101 88 - 4/22

Cropping systems
Africa, Europe, Asia, Congo, Turkey, F.R.Germany, field trials, cassava, legumes, cropping systems, intercropping, crop composition, N fertilization
KIMBENGA, A.
Artenwahl und Anbauverfahren im Mischfruchtanbau unter geographischen differenzierten Anbaubedingungen. (Species and cropping methods in intercropping under different geographical growing conditions (West Berlin, FRG; Bornova-Izmir and Samsun, Turkey; and Brazzaville, Congo).
Diss. TU Berlin, Fachbereich Internationale Agrarentwicklung, No. 183, 1987, 156 pp.

In these experiments the following aspects were looked into: crop composition of different species and varieties in crop mixtures, N fertilization, sowing period for legumes and spacing between different crop components in mixtures. A new method of intercropping was developed.
In all locations, the alternate row planting pattern was adopted. For special analysis in 1981, a strip planting pattern was used. The field experiments were conducted from 1980 to 1983 in West Berlin and in 1984 and 1985 in the Congo. In addition, experiments using the same planting material conducted in West Berlin (1979), in Bornova-Izmir (1980-1981) and in Samsun (1981) were analysed. It could be observed that the intercrop dry matter yields of specific intercrop combinations in specific locations were significantly higher than those of maize and legumes in sole crop stands. However, extreme weather conditions can have inverse effects on the yields.
Taking into consideration the high nutritive value of legumes and the necessity of planting them (legumes are usually less productive) the Land Equivalent Ratio (LER) was calculated for a more objective assessment of the intercropping system instead of taking only the dry matter yield into account. In general, this method gave better assessment in favor of intercropping systems.
The following recommendations based on these research findings can be given for the different locations:
For Germany, it could be advisable to practice intercropping on sloping areas to avoid soil erosion, because the soil remains covered for a longer time in the autumn (maize harvesting time). Appropriate legumes for the warmer areas are soya beans and dwarf beans (Phaseolus vulgaris), whereas for areas with bleak climate Lathyrus cicera and Phaseolus vulgaris are recommended.
For Turkey in areas with good water availability, intercropping is recommended to succeed cereals. Appropriate legume species are: climbing bean type of Phaseolus vulgaris, Vigna sinensis and soya beans (Glycine max.).
For the Congo with its tropical and humid type of climate, cassava is recommended as the main crop in an intercropping system. Legumes are recommended as intercropping partner because of their short period of vegetation. When maize is used as partner, at least 50 kg/ha N should be applied.

102 88 - 4/23

Cropping systems
Asia, Philippines, review, book, IRRI, rice, cropping systems
VERGARA, B.S.
A farmer's primer on growing rice.
IRRI, Los Baños, Philippines, 1987; Distributor for Europe: J. Margraf, Postf. 105, 6992 Weikersheim, FRG

Twenty-five editions of this rice-growing manual have been published in 22 languages in Asia, Africa and Latin America. Editions in at least 14 other languages are in preparation. The "Primer" may be the most widely-translated agricultural text in existence. The author, a plant physiologist from IRRI, conceived the "Primer" when he became aware of the lack of simply yet reliably written information to explain clearly the why and how of good rice growing practices. Vergara felt that farmers and rice production specialists needed a better understanding of the reasons for recommended practices such as seed incubation or proper depth of transplanting.
Vergara relies on illustrations with as few words as possible to convey the rice growing messages. This not only makes the key messages easier to understand, but also makes translation easier. IRRI provides sets of the illustrations, with the English text blocked off, to Third World agricultural agencies and publishers that want to publish local editions. IRRI does not ask for royalties or fees for translations of its books in the Third World.
Abstract from SPORE

103 88 - 4/24

Cropping systems
Review, book, IITA, IRRI, cowpea, riceland, cropping systems, cultivation methods
PANDEY, R.K.
A farmer's primer on growing cowpea on riceland.
IRRI, Philippines and IITA, Nigeria, 1987, 218 pp., ISBN 971-104-169-3; distributor for Europe: J. Margraf, Postf. 105, 6992 Weikersheim, FRG

Rice and rice-based cropping systems occupy a position of overwhelming importance in global food production. Legume crops such as cowpea fit well into these systems, helping to increase productivity by yielding more food from the same land area. Cowpea grown either before or after rice enriches the soil, helps to the pest and disease cycle that occurs in continuous rice cropping, and adds to farm income. Nutritionally, cowpea complements rice, adding protein to largely starchy subsistence diets. Grown for centuries in the tropics, cowpea is well adapted to prevailing environmental stresses. The crop tolerates drought and can grow on poor, even acid soils. Improved short- or medium-duration

varieties from IITA can be profitably fitted into a wide range of cropping systems as a food, fodder or green manure crop requiring minimum inputs.
This primer explains the "hows" and "whys" of cowpea culture to farmers, extension workers, students and technicians. The author relies mainly on illustrations with as few words as possible to transfer the cowpea growing message. This makes the book an excellent guide for the practice of cowpea growing. This handbook can be highly recommended for all interested in cowpea growing.
This primer is patterned after "A Farmer's Primer on Growing Rice" - which has been translated into more than 30 languages - and is similarly designed for easy translation and co-publication in developing countries. The English text has been blocked off from the line drawings. IRRI makes complementary sets of the illustrations available to cooperators, who may translate the text, strip the translations onto the illustrations and print a translated edition on local presses. The cowpea primer was made possible by a collaborative project sponsored by IRRI and IITA. A companion volume is "A Farmer's Primer on Growing Soybean on Riceland".

104 88 - 4/25

Cropping systems
Latin America, Brazil, cropping systems, intercropping, cereals, legumes
CORREA, H. et al.
Consorciacão e culturas intercalares. (Association and intercropping).
In: Empresa de Pesquisa Agrop. de Minas Gerais, Projeto mandioca: 76/79, Brazil, 1982, pp. 117-126

The association of cassava with soybean, maize, rice or peanut, with double rows of cassava, 0.50 m and 0.60 m between plants, and 2.0 m between the double rows (among which the other crops are planted), was studied at the experimental station of the Empresa Brasileira de Pesquisa Agropecuária of Minas Gerais, Felixlandia, Brazil. Cassava var. Riqueza was used in a randomized block design with 4 replications. Best results were obtained with cassava/beans or cassava/maize but production data were not obtained due to the severe attack of CBB in cassava. A similar experiment was conducted at Veragro; however, sorghum and the following fertilizer and liming treatments were included: an absolute check, and 3 treatments in which the application of NPK and Zn was maintained constant at 30-60-60-5 and lime was applied at 3 and 6 t/ha. Intercrops were affected by a period of drought and production was low. In general terms, intercropping affected cassava yield and the application of lime also reduced its production with 21 490, 22 370, 18 340, and 19 185 kg/ha, respectively, for monocropped cassava without fertilization and liming, monocropped cassava with fertilization and no liming, monocropped cassava with fertilization and 3 t lime/ha, and monocropped cassava with fertilization and 6 t lime/ha. Another associated cropping system was evaluated with cassava planted in strips spaced at 1.0 m between rows, 0.5 m

between plants and 5.0 m between cassava strips with 5 rows/strip. Other crops included sorghum, beans, maize, soybeans, crotolaria, and leucaena, the latter two being used as green manure. The number of plants of the associated crops was varied to determine the number of rows corresponding to the equilibrium point. Yields of cassava intercropped with beans were 8330, 8260 and 7660 kg/ha for bean planting densities of 6, 4 and 3 rows, respectively. Cassava yields when intercropped with maize were 7530, 8910 and 8560 kg/ha for 4, 3 and 2 rows of maize, respectively. Soybean production was favored by higher density without considerably affecting cassava yields (7700, 7780 and 8470 kg/ha for 6, 4 and 3 rows of soybean, resp.). At its highest density, sorghum gave optimum yield but significantly affected cassava (4240, 7259 and 7280 kg/ha for 6, 4 and 3 rows of sorghum, resp.). With crotolaria, cassava yields were 9900, 6970 and 9020 kg/ha for 6,4 and 3 rows, respectively. Rapidly growing plants tended to favor cassava production, creating a better environment for its growth provided that the planting density did not affect cassava.

105 88 - 4/26

Cropping systems
Asia, humid tropics, book, review, multiple cropping, crop diversification, intercropping, traditional technology, technological change, agricultural research, rice, maize, cowpeas, crop yield, statistics, bibliography
GOMEZ, A.A.. and GOMEZ, K.A.
Multiple cropping in the humid tropics of Asia.
IDRC, Ottawa; Publ. No. 176e, 248 pp., 1983, ISBN 0-88936-304-8, US$ 12.00

Multiple cropping, the practice of growing several crops on the same piece of land, is an ancient strategy for crop production among farmers in the tropics. Traditionally, it is used by subsistence farmers primarily to increase the diversity of their products and the stability of their annual output. With the rapid increase in farm population and the dwindling supply of new land for cultivation, multiple cropping is being looked upon as an excellent strategy for intensifying land use and for absorbing excess farm labor. In the rain-fed rice paddies, for example, with the use of fast-maturing varieties and management practices that lengthen the growing season, i.e. direct seeding and zero tillage, as many as three crops per year can be grown on a piece of land where formerly only one crop of rice was grown. In the upland areas, yield per ha can be increased 50% or more by intercropping, i.e. the planting of several crops simultaneously in the parcel of land.
With the intensification of land use through multiple cropping, the succession of crops is very rapid (i.e., the interval between harvesting of one crop and planting of another is short), and the management of one crop can significantly influence performance of succeeding crops. Thus, the traditional procedures for the genera-

tion and dissemination of technology, which concentrated on one crop at a time, may not be adaquate for multiple cropping.
What is required for the generation of multiple-cropping technologies is a procedure that is able to measure the interaction among crops grown on the same piece of land. For the dissemination of that technology, more motivation and guidance may be required by farmers before they accept multiple-cropping techniques that generally require more resources and management capability compared to monocropping.
This book is written in recognition of the potential of multiple cropping for increasing farm productivity in the humid tropics of Asia, and of the unique requirements, as well as the urgent need for the rapid generation and dissemination, of multiple-cropping technology. Written primarily for practising and prospective agricultural researchers and rural development workers, the book summarizes the results of current research and development efforts in multiple cropping, evaluates contemporary schools of thought on research and extension methodologies, identifies areas of research and development that are expected to maximize payoffs in terms of increased farm productivity, and describes the Philippine experience in accelerating the adoption by farmers of multiple-cropping techniques.
Although the book was written on the basis of Asian experiences, it is also recommended for people interested in cropping systems in other parts of the world.

106 88 - 4/27

Cropping systems
Africa, book, review, cassava, shifting cultivation, system approach, technology development
FRESCO, L.O.
Cassava in shifting cultivation.
Royal Tropical Institute, Publ. Dept., Maurits-Kade 63, 1092 AD Amsterdam, Netherlands, 240 pp.

Although aggregated data for Africa show a declining food availability per head, these do not adequately reflect the diversity in performance between crops and regions.
This volume presents a case study from the Kwango-Kwilu region in central Zaire. In this area, cassava production has increased considerably in the last 30 years and has kept pace with or even surpassed population growth, despite socioeconomic and agronomic disincentives. The author reviews the evolution of cassava production in the region and its agronomic effects. Cassava, cultivated as a key component of a shifting cultivation system, allows great flexibility in cultural practices. The expansion of cassava onto marginal soils, the increased presence of cassava in crop rotations and associations, and the reliance on female labor explain much of the production growth. At the same time, however, cassava yields have declined and the shifting cultivation system is rapidly breaking down. Past and present research efforts on cassava are discussed with a view to determining strategies for agricultural

technology development. The relevance of this study lies in its detailed analysis of changes in shifting cultivation as well in its method of analysis. It draws upon ecological systems analysis and, to a lesser extent, on Farming Systems Research, and presents a systems framework that allows the integration of technical and socioeconomic aspects of crop production, which has wide application.
Abstract from ILEIA

107 88 - 4/28

Cropping systems
Africa, Nigeria, humid and subhumid regions, experiments, cropping systems, resource use, mixed cropping systems, small-scale farmers, cowpeas, maize, cassava
IITA
Efficient use of resources through mixed cropping systems.
Farming Systems Program Research Highlights 1981-84, IITA, Ibadan, Nigeria, 1985, pp. 25-29, ISBN 978-131-007-3

Small-scale, mixed crop farms of less than one ha make up the majority of farms in the humid and subhumid regions of West Africa. Farmers in these areas sometimes use cowpeas as the minor crop in their cassava, maize, sorghum and yam based mixed cropping systems. Maize is often a minor crop in a cassava or yam based system.
In mixed cropping experiments during 1982, the new IITA-developed 60-day cowpea variety (IT 82 E-60) not only equaled the yield of the late-maturing or full season VITA-5 in different cropping patterns with maize but required no thinning and fewer harvests to recover over 90% of the total grain yield. Traditional varieties of cowpeas commonly grown on farmers field in West Africa have a speading or climbing growth habit and mature in 100-120 days. VITA-5 has similar characteristics but produces higher yields than most traditional varieties and matures in 90-100 days.
Cowpeas intercropped with an erect-typ cassava (TMS X) during the first season gave up to 90% of the yield of sole crop cowpeas and about twice that from a combination of cowpeas and a more bushy-type cassava (TMS 30001). This was due mainly to more pronounced shading by the latter, which has more and larger leaves than TMS X. During the second season, when the cassava had developed a much denser and closed canopy, cowpeas intercropped with TMS 30001 were completely outshaded and showed very feeble growth and low yields.
Cultural control of cowpea pests through mixed cropping with cassava was also studied during 1982. The results did not show significant differences in pod borer populations between monocropped and intercropped cowpeas. However, populations of thrips and pod sucking bugs were reduced substantially by intercropping cowpeas. In the first season, thrips and pod bugs were reduced by about 50% in the mixed crop. In the second season, there was an even more dramatic reduction (90%) in the population of thrips mainly because of the feeble crop. Reducing pest populations in such proportions has important practical implications for farmers.

Interplanting cowpeas with cassava has major advantages in keeping pest population low, and the system can be manipulated to maximize grain yield by planting earlier, using early-maturing varieties and/or increasing spacing, which would singly or in combination minimize the effects of shading by the cassava.
Intercropping maize with cassava caused no reduction in the maize grain yield, primarily because there was little or no competition for light between the two crops at low maize population (30,000 plants/ha). However, increasing the maize population from 30,000 to 60,000 plants/ha resulted in significant reductions in cassava root yields.
Greater light interception by cassava intercropped with maize is associated with higher cassava yields. Not only is the size of the maize population a factor but also the architecture of the plants - whether with relatively erect or spreading leaves. Large differences in cassava root yields are related to small differences in light transmission. For example, a 5-10% higher light transmission to cassava associated with the erect and narrow leaf of Kewesoke maize variety compared with the spreading TZPB variety resulted in a mean increase of 31% in the root yield of the TMS 30572 cassava variety. It is therefore important to consider plant structure when breeding maize for mixed cropping, especially in the tropics where crop production is evidently limited by the amount of light received.

108 88 - 4/29

Cropping systems
Peoples' Republic of China, book, review, cropping systems, production technology
FAO
China: Multiple cropping and related crop production technology.
FAO Plant Production and Protection Paper, No. 2, Rome, Italy, 1980, ISBN 92-5-100977-5

Since liberation, China has fed and clothed her large population almost entirely from domestic production as well as steadily increasing her food reserves. To reach this level of national and regional food security, China organized its abundant resource manpower into teams, brigades and communes, systematically applying it to conserve, nurture and improve the scarce land and water resources, while practising a labor-intensive form of agriculture. Such a highly organized production system allows optimum seasonal, spatial and crop-wise allocation of labor, ensuring maximum output from the land.
In this setting, China steadily increased production from existing cropping systems. There were areas where single paddy crop yields increased from 1.5 to 8 t/ha in 25 years. In general, age-old integrated farming systems combining grains, tree crops, vegetables and animal and fish production were improved upon. An integrated farming system permitted organic recycling of crop and animal by-products, and was the most feasible method of raising productivity through intensive land use in a capital-scarce situation.

Other developing countries may find it worthwhile to intensify their efforts at developing appropriate multiple cropping systems, particularly when land is scarce and manpower is abundant.
This report was the tenth in a series of 13 inter-regional tours to China organized from 1977 to 1979 by FAO, the Government of China and the UNDP. These study tours provided an opportunity for developing countries to learn from the Chinese experience in agriculture, forestry and fisheries.

109 88 - 4/30

Cropping systems
Review, book, tropics, subtropics, cropping systems, soybeans, proceedings, symposium, soybean programs, management practices, economic potentials, physiology, research needs
SHANMUGASUNDARAM, S. et al.
Soybean in tropical and subtropical cropping systems.
Proceedings of a Symposium at Tsukuba, Japan, 1983; revised ed. 1986, published by AVRDC, Shanhua, Taiwan, No. 867-253, paperback, 471 pp., US$ 25.00 (developed countries) or US$ 18.00 (developing countries), ISBN 92-9058-0022-6

These proceedings cover the cropping systems section of the International Symposium on Soybean held in Tsukuba, Japan in September-October 1983.
The papers presented in this publication provide a review of soybean cropping systems research from a variety of viewpoints, including those of international, national and regional programs. There are also a number of papers from the private sector.
The proceedings likewise cover many of the scientific disciplines that relate to cropping systems research in the tropics. In the first chapter the authors review many of the most important tropical soybean cropping systems. This is followed by sections on breeding soybean for specific cropping systems and the development of complementary management practices. Subsequent sections cover topics such as the nutritional, photoperiodic and thermal requirements of soybean, as well as the economic potential of the crop.
There also seems to be a greater sense of urgency to integrate cropping systems research with disciplines such as plant breeding, crop management, pest control and plant nutrition. Each has a role to play if we are to succeed in raising the productivity of soybean in developing countries. This is a hopeful sign and a credit to the many scientists involved.
These proceedings also indicate a number of areas which require increased emphasis. There is, for example, repeated reference to the fact that success will ultimately depend upon economic and trading policies that support soybean production.
This book is, by and large, devoted to applied aspects of soybean production. It is likely to be of principal interest to and, indeed, is a fine, comprehensive resource for professionals actively involved in applied soybean research in the tropics. It is well edited, very readable and has excellent illustrations. There are both author and subject matter indexes, plus a list of symposium

participants with their addresses, a useful addition for those wishing to pursue certain matters further.
The book is highly recommended for both researchers and students.

110 88 - 4/31

Cropping systems
Latin America, rice production, cropping systems, crop management, integrated systems
CIAT
Manejo del cultivo: clave en la producción futura de arroz (Crop management: key to future rice growing).
CIAT Report 1987, pp. 13-15, Cali, Colombia.

Rice production in most countries in Latin America must increase considerably in the future to avoid huge deficits. A CIAT study predicts rice shortfalls of up to 4.6 million tons by 1995 if populations continue to grow and there is no corresponding increase in rice production. The study points to integrated crop management (ICM) as the key to avoid this scenario.
Analysis indicates that at present there is little economic incentive in several countries for farmers to expand production. A few countries, such as Colombia, have high yields of up to 6 to/ha but, because of high production costs, farmer profits are low. Most countries have average yields of 3-5 to/ha, which are far below the potential of the widely grown high-yielding varieties. This demonstrates that the simple introduction of new high-yielding varieties cannot be expected to stimulate production. The high costs of plant protection, lack of appropriate machinery, poor seed quality, and certain diseases tend to be the major constraints to increasing production. These factors vary in order and relative importance from country to country within Latin America.
The Rice Program at CIAT is increasing its efforts to develop, in close collaboration with national programs, varieties and management practices which meet the specific requirements of the various countries. This includes assisting national programs in analyzing production constraints and in developing implementing appropriate production practices. For example, some diseases and pests, such as the `hoja blanca' virus, Sogatodes plant hopper and foliar diseases, are best controlled by using resistant or tolerant varieties, whereas weed control and most other pests are best handled by appropriate cultural practices. Although such management practices, including the establishment of economic thresholds for insect pests, analysis of red rice yield losses, and evaluation of weed control technology, have great potential in many countries, implementing them depends, to a great extent, on the development and use of region-specific production plans.
The Rice Program cooperates with the Colombian National Agriculture Program (ICA) and the Rice Farmers' Federation to prepare, in 1986, a national production plan to improve crop management for Colombia. The plan addressed four key production problems: high and expensive seeding rates, unjustified weed control, costly `preventive' pest control, and poor disease management.

Scientists, field technicians and farmers found that production costs can be reduced by the equivalent of about 0.7 to/ha in upland rice. They projected national savings over the whole rice area of 370 000 ha equivalent to 420 000 tons of paddy (or nearly US$ 72 million per year), of which 55% (or about US$ 40 million) are potential savings in pesticides (most of which are imported). In a similar way, CIAT assisted national programs in Chile and southern Brazil to develop crop production plans.
The widespread adoption of integrated crop management as a part of each nation's total national production plan can play a key role in helping Latin America avoid shortfalls in rice in coming years by making rice farming a more attractive proposition.

111 88 - 4/32

Cropping systems
Review, book, field trials, planning, execution, evaluation
ROHRMOSER, K.
Handbook for field trials in technical cooperation.
GTZ/CTA Publication, 1985, 304 pp., ISBN 3-88085-272-3; TZ-Verlagsgesellschaft mbH, Postfach 36, Bruchwiesenweg 19, D-6101 Roßdorf 1, FRG

All crop production projects have a common goal: to introduce proven, improved production techniques which are adapted to the ecology of the site and are economically viable and acceptable to the farmer. Each crop production project must therefore carry out field trials to obtain data on the optimum type, amount and timing of production inputs and techniques. Agricultural training often fails to give in-depth knowledge of the methodology of planning, implementing and evaluating field trials.
A field trial is a comparison of a number of plant production processes on small plots. Depending on the trial objective, the individual plant production processes differ with respect to type, quantity or timing of one or more production inputs or techniques, while all other growth influences, i.e., meteorological, pedological, hydrological and labor factors, remain equal. The effects of the different variants of the production inputs or techniques on crop yield and quality are measured, weighted and observed. The differences in the results are analysed statistically to verify whether the effects of the variants differ or are the same.
A field trial comprises the following five stages:
- formulating the objectives
- planning the trials
- implementing the trials
- evaluating the results of measurements and observations
- trial report.
The manual deals with the fundamentals of field trial procedures and is tailored to the needs of technical cooperation projects. Particular emphasis is given to understanding the function of field trials, their potentials and limitations for investigating the interrelationship between plants and their environment. The manual is intended for individual study as a teach-yourself

handbook, for reference and as a guide for the procurement of machinery and implements for agricultural trials. The section on evaluating trial results is presented in a simplified manner and limited to essential details. All project co-workers should be able to rapidly familiarize themselves with this subject.
The German Agency for Technical Cooperation (GTZ) has published this handbook on field trials, which CTA helped to make available in English.
There are very few practical books on this subject, and the manual fills this gap. For all those who have to plan, carry out and evaluate field trials, this book is highly recommended.

112 88 - 4/33

Cropping systems
Africa, Ghana, field trials, cropping systems, crop rotation, intercropping, groundnut, cowpea, soybean, cassava, sorghum
SCHMIDT, G. and FREY, E.
Combined intercropping and crop rotation trial with various crops
In: Nyankpala Agricultural Research Report, No. 3, CRC/GTZ Joint Project, Tamale, Ghana, 1988, pp. 83-89, ISBN 3-8236-1135-6; Distributor: J. Margraf, Mühlstr. 9, D-6992 Weikersheim, FRG

One objective of this experiment was to compare over a period of several years the two alternative cropping systems, intercropping and crop rotation, including maize and a number of other crops. The suitability of the latter as intercropping partners for maize was to be determined.
The second objective was to assess the residual value of various crops for subsequent maize. In addition to groundnut and cowpea already examined in previous experiments, soybeans, cassava and sorghum were also tested.
The experiment included 6 main crop combinations with 3 plots each, one of which was reserved for intercropping year after year, whereas the other two served for a rotation of the crops, in one case starting with maize (or maize/sorghum) and in the other starting with the second crop. Intercropping was practised in the form of alternative rows, half of the area thus being allocated to each partner.
Maize at a sole crop density of 75 x 30 cm = 44 444 plants/ha was grown either in rotation or in intercropping combination (alternating rows = half of the area) with the following crops at the following sole crop densities:
- groundnut (G) 75 x 15 cm = 88 000 plants/ha
- cowpea (C) 75 x 15 cm = 88 000 plants/ha
- soybean (Soy) 75 x 15 cm = 88 000 plants/ha
- cassava (CA) 100 x 100 cm = 10 000 plants/ha
- sorghum (S) 75 x 30 cm = 44 000 plants/ha.

In a 6th treatment, maize (M) was replaced by maize/sorghum (MS) interrow intercropping (alternating plants within rows) and grown either in rotation or in row-intercropping with groundnut (alternating rows).

A randomized block design with 5 replications was used. Each cereal or legume plot had 8 rows 75 cm apart and was 10 m long (= 60m²). For yield assessments the border rows were excluded, leaving 4 rows of 9.40 m = 28.2 m².
For cassava, planted at a distance of 1 m between and 1 m within rows, there were 6 rows per plot, 4 of which were used for yield assessments. There were also 6 rows in the case of maize/cassava intercropping in alternating rows at distances of 1 m between rows. Distances within rows were 1 m in the case of cassava and 22.5 cm in maize, leading to identical numbers of maize hills as in the case of the other intercropping combination.
1986 was the first test year as regards residual effects of the crop on maize. Superphosphate (60 kg P_2O_5) and potassium sulfate (60 kg K_2O) were again applied before plant establishment. All non-leguminous plants received 40 kg N/ha as ammonium sulfate; the legumes received no nitrogen. In the case of intercropping, equivalent quantities of N per plant were applied to the rows of non-legumes only.
A comparison of maize yields after various preceding crops showed that cowpea was the best preceding crop, closely followed by groundnut, cassava and soybean. Maize plus sorghum yields in MS intercropping after groundnut were lower than sole crop maize yields after groundnut but definitely higher than maize yields after sorghum, the worst preceding crop for maize.
As compared with sole crop maize, intercropping of maize with various partners was most advantageous for maize in the case of MS intercropping, advantageous also in the case of MC intercropping but disadvantageous in the case of M-Soy intercropping. Maize plus sorghum yields in MS intercropping were also definitely higher than those in the MSG treatment. This is probably due to a heavy competition of groundnut for moisture, abolishing the advantage of maize in the MS rows resulting from retarded S development.
The yields of the partners were not very high, cowpea being more productive than the other cereals or grain legumes. In the cases where yields of maize plus sorghum are presented (MS and MSG), sorghum yields constituted only 9-10% of the total yields.
As compared with the respective sole crop plots, intercropping with maize was very advantageous in the case of cassava, somewhat advantageous also in the case of soybeans, but disadvantageous in the cases of groundnut and sorghum. Cowpea as well as groundnut in MSG were also on the low side. The LERs indicate a great advantage of cassava/maize intercropping as compared with the respective sole crops, mainly attributable to high cassava yields. Maize/sorghum intercropping may also have been advantageous, as maize could develop very luxuriously in rows where every second hill was occupied by a small sorghum plant competing little for moisture.
In addition to cowpea and groundnut, soybean and cassava have also to be considered as excellent preceding crops for maize, whereas sorghum again proved to be a very bad preceding crop.
In MS combinations, maize contributed to about 90% of the total yield.
In intercropping, maize was favored in the combinations MS and MC but depressed in the combination M-Soy. Among the intercropping partners of maize, cassava had the highest benefit from intercrop-

ping. A little advantage was also observed in soybean. Groundnut, sorghum and cowpea had rather low yields in intercropping. The overall result was by far the best in the case of cassava/ maize intercropping. Maize/sorghum intercropping seems to be interesting on account of the retarded sorghum development, assuring a good moisture supply to maize during critical stages.

V AGROECOLOGY

113 88 - 5/1

Agroecology
Review, sustainable agriculture, definitions, principles, economics, social justice, ecology, traditional agriculture, GIPS, T.
What is a sustainable agriculture?
In: Proc. of the 6th Int. Sc. Conf. IFOAM, UC, Santa Cruz, California, USA, 1986, pp. 63-72

The importance of sustainability as a necessary, fundamental goal has received increasing attention worldwide, ranging from discussions of how to create a sustainable society to a focus by the World Bank, the United Nations and other agencies on sustainable development. The need for sustainable agriculture has been understood as environmental contamination has grown, health hazards have mounted, pest control practices have faltered, rural economies have deteriorated and hunger has spread.
As the use of the term sustainable agriculture has become widespread, it has become important to have a clear definition. To "sustain" means "to keep in existence; keep up; maintain or prolong; to provide sustenance or nourishment for".
Various definitions have been provided for what constitutes a sustainable agriculture, ranging from a narrow focus on economics or production to the incorporation of culture and ecology.
One of the earliest definitions stated eight basic components for sustainability: systemic dynamism, harmony with nature, diversity, renewable resources, personal involvement, nutrition, community, and aesthetics.
Quite often, "sustainability" has been focused only on the ongoing, productive capacity of a system. The German Agency for Technical Cooperation has sought to create a "self-sustaining agriculture" with the aim of "establishing high and lasting soil productivity and thereby conserving or re-establishing a well-balanced ecological environment".
Over time, a definition has emerged that unifies these diverse elements into a widely adopted, comprehensive, working definition: a sustainable agriculture is ecologically sound, economically viable, socially just, and humane. This definition is used by an increasing number of researchers, farmers, policy makers and organizations worldwide.
This paper provides a widely accepted working definition for sustainable agriculture, discusses its essential components, examines the sustainability of traditional and conventional systems, and mentions several sustainable approaches.