FARMING SYSTEMS RESEARCH DESIGN

Arsenio D. Calub[1]

Evolving research methodology

By its iterative/dynamic nature, Farming Systems Research (FSR) is evolving. In the Asian Farming Systems Network (AFSN), it was convenient to initially "ride" on the Cropping Systems Research (CSR) Methodology leading to Farming Systems Research (FSR). The latter was developed by the AFSN working group of researchers. It consists of site selection, site description, design, testing, pre-production testing and pilot production program. and production program (Fig. 1).

This methodology could be traced to the intensive multiple cropping work initiated by Dr. R. Bradfield in the 1960s. This was broadened from multiple cropping to cropping systems research in 1972. During 1974-75, the introduction of an interdisciplinary team which included a full-time economist further expanded research effort using the systems approach. The Asian Cropping Systems Network (ACSN) was also formed in 1974 to encourage collaboration between national research programs conducting CSR. In 1983, the network became known as the Asian Farming Systems Network (AFSN).

By consensus in the AFSN, this shift from CSR towards FSR could be done following the CSR method, either in an existing research site and/or incorporating livestock as an additional farm

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[1] Senior Research Fellow, Rice Farming Systems Program, IRRI, Los Banos, Philippines.

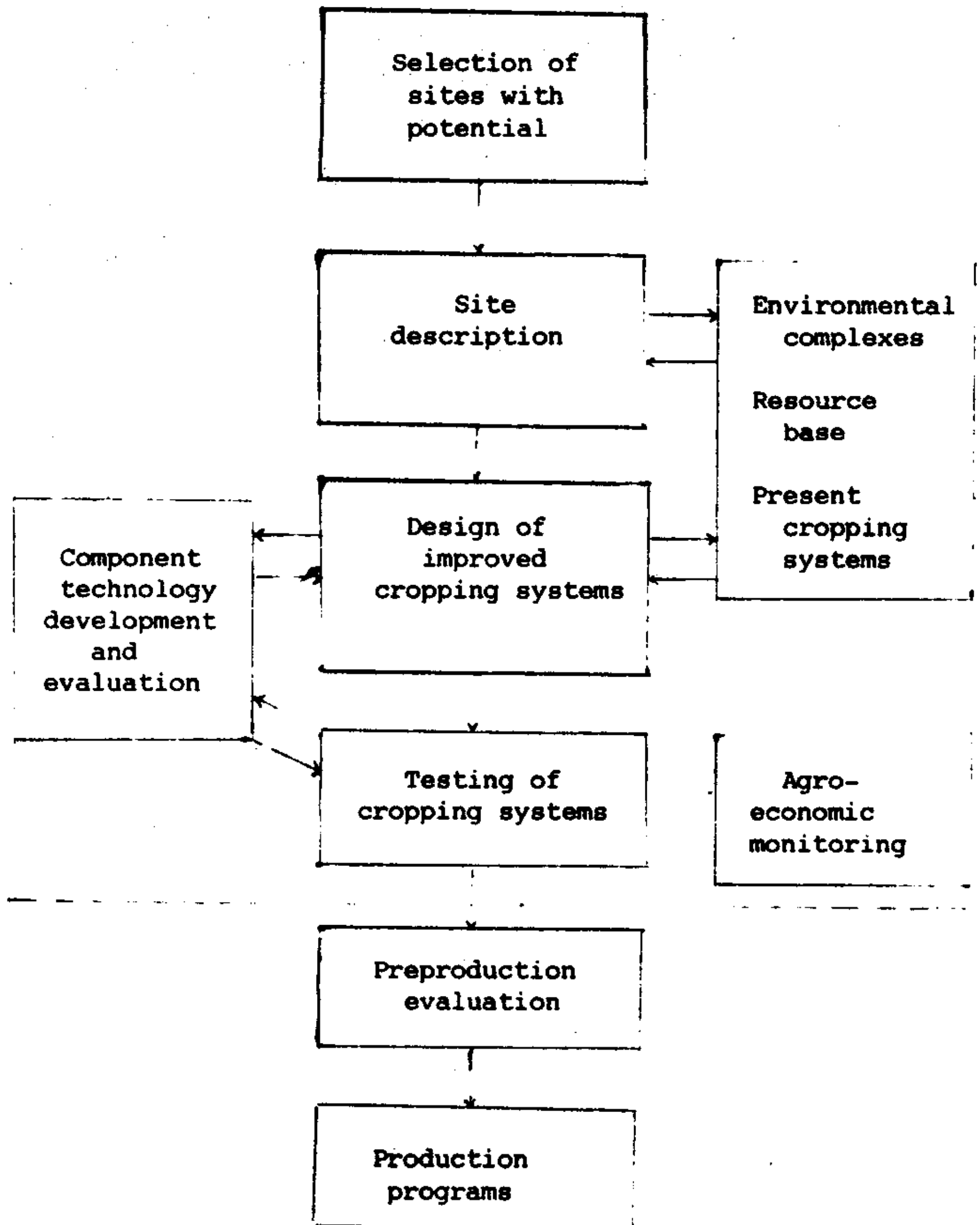


Fig.1. Components of the site-related cropping systems research, IRRI, 1977.

component. This step by step move, instead of considering everything in the system all at once, was deliberately done to (a) facilitate interdisciplinary effort, and (b) focus on more direct crop-livestock interdependence, e.g., use of fibrous crop residues as livestock feed, recycling animal manure for fertilizer, and utilizing animal draft power for traction. Other animals and enterprises may be considered later and as the situation may warrant. In China, for instance, swine is the livestock being considered in a predominantly grains cropping system.

From limited experience in Crop-Livestock Systems Research, modifications in the CSR methodology are most needed with respect to:

1) Whole farm, vs experimental plots.
2) The need to simplify farm record keeping (FRK) vis a vis research data needs by discipline and for economic analysis.

In crops research, it is convenient to conduct trial plots from several up to 1,000 sq m or more. Results are then extrapolated to the hectare or to the whole farm. Proper replication is also done to satisfy statistical interpretation. Livestock research follow similar research procedures, especially in properly replicating experimental units,i.e., animals. This poses logistical problems in farmers' fields. Large animals cannot be cut up to create more units. The research project may not have sufficient funds to provide a minimum number to farmer cooperators. On the other hand, when the researchers include more farmers who own animals, the animal variability problem may be solved but it will mean more work for the researchers in dealing with more cooperators. Ths smaller animals like goats, sheep, pigs, and chicken may permit the use of an experimental plot to accommodate the crop component, i.e., 1,100 sq m, 0.25 ha, etc.

Farm record keeping (FRK) is a tool used by the economists to itemize the farm household farm and non-farm activities as well as costs of inputs, returns from harvests, etc. It continuously challenges the researchers to simplify these records, not only from the standpoint of lessening the burden on both farmer and researcher alike but also and specially in deciding what data are really necessary. Interdisciplinary interaction is important in this regard. For instance, labor standards could be devised by the commodity specialists so that man-hours or man-animal hours need not be recorded by the farmer. It may suffice to say, use 1 man-hour per day to feed and care for 1-2 cattle or buffaloes, 1.5 man-hours for 3-5, etc. These standards can be derived from previous research, then occassionally refined. In the Philippine RIARS setup, researchers are now setting up some standards for determining labor required for field cultivation, harvesting, etc. under varying circumstances.

Similarities With Cropping Systems Research

Farming systems research is similar to cropping systems research (CSR) in that it:

(a) Is done on-farm

(b) Considers farmer's priorities as being the most important

(c) Addresses broblem(s) faced by a large number of farmers, which limits production

(d) Considers government priorities

(e) Evaluates design suitability in terms of

1. Biological feasibility
2. Technical feasibility
3. Economic viability

The researchers strive to arrive at a consensus on the suitability question after consultation with the farmers. This is because there may be few if any research item that will pass all three levels. Growing a new crop variety may be both biologically an technically feasible. The field trial is then done to test its economic viability.

Such degrees of suitability are associated with different components of the environment.

For biological feasibility, the environmental factors are physical, climatological, and biotic, such as amount and distribution of rainfall and irrigation, landscape hydrology, drought, etc. A biologically feasible cropping pattern or farming enterprise will grow or thrive in these conditions well enough to achieve locally acceptable yield/performance levels.

Technical feasibility is determined by the ability of a farmer to execute the cropping pattern or activity with a specified resource structure. This is the resource structure that most probable will prevail at the site during the production program phase. Such technical feasibility of cropping pattern or activity at a site is determined by the availability of such resources as labor, agricultural chemicals. traction power, special equipment, credit, produce markets, etc.

The economic viability of a cropping pattern or activity is determined by the costs of these resources and the prices of the products. The AFSN uses the marginal benefit cost ratio (MBCR), and it should be equal to or greater than 2:1 for the new technology to be acceptable. This is similar to the benefit/cost ratio used by the development banks like the World Bank.

Site Description

The site description phase enables the researchers to identify and describe major regional farming systems and understand the dynamic and interactive relationships of these systems with wider regional systems and overall environment (Jayasuriya, 1984). It is covered by other papers in this seminar. Both secondary and primary data should be exhaustively familiar to the researchers at design phase. All these data should include the farmers' viewpoint: his own assessment on probable success of new technologies, as well as his goals and aspirations. The latter may also include the contributions of a sociologist aside from that of the economist.

In the design phase, after knowing as much as possible about field conditions, the researchers attempt to assemble component technologies that have potential for successful farmer adoption and will improve farm productivity and welfare. These "best bet" alternatives may be new cropping patterns, crop varieties, agronomic practices, animal feed supplementation, etc. Researchers would draw these technologies from experiment station research outputs or from more successful farmers.

The design phase is expected to come up with cropping/livestock schemes specifying all production techniques and data including alternatives based on weather and environmental conditions. Because of inherent limitations for on-farm work, researchers may decide to simplify and concentrate on selected components of current systems. This is more so when farmers are technologically "advanced", attaining high crop yields, practicing improved animal husbandry practices, etc. The design phase may also suggest component technology experiments for specific problems. These may in turn to be done separately or passed on to the experiment station researchers.

A design workshop that may take three days is the best opportunity for all research workers from all levels (national, regional, research site) to draw up the final plans. This is normally done so that detailed plans are available at least one month before the onset of the cropping, i.e. rainy season. Extension agents assigned to the area could also contribute valuable insights in this workshop because of their familiarity with local conditions.

Procedures For Design

Several FSR advocates have listed seven steps in identifying "best-bet" technological improvements to be considered for on-farm trials. These are: (a) identifying key factors limiting farmers' production and income; (b) identifying available technology by which those constraints may be overcome (assessing biological feasibility; (c) listing all changes to the farmer that will result by introducing these technologies; (d) computing rough costs and benefits to the farmer of the changes (assessing economic viability); (e) matching the changes against the relevant circumstances of the farmer (assessing technical or technological feasibility; (f) attaining farmer feedback concerning the proposed technological innovations to be tested (assessing socio-cultural as well as confirming general acceptability); and (g) setting priorities for on-farm research. (Byerlee et al., Zandstra et al., and Shaner et al.)

Design And Ex Ante Analysis of Crop-Livestock Systems Research at Sta. Barbara Pangasinan, Philippines

Site Description and Experimental Design

Site Description

1. Two distinct land types: rainfed (Caosucan) and irrigated (Malanay)*
2. Existing and improved (experimental) cropping patterns: (Fig.)

rainfed: TPR - Fallow (TPR = transplanted rice)

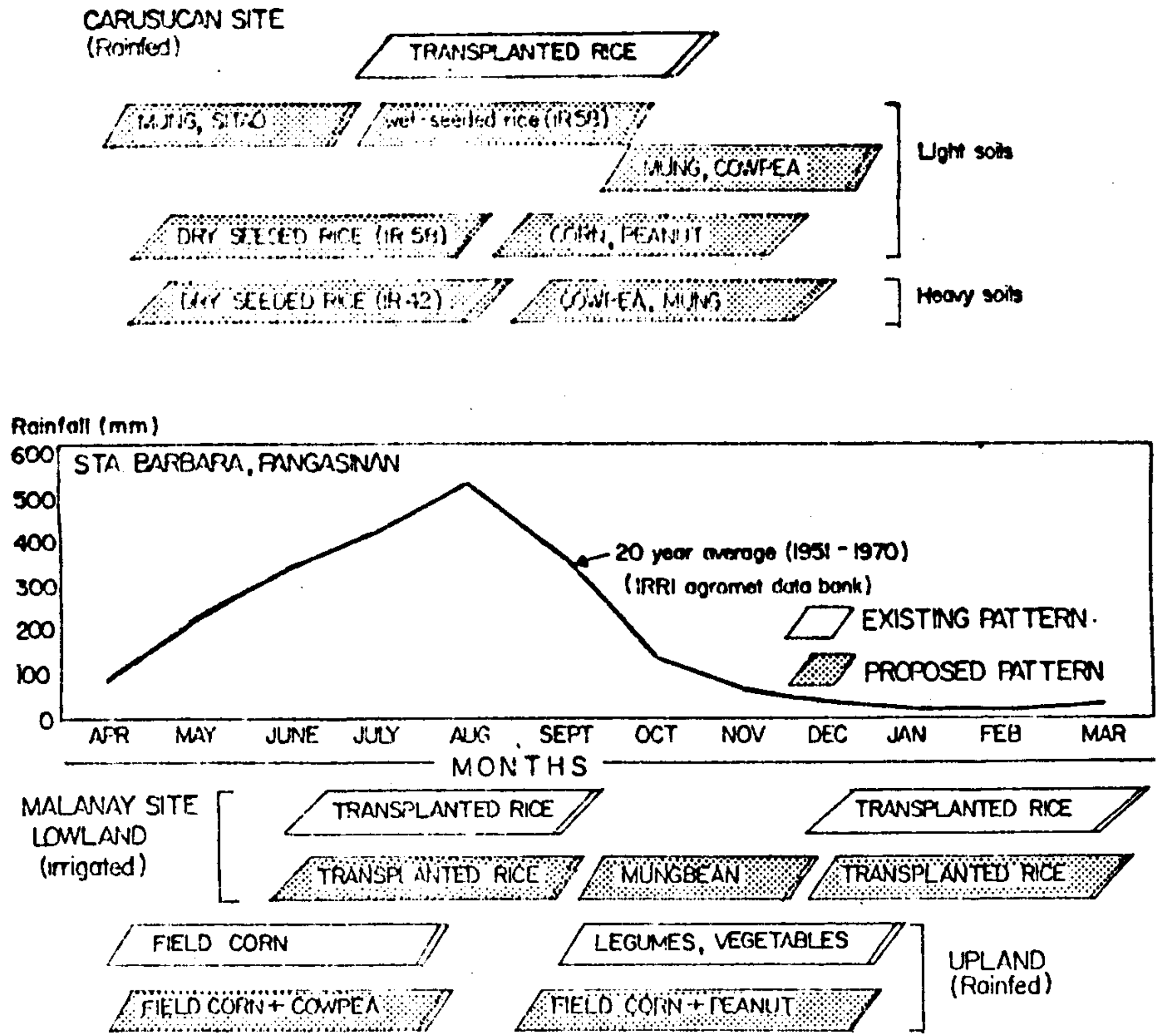
irrigated: TPR - TPR

3. Experimental design (No. farmers)

Crop-livestock Aspect	Landholdings size, ha			
	Rainfed		Irrigated	
	0.5-1.5	1.6-2.5	0.5-2	2.1-3.5
With interventions	5	5	5	5
No interventions(control)	5	5	5	5

Crop Component	Rainfed	Irrigated
Variety trials (Rice)	-	1 cooperator
Cropping pattern	5 cooperators	5 cooperators

* Names of Barangay or village, the smallest political unit in the Philippines.



Improvedand existing cropping pattern graph against average rainfall, Sta. Barbara, Pangasinan, MAF-RIARS, Region 01, 1985-86

4. Interventions (technology innovations)

   (1) Crop-livestock

      a. Farmers feed Leucaena to cattle.

      b. Provide salt + mineral supplement to cattle.

      c. Animal health care.

   (2) Component technology (cropping pattern testing)

      a. TPR - Maize, Peanut (rainfed)

         TPR - Cowpea, Mung

      b. TPR - Mung - TPR (irrigated)

Crop Residue Yields and Large animal Holdings

In the two barangay project sites at Sta. Barbara, the site description survey revealed a high concentration of large animals (Table 1) : it is roughly 1 animal per farm household in the rainfed and irrigated areas. This is in turn about 1 animal unit per hectare (1 A.U./ha) in both locations.

Table 1. Cattle/Buffalo holdings, Malanay and Carosucan.

		Malanay	Carosucan
Cattle			
Cow + breeding heifer		5	7
Bull + bullock		7	5
2-year old		6	1
Yearling		2	3
Calf		3	3
	Sub-total	23	19
Buffalo			
Cow + breeding heifer		10	12
Bull + bullock		15	10
2-year old		1	-
Yearling		1	-
Calf		3	2
	Sub-total	30	24
Grand total, heads		53	43
A.U.		50	40
Mean, heads		1.08	1.43
A.U.		1.02	1.33
A.U./ha		0.92	1.01
Mean land area, ha		1.11	1.32

Such stocking rate or concentration of animals is rather high, especially in relation to the available crop residues shown in Table 2. There appears to be sufficient feed from residues alone, on the basis of roughly 3 MT DM/A.U.*/year. However, deficiency in feed energy (TDN) and protein (CP)** is apparent, assuming crop residues are the only source of feed:

ITEM	DM	TDN	CP
Required by 1 A.U./day, kg	7.1	3.8	0.60
1 A.U./year, MT	2.6	1.39	0.22
Available per farm/year, Malanay	6.6	2.79	0.22
Carosucan	2.6	1.09	0.09

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*1 A.U. or mature animal equivalent = 1 cow or breeding heifer; 1 breeding bull = 1.2 A.U., 1 heifer or steer = 0/75 A.U., 1 yearling = 0.5 A.U., and 1 calf = 0.25 A.U.

**TDN = Total Digestible Nutrients
CP = Crude Protein

Table 2. Estimated crop residues and livestock carrying capacity, rainfed and irrigated rice areas, Sta. Barbara, Pangasinan, Philippines.

Season	Crop	Area ha	Grain yield MT/ha	DM residue MT	TDN MT	CP MT	Carrying capacity A.U.
Rainfed, 1.3 ha	no intervention						
Wet	rice	1.3	2	2.6	1.09	0.09	
	Total			2.6	1.09	0.09	1 (marginal)
Rainfed, 1.3 ha	with intervention						
Wet	rice	1.3	2	2.6	1.09	0.09	
Dry	mung	1	0.5	0.5	0.3	0.06	
	Leucaena	-	4 kg/tree	0.4	0.22	0.08	
	Total			3.5	1.61	0.23	1 (sufficient)
Irrigated, 1.1 ha	no intervention						
Wet	rice	1.1	3	3.3	1.39	0.11	
Dry	rice	1.1	3	3.3	1.39	0.11	
	Total			6.6	2.78	0.22	2 (marginal)
Irrigated, 1.1 ha	with intervention						
	rice	1.1	3	3.3	1.39	0.11	
	rice	1.1	3	3.3	1.39	0.11	
	mung	1	0.8	0.8	0.48	0.10	
	Leucaena	-	4 kg/tree	0.4	0.22	0.08	
	Total			7.8	3.48	0.40	2 (sufficient)

	TDN, %	CP, %
Rice straw	42	3.4
Corn stover	44	4.4
Mung straw	60	12
Peanut straw	43	7.4
Leucaena	55	20

Table 3. Ex-ante cost/return analysis of rainfed crop-livestock system

Rainfed, 1.3 ha	No intervention	With intervention
Rice crop		
2 MT x 1.3 ha x ₱ 3,000	₱ 7,800	₱ 7,800
Mung		
0.5 MT x 1 ha ₱ 8,000	-	4,000
Cattle sold		
100 vs 120 kg LW gain x ₱20	2,000	2,400
Saving from fertilizer cost with manure use		
6 MT = 24 kg N, 12 kg each of P & K*	-	1,937
Total gross returns	₱ 9,800	₱ 15,137
Less: cost of rice production	2,574	2,574
cost of mung production		1,320
labor cost of manure application		280
Gross margin**	₱ 5,226	₱ 10,963

*Estimated nutrient values from manure: 2% N, 1% each P and K (20% DM basis), each ₱185/bag fertilizer or ₱8.22 and 30.83/kg N and P, K, respectively.

**Gross margin = Gross - gross return x .33

In practice, farmers supplement the crop residues by (a) cut-and-carry weeds, ipil-ipil browse, etc., and (b) grazing or tethering the animals. It is also known that cattle and buffaloes consume a maximum of only 5 kg rice straw DM/day because it is unpalatable. This is barely sufficient for maintenance. Thus, animals fed mainly on rice straw tend to lose weight in the dry season and recover slowly in the following rainy season.

Ex-ante analysis

Based on the above requirement for an A.U./year, neither location can support 1 A.U./ha, and have animals reproduce and gain weight satisfactorily. Under rainfed condition and with no intervention only 1 A.U./ha can be supported with supplementary crude protein. The legume interventions are shown to help sufficiently support 1 A.U. for the 1.3 ha rainfed farm.

Under irrigated conditions, a similar pattern occurs: marginal for 2 A.U. without intervention and just sufficient for 1 A.U. with the legume interventions.

Obtaining hard data to support the above estimates is one of the outputs of the research. The ex-ante analysis helps in deciding whether to include an intervention or not after translating "added benefit or loss" in economic terms. For illustration purposes, one year gross return for the rainfed farmer cooperator can be simplified as in Table 3.

5. Ex post analysis

The rainy season rice crop yielded the following (t/ha):

Rainfed	Grain	Straw, fresh (DM)	
IR 52	2.69		
IR 48	3.28		
IR 42	3.55		
IR 36	2.96		
Farmers' (IR 36,42)	3.12	12.31	(9.23)*
Mean	3.12		
Irrigated			
IR 54	3.09	11.09	
IR 42	4.91	11.42	
IR 32	3.83	15.47	
IR 36	3.21	13.31	
Farmers' (IR 36,42)	4.05	15.5	
Mean	3.82	13.36	(10.02)

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* DM = 75%

a. Rice straw yield is surprisingly high, at about 1:3 grain to straw ratio, and at 75% DM.

b. Amount of rice straw actually fed to cattle and buffaloes is erratic. The flood destroyed almost all straw in the irrigated area, after soaking them in mud. Hence, feed shortage in this place is acute in the dry season.

c. 120-days liveweight gains of fattener-draft animals similar in both technology and control groups, partly because of technology adoption in the latter (e.g., Leucaena feeding).

d. Estimated sale price of animals adds premium on fattener-draft vs pure fattener.

6. Research redesign for year 2

a. Rice-mung in rainfed area to accommodate 0.5 ha mung partly to benefit livestock holdings.

b. Increase Leucaena feeding levels in Technology groups; supported by planting more trees.

c. Make all fattener-draft animals for simpler comparison

d. Rice-mung-rice in irrigated area is discontinued; component technology trials on short maturing cowpea, e.g., 55 days.

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GLOSSARY
(From Zandstra et al., 1981)

COMPONENT TECHNOLOGY - the cultural techniques used in the management of a cropping pattern. These include choice of variety, times, and methods of tillage and crop establishment, fertilization, field level water management, pest management, and harvest.

CROPPING INTENSITY INDEX (CII) (Menegay [1975] - a time-weighted land-use index that evaluates the faction of the total hectare-months available to the farmer that are used for crop production.

CROPPING PATTERN - the spatial and temporal combination for crops on a plot and the management used to produce them.

CROPPING SYSTEM - the crop production activity of a farm. It comprises all components required for the production of the set crops of a farm and the relationship between them and the environment. These components include all necessary physical and biological factors, as well as technology, labor, and management.

DRYLAND - land that, except for limited periods, does not hold moisture in the rooting zone in excess of that held at field capacity.

EXTRAPOLATION AREA - the domain of adaptation of a cropping pattern. It is composed of the land types to which the cropping pattern is adapted.

FARMING SYSTEM (FARM SYSTEM OR WHOLE-FARM SYSTEM) - the production and consumption activities used by a person called a farmer to derive benefits from land and other inputs through crop growth and the use of technologies available to him under specific environmental conditions.

INTERCROPPING - growing two or more crops simultaneously in alternating rows or sets of rows in the same plot (see also Mixed intercropping).

MIXED INTERCROPPING - growing two or more crops simultaneously intermingled in the same plot with no distinct row arrangement.

MIXED-ROW-CROPPING - growing two or more crops simultaneously in the sample plot intermingled within a distinct row arrangement.

MULTIPLE CROPPING - growing more than one crop in the same plot in 1 year.

MULTIPLE CROPPING INDEX (MCI) - the sum of the areas planted to different crops harvested during the year, divided by the total cultivated area.

PLOT - a contiguous area of land planted in a homogenous manner during a defined period, normally 1 year.

PLOT PLAN - a diagrammatic representation of the spatial and tempotal combination of crops on a plot during 1 year.

RATOON CROPPING - cultivation of regrowth from stubble after a crop harvest.

RECOMMENDATION (CROP PRODUCTION) - advice in terms of operations, times. equipment, and materials for crop production, presented as a worthy of acceptance.

RELAY CROPPING - growing two or more crops in sequence, planting the succeeding one after the flowering but before the harvest of the former.

SEQUENTIAL CROPPING - growing two crops in rapid sequence, planting one after the harvest of the former.

SOLE CROPPING - growing one crop alone or in pure stand, either as a single crop or as a sequence of single crops within the year.

STRIP CROPPING - growing two or more crops simultaneously in alternate plots arranged in strips that can be independently cultivated.

SUPERIMPOSED TRIALS - experiments composed of a small set of treatments that evaluate the performance of alternative component technology for a cropping pattern. The treatments are superimposed, generally without replication, on four or more similar cropping pattern trial fields.

WETLAND - land of which the rooting zone can be kept saturated for a substantial part of the growing season, where necessary, by encouraging accumulation of water on the soil through puddling and the use of bunds or levees.