PN-AAS-631 39710

TECHNIQUES FOR ON-FARM CROPPING SYSTEMS RESEARCH

Introduction

Methods for cropping systems research have been the subject of papers and Working Group Committee reports on several occasions during the course of 6th Cropping Systems Working Group meetings, the 1975 Workshop, and the 1976 Symposium. Of particular interest for research methods are papers by Harwood (1975), Gomez (1976), Litsinger (1976), Zandstra (1976), and the reports of the Working Group on "Farmer participant research approach" and on "Superimposed trials on cropping patterns" in the report of the Fourth Cropping Systems Working Group and the report of the committee on pest control in the Fifth Cropping Systems Working Group report.

From these sources it is clear that on-farm cropping systems research methods need to satisfy several requirements. They must specify ways in which an interdisciplinary team can compare the agronomic and economic performance of cropping patterns that differ in crop species, the number of crops, their establishment times and their management. In addition to this, the team needs to evaluate component technology for establishment, fertilization, insect, weed, and disease control. Thirdly, the research team must be able to study specific problems affecting crop production in general such as microelement deficiencies or toxicities or special disease or pest problems. The methods must also not exceed the team's capability; nor must it force a discipline to devote time on a problem of low priority.

The cropping systems research methodology developed by the Working Group strongly stresses the use of site description and analysis as a point of departure for the design of research at a site. Site description will identify what variables are to be studied and what ranges of these variables should be considered in the treatments. It will also identify the location and distribution of trials across clearly delineated land types.

On-farm cropping systems research also must allow economic analysis of alternatives tested. The research must be conditioned to the farm resources that can be obtained at the sites, particularly the farm implements and labor availability. In addition, cropping systems research actively pursues the participation of the farmer, as was extensively discussed in the report of that subject during the Fourth Cropping Systems Working Group Meeting (pp. 8-13).

This committee will focus its discussion on field plot techniques that can be used for on-farm cropping systems research. It will propose a format for field plot research that will encompass different field plot designs for different research requirement at the site. This format can be used to study different variables over different ranges in the different

network sites. The criteria and format for experimental design and analysis should however, be sufficiently similar to allow easy interchange of information. Such increased uniformity will provide the Working Group with a base for the development of guidelines for analyses and interpretation by researchers in the many network sites. It is also hoped that some of the complexity and confusion will be removed in the process of casting on-farm cropping systems research in a more uniform format.

SITE DESCRIPTION AND ANALYSIS FOR RESEARCH PROGRAM DESIGN

Zandstra (1976) described the use of environmental description for the identification of land types. As has been the practice in the network sites land types must continue to be identified on the basis of the most important determinants, that is, those factors that most strongly influence the peformance of cropping patterns in the area. Careful observation and study of existing cropping systems in the area generally give important indications of what these factors may be. So far our experience has been that in wet land production complexes soil physical (profile texture, clay type) and hydrological variables (seepage and percolation, enrichment potential or hydromorphicity) are most useful for the identification of land units; in dry land production complexes -- slope and soil chemical factors (pH, organic matter, or cropping history related fertility) become more important.

Having identified the important land types a research team needs to select 2 to 4 landtypes that represent major production areas in the site and in the region or country. Further research will focus on the identification of improved production technology for each of these land types. The research team needs to consider which common production variables -- cultivar, crop establishment method, fertilization, insect, weed and disease occurrence -- are similar across the site and which of these may require separate treatments for each land type. This analysis will later help to interprete differences observed in experimental results. Site description also provides the research team with an idea of the common input levels used by farmers and the range of yield responses to be obtained from these inputs. This allows an approximate analysis of the returns-to-cash inputs that need to be achieved at the site and will help in the selection of treatment levels or studies on fertilization, insect, and weed control. In site description particular attention should be paid to the farmers' technology history. Cropping systems researchers should be aware of the extent to which farmers have experimented with technological alternatives. The reasons why they have incorporated some of these and rejected others for their production systems should be understood.

A first step in design of experimental on-farm research is for the team to familiarize itself with the research history in the area or in similar areas. This should give the team some idea of the yields achievable, the type of input responses they can expect, possibly information about the performance of different crops and varieties and the comparison of the performance of these to those actually used by farmers in the area.

Site description must also include extensive climatic analysis. This involves knowledge about the rainfall distribution (monthly and weekly means over as long as record as available) and a study of the time and probabilities of onset of rainfall and termination of rainfall (Morris and Zandstra, 1978). Where irrigation is available the team must acquire knowledge about the irrigation schedules, their frequency and dependability. If the onset of rainfall precedes the turnout of irrigation or the end of the rainfall is after the irrigation ceases, a careful analysis of these periods for the cropping potential is in order. The research team should attempt to establish the effective growing season for each of their landtypes using a fairly high probability level (P = .8). This will help them design cropping patterns that have a high probability of success. For wetland production complexes, it is particularly important that the research team get a feel for the periods in which the soil will be saturated or have standing water as opposed to the periods in which the soil will be primarily moist but not saturated.

DESIGN OF THE SITE-RELATED RESEARCH PROGRAM

The design of the research program for a cropping systems research site should be completed at least one month in advance of the first seeding date at the site. In most network programs the yearly research program is designed in a workshop format in which all researchers at the site participate. Site researchers should be given prime responsibility for the presentation of previous research results and should be encouraged to contribute their insight about the existing farming systems, the potential for increased production, and farmers' reactions to alternatives. The workshop should draw on the support of advanced cropping systems researchers and subject matter specialists in the areas of economics, entomology, weed science, plant pathology, soil fertility, and plant breeding. Researchers should expect this workshop to take from 3 to 6 days and although the research program for the site is designed before the cropping season starts, it may be useful to re-evaluate the research program after each crop and make the necessary modifications.

The following steps are suggested for the design of the research program at the site:

1. Decide on the landtypes to be studied at the site and describe each of these as precisely as possible. The team need not conduct research on all landtypes in their area of operation; generally by using 2 to 4 of the most important (common) landtypes the team can cover the vast majority of production situations at the site. At times, a landtype may be included because of its importance elsewhere.

2. Identify variables that in general adversely affect crop production, such as fertility problems, minor element deficiencies or toxicities or the common and dependable occurrence of crop pests.

3. Decide on the cropping patterns to be studied for each landtype. These patterns should be carefully designed in accord with the physical and socioeconomic conditions prevailing at the site. Farmer's cropping history, climate, product value, and potential market are all important factors to be considered.[1/] For each landtype the research team should probably limit itself to 3 or 4 cropping patterns. These patterns may be the same for different land types. In fact it is desirable that the performance of one or more patterns can be compared between landtypes.

4. Each cropping pattern needs to be assigned a management technology. Figure 1 is an example of the complexity of a cropping pattern and the information required with respect to component technology. As the research team considers different alternatives it must evaluate the expected response and the cost involved with each alternative. During the design of the cropping pattern a simple cost-and-return analysis is helpful in planning the management of the pattern.[1/] These factors should not be taken lightly as it has been estimated that to decide on varieties, tillage methods, planting methods, pest management, fertilizer additions, weed control methods, and harvest methods in addition to the timing of all operations, more than 30 decisions need to be made for a two-crop cropping pattern. Tables 1 and 2 present examples of component technology specifications.

During the first year the component technology chosen for the cropping patterns will depend primarily on information from the environmental description and previous research at the site and in similar sites. Over time more information on component technology will become available from research at the site and will increasingly form the basis for decision making about the component technology levels to be used for the cropping patterns.

5. As the team discusses the component technology to be assigned to the cropping patterns, it will also identify areas of lack of information that need to be studied at the site. This may involve varietal screening, insect, weed or disease control, soil fertility aspect, tillage methods, or the date of establishment of different crops. During the first year it is often useful to do time of planting trials for the important crops at the site over their potential range of planting dates. These trials should be monitored for the occurrence of insects and diseases whose severity is often strongly affected by planting date intervals as narrow as several weeks.

Component technology research is planned with respect to cropping patterns selected for experimentation. It normally addresses only one crop of the pattern sequence and one or two variables at a time, from among variables, such as variety trials, tillage methods and subsequent levels of weed control, or method and rate of nitrogen application, insect control methods - rates. In such trials all other component technology levels and management methods that are not being varied as

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[1/] See information required to design and test for economic criteria, page 36a to 36c, Fourth Cropping Systems Working Group Report.

part of the treatments must be the same as those specified for the same crop in the cropping pattern trials. Limits to seeding dates that apply to that crop in the cropping pattern must be applied to the component technology trials. This is important as it will allow linking of the component technology research results to those of the cropping pattern trials.

During the identification of the component technology research to be conducted at the site for that year or crop cycle, the team may need to adjust the component technology levels assigned to the cropping patterns. This is because much insight is derived from the discussion of component technology research trials.

EXPERIMENTAL DESIGNS

On-farm research in cropping systems now employs three types of experiments: research managed (small plot, replicated) trials, field-sized cropping pattern trials, and superimposed trials. Each of these satisfies different research objectives.

1. Research-managed trials

As discussed before these trials evaluate specific management components to be assigned to cropping patterns. They generally evaluate a wider range of management alternatives which is expressed in an increased number of variables and levels included in the treatments. Research-managed trials seek to understand more precisely the type of responses to input levels and evaluate high risk treatments about which too little information is available to be included in farmers' managed cropping patterns. The results of research-managed trials are analyzed with an emphasis on treatment differences and require considerable precision. These results determine future changes in cropping pattern management levels.

The experimental designs for research-managed trials will not be discussed in detail at this time. They follow the considerations of small plot experimental design on research stations. Because of limited field size, treatment numbers should normally be kept between below 12. The number of replications should be three or more except where multi-location testing is involved in which case within field replications should be reduced to two as long as the total number of replications is four or more. Normally replication should be such that error degrees of freedom is no less than 12.

Research-managed trials can be conducted at research stations if the environment (climate, soils) at the station is the same as that of the landtype or if the purpose is strictly to compare treatment differences and no strong interaction with the environment is expected. In such cases, the site research team requiring the information should encourage research-

ers on the stations to conduct such experiments. These trials should, however, use the same tillage methods and implements and the same component technology (for fixed management) as that used for the corresponding crop in the cropping pattern trials. For factors that are varied, one of the treatment levels must be that used in cropping pattern trials.

2. Cropping pattern trials

These trials compare patterns that differ in crop species or species combinations, the number of crops, their establishment method and time as well as their management. Cropping patterns are evaluated on the basis of their performance in the landtype for which they were designed. They are managed with farmers and in this way partially evaluate the farmers' capability to manage new technology and give feed-back of farmer's views of the technology. This gives opportunities for the identification of conflicts of the pattern with the farmers' resource base. Cropping patterns are tested in large* plots to allow measurement of labor and time required for the operations used in execution of the patterns. This in turn allows precise cost-and-return analysis for the patterns.

For the design of cropping pattern trials, the following general guidelines are suggested:

a. The research team should select 2 to 3 landtypes on which it wants to focus its research.

b. For each landtype the team should select about 3 cropping patterns to be evaluated. For some patterns on some landtypes these patterns may be the same.

c. Each cropping patterns should be replicated in at least 5 fields in total and in at least 4 fields per landtype.

The above research design should be modified as the team acquires more experience in the site. During the first year the number of patterns to be studied may be higher than 3 per landtype, so that the number of replications may need to be reduced to at least 4 in total and at least 3 per landtype. During the second year the number of patterns can be reduced and the number of replications can be increased to at least 5 in total and at least 4 per landtype. During the third year the team should have focused in on the most promising cropping patterns. This will allow them to further increase the number of replications per pattern to at least 6 in total and at least 4 per landtype (Table 3). It is recommended that the research team manage from 40 to 50 cropping pattern fields.

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*Subsequent committee discussions indicated that this site may need to be reduced where field sites are small. For extremely small field sites, operations may need to be measured over several fields to obtain accurate time estimates.

Analysis of cropping pattern trials involves the analysis of agronomic and economic performance of the patterns within the landtypes. To compare pattern performance simple T-tests for significance of difference may be used. By combining patterns in different groups within and across landtypes several comparisons can be made, giving the researcher a feel for the statistical significance of the differences found. Important criteria for evaluation of pattern performance is the size of the variation in yields and economic performance of each of the component crops and the total pattern. A close study of means and standard deviations for these alternative ways of grouping the results of pattern trials provides much insight.

Researchers may be interested in comparing the productivity of the landtypes they have selected. This can be done by evaluating the combined performance of all cropping patterns tested within each of the landtypes. It is probably better to compare the productivity and variance in productivity of the best performing pattern for each landtype as a measure of the cropping potential of that landtype.

An important analysis of cropping patterns is to compare the performance of the same crop in different patterns. The "same crop" in this context means that it is established in the same way and at about the same time in the cropping season, but it can be preceded or followed by a different crop and can thus be part of different cropping patterns. It is useful to pull together the results for each of these crops and compare them. This will allow a more valid comparison of the effect of landtypes and previous crops on the performance of the crop under evaluation.

The major contribution of cropping pattern trials is the in-depth analysis of environment by technology interactions. This analysis requires researchers to associate differences in crop performance with measured site variables, both land and climate related. This will be discussed as part of the Collaborative Cropping Pattern Monitoring project.

3. Superimposed trials for component technology evaluation

Superimposed trials are used to evaluate performance of the component technology assigned to the cropping pattern against alternative formulations while the pattern is managed by farmers. It should also give the team a measure of spatial variability in component technology performance and in the response to inputs when managed by the farmer. The alternative component technology should be over and above that used by the pattern.[2/] At times several alternatives (levels or sources, methods, etc.) may be compared.

[2/] To make the alternative levels lower than that specified for the pattern would require complete research management of the area of the superimposed trials. This aspect should be discussed by the Working Group, but I consider that input levels in the cropping patterns should be sufficiently low (economic considerations) to make lowering these levels not an attractive research design.

The number of superimposed trials and treatment is limited by the number of cropping patterns tested; and as the main objective of the superimposed trials is to evaluate the adequacy of component technology used in the pattern trial, it is felt that these trials should follow a standard format that allows an evaluation of all major management components that involve cash or sizeable labor inputs.

For the design of superimposed trials the following guidelines are suggested:

a. Select 2 to 4 component technology factors that strongly influence the performance of the cropping pattern. In this selection thought should be given to the cost of the component. Of particular interest are components that carry a high cash or labor cost. The factors to be studied can compare a combination of inputs, such as no insect control (P) vs. insect control (consisting of several activities during the crop seasons) (A). They may also compare single action inputs such as the insect control recommended for the pattern (P) vs. the insect control recommended for the pattern + an additional prophylactic control of head worms five days after flowering time (A). The factors of most interest will depend on the crop and pattern involved and on the land qualities considered. Some teams may want to superimpose 2 levels of a single factor, e.g. Nitrogen fertilizer rates because other factors appear less important when considering results of previous research at the site.

b. Identify the pattern level of each of these factors. It is suggested that this level be close to a low input level approximating that normally used by farmers in the region in similar situations, but sufficiently high to guarantee adequate production. For example, in cases where farmers do not use any nitrogen fertilizer on their rice, the cropping pattern level for nitrogen should not be 0, neither should it be 120 kg/ha. In most rainfed situations, depending on soil qualities it should probably be between 40 and 60 kg/ha in the initial cropping pattern trials. In considering this the reader must recall that to achieve superimposition and thereby farmers management of the basic pattern treatment, superimposed treatments often to be over and above that applied in the pattern. To compare the pattern treatment to a lower input treatment may require research management of superimposed trials. In this sense, the check, if included for economic analysis, is to be excluded from the rest of the cropping pattern treatment.

c. Identify the alternative level for the management component selected to be included in the test. Superimposed trials should include treatments comparing the pattern treatment (P) to treatments of a higher level of each of the important components -- weed control, insect control, fertilization, variety (where applicable or possible)* that would approach a prejudged optimum management. In this way additional returns obtained from increasing input levels for each of these factors beyond the cropping

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* Committee discussions and working group reactions indicated that varieties can best be studied in small plot trials at the same time and with the same inputs as the cropping pattern trials.

pattern level can be used as a criteria for considering a future increase in the level of that management component. In the above example, the team might want to evaluate 90 kg/ha of N as an alternative recommendation. Similarly it might want to add an additional prophylactic insect control treatment over and above that specified for the cropping pattern.

Figure 2 shows a proposed field plan for superimposed trials for the first crop and the second crop of a cropping pattern. Table 4 and 5 show the treatments and analysis of variance for the 2-, 3-, 4- and 5-factor designs proposed. These employ a partially replicated design in which the cropping pattern treatment (PPP) is replicated by taking two random yield samples from the pattern trial that are of similar size to those of the superimposed treatment plots. The alternative treatments (AAA), (which would be the highest input treatments) and a random other treatments (not the check) are replicated in the strip of superimposed plots.

Examples of the type of pattern treatments and alternative treatments are provided in Table 6. These treatments have been combined in example treatment desings for some 3-, 4-, and 5-"factor" superimposed trials (Table 7). Trials 2, 3, and 4 of Table 7 include more than one alternative for fertilization, insect control, and weed control.*

Because plot size of on-farm research trials should be larger than that of research station trials (Gomez, 1976), the following plot sizes are suggested:

- For rice (DSR, WSR, or TPR) 4 x 6 m
- For corn 6 x 8 m
- For sorghum 5 x 8 m
- For mungbean, cowpea, soybean 4 x 6 m

These are minimum plot sizes and depending on the size of the field in which the pattern trial is conducted and the special requirements for superimposed treatments (See Litsinger, 1976), these plot sizes may be increased.

For a given site, field sizes tend to be in a defined range and the research team can select their plot size and number of factors to be included in the superimposed trials accordingly.

Analysis of superimposed trials. Replication of some of the superimposed treatments within the field and the replication of trials across at least four cropping patterns allows the estimation of a reasonably pure error term from the analysis of variance (Table 5). This allows an F-test for the treatment x field interaction using the mean square ratio "TF/E". Where this test is significant the superimposed treatments gave different results in one or more of the different fields. Careful

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* These examples include a check treatment, which most working group members and the committee felt should not be recommended.

inspection of field characteristics and results of pattern monitoring may reveal reasons for these differences. At times a field may not belong to the landtype it was thought to fit into. Results from such fields can be recombined with those from other landtypes only if field description or plot monitoring results warrant this. Although strong TxF interactions may indicate that the landtype is poorly defined, most TxF interactions will arise from spatial variations for weed control and fertility factors caused by current or recent management and for insect control caused by differences in pest incidence. Re-evaluation of the definition of the landtype and the ways determinants changed from field to field to cause site differences, may, however, improve the land classification.

Where a significant treatment by field interaction exists and no valid regrouping is evident, the overall effect of treatments, averaged over all fields needs to be evaluated by the F-test: T/TxF. Where treatment by field interaction is not significant, the researcher may combine the TxF and Error sums of squares and their associated degress of freedom for testing the effect of treatments and fields.

The economic analysis of superimposed trials will evaluate returns from the recommended cropping pattern levels (PPP) from the difference in production and costs between PPP and 000. Economic analysis should evaluate the profitability of further increasing input levels for each of the factors studied by comparing the PPP treatments to APP, TAP, TTA, and AAA for the first, second, third, and all three technological components combined. Where farmers' reaction are positive and economic returns are sufficiently stable and above the average returns to cash and labor in the region, researchers should consider increasing the component technology specification for that factor for the crop and pattern studied.

More comprehensive analysis can compare responses of similar crops in different patterns or landtypes and evaluate if the component technology recommendation needs to be different for these or if it can be generalized (which is preferable from an extension point of view).

This design of superimposed trials will lead to an upward optimalization of component technology. It depends strongly on the initial specification of conservative (low) input levels for the pattern trials.

Evaluation of component technology for farmers' cropping pattern

The designs discussed for superimposed trials can be used to evaluate the adequacy of input levels used by farmers on existing cropping patterns. Where this is desired the treatment PPP in Table 4 and Figure 2 becomes the farmers' treatment and the treatment AAA becomes an alternative, higher input treatment. Where available, this treatment can be the "recommended" treatment for the site. Normally, landtype or cropping pattern conditioned recommendations are not available, in which case the research team may need to use site description or site research results

to estimate optimum input levels. These should be higher than those employed by farmers, but must satisfy economic criteria when input costs are evaluated against their probable effect on production (See Fourth Cropping Systems Working Group Report pp. 36a to 36c).

SUMMARY

This paper discusses the design of site related research. It covers the testing of cropping pattern trials and the evaluation of component technology. The use of superimposed trials, in combination with cropping pattern tests is discussed in detail. While a proposal is made for the use of similar designs for such tests, the type of factors to be studied will depend on the characteristics and previous research at the site.

The research design proposed ties cropping pattern trials, on-farm research managed trials, and superimposed trials together. Each type of experiment is used for different purposes, yet their results can be compared due to the commonality of the cropping pattern treatment. The design for superimposed trials allow an upward approximation of the best management package for the pattern, while it discourages the inclusion of input levels that have not been proven to be of benefit.

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Table 1. Insect control for premonsoon greencorn and sorghum after rice for Pangasinan, Crop year 1978-79.

Prophylactic applications	Corrective applications
Premsonsoon Greencorn	
Seed treatment: 2% wt/wt Furadan 50 DB for ants and corn seedling maggot (Caution: Be careful and do not smoke while planting, wash hands frequently).	None
Sorghum	
None	Visit the fields frequently during heading. If 1 corn earworm larva per 2 plants is seen, spray Sevin 85 WP (1.0 kg a.i./ha)

Table 2. Recommended weed control practices for cropping patterns, Pangasinan, 1977-78.

Crop	Weed control methods	Rate (kg ai/ha)	Time of application
Corn (before rice)	Hilling-up, 2 passes	-	3 WAE[a] or just after fertilizer topdressing
Dry seeded rice	Butachlor followed by one hand weeding	2.0	Immediately if soil is moist, or if soil is dry, after germinating rain followed by "as needed"[b]
Wet-seeded rice	Well puddled seedbed. If there is standing water - no weeding; otherwise, spot weeding.	-	As needed
Transplanted rice	Well puddled seedbed. If there is standing water - no weeding; otherwise, spot weeding.	-	As needed
Upland crop			
Field not plowed	Paraquat to be applied if 50% plant cover at time of crop establishment; otherwise, no weed control.	0.75	Prior to furrowing
Field plowed	Mungbeans and cowpeas - no weeding	-	
	Sorghum - interrow cultivation	-	to 4 WAE

a/ WAE - weeks after emergence

b/ Refers to manual weeding or spotweeding as needed

Table 3. Year to year variation in the design of cropping pattern trials reflecting trend towards reduced number of patterns and increased number of replications.

YEAR 1

Land type	Pattern 1	2	3	4	5	6	7	Total
1			3	4	3	4 a/		14
2	3	4	3				3	13
3	3		3		3		3	12
Total	6	4	9	4	6	4	6	39

YEAR 2

Land type	Pattern 1	2	3	4	8	Total
1			4	5	4	13
2	5	4	4			13
3		4	4		4	12
Total	5	8	12	5	8	38

YEAR 3

Land type	Pattern 2	3	4	8	Total
1		4	6	4	14
2	6	4			10
3	6	4		4	14
Total	12	12	6	8	38

a/ Number of replications (fields) of pattern 6 in landtype 1.

Table 4. Proposed treatments for the partially replicated superimposed trial design.

Treatment number	Number of factors[a] 2	3	4	5
1	PP	PPP	PPPP	PPPPP
2	AA	AAA	AAAA	AAAAA
3	OO	OOO	OOOO	OOOOO *
4	PA	PPA	PPPA	PPPPA
5	AP	PAP	PPAP	PPPAP
6	PP	APP	PAPP	PPAPP
7	AA	PPP	APPP	PAPPP
8	AP[c]	AAA	PPPP	APPPP
9		PPA[c]	AAAA	PPPPP [b]
10			PPAP[c]	AAAAA
11				PAPPP[c]

[a] Can be factors (f) or levels (l) so that $N = \sum_i f_i \times l_i$

[b] Treatments below this line are replicated

[c] Randomly selected treatment, excluding treatments 1, 2, and 3.

* Committee and working group discussions indicated that the inclusion of this check treatment is not generally desirable.

Table 5. Analysis of variance of proposed superimposed trials, assuming four and five replications (Fields) of the cropping pattern trial.

Source	Degrees of freedom				Mean square
	2-factor	3-factor	4-factor	5-factor	
	Analysis of variance table for 4 replications				
Total	32	36	40	44	
Mean	1	1	1	1	
Fields (F)	3	3	3	3	F
Treatments (T)	4	5	6	7	T
T x F	12	15	18	21	TF
Error	12	12	12	12	E
	Analysis of variance table for 5 replications				
Total	40	45	50	55	
Mean	1	1	1	1	
Fields	4	4	4	4	F
Treatments (T)	4	5	6	7	T
T x F	16	20	24	28	TF
Error	15	15	15	15	E

Table 6. Examples of treatments (factors) for inclusion in superimposed trials.

Factor	Level for that factor (all others = P	
	P	A[a]
1. Insect control (sorghum after rice)	None	Complete (2 actions)
2. Insect control (DSR rice bug)	None	Spray Sevin 85 WP at 5 DAF[b] (0.75 kg a.i./ha)
3. Insect control (DSR)	0.5-kg a.i./ha BARADAN 3G basal in furrows	P3 + Sevin at 5 DAF
4. Fertility (DSR)[c]	30-30-0 basal 30-0-0 PI	30-30-0 basal 60-0-0 PI
5. Fertility (DSR)	30-30-30 basal 60-0-0 PI	30-30-0 basal 90-0-0 PI
6. Fertility (DSR)	30-30-0 basal 30-0-0 PI	30-30-30 basal 60-0-0 PI
7. Fertility (DSR)	30-30-0 basal 30-0-0 PI	30-30-30 basal 30-0-0 PI
8. Weed control (DSR)	1 handweeding	Butachlor 2 kg a.i./ha + 1 handweeding
9. Weed control (DSR)	1 handweeding	Butachlor + interrow cult. + 1 handweeding
10. Weed control (DSR)	1 handweeding	Interrow cult. + 1 handweeding
11. Weed con-rol (DSR)	Butachlor + 1 handweeding	Butachlor + 1 hand-weeding + 1 spotweeding

[a] Alternative treatments must be such that they can be obtained by applying additional inputs (during additional operations if need be) to those applied to the pattern treatment (P).

[b] Days after flowering

[c] Seeded in dry or moist soil or "dry seeded rice"

Table 7. Examples of superimposed treatment designs for a dry seeded rice crop using treatments listed in Table 6.

Trial no.		Factor 1	2	3	4	5
1	Pattern treatment	P1	P4	P8[a/]		
	Alterantive levels	A1	A6	A8	b/	
2	Pattern treatment	P3	P4	P11	P4	
	Alternative levels	A3	A4	A11	A5	c/
3	Pattern treatment	P2	P2	P2	P4	P4
	Alternative levels	A2	P3	A3	A4	P5[d/]
4	Pattern treatment	P3	A4	P8	P8	P8
	Alternative levels	A3	A5	A8	A10	A9[e/]

a/ P8 refers to column P and row 8 in Table 6.

b/ This is a simple 3-"factor" trial that evaluates increased inputs in Insecticides. Nitrogen (additional 30 kg N/ha at PI) and weed control (use of herbicide).

c/ Factor 4 in this trial compares an additional fertilization alternative

d/ This trial compares the pattern management against three insect control alternatives and two fertilization alternatives

e/ This trial already has a high input level for the pattern. It evaluates further additions to insect control (1 alternative), fertility (1 alternative) and weed control (3 alternatives in factorial combination with pattern level).

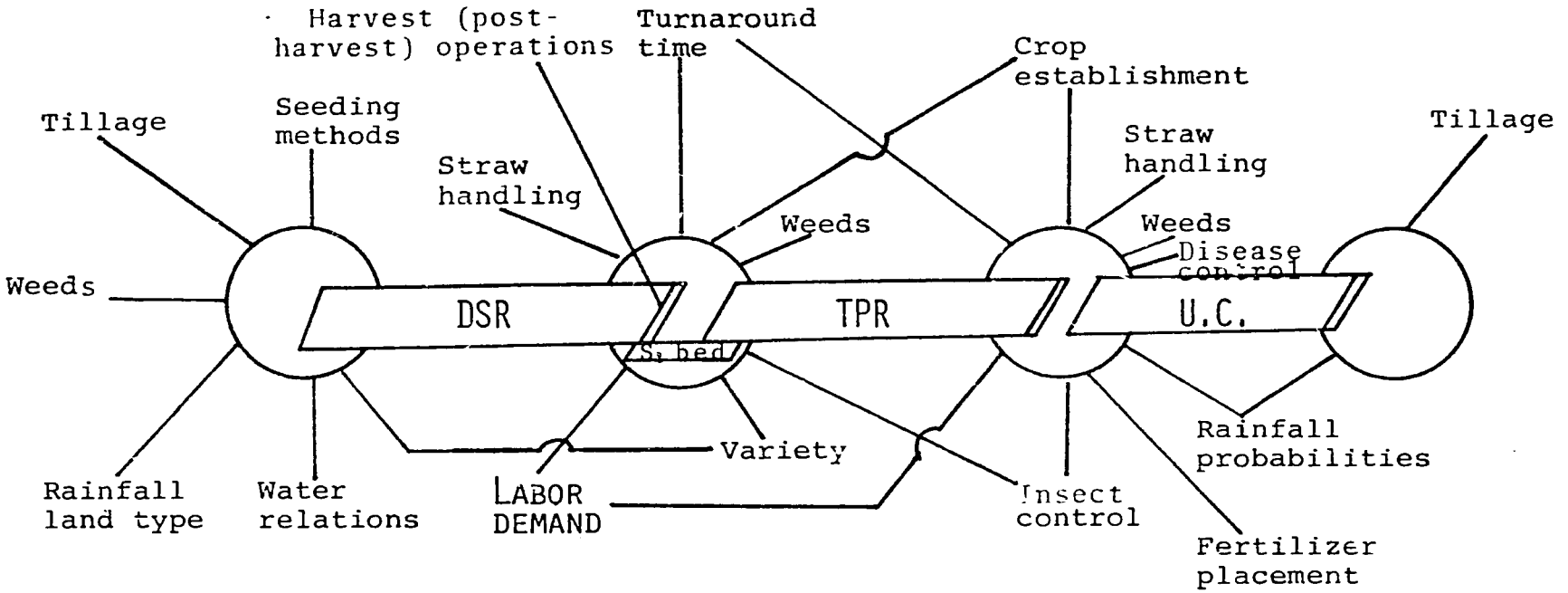

Figure 1. To assign component technology to a pattern requires a careful selection from many alternatives.

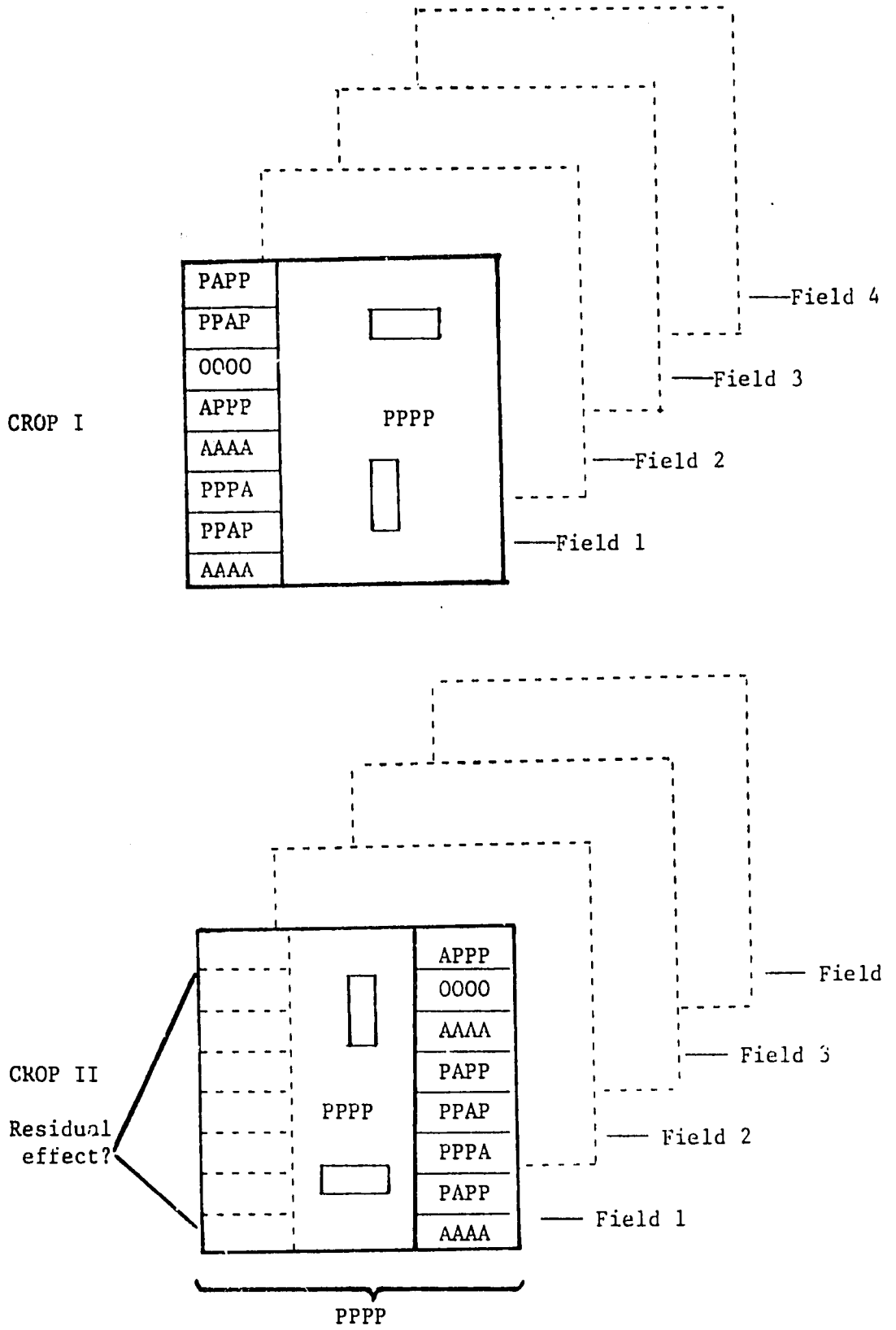

Figure 2. Proposed partially replicated design of superimposed trials for use in the evaluation of component technology used in cropping pattern trials. Example of 4-factor trial.