic" conception of economics implies that any tendency to regard things as "more economic" when a monetary price has been put on them should be

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361 89 - 5/28

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counteracted. Money is certainly a very important and useful instrument in facilitating transactions and monetary incentives may be very powerful in influencing the course of development of the economy. But principles of housekeeping or management of resources may be nonmonetary as well as monetary. And nonmonetary principles are not "less economic" than monetary ones.
The search for useful principles of housekeeping should therefore be directed as much towards nonmonetary as towards monetary factors and variables. Productivity estimates connecting the outputs and inputs of specific industrial or agricultural activities are relevant in this context. The endeavor to increase productivity in terms of yields per hectare or milk per cow from one period to another is certainly a nonmonetary principle of housekeeping. But it is narrow in the sense that there are many kinds of outputs (some of which, like pollution, are negatively valued) and many kinds of inputs in a given agricultural activity, and thus many possible output-input ratios. To get a many sided picture of the development over time of a given farm activity, a set of productivity estimates and also a description of changes in resource positions with respect to soil, groundwater, human health, etc. is needed.
Agricultural practices which conform to a specific definition of organic farming will certainly not mean that all environmental problems have been eliminated, but such practices are likely to perform better according to environmental criteria. This is not unexpected, however, since the philosophy behind organic farming incorporates long-run considerations of what is good for ecosystems, human beings, and society at large. Or, to put it in the terminology the theory behind organic farming involves a holistic rather than reductionistic concept of economics and housekeeping. Monetary criteria are relevant for the organic farmer too, but the relative role of monetary success criteria in relation to environmental and social criteria seems to be different.
Money and monetary incentives can play a significant role in efforts to transform present agriculture to practices which are environmentally sound. There are nonmonetary incentives in addition to the monetary ones. And beyond prices and perceptions of supply and demand, there are always human beings and often social relationships rather than mechanical forces. Social pressure within a bussiness community can certainly give considerable scope to unrestricted egoism and be destructive. On the other hand, to the extent that business leaders think and behave according to judgements of social and environmental responsibility, they will play a more constructive role in building a future sustainable society.

89-5/29

362

Agroecology
Review, sustainability, developing countries, human development, agricultural sector, training, economy theory, systems approach, holistic thinking

WOODS, B.M.

Human development and sustainability.

In: Proc. of the Seventh Agric. Sector Symposium - Sustainability Issues in Agricultural Development -; The World Bank, 1818 H Street, N.W. Washington, D.C. 20433, U.S.A., 1987, pp. 80-91

Sustainable development requires the necessary human skills, attitudes, motivation, understanding, leadership, organizations, policies, plans, and administrative and financial systems for whatever activities are involved - as well as the necessary infrastructure, funds, and physical inputs.
Despite all the resources and dedication that have been applied to development, shortcomings in "institution building" and "human resource development" remain, and a great many well-intended projects and programs have failed to be sustainable as a result.
The problem is well known, but its solution continues to exist.
A better understanding of the reasons for this persistent difficulty in development would be half way to its solution.
This paper addresses this issue and draws together the separate conclusions of authorities in a variety of relevant fields. They show the reason to be simple, but the solution to affect some of the underlying assumptions and philosophies on which development assistance has been based.
The paper considers findings in the agricultural sector; it touches on economic theory; examines the learning process on which human development depends, and how this has been approached in "development"; and it describes an underlying cause of a pervasive problem.
The paper summarizes that one can view the human development required for sustainability first in the context of what is needed within the agricultural sector, and in the context of what is needed for the total universe of learning on which development depends and then concludes within agricultural sector:
- that the staff profile, skills, language, and perceived role of the sector have led to great emphasis on the technical/physical, an economic/financial dimensions of agricultural development, but excluded equal attention to the human dimension;
- that development has to be effective in the human dimension to achieve sustainability, but prevailing conventional wisdom and the mental programming of most development planners and practitioners which derive from traditional education systems currently prevent wide success in that dimension;
- that the imbalance between the three dimensions through "reprogramming" of those involved in the sector can be corrected;

- that there is a need to focus on the root cause of the problem which lies in the reductionism of traditional educational systems, and in agricultural education especially.

Byond the agricultural sector there are other essentials, but missing, ingredients of sustainable development on which the sustainability of agricultural development depends. These include particularly the extent to which development approaches deriving from the technical sectors now in place are unable to deal with the whole spectrum of adult learning needed for development. The addition of the organizational structures, expertise and resources needed to achieve this whole spectrum of adult learning offers new opportunities for investment and for success in development. But it calls for a move toward holistic systems approaches and away from the reductionist thinking styles which have dominated development assistance to date.

363 89-5/30

Agroecology
Review, sustainability, definition, development, environmental management, ecology, sociology, economy, energy, global concept, indicators, policy making
BROWN, B.J. et al.
Global sustainability: toward definition.

Environmental Management, 11, No. 6, 1987, pp. 713-719

Sustainability is clearly becoming a popular word in the environmental policy and research arena. "Sustainable development","sustained use of the biosphere," and "ecological sustainability" are terms increasingly used by institutions and individuals concerned with the relationships between humans and the global environment.

In recent years, much attention of the scientific and policy-making community has become focused on global sustainability. For example, the Man and the Biosphere Program of UNESCO is concerned with integrated approaches to global natural resources management, particularly in and around designated biosphere reserves.

Sustainability is raidly becoming one of those transcendent terms, like "appropriate technology" or "environmental quality," which are cornerstones of environmental policy and research, but difficult to measure and rarely defined explicitly.

In this article, the concept of sustainability is examine, some of the ways in which it has been defined, and the use of the terms sustainable, sustained, and sustainability in the global context are clarified.

There are obviously many ways of defining sustainability. The common themes that emerge include:

- The continued support of human life on earth
- Long-term maintenance of the stock of biological resources and the productivity of agricultural systems
- Stable human populations
- Limited growth economies

- An emphasis on small-scale and self-reliance
- Continued quality in the environment and ecosystems.

If one accepts an anthropocentric view of sustainability, with the focus being on indefinite and global sustainability, then there is a range of ways in which to construct a definition from the essential elements.

In the narrowest-sense, global sustainability means the indefinite survival of the human species across all regions of the world.

A broader sense of the meaning specifies that virtually all humans, once born, live to adulthood and that their lives have quality beyond mere biological survival.

The broadest sense of global sustainability includes the persistence of all components of the biosphere, even those with no apparent benefit to humanity.

The emphasis in agriculture is gradually shifting from a goal of maximizing production in the short term to a perspective that also considers long-term maintenance (that is, sustainability) of production.

Sustainable agriculture must conserve the land resource base without degradation and must be economically viable and socially acceptable as well. Recent volumes on sustainable agriculture discuss the importance of soil and water conservation, genetic diversity, and appropriate technologies in insuring a continued supply of food, a reasonable quality of rural life, and a healthy environment.

The meaning of the term is strongly dependent on the context in which it is applied and on whether its use is based on a social , economic, or ecological perspective. Sustainability may be defined broadly or narrowly, but a useful definition must specify explicitly the context as well as the temporal and spatial scales being considered.

Setting the priorities for sustaining or being sustained, and at what costs, is a process that can only be accomplished within the context of a clearly stated definition of sustainability. Deciding what actions and policies should be taken to achieve sustainability can only be accomplished with appropriate measures and indicators of sustainability.

364 89-5/31

Agroecology
Review, environment, agriculture practices, pre-industrial impact, shifting cultivation, permanent agriculture, hunters, gatherers, pastoralism
SIMMONS, J.G.
The environmental impact of pre-industrial agriculture.

Outlook on Agriculture, 17, No. 3, 1988, pp. 90-95

The growing impact of changing agricultural practices on the environment is a matter of general concern, but it is generally supposed to date largely from the introduction of machinery and agrochemicals. In fact, the impact was substantial long before this, and can be tracted back to hunter-gatherers like the Australian aborigines who, without actively cultivating the land nevertheless deliberately controlled their local environment - as by burning or simple water management - in order to conserve the wild life on which they depended.

The purpose of this paper is to give an idea about some of the ways in which agriculturalists changed the maps of their regions even in the days before they had access to the products of industrialisation.

The paper deals, therefore, with the period between the emergence of the first plant and animal domesticated in the 9th-7th millennia BC and about 1890 AD when the products of the iron- and chemical-based industrial revolution began to affect farming practice in a way which has undoubted environmental significance. The terminal date is also arbitrary in the sense that the agriculture of many Third World countries today has not experienced the full impact of industrialization, so that process is incomplete. But to demarcate any period of history is to acknowledge that one cannot entirely sever it from what went before and what comes after, and so one needs to sandwich the main theme with some account of the predecessors of pre-industrial farmers as well as with a few remarks concerning perspective now afforded by about 150 years of the industrialised way of life.

365 89-5/32

Agroecology
Discussion, developing countries, ecological agriculture, environmental problems, calamity approach, conservation strategy, agriculture strategy, small-scale farmer

GERRITS, R.

Environmental problems and the role of ecological agriculture in the Third World.

In: Global Perspectives on Agroecology and Sustainable Agricultural Systems, Proc. of the Sixth Int. Sc. Conf. of the IFOAM, Ed. Patricia Allen and D. van Dusen; The Agroecology Program, Univ. of California, Santa Cruz, CA 95064; 1988, pp. 153-158

This paper discusses the concept of ecological agriculture within the Third World as a means to overcome some of the adverse effects brought about by increased use of Green Revolution techniques. Major environmental problems associated with agriculture are described as well as some global alternatives suggested by the World Conservation Strategy and the World Commission on Environment and Development.

Today the world faces environmental problems that are both serious and complex. Generally stated, these include:
- Soil erosion.
- Air/water/land pollution.
- Loss of genetic resources.
- Deforestation.

- Desertification.
- Population.

Until now the principal way of dealing with global environmental issues has been the so-called "calamity approach." That is, whenever a global ecological problem reaches the level at which calamities occur, politicians tend to do the minimum necessary to avoid growth of the problem, be it a short-term solution or long-term containment. Military defense and economic growth are the top priorities, while global environmental issues still have a low priority within most governments.

Unique ecosystems are being destroyed - quickly and thoroughly. Due to the delayed "development" of the Third World and its high genetic diversity, ecosystems destruction is today worse in the Third World than in the First World. There is more to destroy, the Third World still has the better part of the world's genetic diversity scattered over countless unique ecosystems, while the First World has already lost most of its own ecological heritage. In slowing and stopping this destruction, ecological agriculture clearly has a role to play as a sound environmental-management counterstrategy to the Green Revolution.

Ecological agriculture can be a sound strategy for solving the ecological problems of increased pesticide use, population growth, erosion, deforestation, and desertification. With ecological agriculture, chemical pesticide use is minimized or avoided completely; biological and integrated plant protection is utilized. Mulching and composting are necessary since they add to the organic content of the soil. Humus is an essential factor for soil fertility with positive effects on soil structure, air, water, nutrient interactions, and soil health. Together with multicropping, biological nitrogen fixation, agroforestry and combinations of animal husbandry and crop farming, ecological agriculture is also a form of erosion control.

Ecologically oriented agriculture aims at establishing high and lasting soil productivity, thereby conserving or re-establishing a well balanced ecological environment to enable the future existence of humanity within sound ecological systems.

Most promotion of ecological agriculture in developing countries will need to take place at a grassroots level with the help of local and foreign nongovernmental organizations. The principal target group will be Third World men and women, small-scale farmers who produce food for their own consumption or for local markets.

366 89 - 5/33

Agroecology
Review, book, developing countries, GTZ, ILEIA, AGRECOL, ecofarming, agricultural development, technical cooperation, techniques, principles, traditional practices, participatory research and development, training, sustainability, low-external-input
KOTSCHI, J. et al.
Ecofarming in agricultural development.

Verlag J. Markgraf, Mühlstr. 9,P.O.B. 105, D-6992 Weikersheim, F.R.G. and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, F.R.G.; ISBN 3-8236-1163-1, 1989, 131 pp.

"Ecofarming in agricultural development" contributes to the discussion of the principles and methods of sustainable agricultural development, and its importance for the development of smallholder agriculture in the tropics.
The book contains a definition of ecofarming (sustainable agriculture with low levels of external inputs), and an outline of the major ecofarming techniques from the point of view of formal agricultural science, the major results of a GTZ survey of ecofarming development activities, and a commentary on the state-of-the-art of ecofarming development within technical cooperation. The book takes a close look at indigenous agricultural knowledge and ecofarming practices in the tropics, and the possibilities of collaboration between local farmers and agricultural scientists in developing site-appropriate techniques of sustainable agriculture. This leads on to a consideration of the implications of this approach for project and advisory work, professional training, research emphases, and the planning and organization of technical cooperation.
In detail the book deals with the following aspects:
1. Why "ecofarming"?
   - What is ecofarming?
   - Why is the promotion of ecofarming necessary?
2. Ecofarming in Technical Cooperation
   - Major techniques and principles of ecofarming
     Vegetation design: multiple cropping and agroforestry
     Use of biological symbionts
     Green manuring
     Mulching
     Composting
     Integrated plant protection
     Integration of livestock
     Integration od aquaculture
   - Current research activities and development approach
     Ecofarming research activities
     Prevailing approach to ecofarming development

3. An underutilized resource: Indigenous ecofarming knowledge
   - Indigenous ecofarming practices
     Vegetation design and manipulation
     Soil fertility enhancement
     Crop-livestock integration
     Plant protection
   - Indigenous experimentation
4. Toward scientist-farmer cooperation in ecofarming development
   - Participatory research and development
     Situation analysis
     Innovation design, testing and evaluation
     Spreading the ideas
   - The challenge for Technical Cooperation
     Form and content of project and advisory work
     Training of professionals in agricultural development
     Priorities in terms of regions and activities
     Planning and organization of Technical Cooperation
5. References

Annex 1: GTZ survey of ecofarming activities in Technical Cooperation
Annex 2: List of contact addresses
Annex 3: List of relevant GTZ projects

The authors welcome reports from additional individuals, groups and institutions involved in ecofarming research and development, to permit more detailed and up-to-date documentation of activities and wider dissemination of information between interested parties. Furthermore it is hoped that this volume will stimulate further thought and discussion among development workers in the field as well as in the head offices of Technical Cooperation agencies.
Numerous development institutes and concerned individuals provided information and ideas for this study; most of them are mentioned in the address list or references.

367 89 - 5/34

Agroecology
Review, compendium, subhumid zones, arid zones, sustainability, erosion control, water management, pastoralism, integrated systems, agroforestry, extension, training, participatory approach
ARRIGNON, J.
Agro-écologie des zone arides et sub-humides.
(Agro-ecology of arid and sub-humid zones).

Maison neuve et Larose - ACCT, 1987, 283 pp., available ACCT, 13 Quai André Citroën, 75015 Paris, France

This work is a compendium of short notes, taken by the author during 30 years work as a tropical agronomist. It doesn't claim to be exhaustive nor to be a pedagogic book; its wealth is elsewhere: it gives the reader the experience of a "field man" hints tricks, facts in numbers, sketches etc. And that all about a subject, which is more spoken of, than precisely referred to.

Following attentively the author's plan, one learns that agro-ecology concerns many fields such as: erosion control, water management, pastoralism, integrated production, agroforestry and other technologies. The logic is not always evident, and the reader is obliged to consider many cross-references through the chapters.
The "spirit" of the book is: more ecological management in arid and sub-humid zones. The compendium closes with 2 methodological chapters considering problems of sensibilization, popularization, formation, participation of the population and external intervention.
Abstract from Agricultures actualité

368

89 - 5/35

Agroecology
Review, humid tropics, case studies, economic development, agricultural projects, applied ecology, agroecological approach, research needs, integrated agroecosystems, weed management, sustainability
GLIESSMAN, S.R.
The role of applied acology and agroecology in the design of agricultural projects for the humid tropics.

Paper from the Workshop "Application of Ecology to Enhancing Economic Development in the Humid Tropics"; 38th AIBS-Annual Meeting, Ohio State University, Columbus, 1987, 29 pp.

The term sustainability has become the topic of considerable discussion and concern among a broad spectrum of people involved in the multiple components of the production, processing and distribution of food, feed, and fiber around the globe.
This is especially true for those people working in agriculture in the humid tropics.
A focus on managing agricultural resources in the tropics needs to be developed that both reduces the dependence on costly, non-renewable inputs, and ameliorates the impacts that current practices are having on the environment. By applying an ecological element to the design and management of agricultural projects, as well as developing an analytical model that allows for the incorporation of longer-term aspects of sustainability, prospects for the future of agriculture in the tropics can be greatly improved.
Agroecology is the application of ecological concepts and principles to the design and management of sustainable agricultural systems. It has as a goal the development of agroecosystems that depend on low external-inputs, function more on the use of locally available and renewable resources, have benign impacts on the environment, and are built upon the knowledge and culture of the local inhabitants of the region. The agroecosystem is the basic unit of analysis of any particular production system, and to a certain extent, can be analyzed using systems methodology common in most economic analysis.

In detail the following aspects are discussed in this paper:
- Agroecological approach
- Agroecological research focus: case studies
- Integrated agroecosystems
- Agroecological approach to weed management
- Future research needs

In the final chapter "future research needs", the author states that an agroecological focus on tropical agriculture goes much beyond crop yields, delving deeply into the complex set of factors that make up the agroecosystem. Local, indigenous agroecosystems that have evolved under the diverse and often limiting conditions of the tropical environment, are adapted to this set of factors. They have evolved through time as low external-input systems, with a greater reliance on renewable resources and on ecological-based management strategies. A research focus in agriculture that can take advantage of this knowledge and experience permits to explore the multiple bases upon which sustainability rests. It represents the blending of knowledge gained by ecologists studying the dynamics and stability of natural tropical ecosystems with the knowledge of farmers and agronomists on how to manage the complexities of food producing agroecosystems. From this can become the sustainability in the production base so critical for the long-term cropping of farmlands in the tropics. Therefore, it becomes critical that one has found ways to combine the short-term demand that economic models place on agricultural development with the need to project the long-term ecological models of sustainability generations into the future. This can only be done by demonstrating the absolute need to link ecological knowledge with long-term economic viability and environmental quality.

369

89 - 5/36

Agroecology
Review, book, Africa, Sub-Sahara, food production technology, nutrition, women's role, agriculture, labour use, support systems, food policy, development strategies, assistance strategies
MELLOR, J.W. et al.
Accelerating food production in sub-Saharan Africa.

The Johns Hopkins University Press, 701 West 40th Street, Baltimore, Maryland 21211; published for the Int. Food Policy Res. Institute, ISBN 0-8018-3390-6, 1987, 343 +xvii pp.

Sub-Saharan Africa is an enormous region comprising 39 countries with a combined area of more than 22 million square kilometers. It represents nearly three-quarters of the African continent and about 15 percent of the land mass of the entire world. The population in mid-1979 numbered about 344 million, slightly more than three-quarters of the total for all of Africa and 8 percent of the global total.
The climates in these regions range from tropical rain forest to arid desert. The question arises as to whether agriculture can in fact reasonably be expected to fulfill its required role.

This book provides up-to-date definitions of the food and nutrition problems that face us now and in the medium-term future. The book also deals with the policy needs for promoting growth of food production.
The book examines food policy in the context of national development strategies.
Several chapters in this volume, written by representatives from both sub-Saharan Africa and donor countries and agencies, analyze past experiences and suggest aid strategies for accelerating agricultural growth in oll part of the world. Several stress the point that the aid most urgently required is that which would assist our region in greater utilization of its agricultural base in order to increase overall production and lessen dependence on food aid.
The papers provide a wide-ranging, up-to-date, and varied approach to key issues, which reflect the diverse physical, cultural, economic, and political environment of Africa.
Perhaps the most telling message of the book is the urgent need for immediate action.

370 89 - 5/37

Agroecology
Europe, France, regions, study, marketing structures, biological agriculture
GRÉGOIRE, M.C. and ROCQ, S.
Quel développement pour l'agriculture biologique?
(Biological agriculture and its development?).

Nature et Progrès, 1988, 54 pp., available at: Nature et Progrès, Service Librairie, 142 rue de la Gravière, F-30460 Lasalle, France

This a thorough study of marketing structures in biological agriculture in three regions: Rhône-Alpes, Franche-Comté et Provence-Alpes-Côte d'Azur.
The biological agriculture has often preferred short circuits (direct sales) to long ones (markets dependent from transport = expedition marketing); the study begins with this statement, gives reasons and motivations for this fact.
Since few years, marketing structures arise in the investigated regions, some disappear or are transformed, other develop and become slowly professional.
What are the hindrance to a real development of the "expedition market" of biological products? Be it cereals, fruits or vegetables which have to be transported, the producer/wholesaler should concentrate exclusively on organizing themselves to plan the production and the sales. The main problem is thereby the quantity and regularity in production; another problem arises from a certain incapacity to offer a satisfactory range of products to the wholesaler, i.e. to the potential consumer.
Furthermore, other obstacles are: the lack of technical knowledge (in tree cultivation for example, where the schedules of conditions are sometimes too constraining); the insufficient

results in research (varieties not adapted to the market, lack of information about bio-pesticides), which all slow down the professional penetration of the market.
On the whole, the authors note that most of the problems could be solved, if the farms were better organized.
At the end of the study, it is striking to understand that the development of the biological agriculture is closely bound to an increasing exchange of technical and economical information and to better market commodities. But this development depends also on a change of mentality for a better integration of these new concepts into the methods and structures of conventional agriculture.
Abstract from Agricultures actualité

371 89 - 5/38

Agroecology
Review, book, developing countries, case studies, Pakistan, Peru, Sudan, humid tropics, arid and semi-arid zones, mountain zones, rural development, ecological resources, preservation, DSE, BMZ, GTZ, RF
KLENNERT, K.
Rural 'development and preservation of natural resources: challenge: or contradiction?

Report of a Conference of the German Foundation for International Development (DSE), 1983, 124 pp.

In view of the decline in food availability per capita and the rapid increase in (imported) food requirements in the developing countries, the need for an increase in food production in these countries is so massive that it would even exceed the growth rates achieved in the 1960s and 1970s. At the same time, natural resources are being placed under such strain that the objective of ensuring food production levels in the countries of the Third World, which are least adequate in terms of quantity and quality, can be achieved only by means of a major effort on the part of both researchers and those engaged in the field.
This report on an international seminar organized by the Food and Agriculture Development Centre of the German Foundation for International Development on the subject of "Rural Development and Careful Utilization of Resources" looks at case studies from Pakistan, Peru and Sudan. The report examines the specific conditions in various regions and production systems of these countries, but its results should also be applicable to neighbouring countries with similar ecological and socio-economic structures.
The basic assumption underlying the Conference was that rural development should be accorded highest priority in all future development efforts, this in the interest of ensuring that the development process as a whole should remain well balanced.

The most important development objectives in this connection are the following:
- improving food and energy supplies by means of an increase in agricultural and forestry production and adjustment of the production structures;
- securing from such measures the greatest possible employment and income effects for the broad mass of the populations;
- long-term protection of natural resources.

The task at hand was to develop strategies which would give due consideration to this entire package of objectives. Since the individual objectives are interdependent in the long term, overly pronounced emphasis of one of them would ultimately prevent a self-sustaining development process. Of extraordinary importance in this connection was an analysis of the reciprocal dependencies between natural, technical and social factors in their significance with respect to goal attainment.

372

89 - 5/39

Agroecology
Review, book, developing countries, development, international cooperation, microprojects, NGO's, accountability, improverishment, pragmatic approaches, economics, sociology, Club of Rome
VILLON, A.F.
The barefoot revolution.

Intermediate Technology Publications, 9 King Street, London WCZE 8 HW, UK, ISBN 0-946688-19-2, 1988, 245 pp.

A new pattern of development is taking shape at community and village level in rural areas of the Third World. In a spirit of self-reliance, numerous "grassroots" groups have decided to take charge of their own development in rural villages throughout Latin America, Africa, and Asia.

This book is based on the results of surveys of 93 small-scale development projects carried out by six teams of researchers in nineteen countries of Latin America, Africa, and Asia from September 1983 to January 1985. Each team was made up of two professionals, one from the social sciences - sociologist, anthropologist, historian - the other an economist, agronomist, or experienced development field-worker. Each team spent an average of a week to ten days at the project site, interviewing its participants, beneficiaries, NGO workers, villagers, officials, religious leaders, local organizations. The teams also sought out people in neighbouring villages and areas to determine the local impact of the project and how it was perceived by outsiders.

The field surveys were followed up by a documentary study of a further 227 small-scale projects primarily supported by organizations in the developed world. Appendix I outlines the methodology of the entire project.

In detail the book contains the following chapters:

PART ONE
- Twenty years of misguided development
- Microprojects - a new world-wide development
- Development of the Third World - a continual concern of the Club of Rome

PART TWO
- First aid, then development
- Factors of impoverishment

PART THREE
- Factors of development
- NGOs: a new world phenomenon
- NGOs in the field
- The significance of NGO activity around the world
- Accountability

PART FOUR
- Can NGOs limit the factors of impoverishment?
- Can NGOs create factors of development?
- Obstacles and limits to NGO action

PART FIVE
- Economic and social achievements
- A new approach to development

Conclusion
Appendix I: Methodology of the study
Appendix II: List of projects visited
Appendix III: The Club of Rome

The purpose, was to identify and measure the impact of small-scale operations on the severe problems affecting rural areas in the Third World.

In order to ensure lasting social and economic progress, the communities had to achieve a certain degree of self-reliance and regain the initiative, choice, and responsibility for their own development. The ultimate aim of the study was to determine whether small rural development projects really offer a valid development alternative for the Third World.

The importance and urgency of the so called "barefoot revolution" require from governments, international institutions, and non-governmental organizations new thinking and novel approaches, closer co-operation and greater responsiveness to the growing expectations of rural communities. Failing such a response, the quiet revolution might very well grow more radical and fall prey to the temptations of violence.

NGOs are beginning to emerge as a significant force for development.

373 89 - 5/40

Agroecology
Review, sustainability, policy, natural resources, institutions, World Bank
HOPPER, W.D.
Sustainability, policies, natural resources and institutions.

Proc. of the Seventh Agricult. Sect. Symposium on Sustainability Issues in Agricultural Development, Eds. T.J. Davis and I.A. Schirmer; The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A.; ISBN 0-8213-0909-9, 1987, pp. 5-16

The author of this paper is focussing on the term sustainability and tries to forge a tie between it and a core definition of social and cultural institutions.
After a definition of the term sustainability, the paper is dealing with agricultural projects in the context of the core issues of development change.
Based on practical examples the implication of sustainability, natural resources and institutions are discussed.
Finally the paper is closing on the question of sustainability by referring to South Asia's green revolution story.
In laying the groundwork for massive change in agricultural practices there was a firm assumption that farmers would adopt new techniques if they were profitable and if the required behavior was in conformity with the cultural traditions of village society. For the diffusion of the high yielding crop varieties, these assumptions proved valid. More difficult was the organization of farmer cooperation. The competitive structure of village kinship groupings has made and will continue to make farmer cooperation a difficult social innovation. Health practices, changes in social organization, legal system reforms, etc., will be much more difficult to engineer without significant and continuous pressure on the structure of traditional social and cultural values and institutions. Obviously if project execution is faulty due to poor management even those activities that do mesh with the basic cultural framework of the society will have little impact and even less duration. And if the economic, social or administrative infrastructure of support for the project and its several components is not in place, the likelihood of later finding much of a residual of the project vision will be very small indeed. Education, training and an understanding of how cultures evolve, how practices within a culture, within a society interact and evolve and alter are keys to the sustainability of the endeavours we seek to initiate and nourish to completion.

374 89 - 5/41

Agroecology
Review, sustainable development, IIED, water resources, land resources, planning, management, pesticide losses, nutrient losses, soil erosion, integrated approach, partnership
PRETTY, J.N.
Planning and management for water and land resources: partnerships for sustainable development.

Paper from Development Interregional Seminar on Water Quality Management in Developing Countries; International Institute for Environment and Development - Sustainable Agriculture Programme -; 1989, 27 pp.

This paper summarises the impact of agricultural activity on natural resources and, in particular, on the water environment.
For most of its history agriculture has been environmentally benign. Crop residues were incorporated into the soil or fed to livestock, and manures returned to the land in amounts that could be absorbed and utilised. This kind of traditional mixed farming system was closed and sustainable, generating few external impacts and using few external resources.
But this has changed over recent years. Increasing pressures for food production growth to feed expanding populations have resulted in the production and distribution of externalities, and consequent costs, that affect both the human and natural environment. These increased social costs principally arise from the intensification of land use, often involving the use and overuse of fertilisers and pesticides.
The impact of agriculture activity on natural resources and in particular on the water environment can be widespread and severe, though not always due to agriculture alone. Given a continued need for growth in food production, the evidence indicates a likely increase in contamination for the future years.
This contamination constitutes a widespread social cost. It also threatens the sustainability of natural resources and compromises the ability of future generations to meet their needs. Quite clearly approaches must be found that will enable a satisfactory resolution of this key trade off between production and sustainability. These include approaches for integrating pest management, nutrient conservation and soil and water conservation. But the challenge still remains to extend such integrated approaches to farmers and rural people themselves. Greatest advances are currently being made where rural people are involved in the process of planning and management in a partnership with research scientists, developers and extension workers. Only through joint analysis will these conflicts over development goals be avoided, and natural resources sustained to meet the needs of future generations.
In detail the paper deals with the following aspects:
- Impact of nutrient losses from fertilisers and livestock manures
- Impact of pesticide losses on water resources
- Soil erosion

- Future trends in contamination
- Conflicting development goals
- Integrated approaches to management
- Partnership in planning

Management of agricultural and natural resources must resolve the conflicts between production goals and those relating to equity and sustainability. This can only be achieved by extending finetuned and integrated approaches to farmers which, if they are to be adopted in sufficient numbers to make a significant impact, must be planned in partnership with the rural people themselves.

375 89 - 5/42

Agroecology
Review, tropics, ecosystems, Africa, Rwanda, GTZ, ecofarming, ecology, sustainability, shifting cultivation, ecological intensification, diversity, site specific compatibility, stability, integrated approach, low-external-input agriculture
EGGER, K.
Ecofarming in the tropics.

IFOAM, 6, 1988, pp. 3-6

In the industrialized nations, ecofarming has developed in opposition to extreme intensification. Fertilizers and pesticides contaminate the food of human beings and animals, endanger the environment and lead to overproduction. In the developing countries of the tropical area, ecofarming is based on a "lack". It is the soil exhaustion along with an intensive exploitation that destroys the ecological basis and creates insufficient provision, and even hunger. Thus, an intensification is still useful, but: Certain criteria are therefore necessary regarding an ecofarming in the tropics ensuring sustainance and variety with little help from outside (sustainability - diversity - low external input).
In this paper the author refers to the following aspects:
- Shifting cultivation
- The Green-revolution-strategy
- Ecological consequences
- Autochthonous "Ecofarming"
- Permanent agroforestry
- Organic farming
- Intercropping, relay cropping
- Intensive fallow
- Goals of ecofarming
- Stability
- Diversity
- Site specific ecosystems
- Stability
- Diversity
- Site specific compatibility
- Ecofarming in Rwanda - the concept of ecological intensification
- Integration of trees = Agroforestry

- Integration of animals
- Intensive bush fallow/green manuring/compost
- Water retention, hedgeline, terracing/-complex
- Intercropping, rotation
- Modern technical inputs (tools, fertilizer, pesticides)
- Extension and transfer of ecofarming

The paper concludes that an internationally spread network of centres, where ecofarming is practised and shown, should be aimed. The great research centres cannot play this role - they are conceptionally dominated by other interests. It should be an alternative network. This is an important task for IFOAM, to publicize the underlying beginnings, to report about them and to stimulate the exchange of experiences between them. The centres have to be distributed in such a way that they cover the most important climatic zones and can be reached easily.
The GTZ-project in Nyabisindu/Rwanda played the role of such a centre, but it can only do that in the future, if the GTZ continues to carry on the concept.
At present, the research and development centre IPIASP in Mugusa/Rwanda, which is financed by the Land of Baden-Württemberg and by private partnerships, is prepared to admit persons interested in ecofarming. A lot of groups carried by NGOs make use of this offer.

376 89 - 5/43

Agroecology
Africa, Nigeria, study, NGO, pioneer project, results, illiteracy, motivation, sociology, integrated approach
AKOMOLAFE OLATUNJI
The limits of ecological agriculture in Nigeria.

IFOAM, 8, 1989, pp. 7-8

The various research projects carried out by the Village Pioneer Project (VPP), Ajue, Nigeria, are discussed in this paper. The VPP observations of the factors hindering ecological awareness are mentioned.
All ecologists agree that ecological awareness is a product of general awareness. The farmers and people in Nigeria are probably only as ecologically aware as they are scientifically and economically aware.
Advancement of technology and innovation have been failing in Nigeria because of the conservative attitude of the people. Most people are traditionally fixed to a particular way of doing things and would hardly accept any ecological improvement, no matter how well this may be intended.
The most difficult but important aspect of ecological agriculture is integrated agriculture, that is, the combination of animal and crop production.
The integration is as yet very limited in Nigeria, where the animals are roaming about without a specifically controlled confinement. The research in the Village Pioneer Project, Ajue in

Ondo-State of Nigeria confirmed: "That while the production of pigs, rabbits, and poultry makes mixed-farming possible for the small farmers, the goat production requires a very large area of farmland, which the farmers with small plot holdings cannot afford". Research further confirmed that the mere integration of plants and animals would not wholly solve the problems of ecological agriculture without an integral knowledge of the utilization of all possible local resources.
It is understood that Nigeria poisons itself continuously by its ignorance, in spite of the knowledge the scientists acquired, which is of no practical use for Nigeria. The new eco-tactics now developed by the ecologically advanced countries would not produce any effect in Nigeria if the Nigerians are to remain stagnant in the understanding of the essence of ecological awareness required in protecting their environments. The government of Nigeria cannot achieve any tangible development in her agricultural programmes if sufficient encouragements are not given to the eco-farmers in order for them to be able to expand their productions.
The ecological balance which the Village Pioneer Project anticipates would not be restricted to teachers and educationalists but would also include religious leaders in their places of worship. Nigeria would then reserve much more time for eco-campaigns than preaching in the parks. The effectiveness of the above mentioned solutions would depend on an integral education from the smallest school of thought, the kindergarten, to the highest institute of learning.

Village Pioneer Project
c/o Revd. Bishop Goonigi,
P.O. Box 1622, Akure,
Nigeria.

Information integrated agriculture can be obtained from Village Pioneer Project in Nigeria. The VPP is fully prepared to enter into partnership whit any person or the organisations on the road to improve agro-allied training and ecological self-sufficiency.

377 89 - 5/44

Agroecology
Review, book, report, Africa, natural resources, sustainable development, human environment, agriculture, food, climate, soil, water, forest, wildlife, pasture, livestock, fishery, genetic resources, environmental problems, erosion, soil degradation, deforestation, desertification, land utilization, pollution problems
FAO
Natural resources and the human environment for food and agriculture in Africa.
FAO Environment and Energy Paper No.6, ISBN 92-5-102354-9, 83pp.

The productive capacity of most of Africa's natural resources for food and agricultural production depends on delicate physical and biological balances that are not yet fully understood. Man's capability of disturbing these balances has vastly increased.

Whenever a resource is used beyond its productive capacity, it is degraded and depleted, often beyond the possibility of recovery, for many generations to come.
The report surveys the state of the principal natural resources for food and agricultural production in Africa, and some of the more critical problems that have arisen from man's growing demands on these resources. The greater part of the report consists of an overview of present knowledge of the extent, state and potential of natural resources for food and agricultural production (including fisheries and forestry) in Africa, and of related environmental issues. It includes a brief account of the mineral resources for fertilizer production. A main conclusion of the survey concerns the need for a better database and for its use for the regular assessment and monitoring of the use and the state of natural resources for food and agricultural production in Africa. A further conclusion is that, while Africa as a whole appears to be endowed with natural resources that are abundant enough to feed a greatly expanded population, these resources are very unevenly distributed. This applies especially to the quantity and quality of soil and water resources, to agroclimatic suitability, and to forest and marine fishery resources. Most of the action that is needed, both for the proper management of natural resources and for the prevention of pollution, must be at the national level. In some cases, such as the management of watersheds, river basins and fish stocks crossing international boundaries, as well as the conservation of some genetic resources, intergovernmental cooperation is also necessary.
The final part of the report attempts to draw some preliminary general conclusions on the state of the natural resources for food and agricultural production in Africa, and on some of the requirements for their better assessment and management.
As far as possible, the report covers the whole of the developing continent of Africa (i.e. excluding South Africa). In some cases, however, information is only available on a limited basis. Since Africa is a very diverse continent, different sub-regional groupings are used where appropriate.

378 89 - 5/45

Agroecology
Discussion, low external-input agriculture, community ecology, species interaction, nonrenewable sources, intercropping, polyculture systems, pest, diseases, cover crops, environment changes
GLIESSMAN, S.R.
Species interactions and community ecology in low external-input agriculture.

American J. of Alternative Agriculture, <u>II</u>, No. 4, 1987, pp. 160

External production inputs have contributed greatly to the remarkable increases in crop yields achieved during the past several decades. These inputs take many forms, including

fertilizers, pesticides, irrigation water, various soil amendments, machinery and labour. Most of these inputs have been developed to both stimulate farm system output as well as replace materials that have been removed with the harvest. Limited concern has been given to the long-term availability of these inputs as long as farming produced a net profit. Relatively little attention was paid to understanding the biological and ecological bases of interactions occuring within the cropping system as long as such interactions were not considered detrimental to yields. But today agriculture is confronted with the need to assess the long-term sustainability of its production practices. It must consider the availability and cost of inputs and the impacts of conventional practices on the environment, food safety, and the quality of life for the people involved in food production and consumption. In essence it is now as or more important to understand agroecosystems processes that promote productivity in the short term and sustain it over the long term than it is to concentrate on how much is produced.
Agricultural productivity is being examined through the study of such ecosystem characteristics as biotic interactions in species mixtures, nutrient cycling mechanisms, habitat management for pest and disease population regulation, multi-trophic level species dynamics, and application of recent developments in mutualism and competition theory. Establishing an ecological basis for low external-input agriculture builds upon the ability to capitalize on knowledge gained from the study of species interactions at the level of the crop community.
Polyculture systems can be managed for nutrient cycling efficiency and pest and disease regulation using knowledge of multi-trophic level interactions and application of recent developments in mutualism and competition theory. A mechanistic model of additive and removal reactions on the environment is proposed as a means of studying species interactions.
The agroecosystem can be examined as a complex set of species assemblages with many levels of organization that build upon the basic understanding of the ecology of interactions at the individual organism level, emerging at the ecosystem level to understand the dynamics of what makes the entire system function. This is especially important as the understanding of ecosystem level processes of sustainable agriculture then interface with yet more complex aspects of the social and economic systems within which agroecosystems function. Eventually such an integration of social system and ecological system knowledge about agricultural processes will not only lead to a reduction in external inputs used for maintaining productivity, but will also permit the evaluation of such emergent qualities of agroecosystems on long-term environmental quality, the importance of the human element to production, the long-term effects of different farm input/output strategies, and the relationship between economic and ecological components of sustainable agroecosystem management.
It is time to redirect a large portion of the resources that have generated all of the knowledge about single-species cropping systems towards the integration of both ecological and agronomic knowledge, with a broader goal of developing the ability to

quantify the ultimate emergent quality of the agroecosystem - its sustainability. This is an extremely complex process, requiring a systems-level approah and the interaction of many disciplines, but with the outcome of being able to understand where and how effective change in agriculture can come about.

379 89 - 5/46

Agroecology
Review, Europe, France, F.R.G., Holland, Asia, Japan, EEC, biological agriculture, producers, products, cooperation groups
GHESQUI`ERE PH., D.P.
L'agriculture biologique à l'étranger.
(Biological agriculture abroad).

Nature et Progrès, 105, 1988, pp. 11-23

This document illustrates the meaning of biological agriculture in Europen and in Japan.
As introduction, a summary of a EEC study gives the essential points of reference: description of different producers' groups and their development, a list of the products concerned, label types and other important items.
Two more in depth studies follow concerning the situation both in Holland and W. Germany, two countries where production and networks are well structured. Which lessons can be drawn from these countries? First that Holland has more satisfactory results than France and the record of a very efficient marketing organisation in W. Germany, promoting the development of biological production. Two other countries are also briefly mentioned: Italy and Japan, where the notion of "biological" label does not exist, as the very active cooperation producer/consumer is based on selfcontrol and selfhelp.
On the whole, an excellent introduction to "bio" in Europe which should also contribute to the preparation of what will be the agreement of the EEC in 1992. For more detailed informations, contact FNAB, 9 rue Cels, F-75014 Paris, which will send following documents for each country: "Bilan des connaissances... (Statement about the actual stand of knowledge and implementations of biological agriculture as well as the interest results for community agriculture).
Abstract Agricultures actualité

380 89 - 5/47

Agroecology
Review, book, holistic agriculture, scientific approach, soil, cultivation, fertilizer, pest and diseases, rotation, crops, grassland management, seed, animal husbandry, yield, profitability, food quality, energy utilization, pollution, labour usage
WIDDOWSON, R.W.
Towards holistic agriculture: a scientific approach.

Pergamon Press, Headington Hill Hall, Oxford, OX3 OBW, UK, IBSN 0-08-034211-6, Hardcover, 1987, 194 pp. US$ 22,95

This book explains the use of an ecological way of farming, with modern practical applications, to make the fullest use of land resources and the best utilization of available capital and labour. In analyzing the vital relationship between soil, plant, animal and man, the author discusses the best care of land itself, its components, grassland management and the most efficient use of crops to maximize yield, food quality and profitability without the extensive use of chemicals and without damaging the ecology. Widdowson also covers the holistic approach to animal farming, the welfare and health of poultry, cattle, sheep and goats, their nutritional needs through the various stages of their lives, and the best way to balance their diets.
For all those interested in organic farming and its implications for modern agricultural practices.
Author's abstract

381 89 - 5/48

Agroecology
Review, register, working paper, book, Europe, Germany, Switzerland, sustainable agriculture, technical cooperation, developing countries rural development, DGA, Helvetas, GTZ
HOESLE, U. and OPITZ, M.
Sustainable agriculture in German and Swiss Technical Cooperation.

GTZ Working Papers for Rural Development No. 15, 1989; available at Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ), Departm. 4210, Eschborn, Postf. 5180, 6236 Eschborn 1, FRG

Practical questions, which come up so often in talks with field staff has led to the compilation of the third edition of a register of projects working in the field of sustainable agriculture.
The register itself cannot of course provide an answer to these questions, and neither is it intended to. It aims to assist and improve the inter-project exchange of concrete experience gained and information available on the topic "sustainable agriculture".

The questionaire for this third edition met with a good response, as did those sent out for the first and second editions of the register.
The first edition, published in 1986 listed 67 projects. By the time the second edition went to print, this number had already rocketed to 102, while this third edition covers an impressive total of 117 projects and features various other improvements over the previous editions.
This edition includes projects run by the Swiss organisations DGA and Helvetas for the first time. This expansion can only further a wide-scale exchange among experts. There exists the intention to include other appropriate institutions in future editions.
The register will in future be published in English, to enable the counterparts to work with it without difficulty.
The principal part of the register comprises the project descriptions, divided into countries. At the top of each description one finds the project address, details about the counterpart organisation, term of the project and the status enjoyed by sustainable agricultural within the agricultural policy of the partner country. To give a better overview of the location topographical and climatological data along with the geographic information are included. This is followed by a brief description of the target group.
After the project description the key words used to characterise project activities are indicated, arranged firstly by topic, and then the most important ones also alphabetically. To find the projects which particularly interest more rapidly one can find the fourdigit code allocated to the project in the key word list.
The following system to classify topographic and pedological characteristics and the status of project activities are used:
(1) shows that there is primarily one type of country or soil quality or one priority activity
(2) shows that a certain topographic or pedological characteristic can also be found or that a certain activity is also carried out, but that it is not the primary land form/activity
(0) no details available.
Where there are no data on specific aspects of a project the spaces are kept blanc pertaining to this data.
This third edition carries forward the tradition of the two previous works of giving contact addresses and the names of contact persons working in the field of sustainable agriculture at GTZ head office and outside.
Although the register has been expanded it does not claim to be an exhaustive overview of the activities of each of the projects included, nor does it give a detailed description of the location of the individual projects.
The authors would like to use thie opportunity to ask all to continue to help update and improve this work.
Author's summary, amended

Agroecology
Review, developing countries, ACP-States, ISNAR, DSE, CTA, Africa, Caribbean, Pacific Islands Lomé Conventions, sustainability, physical factors, climate, soil, research implications, organizational aspects, agricultural policy, agricultural cooperation

TREITZ, W. and T.M. NARAIN

Conservation and management of the environment and natural resources in developing countries - policy implications for ACP States.

In: Proc. of a ISNAR/DSE/CTA-Seminar/Workshop on Res. Policy Implications for Nat. Agric. Res. Systems - "The changing dynamics of global agriculture" -, Eds. E. Javier and U. Renborg, Feldafing, F.R.G., 1988, pp. 137-150

The authors of this paper point out that definitions of sustainability in standard reference books are inadequate. Only in specific recent publications is the problem of sustainability dealt with more comprehensively with a more precise definition.
The Brundtland report explained sustainability:
Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
TAC's definition is that:
Sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources.
The concern about sustainability is that during the last decades considerable changes have taken place. Most developing countries have experienced a rapid population increase. As a result, the pressure on the land has increased at a rate never before known. Millions of hectares of tropical forests have been cleared for food production, in most cases without consideration for ecologically sound agricultural practises after deforestation. The results are frightening: land degradation, erosion, silting of rivers and lakes, to name only a few. The stocking rate of animal populations has been augmented at a rate which in many countries exceeds the carrying capacity of the land. Shifting cultivation, which does not allow the soil to recover after its exploitation, is taking place at an ever-increasing rate due to land shortages.
On a global basis, the most serious problem during the next century will be to feed people without destroying the natural resources. In other words, to implement systems of sustained agriculture.
The physical factors of the ACP-States (Africa, Caribbean, Pacific) related to the term sustainability are discussed in this paper.
From the experiences of 20-25 years of international agricultural research the authors draw some general principles for research priorities:

More attention to special situations. International agriculture must give more attention to regions with special constraints due to extreme climatic conditions, poor soils, weak infrastructure, and high population pressure, which among other problems, leads to indiscriminate forest clearing for food production, followed by desertification.
Food crops. Food crops other than wheat and rice also improving the soil should be given higher priority. Improved cultivars of cassava, cowpeas, and potatoes are already available, but need to be introduced more widely through national agricultural research systems (NARS). Research on other crops that improve the soil is being conducted, but these activities should be intensified. Research on other traditional crops should also be pursued.
Soil research. Research on soil conservation, maintenance, and improved soil fertility has to be strengthened, even at the cost of crop research. The development of appropriate agricultural technologies to be used after forest clearing is of the highest priority, and land-use patterns for agroforestry have to be developed.
Fertilizers. Optimal utilization of manures and inorganic fertilizers is of great significance both for sustainable agricultural systems as well as for meeting the needs of small farmers and regions with special constraints.
Trypanosomiasis research. Research on this livestock disease is required for sustainable agricultural production systems, especially to introduce animal traction in specific regions of Africa.
Water use. Optimal water utilization for both irrigated and rainfed agriculture is an important factor for sustainable agriculture, and needs a higher priority from both IARCs and NARS.
Breeding for resistance. In view of the damage to the environment caused by pesticides, as well as their high cost, breeding for resistance should be given more attention, even to the detriment of yield. Conservation of plant and animal genetic resources is fundamental for sustained agricultural production.
On-farm research. Socioeconomic and on-farm research of farming systems or technologies, especially for ACP countries, is required for studies of sustainability.

The authors refer then to organizational aspects for research and state that research aiming for sustainable agriculture is complex and difficult because it must be location specific.
This considerations has implications for the future organization of international agricultural research. Because of the more complex and location-specific problems, IARCs may have to relocate more research from the centres to different locations.
Furthermore, much more research will be needed where the farmer is not an object of research, but rather an active participant. If farmers are actively involved in research projects for sustained agriculture, expensive experiments without much probability for success can be avoided.
With respect to the agricultural policies the authors point out that in order to achieve sustainability, priorities have to be set for national laws and regulations, as well as in agreements, or

even treaties, drawn up for regional and international cooperation. There are a number of activities that can be launched without serious budget implications, but other activities require a reallocation of funds from less important projects to programmes of sustained agriculture. In donor-funded programmes, sustainability should be given the highest priority. Developing countries should be assisted, especially in areas, such as conservation of plant and animal genetic resources, that serve the international community as a whole.
Questions of dissemination of scientific and technical information for sustainability are discussed in which CTA is playing a leading role.
Finally the Lomé Convention with respect to sustainability is mentioned.
Concluding the authors point out that the development of sustainability in agriculture is essential for two reasons:
- to allow the necessary increase of food production to feed a rapidly growing population;
- to protect and develop the productive potential of soils, water, and genetic resources;

Research for such harmonious development should be an on-going process and must be location-specific. NARS have to play a more central role in such a venture. Networking of research and the dissemination of its findings through scientific and technical information are becoming more and more important in the development of sustainable agricultural systems.

383 89 - 5/50

Agroecology
Review, Latin America, Chile, Mexico, Bolivia, alternative agricultural systems, small farmers, sustainability, developing countries, ecological basis, traditional systems, rural development, agroecological approaches, peasant assistance programs, recommendations
ALTIERI, M.A. and M.K. ANDERSON
An ecological basis for the development of alternative agricultural systems for small farmers in the Third World.

IFOAM, 3, 1988, pp. 3-8

Promotion of a large scale agriculture based on uniform crop varieties and farming techniques has largely ignored the heterogeneity, both environmental and socioeconomic, that characterizes small farming systems. Consequently, agricultural development has not been matched with the needs and potentials of local peasants.
As a result, the development and extension of appropriate technology for peasants is being re-examined and it is slowly becoming recognized that technologies developed for small farmers in developing countries must fit the socioeconomic and agroecological features of small farming systems.

Examples of sustainable traditional farming systems are discussed:
- Paddy rice culture
- Shifting cultivation
- Raised field agriculture

In Latin America, several assistance programs for peasants are directed at meeting their subsistence needs. The general approach is to take existing peasant production systems and to use modern agricultural science to improve their productivity, progressively and carefully. The programs have a definite ecological orientation and rely on resource-conserving and yield-sustaining production technologies. They emphasize an ecological engineering approach in which the various components of agroecosystems including crops, trees, soils, and animals interact in a way that enhances use of internal resources, recycling of nutrients and organic matter, and trophic relationships among plants, insects, pathogens and weeds that foster biological control. Three levels of interactions are discussed in this paper:
- Temporal interactions at the cropping system level
- Spatial interactions at the cropping system level
- Farming systems interactions

Positive peasant assistance programs in Latin America are described.
In summary, the few examples of grassroots, bottom-up rural development programs described here suggest that development and diffusion of appropriate technologies for peasants must meet four criteria: that it be based on a knowledge of peasant needs as they are perceived by peasants; that it uses autochthonous technologies; that it be a village-based effort with the active participation of peasants; and that it emphasizes local and indigenous resources.

384 89 - 5/51

Agroecology
Review, alternative agriculture, sustainability, scientific approach, grassroot approach, data processing method, participative method, social science, natural science, image-building approach, emphasis on growth, system imbalance, rethinking growth
VAN MANSVELT, J.D.
Basic concepts of alternative agriculture.

In: Proc. of the Sixth Int. Sc. Conf. of the IFOAM, Eds. P Allen and D. van Dusen; Univ. of California, Santa Cruz, USA, 1988, pp. 135-145

The theoretical and the practical approaches to agriculture are based upon an overemphasis on a particle-interaction concept. To balance this abstract modeling trend in agriculture, in this paper a concrete imaging approach will be proposed, illustrated, and discussed.
Studying agriculture on any level relies on "pictures" of crops, fields, cattle, farms, countrysides, etc. These pictures are

partly based on observation (perception) and partly on theoretical modeling (conception). Over time, the interaction of perceptive and conceptive activities brings about an image (in researchers as well as in practitioners) of agriculture in which the two are strongly interwoven. Because they are so deeply embeded in our concept of agriculture, these images or pictures tend to be taken for granted, even if contradictory experiences accumulate.
The author summarizes the contents of the paper with images and ecological agriculture. Emphasis on direct observation of the full range of authentic agroecosystem phenomena can serve as a methodological tool to:
- restore and enlarge the essential contact between the observer (farmer, researcher) and the observed, which has been narrowed or even broken by reduction and abstraction;
- extend the corresponding concepts and images of the observed subjects toward a deeper and more whole understanding;
- adjust the gauging marks for appropriate quality judgements, serving the joint health of consumers, producers, and their common environment;
- complement necessary analytical and reductionist steps with a frame of reference appropriate to an understanding of the object's full, long-term significance for the subject and vice versa.
Images of agriculture structure the attitudes and actions of farmers, researchers, consumers, and politicians. In a general sense we all share the notion that we each function within and are responsible for a holistic, globally connected environment. Yet the conceptual bits and pieces we have abstracted and reduced from our agricultural reality often appear to be incoherent and certainly not congruent with a more generalized, holistic conception of reality. Without a conscious, explicit revision of the images of reality held by those participating in agriculture, discussions of what is evident, necessary, desirable, healthy, or even economically sound in agriculture will be unproductive. These images must be adjusted toward holism if ecologically sound agriculture is ever to become as normative as conventional agriculture is today.
Author's summary

385

89 - 5/52

Agroecology
Review, Africa, savannah soils, agroecology, soil fertility, soil management, practices, development projects, low-external input, minimal fertilization
PIERI, CH.
Fertilité des terres de savanes. (Fertility of savannah soils).

CIRAD-IRAT, Service des éditions, BP 5035, F-34082 Montpellier Cedex 1, France, 1989, 448 pp.

The crucial question arising in the Westafrican agriculture is: how to suppress fallows and increase yields to meet with demographic growth without causing soil degradation? Soil studies carried out since 30 years show systematically that the higher the population density, the better soil fertility is preserved. In the contrary, where migrants start exploiting "new soils" (with low population density), they practice an extensive agriculture favourising erosion and soil impoverishment.
Among the "classical" methods of soil-fertility management, a certain number of them appear to be unsuitable for African Savannah zones. So for example the "artificialised" agricultural management.
The mineral fertilization would be the most efficient solution - at least for short term - to prevent the African soils' degradation, if the costs for the fertilizers wouldn't be out of reach for the farmers. So after all, it is the organic fertilization, propagated through advisors of many countries, which seems to be best adapted to spread rapidly. Last not least, two low-cost solutions deserve to be rehabilitated or propagated: on the one hand the use of trees in agriculture, which have a very positive effect on the undercrops, particularly if they are leguminous trees; on the other hand the development of appropriate crop rotations. This last method, so important in practical agriculture, has been often "forgotten".
Nearly 30 years of research results on soil fertility in Westafrica and its management have been quoted and analysed here. This work is of great value, because it is objective and describes successes and failures of development projects carried out by French experts since decades in this region.

386

89 -5/53

Agroecology
Review, sustainability, natural resources management, developing countries, rangelands, semi-arid areas, desertification, soil erosion, upland areas, tropical forests, biological diversity, institution building, policy opportunities, World Bank, World Resources Institute
REPETTO, R.
Managing natural resources for sustainability.

In: Proc. of the Seventh Agric. Sector Symp. - Sustainability Issues in Agricultural Development -, Eds. T.J. Davis and A. Schirmer; The World Bank, Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 167-179

After an introduction the paper deals with the following aspects:
- Deterioration of natural resource assets in Third World countries
- Rangelands and semi-arid areas: desertification
- Watershed and upland areas: soil erosion
- Irrigated lands: waterlogging and salinization
- Depletion of tropical forests and biological diversity
- Atmospheric concerns

- Strengthening natural resource management
- Institutional strengthening
- Policy opportunities

The paper concludes that the broader policy question of sustainability is whether the framework of agricultural incentives, taken as a whole, does not bias the evolution and adoption of farming systems. The author refers to the widespread direct and indirect subsidization of fertilizers, pesticides, water, machinery, and credit - and the equally widespread implicit taxes on farm production. Impositions on agricultural output reduce the benefits of investment in soil conservation and land improvement. Subsidies reduce the costs of external inputs to the farm, including fertilizers to restore soil fertility, and heavily discriminate against alternative agricultural systems that rely on nutrient recycling, inter-species population balancing, and labour inputs for sustained productivity. Even in the United States and other industrial countries where purchased inputs are relatively cheap, farms using alternative "regenerative" technologies are close to commercial viability, and would probably be competitive were the external costs of chemical run-off and soil erosion internalized into farm production costs. In the Third World, the World Bank has helped to develop and demonstrate alternative farming systems involving multiple cropping and integrated animal, tree, and crop production that are capable of sustained high productivity with fewer external inputs. However, even if such an alternative approach were more productive and sustainable over the long run, will it emerge in the face of the overwhelming policy-induced bias in incentive against it?

As natural resources are increasingly stressed by the pressures of growing demands, it would be surprising if mismanaging them could be good economics. Generally, it is not. Numerous government policies not only fail to reflect the true opportunity cost of resource use, they perversely encourage more rapid and extensive degradation of soils, water, and biota than market forces alone would. Many current policies - subsidies, fiscal incentives, and market interventions - artificially increase the profitability of activities that result in serious resource deterioration. Changing these policies would often raise current welfare by reducing economic distortions, and also reduce long-term environmental damage. Typically, these changes would also reduce fiscal burdens on government and eliminate important sources of inequity within the economy as well.

Eliminating these perverse incentives has large payoffs. They are important issues for policy dialogue with borrowing countries, and for policy-based lending. Like other policy changes that reallocate resources significantly, they arouse political opposition from interests that have captured the benefits of existing arrangements.

387 89 - 5/54

Agroecology
Review, book, agroecology, food production, ecofarming
KICKUTH, R.
Die ökologische Landwirtschaft. (Ecological agriculture).

Alternative Konzepte 40, 3. Auflage, Karlsruhe, ISBN 3-7880-9746-9, 1987, 207 pp.

The book tries to give a scientific answer to numerous questions being more and more important not only for the agricultural producer but also for the consumer. One can find fundamental ideas referring to the complex of subjects as agriculture and ecology, economy, toxicology as well as biological cropping and world food programme with particular details of: ecological-biological and energetic farm analysis, soil biological questions, behaviour research in the productive livestock farming, consequences of the large-scale livestock farming and realization of the eco-cultivation in the tropics.

Three practice reports - one of them about a farm successfully running for 58 years in a biological-dynamical way - are proving that eco-farming is reality. Well known experts give concrete evidence based on research work. Practicable experiences give an account of realistic possibilities and prospects of an ecological orientated food production.

In the annex one can find characteristic features of eco-farming, important addresses in Germany, Austria and Switzerland as well as valuable references of literature.

388 89 -5/55

Agroecology
Review, paper, sustained agricultural development, institutional requirements
RUTTAN, V.W.
Institutional requirements for sustained agricultural development.

In: Proc. of the Seventh Agric. Sector Symp.: Sustainability Issues in Agricultural Development; Eds. P.J. Davis and I.A. Schirmer, The World Bank, Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 57-74

In this paper the author elaborates a theory of institutional innovation in which shifts in the demand for institutional change are induced by changes in relative resource endowments and by technical change. There discusses the seemingly contradictory export promotion and import substitution policies followed with respect to industry and agriculture in East Asia to illustrate the effect of changing resource endowments and changes in the economic environment are discussed. Then the author turns to a review of the efforts by the World Bank and other members of the donor community to build institutions to sustain agricultural development in Pakistan. In a final section an attempt is made to see if one can draw any lessons from the theory and the experience. Finally, a more inclusive framework within which the attempt to understand the process of institutional innovation is suggested.

389 89 - 5/56

Agroecology
Review, humid tropics, ecology, soils, population, diseases, work capacity, climate, development model, sustained growth, land-use-ecological constraints
WALLER, P.P.
The ecological handicap of the tropics.

Intereconomics, 19, 1984, pp. 137-142

The three main ecological handicaps of the humid tropics are infertile soils, which may only sustain a system of shifting cultivation and low population densities, high incidence of human and animal disease, and lower work capacity because of daily and seasonal high temperatures. Economists have tended to assume that these could be overcome by modern technology and have tended to neglect the very high capital investment which agricultural development under those conditions involves. The traditional development model, sustained increase of work output in agriculture and transfer of agricultural surplus to develop other sectors, does not work under these conditions, especially with an increasing scarcity of land. In many such countries rural areas must be net receivers of capital if they are to have any hope of survival. The opposite policy, which has been followed particularly by some African countries, has led them into an economic crisis threatening their basis of existence. Appropriate forms of land use (shifting cultivation with adequate fallow periods, irrigated rice cultivation, some tree crops, agro-forestry) in different areas should produce small surpluses and meet subsistence needs of the rural population. It is important to realize that the ecological handicap of the tropics constitutes a complex and substantial development threshold which it will not be easy to surpass.
Abstract from CAB

390 89 - 5/57

Agroecology
Review, agricultural sustainability, development programmes, projects, rural development, USAID
BLAKE, R.O.
Sustainability in agricultural development programmes: The approach of USAID.

Gatekeeper Series No. SA 15, Int. Inst. for Environment and Development (IIED) - Sust. Agric. Programme - ; Endsleigh Street, London, WC1H ODD, UK, 1989, 15 pp.

This paper is a summary of recent testimony by the Chairman of the Committee on Agricultural Sustainability to the House Committee on Foreign Affairs, Washington, March 1989.
Recently great progress has been made in the United States over collaboration between leading environmental organisations, private voluntary organisations, research and academic groups and individual scientists and experts on the topic of agricultural sustainability for developing countries.
There are two critical reasons why AID should help developing countries achieve sustainability in their agricultural development. First, sustainability is a powerful political paradigm. Secondly, AID's having to apply the test of sustainability adds an element of very desirable rigor to both initial and continuing evaluations of AID's agricultural (and other) programmes and projects.
Agricultural sustainability does not depend only on environmental sustainability. Sustainability cannot be achieved in agriculture or any other area except by also assuring economic, political, sociological, and institutional sustainability. If concerned groups tend to emphasize the environmental and ecological facets of this problem, it is because these aspects have too often not been given enough attention by development agencies including AID.

The paper concludes with some prescriptive measures for the 1990s:
The central purpose of development assistance should be to promote environmentally sustainable broad-based economic growth. Efforts must be focused on a small number of key objectives, one of which must be sustainable agricultural development. New legislation should place primary emphasis on helping farmers (and governments) make this transition to sustainable agricultural systems. AID's efforts in this regard should also encompass better management of sustaining non-agricultural natural systems (forests, watersheds and water resources, for example) as well as associated energy systems.
The highest value should be placed on AID's continuing support to developing countries'family planning programmes, upon which the ultimate success of all that we advocate depends.
In working towards agricultural sustainability the greatest emphasis should be placed on developing human resources at all levels of agricultural effort, on training and motivating people who can help energize the small farmer, as well as the researcher

in agronomy and the government planner. Development assistance organisations should make special use of the developed countries' comparative advantage in science and technology through the expansion of collaborative and cooperative relationships in agriculture, including efforts that involve people from the advanced developing and newly industrialized countries. In addition these agencies should be countinuing strong support for the international agriculture research centres.
In all these efforts strong reliance should be placed on utilizing the talents represented by US universities and scientific institutions. Ways must be found to recreate and sustain the links between US universities and agricultural experts which were so strong and mutually beneficial in 50's and 60's but which are now eroding.
On another level, continuing efforts to strengthen the position of the small farmer and the landless and to reinforce equity within farming communities should be sought. Combating rural poverty is essential to environmentally sound rural development. The United States must remain the strong advocate of "bottom up" agricultural development.
Slimmed down US economic assistance should, with a few exceptions where major US financial leverage will continue to exist, continue to play only a supporting role in global programmes of structural adjustment. Finance should be restricted to only relatively small agricultural infra-structural programmes.
Finally giving aid-giving organizations more flexibility in the use of funds, but only within congressionally established guidelines, would ensure a focused, balanced approach which will provide continuity of purpose and programme.

VI AGROMETEOROLOGY

391 89 - 6/8

Agrometeorology
Review, book, Africa, drought, hunger, development, cooperation, climatology, economy, politics, food, self-sufficiency, sociology
GLANTZ, M.H.
Drought and hunger in Africa: Denying famine a future.

Cambridge Univ. Press., Cambridge, UK, ISBN 0-521-32679-6, hardcover, £ 37.50/USD 49.50, 1987, 457 pp.

This is an interesting book, and many of the contributions raise serious issues on the African development process as a whole for which there are no simple answers. It is primarily an American perspective on the African problem.
In this foreword, Bradford Morse, the former Administrator of the United Nations Development Programme, points out that drought itself is not the fundamental problem in sub-Saharan Africa since drought prevails in many parts of the world, and when properly managed need not be more than a nuisance. Drought in Africa has triggered a crisis of development, since the efforts underway have been badly disrupted. Morse acknowledges that much of the development assistance provided for sub-Saharan Africa in the past has not produced the anticipated results, a main reason for which is the inadequate consideration and understanding of agro-climatic conditions and socio-cultural frameworks of the African countries.
The book is divided into four parts. Part 1 deals with physical and social setting, and contains four papers. The main emphasis in this section is on climatological aspects of drought, which is very well covered. It would have been helpful to the readers if corresponding emphasis could have been placed on water resources and land-use aspects as they related to drought and agricultural production. Much of this part provides a general review of the works of various climatologists and some selected development specialists. The paper on some aspects of meteorological drought in Ethiopia is the only paper in the book by a scientists from Africa.
The second part, consisting of four papers, examines the internal-external perspectives. Among the subjects covered are the decline of African agriculture, internal factors that affect famine, political economy of the crisis, and economic externalities and the persistence of destitution and famine. Together these four papers attempt to review the multitude of external and internal factors that could transform food production shortfalls into famine. Two broad schools of thought on the causes and potential remedies for Africa's agricultural crises are identified internalists and externalists. Internalists argue that the basic reasons for the crisis can be found by the constraints imposed by the policies pursued by the recent governments, a point that was also alluded to by Morse earlier. Externalists believe that the

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VI AGROMETEOROLOGY

391 89 - 6/8

Agrometeorology
Review, book, Africa, drought, hunger, development, cooperation, climatology, economy, politics, food, self-sufficiency, sociology
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main reason is the international economic environment which adversely affects the economies of the individual countries.
The third part, which is on case studies, constitutes nearly half of the book. The seven papers in this part discuss various problems from different parts of Africa. Among the subjects discussed are the following impact of drought, environment and food security on peasants, pastoralists and "commoditization" in dryland West Africa; drought, food and social organization of small farmers in Zimbabwe; social impact of drought in Ethiopia; Kenyan experience on the role of government in combating food shortages; social impacts of planned settlement in Burkina Faso; evolution of food rationing systems with reference to African group farms in the context of drought; the role of non-government organizations in famine relief and prevention.
The final part deals with the lessons for the future. Liebenow discusses the reasons not only for Malawi's food self-sufficienca but also its ability to export substantial quantities of agricultural products to its neighbours suffering from food shortages. Two chapters deal with famine relief policies in India and China and their potential transfer to Africa. The reviewers, however, will point out that in depth analyses indicate that many of the policies and agricultural technologies that have succeeded in India, when transferred to Africa, have proved either to be marginally successful or failures due to a variety of socio-economic, institutional and technical reasons. South-south transfer of policies and technologies appear to be more difficult than many of its proponents believe.
Understanding the complexities of drought and associated hunger in Africa is a difficult process under the best of circumstances. The problem is further complicated by the fact that physical, social, economic, institutional and political systems often vary from one country to another, and thus what may be an acceptable solution in one part may not be appropriate for another. Overall, the book is a useful contribution to the ongoing debate on the African crisis.
Abstract by M.R.BISWAS and A.K. BISWAS, UK

392 89 - 6/9

Agrometeorology
Africa, Ghana, humid tropics, lowland, review, agrometeorology, plant protection, farmers, rainfall, temperature, humidity, solar radiation, sunshine duration, wind speed, soil temperatures
USSHER, A.K.E.
Agrometeorological Activities for Plant Protection.

In: Proc. of the Seminar on: Agrometeorology and crop protection in the lowland humid and sub-humid tropics, Cotonou, Benin, 1987, pp. 229-230

In Ghana a monthly Agrometeorological Bulletin containing agrometeorological data and their departure from long term average values is published and disseminated to the authorities at the Ministry of Agriculture and other related agencies for their

information and action in formulating plant protection advice for farmers and agencies engaged in agriculture. Listed data include rainfall, temperatures, humidity, solar radiation and sunshine duration, wind speed and direction, and soil and earth temperatures.
Excessively high temperatures have been known to be detrimental to young crops especially in absence of adequate moisture. Therefore, occasions of temperatures above 30°C in the screen are reported immediately to the agricultural authorities. Shading is recommended for the months of February and March if planting is done, since highest temperatures occur during these months.
Bright sunshine hours range from a minimum of about 2.5 hours in August to about 10 hours in November/December with radiation levels ranging from about 280 cals/cm² /day in August to about 570 cal/cm² /day in February/March. This latter period coincides with the beginning of the rainy season in the southern parts of the country. Tender grain crops are usually adversely affected by the intense heat especially when the rains are late or initial amounts are rather low. This situation is taken into consideration when determining the onset of the rainy season so as to minimise crop losses and the need for replanting.
The early rains are associated with high winds leading to battering and flattening of plaintain and banana plants as well as young grain plants. The meteorological service therefore gives warnings of approaching squall lines on the radio.
Heavy rains damage tender crops by either breaking the stems or eroding whole planted areas. Intensity-duration data have therefore been prepared and are supplied to agriculturists on request to enable them select viable areas for farming activities.
For irrigation, evaporation data from Penman's method are available.
Winds associated with squall lines usually cause damage to plants especially plantain, banana, corn, millet, and sorghum. by battering and flattening, as mentioned earlier. Data on highest wind gusts have been compiled. The construction of wind breaks have been suggested to the agricultural authorities, as a means of reducing damage. Spraying of cocoa are carried out in months of low wind speeds and in the mornings or evenings mainly.
Warnings of the risk of bushfires are given in the news media when excessively low humidities prevail, especially in the dry season.
A study to attempt to forecast drought years is in progress. Monthly rainfall data are being analysed to augment studies on annual rainfall data.
Plant protection activities require agrometeorological information on:
- Onset of crop pests and diseases
- Air pollution
- Agroclimatological surveys
- Crop production and yield relationships with meteorological information

All these data give an idea of the agrometeorological activities recorded in Ghana.

393 89 - 6/10

Agrometeorology
Africa, Nigeria, case study, smallholder, cropping systems, agricultural production, rainfall, solar radiation, relative humidity
NWEKE, F.I.
Weather Constraints on the Smallholder Cropping System of Southeastern Nigeria: A Case study of Two Villages in Anambra State.

Agricultural Meteorology, 23, 1981, pp. 309-315

In Enugu in southeastern Nigeria there are two climate seasons, the dry season from November to April and the rainy season from May to October which is interrupted by a drier spell in July-August. In the rainy season, the rainfall is adequate for most crops grown in the area. However, the rainy season is associated with high humidity and low solar radiation with the consequence that available moisture at this period is not used to the best advantage by farm crops. In the dry season, humidity is low and solar radiation relatively high, but it is so dry that most crops would not grow without irrigation water. Moreover, the timing of the rainy season with respect to the beginning and end of the rains, as well as the timing of the drought, is irregular.
A random sample of 20 farmers was selected in two villages from a list of 205 compiled on request by the agricultural extension officer in Ogboji, and also from a list of 151 compiled on request by the village chief in Ndubia. Information on available farm land and cropping practices was obtained from the sample farmers.
The above analysis suggests that although aggregate annual rainfall could be adequate for food crop production in southeastern Nigeria, irregularities in timing of the rainfall, and in month-to-month distributions of rainfall, relative humidity and solar radiation, are in fact limitations on food crop production expansion and that the use of supplementary irrigation water to grow food grains in the dry season would enhance food crop production in the area. However, experience in some tropical African countries, such as Ghana, has shown that investment in irrigation development could have high costs and low returns, partly because of high overheads and partly because the change from rain-fed farming to irrigation farming takes time to accomplish. It may be possible to achieve the same objective at a lower cost by investment in research in the development of short duration foodgrain varieties which can be planted in August or September to grow when the humidity is not too high or solar radiation too low.
Still another alternative, especially for maize, is the development of drying facilities. Before the Nigerian Civil War centralized grain silos for drying and storing maize were being erected in various locations for farmers throughout the former Eastern Region (most of southeastern Nigeria) with the assistance of the United States Agency for International Development. Since the War no attempt has been made to re-introduce them. At present, however, the International Institute of Tropical Agriculture, Ibadan, is working on a small and simple drying and storage facility which could be purchased by a small farmer. It is possible that such a facility coupled with an available market for maize would encourage the smallholders to grow maize. This in turn could encourage them to use and possible employ mechnaical equipment in maize production.

394 89 - 6/11

Agrometeorology
USA, study, climate, management practices, crop water requirements, soybean, sandy soil, model, evaporation, transpiration
JAGTAP, S.S. and J.W. JONES
Stability of crop coefficients under different climate and irrigation management practices.

Irrig. Sci., 10, 1989, pp 231-244

In many parts of the world where water holding capacity of the soil is low and precipitation is inadequate during the growing season, irrigation is practised to avoid drought-caused yield losses. A critical problem in irrigation is to determine just when, how, and how much water to apply. Irrigation scheduling using evapotranspiration (ET) estimated from climatic data is appealing because this approach is relatively simple compared to on-site measurements. One such approach makes use of crop coefficients to relate actual ET of a disease free crop grown in a large field adequately supplied with water to a reference crop.
Using principles of heat and mass balance, a comprehensive evapotranspiration model was developed. This model referred to as the Jagtap model, predicts water use, soil evaporation, transpiration, and microclimate of a well irrigated developing crop where the soil may go through cycles of wetting and drying.
The specific objectives of this paper were to use the mechanistic model developed to:

- Determine the effects of variation in irrigation interval and climatic variables such as temperature, vapour pressure, radiation, and wind speed on water use and coefficients.
- Determine the effect of planting date, crop development rate, and length of the growing season on water use and coefficients for a soybean crop grown in sandy soil and actual weather data in humid Florida climate.
- Discuss corrective procedures when applying crop coefficients developed at one site under a given environment to other sites with different climate and agronomic conditions.

It was found that seasonal errors could be as high as 190 mm when crop coefficients developed under one set of conditions were used under different climate and management conditions. The largest error in ET occurred when vapour pressure was reduced from 26 mb to 14 mb; next in importance were site differences in wind speed, radiation, irrigation interval, temperature and planting date. Correction factors needed to adjust crop coefficients to those site specific conditions ranged from 0.73 to 1.30 depending on the time of season and climate or management variable that was changed. When the overall crop coefficient was divided into a plant specific and a soil specific coefficients, the plant coefficient was relatively stable compared to soil coefficients. The results of this study can help establish a practical range of conditions over which crop coefficients developed at one site can be used to compute the appropriate values for sites where measurements have not been made.

395 89 - 6/12

Agrometeorology
Africa, Nigeria, IITA, study, weather, insect population, sweet potato weevil, planting time, control strategy
LEMA, K.M.
Effects of Weather Conditions on Insect Populations with Particular Reference to the Sweet Potato Weevils (Cylas spp.) and Time of Planting as Control Strategy.

In: Proc. of the Seminar on Agrometeorology and crop Protection in the lowland humid and sub-humid tropics, Cotonou, Benin, 1987, pp. 223-227.

Empirical observations reveal that populations of the sweet potato weevils, Cylas spp., are affected by weather conditions in Africa. The weevils are the most destructive pests of sweet potato (*Ipomoea batata*) in the tropics. Losses of tubers generally range between 10% and 50% but losses of up to 90% have been reported.
Throughout Africa these insects are scarce in the rainy season but their populations rapidly build up to damaging levels during the dry season. In this paper direct and indirect effects of weather on insect populations are discussed with special reference to Cylas spp. and the manipulation of time of planting as a control strategy.
The annual averages of climatic components, temperature, humidity, rainfall, etc.,(or climate) do not affect insect populations but rather the day-to-day changes of the components (weather). Weather may affect directly insect populations.
The results confirm that early planting and early harvesting is effective against the sweet potato weevils. Sweet potato is a relatively short cycle crop (about four months). If planted early enough in the rainy season, the crop can be harvested before the weevil populations increase to damaging levels.
Unfavourable weather has an adverse impact that may determine a period of reduced activity or low populations for some insects. This weak point in the biology of such insects can be used as the basis for the manipulation of planting time recommended as control strategy. This strategy effectively controls Cylas spp.. However, this method alone may not be readily implemented by the farmers who generally grow a variety of crops. Sweet potatoes (where they

are not the main crop) are planted late in the rainy season after the main crop (yams, cassava, beans, etc.) has been planted. An integrated pest management program against the weevils may alleviate this problem. Such a program is being developed at IITA. It combines use of sweet potato lines with moderate resistance to the weevils, early planting and early harvesting and re-ridging (or earthing up the plants).

396 89 - 6/13

Agrometeorology
Review, book, technical note, humid tropics, monsoon climate, cold seasonal climate, land-use, management practice, recommendations
World Meteorological Organization (WMO)
Land-use and agrosystem management under severe climatic condition.

Techn. Note No. 184 of the World Met. Organization, Geneva, Switzerland, ISBN 92-63-10633-9, softcover, SwFr. 25 (surface mail), Sw Fr. 40 (airmail), 1986, 161 pp.

This technical note is the product of a working group established by the Commission for Agricultural Meteorology to study the interactions between changing climate and land-use and to make recommendations for improved management practice in areas of severe climate. The publication of this book is clearly most timely while there is considerable global awareness of climate-related crop failures and starvation in areas of marginal agriculture.
The book describes the macroclimate and agrosystems in a range of severe environments from regions which are hot and arid through to monsoon regions, the humid tropics and regions dominated by the cold seasonal climate. Five chapters describe the climatic envelopes of these particular regions, followed by a resumé of the range of agricultural practices in the particular climatic zone and generally ending with some recommendations for improving agricultural methods. Each selected macroclimate extends beyond national barriers and so it is most interesting to learn of the different agricultural techniques which are employed in different countries.
The first two chapters provide general introductory detail on the methods for describing and classifying climate. The methods which are employed in these chapters and throughout the book are strongly based on those developed by Köppen in 1931. The effectiveness of ten such systems of classification in predicting global vegetation from climatic factors is also assessed in Chapter 2. The smallest error of prediction for the major global biomas was 39% for the best system increasing to a worst case of 64%. Such a poor success in prediction must be a major concern when providing climatic classifications of areas which are suitable for a particular type of agriculture. In this respect it is surprising that there has been no attempt in this volume to apply more mechanistic models of evapotranspiration, such as the

Penman-Monteith equation, and to tie such models in with known physiological limits to survival, e.g. chilling and frost sensitivity. Agricultural research has, over the years, provided a large data set of such information for a wide range of crops and so limited data sets are not the primary obstacle.
The limitations of the models used in the chapters are noted in Chapter 6, by Molion, who notes when discussing some idealized models of energy transfer in ecosystems that "There is an urgent need to establish pilot projects with special emphasis on the energy and water balances and sediment transport rates, so that the sketches ... can be replaced by actual numbers".
This volume clearly indicates the problems of agriculture in areas of severe climate, however, there is a need for more work to quantify the interface of climate and agriculture.
Abstract by F.I. Woodward, UK

VII AGROFORESTRY

397 89 - 7/21

Agroforestry
Africa, Nigeria, humid zone, economic analysis, alley farming, small ruminants, models
SUMBERG, J.E. et al.
Economic analysis of alley farming with small ruminants.

ILCA Bulletin 28, 1987, 2-6

Several evaluations of the economics of alley cropping have been conducted. None of these analyses have considered livestock. While alley cropping was conceived primarily for crop production, it offers considerable potential for integrating crop and livestock production by supplying mulch for crops and high-quality fodder for animals.
In humid West Africa, sheep and goat production is generally a minor enterprise using few inputs. Production is limited by a viral disease.
However, realisation of the potential of small ruminants, following disease control, may eventually be constrained by feed resources.
Alley farming, which is the addition of animals to an alley cropping system, offers the opportunity to realise this potential by producing high-quality feed year round.
In this paper alley farming models are evaluated with small ruminants, based on field and experimental data from southwest Nigeria, and compare them with basic alley cropping and with fallow systems. The analysis is used to define key management areas within alley farming, as well as areas where further information is needed.
These models indicate that under conditions found in southwest Nigeria maize production with alley cropping is more profitable than with a 3-year fallow system. While alley cropping requires more labour than the fallow system, this is more than offset by the increased maize yields, and relative profitability of alley cropping is insensitive to changes in labour requirements.
The amount of tree foliages and the method of mulching affect alley cropping profitability. The models assume a low tree foliage yield of 3000 kg/ha/year based on difficulties of obtaining good tree stands in village conditions. Low foliage yields reflect farmers' hesitancy to plant densely to obtain high populations. Better methods of tree establishment (or better instructional methods) that assure good stands would therefore add to the overall attractiveness of alley cropping. Mulch incorporation, particularly if done at tillage or weeding times and thus not requiring additional labour, can increase the profitability of alley cropping.
With control of viral diseases particularly for goats, increases in net output of 20 to 30% per dam from 25% supplementary feeding are needed to make small ruminant feeding competitive with maize

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