AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY: Food production and nutrition — AF00-0150-G635

B. SECONDARY: Plant production--Rice--India

2. TITLE AND SUBTITLE

Barriers to increased rice production in eastern India

3. AUTHOR(S)

Barker, Randolph; Pal, T. K.

4. DOCUMENT DATE: 1979

5. NUMBER OF PAGES: 24p.

6. ARC NUMBER: ARC IN633.18.B255

7. REFERENCE ORGANIZATION NAME AND ADDRESS

IRRI

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(In IRRI res. paper ser. no. 25)

9. ABSTRACT

10. CONTROL NUMBER

PN-AAG-697

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Rice
Yield
Varieties
Production
Technological change
Cropping patterns
Water management
India

13. PROJECT NUMBER

14. CONTRACT NUMBER

AID/ta-G-1074 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

IN
633.18
B255

IRRI RESEARCH PAPER SERIES
Number 25 March 1979

BARRIERS TO INCREASED RICE PRODUCTION IN EASTERN INDIA

Randolph Barker and T. K. Pal

The International Rice Research Institute
P.O. Box 933, Manila, Philippines

BARRIERS TO INCREASED RICE PRODUCTION IN EASTERN INDIA[1/]

ABSTRACT

This paper covers some of the factors limiting an increase in rice production in eastern India, an area where the new rice technology has not been widely adopted. Physical environment, lack of suitable technology, and socioeconomic constraints all appear as important factors explaining the persistent low yields.

Yields can be raised by either improving water control or by developing varieties of rice tolerant of the prevailing floods and droughts. Neither strategy offers a quick solution, but both should be pursued vigorously, which will require the collaboration of biological and social scientists.

[1/] By Randolph Barker and T. K. Pal, agricultural economists, The International Rice Research Institute, Los Baños, Philippines and Central Rice Research Institute, Cuttack, India, respectively. The background information for this paper was obtained during a 2-week trip in India in September 1977, after which a joint Government of India-IRRI team prepared a report for the Government of India on strategies to raise rice production in eastern India. Submitted to the IRRI Research Paper Series Committee June 1978.

BARRIERS TO INCREASED RICE PRODUCTION IN EASTERN INDIA

The new rice technology has, to a large degree, bypassed the rice growing regions of eastern India. Yields have risen significantly during the past decade in northern India and neighboring Pakistan, and in southern India and neighboring Sri Lanka. But in eastern India and Bangladesh, there has been no upward trend (Fig. 1).

We focus on three states of eastern India -- Bihar, West Bengal, and Orissa -- which account for 40% of India's rice area and 34% of its total rice production. These states are compared with rice producing states in northern and southern India in Table 1. The contrast is striking. For example, while the three eastern states account for 40% of the total rice area and the four southern states 20%, they each produce about one-third of India's total rice. The reasons are not difficult to identify. Yields of rice in the southern area are nearly double those in the eastern states. The higher yields are associated with a higher level of adoption of modern semidwarf varieties, fertilizer input, and irrigation, all of which are highly complementary. While these observations suggest some of the contributing factors to low yield, they do not tell us why yields have remained low in eastern India.

Factors that prevent farmers from achieving high yield can be classified into two categories:

- those that affect the potential of the crop in the farmers' environment, and
- those that affect the farmers' ability and willingness to achieve the yield potential on his own farm.

The first set of factors determines the potential of the technology, while the second relates to the capacity of the farming system to realize the potential of the technology. There is a tendency for observers to believe that low yields in eastern India are due to one of the above. Biological scientists, for example, are often inclined to feel that the fault somehow is with the farmer or the institutional system and not with the technology. Social scientists, on the other hand, are often quick to suggest that the technology developed under experiment station conditions is not *appropriate* for the farmers' environment.

Many who are convinced that the technology is available but not being properly applied argue that the solution lies in expanding extension efforts. However, there are others who argue that the variance in response among farmers is due to institutional constraints which affect some farmers, particularly the small ones and the tenants, more seriously than others. A recurring theme of the

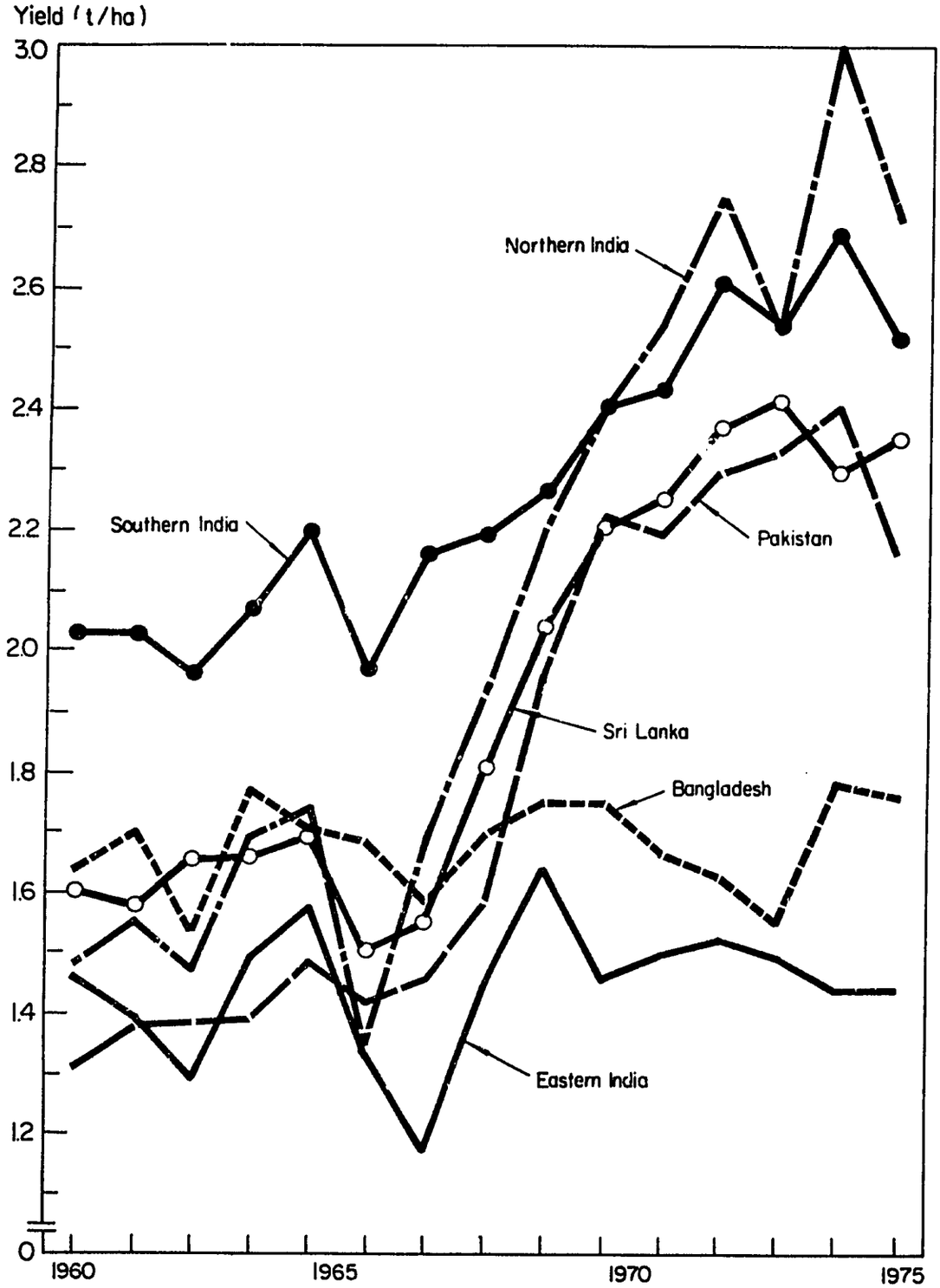

Fig. 1. Rice yield trends in 3 regions of India, Bangladesh, Pakistan, and Sri Lanka, 1960-61 to 1974-75.

Asian Development Bank's Second Asian Agricultural Survey is that institutional constraints, not lack of technology, are now the major factor slowing the rate of agricultural and economic development in Asia (Asian Development Bank 1978).

The problem is more complex than is often recognized. Different constraints may prevail in different situations at different times. In the following discussion, we emphasize that there is no simple and quick solution for increasing rice yields and production in eastern India.

PHYSICAL ENVIRONMENT AND YIELD POTENTIAL

A detailed classification of the rice environment would include factors such as soil type, water conditions, topography, climate, biotic characteristics, and socioeconomic conditions. In this report, we emphasize water control, topography, and temperature.

Table 1. Statistics for selected states[a/] of India, 1974.

	Northern India	Southern India	Eastern India
Total rice area (%)	2	21	40
Total rice production (%)	3	33	34
Rice irrigated (1970) (%)	89	84	29
Area in modern varieties (%)	71	62	12
Fertilizer (kg NPK/ha)	28	28	10
Yield paddy (t/ha)	3.0	2.6	1.4
Area in rice (000 ha)	9000	7900	15,100
Total production (000 t)	2700	20,540	21,140

[a/] Northern India: Punjab, Haryana, Jammu, and Kashmir; Southern India India: Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu; Eastern India: Bihar, West Bengal, and Orissa.

The 15.1 million hectares of rice in eastern India have been classified by water regime as follows:

- *irrigated rice* - when water from canals, pumps, storage tanks, etc. is added to the field;
- *upland unbunded rice* - when rice is grown on flat land, terraces or slopes without impoundment of water;
- *deepwater rice* - mostly broadcast-seeded fields, usually unbunded, with a water depth exceeding 100 cm from tillering to flowering.

The remaining rice area is termed *rainfed rice* and can be divided into three categories by water depth:

- *shallow rainfed* - (0 to 20 cm maximum water depth),
- *intermediate rainfed* - (21 to 50 cm depth), and
- *semideep rainfed* - (51 to 100 cm depth).

These water depths relate to the rice plant type. Modern semidwarf varieties can withstand water as deep as 20 cm, although they may not perform well in stagnant water. A few modern varieties of medium height (e.g. Pankaj and Mahsuri) may withstand water depths to 50 cm. Traditional tall varieties survive in water 1 m deep. Floating rices are grown where water depth exceeds 1 m.

It is presumptuous to assume that we can accurately determine the amount of rice grown under each water environment. Nevertheless, rough indications are useful, and the definition by water depth helps prevent confusion in terms. About 2/3 of the total rice area can be classified as either irrigated or shallow rainfed (Table 2). However, only a small portion of the area where modern varieties can survive is currently planted to modern varieties; the major portion is planted to traditional, photoperiod-sensitive varieties.

The topographic sequence in rice culture can be divided into the following land categories:

- Knolls - small hilly areas that can be easily drained, but cannot accumulate water
- High plateaus - flat areas with deep water tables
- Side slopes - terraces that can accumulate water and can be drained easily
- Low plains - include floodplains that have a high water table and generally poor surface drainage
- Drainageways - intermittent waterways and swamps that flood during the wet season.

The lowland plains and river floodplains probably account for half to two-thirds of the total rainfed rice area. Flooding and stagnant water are the

Table 2. Rice areas (million ha) in Bihar, West Bengal, and Orissa, by specified characteristics, 1977.

Type of culture	Variety grown		
	Photoperiod sensitive	Photoperiod insensitive	Total
Irrigated			
Wet	2.0	1.0 (modern)	3.0
Dry	-	1.0 (modern)	1.0
Upland (unbunded)	-	1.5	1.5
Rainfed			
Shallow (0-20 cm)	3.5	2.0	5.5
Intermediate (21-50 cm)	2.0	-	2.0
Semideep (51-100 cm)	1.0	-	1.0
Deepwater (100 + cm)	1.0	-	1.0
Total	9.5	5.5	15.0

most serious problems in these areas. On the terraced slopes, drought is the major problem, on plateaus, it is either drought or waterlogging.

Lenka shows how the general classifications above can be used to define rice culture in Orissa State (Fig. 2 and Table 3).[2/] After the monsoon starts, side slopes and low plains flood to different depths, with duration determining the suitability of varieties in terms of growth duration. Upland terraces and plateaus never flood and shorter duration varieties are grown there to *escape* drought. The farming practices and research requirements for the two broad areas appear to be extremely different. Flooding is the major problem in the lowlands and drought on the terraces and plateaus.

The Orissa coastal plain and southern parts of West Bengal are tropical-subtropical regions where it is possible to grow rice crops in any of the three seasons (aus, aman, and boro) provided there is water control, but where stagnant water and flooding present a serious problem.[3/] The terraces and plateaus of the Chotanagpur hilly region, covering parts of all three

---

[2/] Personal communication with D. Lenka, Department of Agronomy, Orissa University of Agriculture and Technology, 1977.

[3/] *Aus* is wet-season grown from June to September, *aman* is wet-season grown from mid-July to December, *boro* is dry-season grown from January to May.

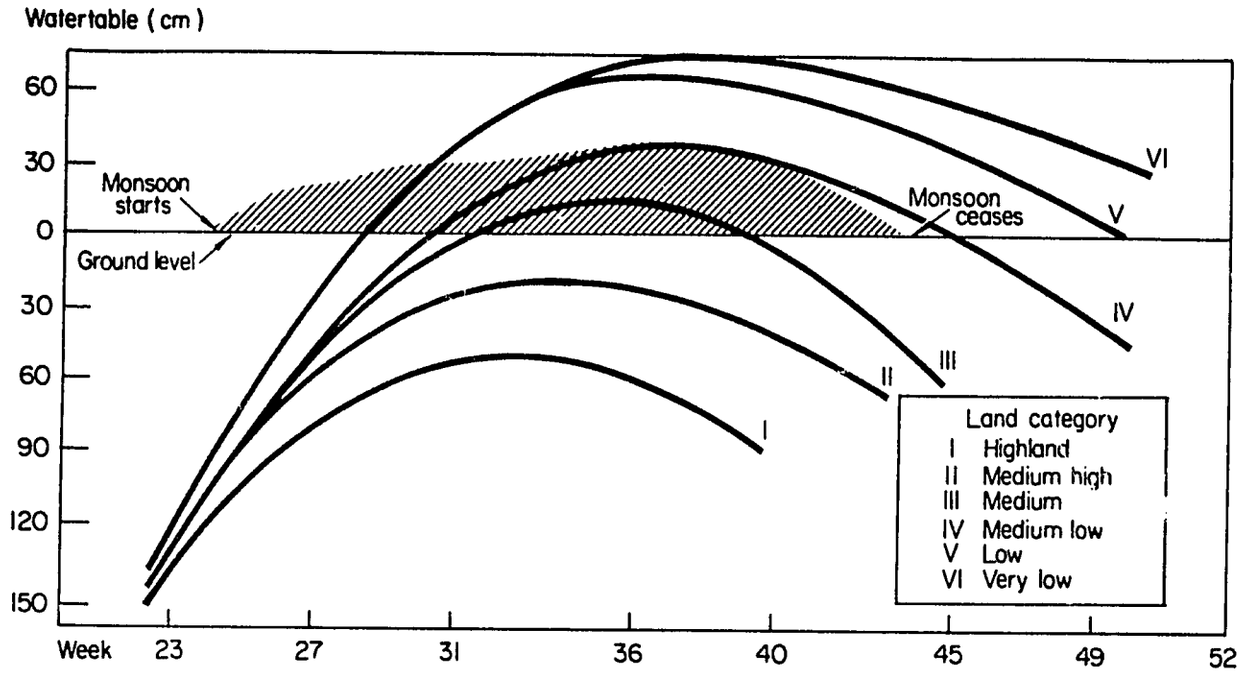

Fig. 2. Variation of water table in rice field of Orissa (Source: D. Lenka, Department of Agronomy, Orissa University of Agriculture and Technology, 1977).

Table 3. Land category and rice culture in Orissa.

Group	Land category	Rice Area (%)	Duration	Period of Sowing	Panicle initiation	Flowering	Ripening
I	Highland	15	85-105	10 June to 25 June	15 July to 25 July	10 Aug. to 25 Aug.	10 Sept. to 30 Sept.
II	Medium high	20	105-120	10 June to 25 June	25 July to 10 Aug.	25 Aug. to 10 Sept.	22 Sept. to 10 Oct.
III	Medium	27	120-135	8 June to 20 June	10 Aug. to 25 Aug.	10 Sept. to 25 Sept.	10 Oct. to 25 Oct.
IV	Low medium	23	135-150	6 June to 14 June	10 Sept. to 25 Sept.	20 Oct. to 5 Nov.	10 Nov. to 20 Nov.
V	Low	12	150-165	4 June to 14 June	20 Sept. to 5 Oct.	20 Oct. to 5 Nov.	20 Nov. to 5 Dec.
VI	Very low	3	> 165	4 June to 12 June	30 Sept. to 15 Oct.	30 Oct. to 15 Nov.	30 Nov. to 20 Dec.

Source: D. Lenka, Department of Agronomy, Orissa University of Agriculture and Technology, 1977.

states, present another set of conditions. The highly acid reddish brown soils are generally sandy with low water-holding capacity. Drought is the major problem in these areas.

In addition to the distinction in rice culture based on water control and elevation, one must consider climatic changes that affect production possibilities. In the districts of northern Bengal and northern Bihar, the dry season temperature drops to as low as 14-23 °C preventing the growth of a dry season rice crop. In the lowlands, one finds rice-jute cultivation and on the slightly higher, better drained land, rice in combination with other cereal grain crops, such as wheat, corn, or millets.

In summary, we divide the eastern states into three broad regions based on agricultural conditions and rice-based cropping patterns:

1. lowland rice and rice-jute areas,

2. rice-wheat areas of northern Bihar and West Bengal, and

3. terraces and plateaus.

The most rapid growth in agricultural production during the past decade was experienced in the rice-wheat area, principally because of the expansion of wheat area and rapid increase in wheat yields (Fig. 3). There are now 2.5 million ha of wheat in Bihar and West Bengal, an almost threefold increase in 10 years. Rice production, on the other hand, has made little headway, particularly in North Bihar where rapid flooding rules out the use of modern dwarf varieties in the nonirrigated areas, and where poor control of canal irrigation in the wet season can result in excessive silting in farm fields.

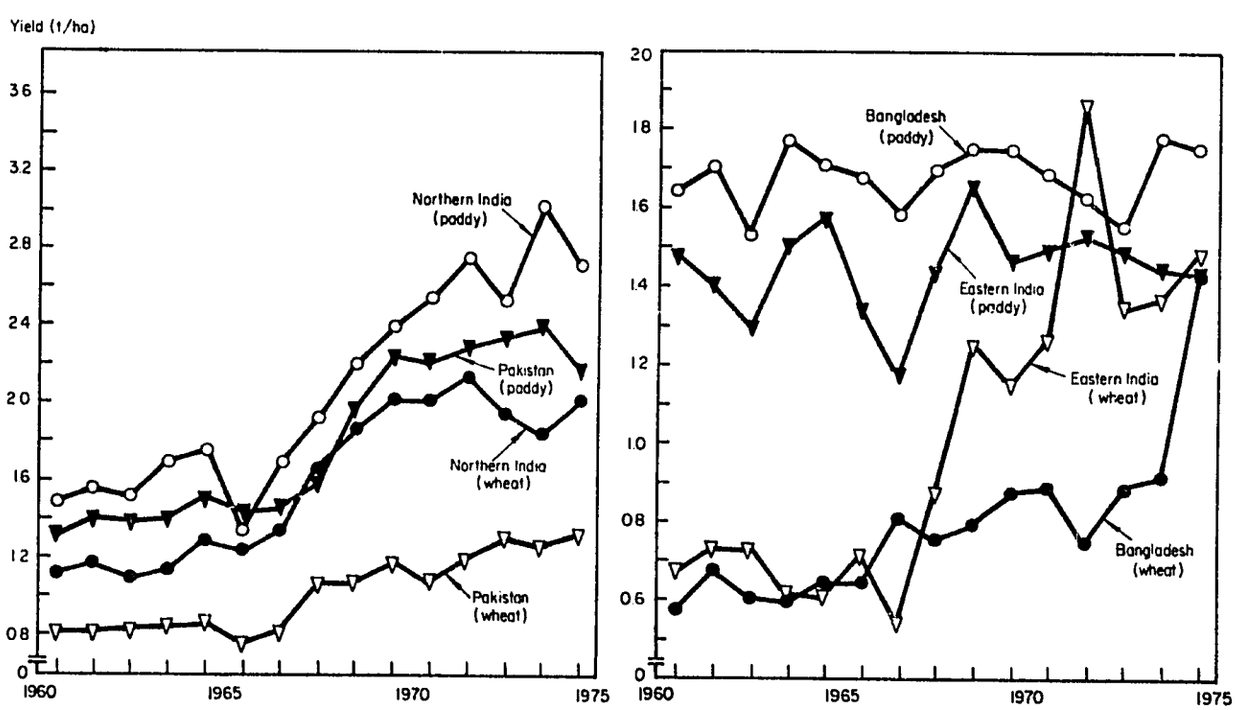

Fig. 3. Yield trends of rice and wheat in Northern India and Pakistan (left) and Eastern India and Bangladesh (right), 1960-61 to 1974-75.

The success of wheat suggests that farmers in eastern India will respond rapidly given the proper combination of technology and incentives.

The lowest growth in agricultural production is in the upland areas, which have experienced no impact from the modern rice varieties. For most of the upland area only one rice crop is grown, often with severe lack of moisture. In fact, millet and other crops are more suited than rice in the drier portions of this area. Rice nevertheless remains the dominant crop.

Of the total number of farms in the three-state region, about 50% are 1 ha or less in size, and 70% are 2 ha or less. However, farms 1 ha or less in size occupy only 10% of the area, whereas those 2 ha or less account for 40% of the area. Given the inequitable distribution of landholdings, there is a natural conflict between the goals of production and equity. Purchase of inputs and investment in equipment to raise production can be more easily accomplished by the larger farmers. Developing technology that gives equal benefit to large and small producers is a formidable task, made all the more difficult by the slow progress in land reform and land consolidation programs.

Yield potential and the yield gap

There is a good deal of confusion about the meaning and interpretation of the concept of *gap* between actual and potential yields. There are many scientists who believe that technology exists in the experiment stations of eastern India, which, if applied on farmers' fields, would significantly increase farm yields. However, we found no evidence to prove or disprove this point. In the *operational research* projects, inputs, technology, and extension have been intensively applied in a 2000-ha area. At the operational research project at Galsi, Burdwan District, West Bengal, for example, the area growing modern rices during the wet season has increased from 25% to 60%. But yield gains are modest -- about 10% in the 4-year period since the project started. The inability to control water from the canals has clearly been a major factor limiting gains in production.

With the controlled experiments of the experiment station, yields of 4 to 4.5 t/ha can be obtained in the wet season and more than 5 t/ha in the dry season. But in farmers' fields, the yield potential is much less. We present our best judgment of present and potential yield for different types of rice culture in Table 4. Even with irrigation, the potential yield does not approach the level that can be achieved in the experiment station. The average potential yield of 2.5 t/ha for eastern India is about the same as the present average yield level in the more favorable environment of southern India (Table 1). The figures in Table 4, however, represent little more than judgment. It is virtually impossible to estimate potential yields with existing technology in the various rice-growing environments until there is more information from controlled experiments in farmers' fields.

FARM PRODUCTION AND CULTURAL PRACTICES

To understand more clearly the farming situation and the constraints to increased rice production, we surveyed eight villages, spending about 3 hours

in each. Our survey was supplemented by information from a wide range of other sources to give us an impression of farming conditions. One striking feature is the extremely small size of holding on the nonirrigated lands (Table 5). To provide an equitable livelihood, the nonirrigated farms should be, and in many parts of Asia frequently are, larger than the irrigated farms. But in eastern India, the reverse is normally the case; the larger farmers occupy the better lands and the marginal farmers settle in the poorer areas. The implications are important in the introduction of modern technology, because the smaller farmers will encounter considerably more difficulty purchasing modern inputs.

Varieties

The area planted to modern varieties occupied a negligible portion of the land in all the eight villages except in the irrigated villages in Orissa where modern varieties are planted principally in the dry season. Transplanted photoperiod-sensitive varieties were being grown on the lower slopes and bottomland in the terraced rainfed rice areas. Photoperiod-insensitive varieties of short duration were being broadcast on the upper bunded slopes that are subject to drought. Typically, the lower land in the upland areas was planted first and harvested last. In the rainfed, flood-plain villages essentially all of the rice varieties were photoperiod-

Table 4. Estimated actual and potential rice yields (t/ha) based on type of rice culture.

Type of culture	Present average yield	Potential yield
Irrigated		
Wet	1.8	3.6
Dry	2.6	4.2
Upland (unbunded)	1.0	1.5
Rainfed		
Shallow (0-20 cm)	1.5	2.3
Intermediate (21-50 cm)	1.2	2.0
Semideep (51-100 cm)	1.0	1.5
Deepwater (100 + cm)	1.0	1.5
Average	1.5	2.5

Table 5. Selected factors from a survey of eight villages in Bihar, West Bengal, and Orissa, September 1977.

	Terraced rainfed		Rainfed floodplains			Irrigated-wet season[a]		
	Bihar Ranchi	West Bengal Purulia	Bihar Muzaffarpur 1	Bihar Muzaffarpur 2	West Bengal 24 Paraganas	Orissa Cuttack 1	Orissa Cuttack 2	Orissa Sambalpur
Population	1175	354	3500	1698	350	1400	-	2450
Cultivated ha	205	42	333	180	75	229	-	240
People/ cultivated ha	6	8	10	9	5	6	-	10
Landless farmers (%)	2	17	35	20	30	40	25	20
Size of farm (ha)	0.6	0.4	0.8	1.0	0.4	1.2	1.2	1.2
Fragments on typical farm (no.)	15	5	7	11	9	4	-	5
Average yield (t/ha)	1.3	.8	1.0	1.0	1.5	1.5	1.6	3.3
Years in 5 yield loss over 20%	2	2	2	4	2	1	2	2
Trend in yield over 10 years	up	up	same	down	down	down	down	down
Farmers selling (%)	10	100	5	50	50	100	100	100
Cost of paddy (Rs./kg)[b]	0.65	0.85	0.75	0.75	0.92	0.75	0.75	0.75
Cost of nitrogen (Rs./kg)[b]	4.50	4.10	4.50	4.50	4.10	4.50	4.50	4.50
Kg N/kg Paddy	6.9	4.8	6.0	6.0	4.5	6.0	6.0	6.0
Wage rate (male day)	3.0	-	3.0	3.0	6.5	3.5	3.5	3.5

[a] The first village is low lying and not very well suited to modern varieties in the wet season. The second village is located at the end of the canal and subject to drought.

[b] Exchange rate is Rs 8.25/US$1.00.

sensitive, with half transplanted and half broadcast seeded. In irrigated villages, all rice was transplanted, and most of the wet season rice was a local photoperiod-sensitive variety (Table 5).

The overwhelming reliance on the photoperiod-sensitive varieties for the rainfed rice areas has become a recent issue of debate. There is considerable argument in favor of the sensitive types as most of the modern insensitive rice varieties become unsuitable with increase in water depth. Even varieties like Pankaj, Jagannath, and Mahsuri perform well only to a water depth of 30 cm and are among the most widely planted modern varieties in this area. On the other hand, the monsoons in the region typically end in late September or early October when the longer duration photoperiod-sensitive varieties are at the flowering stage. Thus, photoperiod-insensitive varieties seem more appropriate for the water regimes considered here. At the same time the criticisms against the existing photoperiod-insensitive varieties remain valid. A suitable modification is needed, either through increasing the height by incorporating elongation genes, or by incorporating some tolerance for submergence. There is a need, in the stagnant water and flooded areas, to determine precisely which areas should have photoperiod-sensitive and which should have photoperiod-insensitive varieties.

In Table 6, we present farmers' experiences with the modern rice varieties in the wet season. In six of the eight villages, modern varieties had been tried some years in the past. In five of these six, modern varieties performed better. But as noted earlier, modern varieties were not being grown in the area in any significant amount. The reason was the higher input requirement. Farmers say they cannot afford these inputs.

Cultural practices

The typical farmer owns a *desi* (country plow) and a pair of cattle. The cattle are small, and the lack of power for plowing tends to delay land preparation. We judge this as important in delaying the planting of the first crop. Weeding practices seemed generally adequate. Essentially no chemical fertilizer, but some compost, is used for the rice crop except when modern varieties are planted where there is assured water. Yields are about 1 t/ha in the nonirrigated areas.

Why are the yields low? This may be due partly to the short duration of monsoon rains coupled with delayed planting due to lack of farm power, which causes flowering of most of the rice crop in October when rains are uncertain, and drying up of land in areas other than the stagnant water areas. In some areas, the photoperiod-sensitive varieties are harvested a full 2 months after the rains have stopped. A possible solution to the problem is to provide farmers with photoperiod-insensitive varieties of short duration, and preferably with grain dormancy, because the farm power constraint cannot be easily overcome.

The normal yield levels in the villages and the best and poorest yields are presented in Table 7. Note that not only are the average yields low, but even the best yields in the villages are poor. The farmers were asked to explain the differences between the best and the poorest yields in each village. In three villages in areas frequently flooded, farmers ranked favorable soil-water relationship as the most important reason for observed yield differences.

In four other villages, financial capacity to buy fertilizer was seen as the most important factor. In the eighth village, management was given as the key factor explaining the difference. Better yields are always obtained in higher elevation lands, which are relatively safer from inundation.

We wanted to find out if the farmers perceived any potential for increasing the rice yield assuming no improvement in the water condition of their farms, and what, in their opinion, were the barriers to achieving this potential. In two flood-affected villages in Bihar, the farmers were convinced that, with the water situation, no further improvement of existing yields was possible. Until suitable varieties are evolved for these conditions, no significant improvements in rice yields can be achieved. In four other villages, the farmers believed that higher yields could be achieved only through the use of larger quantities of fertilizers for which, most farmers argued, they did not have the required purchasing power.

The risks of farming

The wide variability in cropping patterns from one location to another, and

Table 6. Farmers' experience with modern rice varieties in eight villages of Bihar, West Bengal, and Orissa, September 1977.

Villages	Were modern varieties ever tried?	How did they perform as compared to traditional varieties?	If better, why not being grown?
Terraced rainfed			
Ranchi, Bihar	Yes	Better	High cost
Purulla, West Bengal	Yes	Better	High cost
Lowland rainfed			
Muzaffarpur, Bihar 1	No	-	-
Muzaffarpur, Bihar 2	Yes	Failed as rainfed	-
24 Paraganas, West Bengal	Yes	Better	High cost
Irrigated, wet season			
Cuttack, Orissa 1	No	-	
Cuttack, Orissa 2	Yes	Better	High cost
Sambalpur, Orissa	Yes	Better	*

Table 7. Ranges of yield of paddy (t/ha) in eight villages of Bihar, West Bengal, and Orissa, September 1977.

Villages	Best yield	Lowest yield	Average yield
Terraced rainfed			
Ranchi, Bihar	2.0	1.0	1.3
Purulla, West Bengal	1.0	0.3	0.8
Lowland rainfed			
Muzaffarpur, Bihar 1	2.0	0.5	1.0
Muzaffarpur, Bihar 2	1.5	0.7	1.0
24 Paraganas, West Bengal	2.4	0.6	1.5
Irrigated, wet season			
Cuttack, Orissa 1	2.5	0.5	1.5
Cuttack, Orissa 2	2.5	0.8	1.6
Sambalpur, Orissa	4.6	1.8	3.3

even within a given location, reflects the extreme heterogeneity of conditions, and the attempt on the part of farmers to stabilize production by providing contingencies for variable weather conditions. Cropping patterns generally vary according to topography, but are also adjusted to annual variation in climatic conditions. For example, we found 1 village in Bihar where 30% of the area was planted to corn. In years of heavy rains (2 of the last 5) the corn washed out. The area is then replanted to either sweet potato on the higher lands or rice on the lower lands. The implications of these types of adjustments are also important for technology development. Researchers can provide technology components, such as shorter season varieties, which farmers can incorporate into cropping patterns and can increase production. However, because of the extreme heterogeneity of environmental conditions, working out the most appropriate cropping patterns must normally be left to the farmers.

In terms of cropping patterns, one of the more controversial issues among research workers and government administrators is the use of the rainfed unbunded upland areas. The official policy is to discourage the planting of rice in these areas, but there are differing opinions about this. Many argue that the farmers in these areas, who are subsistence oriented, are likely to continue to plant rice. No substitute for rice seems to have attracted farmers to any major degree.

The year-to-year variation in yields is extremely great. Typically in the past 2 years 5 farmers lost 20% or more of their crop primarily to drought or flood (Tables 5 and 8). The villages surveyed were not in any of the insect-infested areas, except Sambalpur where gall midge was a problem. In general, insect and disease problems do not seem to be of major importance except in specific areas such as Sambalpur district.

On the other hand, in all but two upland villages, significant changes in soil-water apparently brought about a decrease rather than an increase in wet season yields during the past decade (Table 5). Causes for the decline were increased incidence of flooding, intensified salinity, and, in the irrigated villages, decrease in fertility, which we believe is due to zinc deficiency.

Price incentives

When asked why they were not obtaining higher yields, most of the farmers

Table 8. Years of crop loss of more than 20% from 1972 to 1976.

Village	Reason cited and year				
	Drought	Flood	Insect	Diseases	Others (specified)
Terraced rainfed					
Ranchi, Bihar	1975,1976	-	-	-	-
Purulla, W. Bengal	1971, 1972	-	-	-	-
Lowland rainfed					
Muzaffarpur, Bihar 1	-	1974,1975	1974	-	-
Muzaffarpur, Bihar 2	1973	1974,1975	1972	1972,1973	-
24 Paraganas, W. Bengal	1976	1972	-	-	Aquatic weeds every year
Irrigated, wet season					
Cuttack, Orissa 1	-	1971	-	-	-
Cuttack, Orissa 2	1973,1974	-	-	-	-
Sambalpur, Orissa[a]	-	-	1975,1976	-	-

[a] Irrigation water is revived in 50% of area only.

said they could not afford to buy the inputs. Extension workers expressed a similar view. We examined the profit margins. Urea costs about Rs 2.00/kg and nitrogen, Rs 4.50/kg (Table 5).[4/] The price of paddy varies from about Rs 0.75/kg (the approximate government support level) to Rs 1.00/kg). At harvest time, in the surplus areas, the price is close to Rs 0.75/kg. The ratio of kg N to kg paddy is 6.0 indicating that it requires 6 kg of paddy to buy 1 kg N. Assuming a typical conversion ratio, 1 kg N applied increases paddy yield by 10 kg. Thus, the farmer pays 6 kg of paddy for fertilizer that returns 10 kg of paddy. This considers neither the interest charged for credit, which is often 50%, nor the risks involved. In short, at current prices, fertilizer is not much of a bargain.

INSTITUTIONS, ORGANIZATIONS, AND MANAGEMENT

Parthasarathy and Prasad (1977) analyzed the differences in the rate of growth of rice yield in 583 districts in India. *Top* districts with more than 2% growth rate were compared with districts showing *negative* growth rates. They concluded that this *gap* in performance was associated with a difference in environmental factors. They noted a high correlation between environment, infrastructure development, level of input use, and development of institutions on the one hand, and growth rates on the other. No causal relationships could be established with their data, but they suggested the need to study the sequence of the growth process.

In the recent comprehensive report *Agricultural Intensification Project*, the state government of Orissa notes that "The most serious obstacle to catalyzing an upsurge in production is the lack of communication between the interrelated services of research, extension, input supply, and credit." The recent report *Development of Intensive Agriculture -- lessons from IADP*[5/] identifies three subsystems of the agricultural production system that will form the framework of our discussion:

1. producer-farmer subsystem,
2. credit and input supply subsystem, and
3. government administrators subsystem.

The objectives of decision makers in each of the three subsystems differ. Therefore, if the communication between subsystems is inadequate, production gains may not be satisfactory even though proven superior technology is available. The farmer is interested in higher profits for himself, the input supplier is interested in high profits for his company, and the government administrator is interested in higher production. It might be noted that the input level that maximizes yield serves the interest of the

---

[4/] Rs 8.25 equals US$1.00.

[5/] V. R. Gaikwad, G. M. Desai, P. Mampilly, and V. S. Vyas. Development of Intensive Agriculture: Lessons from IADP. Indian Institute of Management, Ahmedabad.

input supplier and the government but not of the farmer. Also, the linkages between subsystems tend to be weaker in the nonirrigated areas that predominate in eastern India.

We can list the major factors within each subsystem as:

Farmer	*Credit and input supply*	*Government*
Knowledge	Seed	Research
Community leadership	Credit	Extension
Land fragmentation	Fertilizer and chemicals	Water management
Equitable size of holdings		

The above list is not exhaustive but includes what we believe should be the major items of concern in each subsystem. From this list, we single out four areas where communication between subsystems is vital to the function of the system as a whole and where, in some instances, further research is required to decide on appropriate courses of action. These areas are:

- farmer-seed delivery-research,
- farmer-extension-research,
- farmer-research-water management, and
- farmer incentives.

We have listed the farmer first to emphasize that it is his interest we seek to serve, and that the farmer himself, therefore, has much to communicate to the other subsystems in terms of his needs. The communication linkage in all cases should be two-way among subsystems rather than from the top down as is too frequently the case.

We observed what appeared to be a serious lack of community leadership in the villages we visited. In some areas, a substantial proportion of the land was owned by absentee landlords and cultivated by landless laborers, which aggravated the situation and constituted a serious gap in communications between the government extension workers and the decision maker on the farm. It was not apparent how widespread this condition was, but it is clearly a factor that merits closer study to determine its importance as a constraint to production.

Farmer-research-seed delivery

A major weakness in the current system seems to be the linkage between the farmer, the plant breeder, and seed multiplication and delivery. We were told that it takes about 10 years from the time of the first cross to release a new rice variety. Even when the variety is released, there is no assurance that the seed will be made available to farmers. In contrast, in the Philippines, new varieties are made available to the farmers within 5 years

from the time of the first cross. The only modern varieties currently grown in wide scale in eastern India are Jaya, IR8, and Pankaj. Hargrove's research (1977) suggests that the problem begins with breeding objectives. Breeders, at least until recently, have not been emphasizing the genetic characteristics required for the drought and flood conditions common in eastern India.

One could question to what degree the initial focus of the International Rice Research Institute and the All-India Coordinated Rice Improvement project on semidwarf varieties diverted researchers' attention from the problems and needs of eastern India. The headquarters of both organizations (IRRI in the Philippines and AICRIP in Hyderabad) are in agroclimatic environments totally different from eastern India.

The problem, however, is not only with research. We saw varieties that seemed to be more suitable than what farmers are now using (e.g. IR1442, which has tolerance for drought). But the mechanism for field testing and for multiplying the variety to assure its rapid and wide dissemination does not seem to be adequate.

In short, the linkage between the farm, the researchers, and the seed delivery system are now so weak that it is difficult to determine whether or not superior varieties, which are not being widely used by farmers, exist. All the units of the subsystem must operate on a sense of urgency, because superior varieties, especially when combined with improved cultural practices, are the essential core to increased production.

Farmer-extension-research

The extension system in the states we visited is now undergoing a major revision under the Training and Visit System proposed by the World Bank. The system is designed to strengthen the communications link between the farmer, extension, and research. The *village level workers*, now called *village agricultural workers*, devote full time to agriculture. They receive bimonthly training and relay information through a series of contact farmers. Although the principle appears to be sound, the system is new in eastern India and cannot yet be evaluated. To further strengthen the link between the farmer, extension, and research, it may be desirable to use contact farmers in testing new varieties and multiplying seeds. The point that should be emphasized, however, is that the success of the extension program depends ultimately on the availability of research information and new technology to be fed into the system. A strong program to observe and evaluate the Training and Visit System should be developed now. Social science research workers should be asked to suggest modifications in, or alternatives to, the system where needed. The creation of new and more effective organizations and institutions through social science research is equivalent to the creation of improved technology through biological sciences research. Both efforts can be highly complementary in raising agricultural production.

Farmer-research-water management

As noted earlier, water regime in eastern India is extremely heterogeneous.

The major thrust in raising yields will come from improved water control and improved varieties of rice. Both steps require public investment and a high degree of complementarity between both activities.

How research on varieties and water control interact is best illustrated in the *operations research project* at Galsi, Burdwan District, West Bengal mentioned earlier. By making inputs readily available and by strengthening extension in the operations research area, the state government removed some of the major obstacles to increased production in this area. Production did increase somewhat, but it soon became apparent that the failure to drain water from the fields until December forced farmers to grow later-maturing varieties such as Pankaj and made it impossible to plant wheat in the dry season. Even if these problems were remedied, it would be necessary to construct a more adequate system of tertiary and farm level canals to give the farmers a more adequate control of water needed for wheat irrigation. If these steps could be accomplished, a shorter-maturing rice variety would be needed. The need for research in water management has become obvious. These accomplishments, not the modest increase in production, are the most important lessons of the operations research project in the area.

Farmer incentives

The disincentives for farm production are many. They include land fragmentation, small size of farms, lack of credit, high cost of inputs, and lack of knowledge on proper use of inputs. Land reform and land consolidation programs are being implemented at an extremely slow rate. Lack of community leadership is another important problem that prevents successful implementation of programs such as the Community Nurseries. If properly implemented, the Extension Training and Visit System can, through contact farmers, strengthen community leadership and knowledge. In this matter, however, even the choice of the contact farmers becomes a critical issue.

Research can provide another important incentive to farmers in terms of a more cost-efficient package of inputs. The recommended doses of chemical inputs are generally high (they serve the objectives of the chemical dealers and the government, not of the farmer). There is far too little effort to teach farmers how to use fertilizers and other chemicals efficiently. For example, despite excellent research demonstrating the possibility of reducing the fertilizer requirement by proper timing and placement, this knowledge is not yet available to farmers.

Getting the fertilizer and other chemical inputs delivered on time also poses a problem. The distribution system is such that farmers frequently have to travel several kilometers to purchase inputs. We have previously noted the almost universal concern regarding the high cost of inputs and have identified what appears to be low profit margins for input use given the risks involved. We can compare the prices paid locally with world market prices for fertilizer. Urea in the international market is about $150/t. This compares with $235/t charged an Indian farmer. A ton of ordinary rice in the international market is currently (September 1977) $190, which is about the same price received by Indian farmers allowing for normal milling and transportation charges. It is sometimes argued that in the subsistence-oriented rainfed villages, farmers are not responsive to price. However,

in most of the villages we surveyed, a significant portion of the farmers were selling rice to purchase other consumption goods (Table 5). A more favorable fertilizer price would stimulate the adoption of the new technology.

Indian farmers today face one of the least favorable nitrogen-paddy price ratios in Asia. The nitrogen-paddy price ratio should be 3-1 or less to stimulate fertilizer consumption. The current ratio is between 5 and 6-1.

PRIORITIES FOR INCREASING RICE PRODUCTION

Most of the rice areas in eastern India are nonirrigated. Even the irrigated ones tend to suffer from lack of water control in the wet season. The rice-growing environment is extremely heterogeneous not only in topography, but also in the effect of changing climatic conditions from year to year and even within a year. There are two basic strategies to increase production in these areas:

1. change the environment to fit the technology (e.g. irrigate the nonirrigated lands and improve existing irrigation systems), and

2. develop technology to fit the environment (e.g. develop rice varieties tolerant of drought and flood).

Neither strategy offers a quick solution to raising yields in eastern India, hence, it will be necessary to pursue both with equal vigor.

There is a little doubt that the bulk of increased food production in the next decade will come from the further expansion of irrigated areas, and from the application of existing technology in those areas. Such expansion, however, is very costly. Hence, there will be a high payoff for research and implementation of more efficient water management practices.

Substantial gains in production may be obtained economically by raising yields in the nonirrigated areas. However, because of the heterogeneity of the environment, and the limited funds and personnel available, the research and extension efforts in these areas must be highly focused. The technology for rainfed areas should be, on the one hand, yield stabilizing, and on the other, cost reducing. In fact, for the rainfed areas, it would be more appropriate to refer to high stability varieties rather than the conventional but misleading term high yielding varieties. Farmers should have the choice of using varieties that produce a minimum level of yield every year or those that give higher yields under ideal conditions, but lower yields under unfavorable conditions. We would consider Mahsuri and Pankaj as high stability varieties for the 15- to 30-cm water depth. There are no other high stability varieties being widely grown by farmers (100,000 ha or more) in either the drought-prone or flood-prone rainfed areas, although there appear to be several promising lines in the experiment stations.

Unfortunately, we know too little about the potential yield of much of the material in experiment stations, because it has not been tested in farmers' fields under diverse environmental conditions. Much is said about yield potential and the *gap* between potential and farm yields, but there is no

evidence to verify the existence and magnitude of the gap for each of these environments.

A reliable impression of yield potential can be obtained in a given environment only when the measurement of the *gap* is based on yields for farm level of inputs and high level of inputs obtained in the same set of farms. Although it is possible to estimate the average yields for the wide range of environments in eastern India, it is virtually impossible to accurately estimate *potential* yields using existing technology in the rainfed environments until there is more information from controlled experiments in farmers' fields. It is also difficult to assess the significance of socioeconomic constraints without knowing whether there is a potential for raising yields with the existing technology. Research by a team of biological and social scientists, and designed to provide more reliable information on the gap between actual and potential yields in farmers' fields, and the factors explaining this gap, is planned by the Central Rice Research Institute, Cuttack.

Institutional and organizational problems result in a major constraint to the introduction of modern technology. In the immediate future, it would be desirable to *streamline* the process of developing and releasing new varieties to reduce the time from 10 to 5 years. Development of photoperiod-sensitive high yielding varieties will require a longer period, and attention should be given to ways of shortening the time requirement. At the same time, it will be necessary to strengthen the seed multiplication system and to provide farmers with extensive information on the cost-efficient package of inputs and practices.

Over a longer period, research in water management and communications between irrigation systems personnel, research workers, and farmers need to be strengthened. Ultimately, the strengthening of farmer incentives requires the strengthening of community leadership and organization, which is perhaps the greatest challenge for social science research.

In summary, we would argue that the problems confronting eastern India's rice production are both technical and social in nature. An effective program to increase production in this area must, therefore, involve the collaboration of biological and social scientists.

REFERENCES CITED

Asian Development Bank. 1978. Asian agricultural survey, 1976. Manila.

Hargrove, T. R. 1977. Genetic and sociologic aspects of rice breeding in India. IRRI Res. Pap. Ser. 10. International Rice Research Institute.

Parthasarathy, G., and D. S. Prasad, 1977. Spatial variations in rates of growth productivity in rice: an analysis of "top" and "bottom" districts. Department of Cooperation and Applied Economics, Andhra Pradesh University, Waltair, A.P. India.(mimeo.)