IDENTIFICACTION OF CONSTRAINTS TO RICE PRODUCTION AND THE DEVELOPMENT OF AN INTEGRATED CROP MANAGEMENT PROGRAM*

R.S. Zeigler**
G. Weber
E. Pulver

To address the rice needs of the region from both the farmer's perspective and that of the consumer, the Caribbean Rice Research Network must focus on rice productivity as well as total production. The objectives of the individual national programs should be to develop research and extension activities that will result in increases in production and/or productivity. Clearly, in order to do this a basic understanding of production contraints and limitations is essential. Furthermore, the problems must be ranked in order of importance and separated according to whether or not existing technology can be applied and whether or not the problems are researchable. Before discussing the points, however, it is useful to discuss in more detail the kinds of approach that can be taken to achieve increased rice production and productivity.

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** Pathologist and Program Leader; Entomologist; Agronomist; respectively. Rice Program, CIAT, A.A. 6713, Cali, Colombia.

INCREASE PRODUCTION

Yield Increase.

Yields may be improved by concentrating on the varietal component and/or on the management component of the rice production system.

Varietal Component. Historically the varietal component of rice cropping systems has received the most attention. In the Caribbean it is estimated that 81% of the area planted to rice is planted to improved, modern semi-dwarf varieties (Table 1). These varieties have a high yield potential when grown under adequate and appropriate management. Considering that yields are generally still quite low in most of the region (Table 2), little increase in production can be expected from continued conversion of traditional varieties to modern varieties. However, improving the adaptation of varieties to biotic and abiotic constraints may contribute to some yield increases, where varietal tolerance is applicable.

Management Component. Recognizing that modern varieties are not expressing their potential suggests that modifying the conditions under which they are grown could greatly increase yields. The particular management contraints that are most commonly encountered in this region are inadequate seed bed preparation, water management, and weed control. These are in many ways closely inter-related. No variety can be expected to yield well when it is subjected to periodic and severe drought stress and it is competing with high weed populations.

Increase Production Area

Rice production can be increased by increasing the area under rice cultivation. However, this would not appear to be an attractive strategy if the current yields are to be expected from new lands. A more appropriate strategy would be to correct the deficiencies in the current system to take advantage of the considerable investments in infrastructure already made. Only following this, should the incporation of new land into rice production be persued. Houwever, many countries in the region have little additional land suitable for rice production.

Many potential new rice areas in the Caribbean are not in production for a reason, such as saline or organic soils. These areas will therefore require specific research programs, both at the varietal and management level, as pointed out in other papers presented at this workshop. Some salt tolerance will be required in lines for these new areas. Furthermore specific soil amendments, such as zinc, or sulfer, will be required, and specific water management to "wash" soils may also be necessary.

INCREASE PRODUCTIVITY

If we assume stable yields, the only way to increase productivity of rice farmers is to reduce their costs. Cost reduction may be achieved, again from a varietal perspective and/or a management perspective. In some cases high productivity may encourage farmers to enter the rice sector, thereby increasing production.

Varietal component. The potential in productivity increase are essentially limited to incorporating tolerance to biotic and abiotic factors which farmers are attempting to control via inputs. The most common examples of these are insects and pathogens. Varieties with insect and disease resistance could improve farmer productivity by eliminating the need for costly chemical applications.

Management component. This is by far the most fruitful course to follow when attempting to increase productivity. Cost reduction per ton can be achieved by good land preparation which leads to more efficient water use. This also permits better weed control at less cost per hectare, since less herbicide is required. Timely application of herbicides may also reduce costs and increase yields. Rational use of pesticides and fungicides based on monitoring of insect and disease levels in the field, rather than on "calendar" schedules for application, also can reduce costs considerably in some countries. Appropriate machinery which permits good land preparation and timely chemical application at a reasonable cost can also contribute to cost reduction and reduce expensive constraints of labour availability and costs.

With increasing yields, of course, productivity will also increase if costs remain stable. Productivity will also increase if yields decline at a lower rate than costs. While perhaps acceptable to the producer, to consumers and government policy makers this is not acceptable. Given the current regional deficit, when we consider productivity it is within the control of stable or increasing yields.

The Concept of Integrated Crop Management (ICM)

From the forgoing discussion it is apparent that varietal, abiotic and biotic management activities are interdependent and can rarely be expected to contribute substantially on an individual basis. For example, improved weed control practices will contribute most when accompanied with better water mangement. A cold tolerant or early variety probably will not yield any better than existing lines if subjected to severe drought stress. Therefore, the CIAT Rice Program has came to the conclusion that further increases in rice production will come from exploiting the already high yield potential of modern varieties through improved management practices. Improved productivity will result from reduced production costs per ton following a critical appraisal of actual constraints and alternative technologies.

Development of ICM Strategy

1. Initial Analysis of Production

In order to rationally develop a research strategy priorities must be assigned to the almost limitless research possibilities that confront any imaginative agricultural scientist. In order to assign priorities, perhaps the most direct method is to undertake an analysis of the actual production system to identify constraints. First, current farmer practices must be described and variability among farmers noted. This may be accomplish via questionaries designed to elicit information on land preparation, seeding rates, water management, weed and pest control, etc. At this stage the breakdown of production costs for the various practices permits the researchers to asses the relative contribution of the practices with respect to their impact on total production costs (i.e, which areas offer the greatest potential return on investment of scarce research resources).

Identification of Constraints

The actual farmer practices combined with the costs will provide insight into what constraints to production are, or are perceived to be by farmers. For example, frequent and costly applications of insecticides or herbicides indicate that insects and weeds are perceived to be a problem and excessive costs for land preparation or chronic late harvest indicate that appropriate machinery may be limiting. The constraints must be arranged in order of their priority. Priority is easily set in most cases by the proportion of the cost of production involved in attempting to neutralize the various constraints.

The key to successful implementation of constraint identification is that those problems identified for further work be researchable, or already be solvable using existing technology, using the resources available to the national research program. Generally, only a few selected problems will be addressed at one time. These components, can be assembled with existing acceptable practices to develop a management plan to evaluate alternatives and arrive at recommendations.

In the case where existing technology is available (as in weed control) the methodology should be evaluated on station to develop the general range of effectiveness, within which local adaptation will be realized. Similarly where existing technology is not adequate, new technology must be developed on station. Confirmative evaluation of the various components must be conducted under farmers conditions before the practices can be incorporated into a general management package. A summary of this scheme is presented in Figure 1.

An important point is that each component of a management package is based upon a clearly identified constraint. Furthermore, the demostration of the package, with various modifications, must be done in farmer fields in very large plots (> 1 ha) to be relevant, ideally involving extension personnel. Finally the idea that each part of the package depends on the others if key.

An example of this process as it is being carried out today by the Federation of Rice Growers in Colombia is a useful example.

<u>The Colombian Experience</u>

In 1985 the initial surveys and cost analysis were carried out. Table 3 summarizes some of the results in a very general form. This table illustrates how priorities can be set and research strategies be defined.

First, land rental is very high (~US$433/ha) and contributes 30% to the excessive production costs. However, this problem is not researchable and is more of a government policy consideration. Therefore, although of not inmediate concern to the researcher, policy makers should be made ware of such a situation.

Fertilizers account for only 4.6% of production costs. There is existing technology to improve practices and this component is researchable. However, looking at the return on investment of scarce program resources, a large impact of 50% reduction in fertilizer use would reduce costs by only 2.3%. This probably does not justify a heavy investment of resources.

Seed costs are vey high, accounting for 11.8% of production costs. According to farmers the extremely high seeding rates are because of inadequate weed control, seeding practices and bad land preparation. Thus, combining the seeding costs with weed control costs, 19.6% of the total production costs are accounted for. Clearly, a major impact on these practices would impact on total costs as a whole and, therefore productivity. Obviously more adequate weed control would also have a positive impact on production - permiting high yielding potential to be exploited.

Insect control accounts for only 7.8% of the costs. However, we see that farmers are applying insecticides six times over a cropping cycle. This is environmentally unsound, costly, and probably dangerous to workers and, possibly, consumers. Additionally the risk of hoja blanca outbreaks may be increased. Farmers reported that they apply insecticides on a regular basis as "preventive" measures with no consideration of economic damage levels or the presence of beneficial insects. Clearly this is an area that merits research. Not only from the point of view of reducing costs to the farmers, but to the country as well since these chemicals are quite expensive and imported as well.

The priorities set using this reasoning and the strategies to address then are presented in Table 4 and were used to develop a management/research plan. Seeding rates and adequate weed control were approached as one problem. That is, by controlling weeds it is easily shown that seeding rates of 100-150 kg give yields equal to or superior to 250 kg. Furthermore, abundant data existed already within the FEDEARROZ technical division and ICA that demonstrates that timely and correct application of any number of products can reduce weed populations to below economic levels. Thus a weed management/seeding recommendation was assembled using existing data. These, combined with recommendation for adequate seedbed preparation were installed as demonstration plots this year in Colombia.

The insect control strategy required a much more direct research input. The decision was made to develop an integrated pest mangement approach. That is, pest control ultimately should depend upon varietal tolerance, in-field biological control by predators and parasites and well targeted chemical control only when insect pest populations approach economic thresholds.

The development of an IPM strategy required first that the pests the farmers were trying to control be identified. Secondly, the economic thresholds had to be determined for the various growth stages. Thirdly, a sampling method had to be developed to adequately measure true pest populations, while taking into consideration the benefical insects present. Finally, insecticides needed to be compared to select those which target only the pest and disrupt the natural system as little as possible. This process is well underway, and some components are being tested under production conditions.

Implications for the Caribbean Rice Research Network

It is noteworthy that for the Caribbean countries little data is available that is useful in this type of analysis. For example over 30 different commercial pesticides for rice are available in the Dominican Republic. Are insects a problem, or is insecticide use a problem? Table 5 indicates how pesticide applications can disrupt the field populations and insect transmitted virus levels when chemicals are used indescriminately.

Approximately 30% of the rice area in the Dominican Republic is subjected to chemical control of rice blast (F. Cuevas, personal communication). Is rice blast a problem? If so is blast susceptibility evaluation a dynamic part of the selection and evaluation procedure in the Dominican Republic? If not why not? It is estimated that "modern" farmers are using four applications of insecticides in the Dominican Republic (Medina and Cuevas P., 1986). Has this stimulated research on insect pests or on the rational behind the insecticide applications? If not, why not?

CONCLUSIONS

In order to fully exploit the yield potential of modern varieties to help satisfy the food needs of the Caribbean nations, rice cropping research should be conducted withing the context of an integrated crop management approach. The development of research priorities should be based on data on production practices and production costs. These data are lacking for most of the countries of the region.

The Caribbean Rice Network should coordinate the assembly of this kind of data and assist the individual countries in identifying their constraints, since many will be in common.

However, there are some very preliminary data available which are presented in Table 6. For example, in the Dominican Republic and Surinam crop protection costs are high and probably merit research, while this is not the case for Guyana. For all countries fertilization costs are around 20% or more of production costs and, contrary to our experience in Colombia, fertilizer application probably deserves attention in the Caribbean. High land preparation and harvesting costs indicate that more appropriate machinery should be investigated as a solution.

Research responsibilities can be devided among cooperating countries and/or institutions to maximize resources and investments. Addressing the present constraints of areas already under production should have priority over research on potential constraints for currently unexploited areas. Expertise on appropriate machinery should be obtained from IRRI and Southern Brazil while resistance on agronomic practices and integrated pest management can be obtained from CIAT. Germplasm of course can be obtained from both IRRI and CIAT. Evaluation

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TABLE 1. Percent of area planted in high yielding semi-dwarfs, improved talls and traditional varieties in the Caribbean area. 1/

Country	Type of variety		
	Semi-dwarf	Improved talls	Traditional
		%	
Cuba	100	0	0
Dominican Republic	84	0	16
Guyana	58	32	10
Surinam	100	0	0
Haiti	30	70	0
Trinidad/Tobago	67	22	11
Belize	79	21	0
Jamaica	100	0	0
Average	81	13	6

1/ Source: Information provided by Rice Program Leaders during the Sixth International Rice Conference for Latin America and the Caribbean held at CIAT in August, 1985.

TABLE 2. Area planted, production, yield and consumption of rice in the Caribbean region. 1985.

Country	Area ha x 10^3	Production 1/ t x 10^3	Yield t/ha	Consumption 1/ kg/capita
Cuba	135	500	3.7	84
Dominican Republic	107	450	4.2	81
Guyana	97	297	3.1	153
Surinam	50	200	4.0	100
Haiti	50	110	2.2	25
Trinidad/Tobago	10	22	2.2	55
Belize	3	8	2.7	54
Jamaica	0.5	1.4	2.8	38
TOTAL	452.5	1588.4		

1/ In terms of paddy rice.

Source: Information provided by Rice Program Leaders during the Sixth International Rice Conference for Latin America and the Caribbean held at CIAT in August, 1985.

TABLE 3. General summary of some component of rice production costs in Tolima Valley, Colombia.

	No. Applications	Cost US$/ha	% Total Cost
Land	-	433.0	29.7
Seed.	1 (250 kg/ha)	172.0	11.8
Fertilizer	2	51.8	4.6
Weed control	2	112.9	7.8
Insect control	6	113.0	7.8
TOTAL		1456.0	100.0

FROM: CIAT Annual Report, Rice Program, 1985.

TABLE 4. Research priorities and strategies for the identified constraints in the Tolima Valley, Colombia.

	Priorities	Strategy
Seeding rates	High	Use existing technologies
Weed control	High	
Insect control	High	Research integrated pest management
Fertilizer	Low	No action yet
Land costs	Low	Refer to policy makers

TABLE 5. Relation between *S. oryzicola*, predacious spiders and hoja blanca (HBV) in commercial fields in Ecuador, which differed in intensity of insecticides applications.

Field No.	Number in 10 double net sweeps		Tillers with HB (%)	Number of insecticide applications in the farm
	S. oryzicola	Spiders		
1	20	0	75	8–12
2	43	0.5	41	6–8
3	21	5	35	6–8
4	4	11	6	2–8
5	1	9	3	1–2
6	2	14	1	0–1
7	0	12	1	0–1
8	0	20	1	0–1

Source: CIAT, Annual Report, 1985.

TABLE 6. Comparative costs for land preparation, planting, crop protection, fertilization, irrigation and harvesting in 5 Caribbean countries.

Operation	COUNTRY									
	Dominican Republic		Guyana		Surinam		Haiti		Jamaica	
	USD/ha	%	USD/ha	%	USD/ha	%	USD/ha	%	USD/ha	%
Land preparation	124	25.3	65	30.2	90	18.9	218	34.0	106	32.7
Planting	82	16.7	23	10.7	53	11.1	92	14.3	24	7.4
Crop protection	120	24.5	30	14.0	109	22.9	91	14.2	50	15.4
Fertilization	95	19.4	47	21.9	79	16.6	95	14.8	65	20.1
Irrigation	15	3.1	-	-	63	13.2	13	2.0	42	13.0
Harvesting	54	11.0	50	23.2	83	17.4	132	20.6	37	11.4
Subtotal	490		215		477		641		324	
Paddy price USD/t	173		142		132		311		270	

Source: Information provided by Rice Program Leaders during the Sixth International Rice conference for Latin America and the Caribbean held at CIAT in August, 1985.

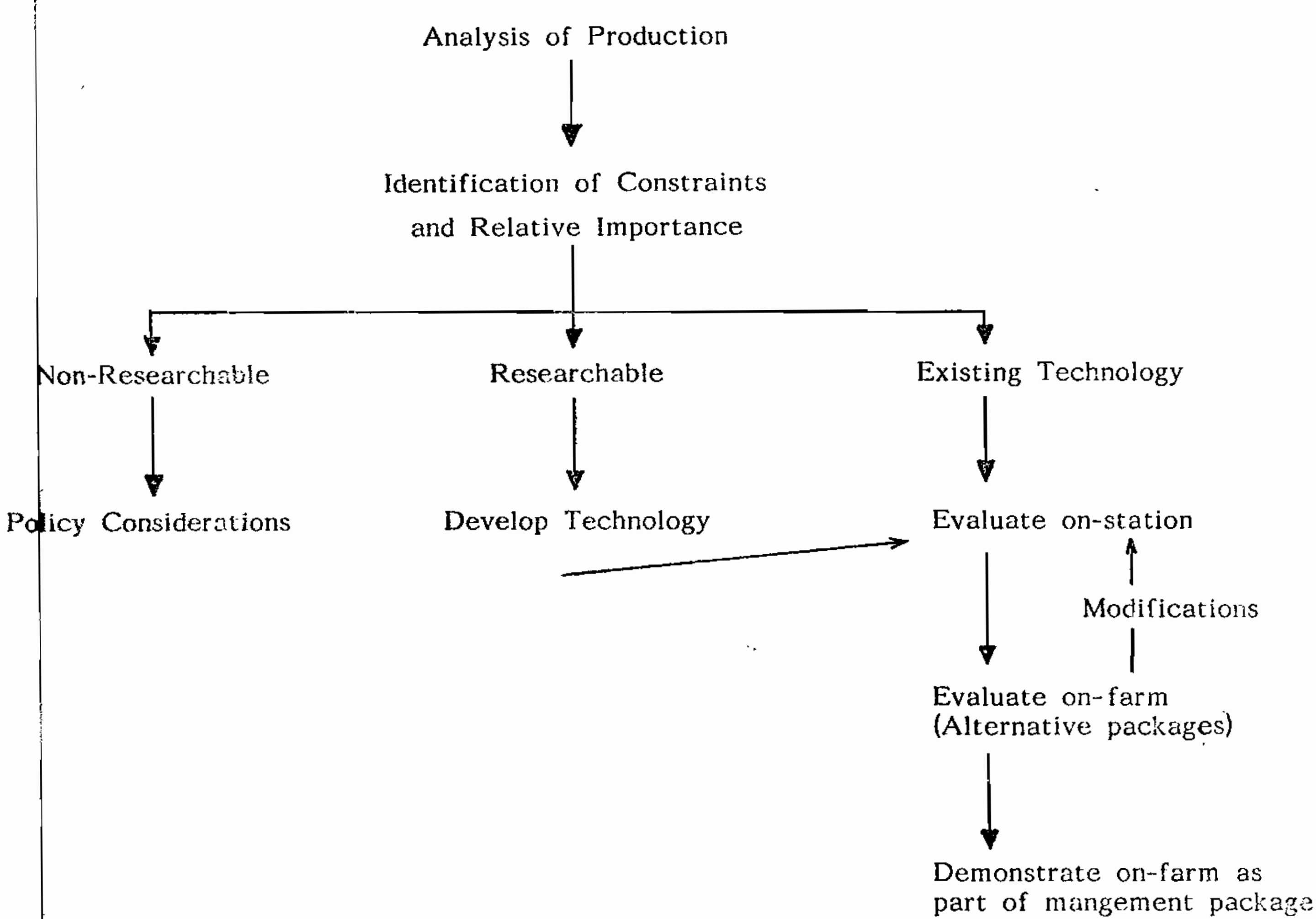

FIGURE 1. Development of components of integrated crop mangement package.