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9. ABSTRACT
This paper was presented at the International Seminar on Photoperiod Sensitive Transplanted Rice of South and Southeast Asia, held at the Bangladesh Rice Research Institute, Joydebpur, Dacca, Bangladesh on October 24-28, 1977. It outlines the dimensions of the socio-economic problems affecting rice production in three states in Eastern India - Bihar, West Bengal, and Orissa. These three states account for 40% of the rice area and 43% of the total rice production of India. There has been essentially no upward trend in rice yields in this area over the past two decades. Only a small portion of the rice area is irrigated, and modern rice varieties and inputs are not widely adopted in the kharif. Half of the rice area is transplanted to local photoperiod sensitive varieties and another 25% broadcast to local varieties. Due to the high risks of farming, the technology for the rainfed compared to the irrigated areas should be yield stabilizing and low cost. High stability varieties are more appropriate than high yielding varieties. The current price structure discourages the use of modern inputs, as the nitrogen to paddy rice price ratio is almost double the world price ratio. In the near future it would be desirable to "streamline" the process of developing and releasing new varieties. In the long run, research in water management and communications between irrigation systems personnel, research workers, and farmers need to be strengthened.

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SOCIO-ECONOMIC CONSTRAINTS TO THE PRODUCTION OF PHOTOPERIOD SENSITIVE TRANSPLANTED RICE IN EASTERN INDIA

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Paper presented at the International Seminar on
Photoperiod Sensitive Transplanted Rice of
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SOCIO-ECONOMIC CONSTRAINTS TO THE PRODUCTION OF PHOTOPERIOD SENSITIVE TRANSPLANTED RICE IN EASTERN INDIA*

Randolph Barker**

This paper attempts to outline the dimensions of the socio-economic problems associated with increasing rice production in the photoperiod sensitive transplanted rice areas of three states in Eastern India - Bihar, West Bengal and Orissa. We begin by defining the area devoted to photoperiod sensitive rice production. Then we discuss the farm level constraints to production. Finally, we discuss institutional and organizational constraints to increased production.

The need to identify constraints to increased production is obvious. Figure 1 illustrates the trend in rice yields in three regions of India, Bangladesh, Pakistan and Sri Lanka. A substantial upward trend in yields occurs in Northern India and Pakistan and in Southern India and Sri Lanka. But yields show no upward trend in Eastern India and Bangladesh, where the crop is grown mainly in the wet season.

The three states of eastern India account for 40 percent of the rice area and 34 percent of the total rice production of India. Sixty percent of India's upland (unbunded) rice, 50 percent of the deep water rice and 43 percent of the rainfed rice, but only 30 percent of the nation's irrigated rice area is found in this region.

These three states of Eastern India 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 have 40 percent of the total rice area and the four southern states 20 percent, 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 high yielding varieties, fertilizer input, and irrigation, all of which are highly complementary.

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*The materials for this paper were obtained largely during a two week trip in India from September 7 to September 24, 1977 during which time a joint Government of India-IRRI team prepared a report for the Government of India on strategies to raise rice production in Eastern India. However, the views expressed in this paper are those of the author and not of the team.

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The eastern states can be divided into three regions based on agricultural conditions and cropping patterns.[1/]

(i) Low land rice-wheat areas of northern Bihar and West Bengal.

(ii) Low land rice and rice jute areas.

(iii) Upland or hill areas.

The most rapid growth in agricultural production over the past decades has been experienced in the rice-wheat area due principally to the expansion of wheat acreage and rapid increase in wheat yields (Figure 2). There are now 2.5 million hectares of wheat in Bihar and West Bengal, an almost three fold increase from a decade ago. Rice production on the other hand has made little headway, particularly in North Bihar where rapid flooding rules out the use of high yielding varieties in the non-irrigated areas and where canal irrigation in the kharif can result in excessive silting in farm fields. The success of wheat, suggests that given the proper combination of technology and incentives, farmers in Eastern India will respond as rapidly as farmers elsewhere.

In the low land rice and rice jute areas, there are approximately half a million hectares of jute. In those areas planted to jute, the delayed planting of the rice crop causes a significant reduction in rice yields. Jute production has remained fairly stagnant over the past decade, but a moderate rate of rice production growth has occurred in the irrigated rice areas due to the introduction of high yeilding varieties particularly in the rabi season. While 90 percent of the irrigated rabi rice crop is planted to high yielding varieties, the figure for the irrigated kharif is less than 20 percent.

The lowest growth in agricultural production is in the upland areas which have experienced no impact from the high yielding varieties. For the bulk of this area only one rice crop is grown, often under conditions of severe moisture stress. In fact, it can be argued that millet and other crops are more suited than rice in the dryer portions of this area. Rice nevertheless remains the dominant crop.

Of the total farms in the 3 state region, about one half are one hectare or less in size and 70 percent are 2 hectares or less. However, the farms 1 ha or less in size occupy only 10 percent of the area while those 2 ha or less account for 40 percent of the area. Given the inequitable distribution of land holdings 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 of land reform and land consolidation programmes.

Significance of Photoperiod Sensitive Transplanted Rice to the Total Rice Production

In order to understand the importance of transplanted photoperiod sensitive rice production, it is necessary to distinguish between those areas which need photoperiod sensitive varieties and those where photoperiod sensitive varieties should be replaced with non-photoperiod sensitive varieties. This can be accomplished by classifying land by varietal type and by water regime (Table 2). Of the 15 million hectares of rice grown in the three states of Eastern India, 7.5 million or half is transplanted photoperiod sensitive (Figure 3). The photoperiod sensitive area can be further sub-classified according to water regime (Table 4). In the irrigated, upland bunded, and shallow bunded areas, it would appear that the urgent need is for a suitable photoperiod insensitive short duration variety. The monsoons in this region typically end in late September or early October when the longer duration photoperiod sensitive varieties are at the flowering stage. Thus for the photoperiod sensitive varieties grown in these conditions, yield is often reduced due to lack of water during the ripening phase of the crop.

The semi-deep and deep water areas, which account for 26 percent of the photoperiod sensitive rice, but only 13 percent of the total rice area, require a photoperiod sensitive variety. For the area of intermediate water depth (15-30 cm), there seems to be some debate as to whether photoperiod sensitive varieties are most appropriate. Varieties such as Pankaj (a sister line of IR5) and Mahsuri (Panjam) perform well as depth of water up to 30 cm and are among the most widely planted modern varieties in this area.

A classification system developed by D. Lenka in Orissa, is similar to ours (Figure 4 and Table 4). By his estimate, water remains until late November or December in about 18% of the rice growing area in this state. Photoperiod sensitive varieties are needed in this area.

Productivity and the yield gap

There is a good deal of confusion about the meaning and interpretation of concept of a "gap" between actual and potential yields. There are a number of scientists who believe that technology exists in the experiment stations in Eastern India which, if applied on farmers fields, would significantly increase farm yields. However, we have found no experimental evidence in farmers fields to prove or disprove this point. The "operations research" projects where inputs, technology and extension have been intensively applied in an area of 2000 ha provide no convincing evidence on this point. For example, at the Operations Research Project at Galsi, Burdwan District, West Bengal, HYV area during the kharif season has increased from 25 to 60 percent. But yield gains have been very modest, about 10 percent over the 4-year period since the project started. Thus, it is not clear that significantly superior technology exists in the experiment stations.

Some research workers, recognizing that yield potential based on the experiment station yields may not be realistic, have chosen to measure the yield gap by comparing: (i) the yield of the farm demonstration plots with the State average yield, or (ii) the yield of the best farmers with the yield of the average. This analysis may be misleading for the very same reason that the experiment station yields are misleading. Demonstration plots and farmers with highest yields tend to be located in the better soil-water 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. This is the yield gap we have defined at IRRI and attempted to measure in a number of locations throughout Asia (IRRI, 1977). Research along these lines is being conducted at BRRI. But we know of no experiments in Eastern India conducted in farmers fields comparing the yield at high inputs with the yield at farmers level of inputs in the same locations. While it is possible to estimate the average yields under the wide range of environments in Eastern India (Table 5) it is virtually impossible to estimate "potential" yields using existing technology in the rainfed environments until we have more information from controlled experiments in farmers fields. It is also extremely difficult to assess the significance of socio-economic constraints without knowing whether or not there is a potential for raising yields with existing technology. This point needs to be kept in mind as we discuss farm level and institutional constraints to high yield in the section which follow.

Priorities for increasing production

Three quarters of the photoperiod sensitive transplanted rice is grown under rainfed conditions. The upland and lowland rainfed areas are extremely heterogenous compared to the irrigated areas, not only in topography, but also in the effect of changing weather conditions from year to year and even within a year. There are two basic strategies for increasing production in these areas: (i) change the environment to fit the technology (e.g., irrigate the unirrigated lands) and (ii) develop technology to fit the environment (e.g., develop drought and flood tolerant varieties of rice).

There can be 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 to these areas. But such expansion will be very costly. Hence there will be a high pay off for research and implementation of more efficient water management practices. In the Operations Research Project at Galsi, for example, despite wide acceptance of new varieties, the inability to control water from the canals has clearly been a major factor limiting gains in production to not more than 10 to 15 percent over a four year period.

Substantial gains in production might be obtained economically by raising yields in the non-irrigated areas. However, because of the heterogeneity of the environment, and the limited funds and personnel available, the research extension effort 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 (HSV) rather than the conventional but misleading term HYVs. Farmers should be given the choice of raising varieties that produce a minimum level of yield every year (HSV) and varieties that produce higher yields under ideal conditions, but lower yields under unfavorable conditions. We would consider Mahsuri and Pankaj to have the characteristics of HSV for the 15 to 30 cm water depth. There are no other HSV currently 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.

Farm Production and Cultural Practices

In order to understand more clearly the farming situation and the constraints to increased production, we surveyed seven villages in some depth, spending approximately 3 hours in each village. This 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 non-irrigated lands (Table 6). To provide an equitable livelihood, the non-irrigated farms should be, and in many parts of Asia frequently are, larger than the irrigated farms. This is a reflection of the pattern of settlement, with the larger farmers occupying the better lands and the marginal farmers settling in the poorer areas. The implications are important for the introduction of modern technology, since these smaller farmers will encounter considerably more diffiuclty purchasing modern inputs.

Varieties

The area planted to HYVs occupied a negligible portion of the land in all of the seven villages we visited with the exception of the irrigated villages in Orissa where HYVs are planted principally in the rabi season. Transplanted photoperiod sensitive varieties were being grown on the lower slopes and bottom land in the upland rice areas (Villages 1 and 2). Non-photoperiod sensitive varieties of short duration were being broadcast in the upper bunded slopes subject to drought. Typically, the lower land in the upland areas was planted first and harvested last. In the lowland rainfed villages essentially all of rice varieties were photoperiod sensitive, with half being transplanted and half broadcast. In irrigated villages, all rice was transplanted, most of the wet season rice being local photoperiod sensitive.

Cultural Practices

The typical farmer owns a desi or country plow and one pair of animals. The cattle are small, and the lack of power for plowing tends to delay the land preparation. This we would judge to be important in delaying the planting of the first crop. Weeding practices in general seemed to be fairly adequate. Essentially no chemical fertilizer, but some compost is used on the rice crop except the case of HYVs which are planted where there is assured water. Yields are approximately 10 quintals/ha in the non-irrigated areas.

Why are the yields so low? Parts of the reason seems to lie in the short duration of the monsoon rains coupled with the delay in planting due to lack of farm power. The result is that most of the rice crop is flowering in October when rains are uncertain and, in other than the stagnant water areas, the land is beginning to dry out. The photoperiod sensitive varieties in some areas are harvested a full two months after the rains have stopped. One solution to the problem would seem to be in providing non-photoperiod sensitive varieties of short duration since the farm power constraint cannot easily be overcome.

There is also a need in the stagnant water and flooded areas to determine precisely which areas should have photoperiod sensitive and which should have non-photoperiod sensitive varieties.

The risks of farming

The wide variability in cropping patterns from one location to another and 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 weather conditions. For example, we found in one village in Bihar where 30 percent of the area was planted to corn. In years of heavy rains (2 of the last 5) the corn is washed out. The area is then replanted either to 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, that farmers can incorporate into cropping patterns and increase production. However, because of the extreme heterogeneity of environmental conditions, it must be left to the farmers to work out the most appropriate cropping patterns.

In terms of cropping pattern, one of the more controversial issues among research workers and government administrators concern the use of the rainfed unbunded upland areas. The official policy is to discourage the planting of rice in the areas, but there is considerable difference of opinion. Many argue that because the farmers in these areas are subsistence

oriented, farmers are likely to continue to plant rice. No alternatives to rice yet seems to have attracted farmers in any major degree.

The year to year variation in yields is extremely great. Typically in two years in the past five farmers lost 20 percent or more of their crop due primarily to drought or flood (Table 7). The villages surveyed were not in any of the insect endemic areas, and in general insect and disease problems seemed not to be of major importance except in specific pockets such as Sambalpur District.

On the other hand, in all but the two upland villages, significant changes in soil-water conditions seem to have brought about a decrease rather than an increase in kharif yields over the past decade. The causes for the decline were increased incidence of flooding, intensified salinity, and in the irrigated villages decrease in fertility which we judge to be due to zinc deficiency.

Price incentives

When we asked farmers why they were not obtaining higher yields, the most common answer was that they could not afford to buy the inputs. Extension workers seemed to share the view. We examined the profit margins. The price of urea is approximately Rs.2.00/kg and the price of nitrogen Rs.4.50/kg. The price of paddy varies from about 0.75/kg (the approximate Government support level to 1.00/kg). At harvest time in the surplus areas the price is close to 0.75/kg. The rates of kg N to Kg paddy is 6.0 indicating that it requires 6 kg of paddy to buy one kg N. Assuming a typical conversion ratio one 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 does not take into account the interest charged for credit, which is often 50%, and the risks involved. In short, at current prices, fertilizer is not much of a bargain.

Institutions, Organizations and Management

In a recent comprehensive report Agriculcural 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 inter-related services of research, extension, input supply, and credit". The recent report of the Indian Institute of Management Development of Intensive Agriculture--lessons from IADP by V. R. Gaikwad et. al. identifies three subsystems of the agricultural production system which will form the framework of our discussion: (1) producer-farmer subsystem (2) credit and input supply subsystem, and (3) Government administrators subsystems.

The objectives of decision makers in each of the three subsystems are quite different. Therefore, if the communication between subsystems

is lacking, 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 input supplier and the Government but not the farmer. It may be appropriate to add that the linkages between subsystems tend to be weaker in the rainfed areas which are more nearly subsistence.

We can set forth the list of major factors within each subsystem as follows:

Farmer	Input Delivery	Government
Knowledge	Seed	Research
Community leadership	Credit	Extension
Land fragmentation	Fertilizer/Chemicals	Water management
Equitable size of holdings		

The above list is not exhaustive but sets forth what we think to 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 functioning of the systems as a whole and where in some instances further research is required to decide on an appropriate courses of action. The four areas are as follows: (i) farmer--seed delivery--research, (ii) farmer--extension--research, (iii) farmer--research--water management, and (iv) farmer incentives. We have properly 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 us to be a serious lack of community leadership in the villages we visited. In some areas, this was aggravated by the fact that a substantial proportion of the land was owned by absentee landlords and cultivated by landless laborers. This 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 would merit closer study to determine the importance as a genuine 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 from the time of the first cross, it took about 10 years to release a new variety of rice. Even when the variety is released, there is no assurance that seed will be made available to farmers. By contrast, varieties are typically available to the farmers in the Philippines within 5 years of the time of the first cross. The only HYVs currently being grown in widescale 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 those genetic characteristic required for the drought and flood conditions common in Eastern India.

The problem, however, is not only with research. We saw varieties that seemed to be more suitable than what farmers were now using (e.g., IR1442) which has drought tolerance). But the mechanism for field testing and multiplying the variety to assure its rapid and wide dessemination don't seem to be adequate. The "minikit" program needs to be greatly strengthened. There are also apparently plans underway to multiply varieties more rapidly through the development of a state seed corporation.

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

Farmer--extension--research

The extension system in the three States visited is now undergoing a major revision under the Training and Visit System proposed by the World Bank. This system is designed to strengthen the communications link between the farmer, extension and research. The Village Level Workers are now called Village Agricultural Workers and devote full time to agriculture. They receive fortnightly training and relay their information through a series of contact farmers. While the principle appears to be sound, this system in Eastern India is new and cannot yet be evaluated. To further strengthen the link between the farmer, extension and research, it may be desirable to use contact farmers for 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 feed into the system. A strong evaluation programme should be mounted now to observe and evaluate the Training and Visit System. Social science research workers should be prepared to suggest modifications 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, the water regimes in Eastern India are extremely heterogeneous. The major thrust in raising yields will come from improved water control and improved varieties of rice. Both of these steps require public investment and there is a high degree of complementarity between both activities. The way in which the interaction between research on varieties and water control occurs is best illustrated in the "operations research" project at Galsi, Burdwan District, West Bengal referred to earlier.

By making inputs readily available and strengthening extension in the operations research area, the 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 field until December forced farmers to grow late maturing varieties such as Pankaj and made it impossible to plant wheat in the rabi 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 the more adequate control over water needed for wheat irrigation. If these steps could be accomplished, a shorter maturing variety of rice would be needed. As a result of this experience, the District Agricultural Officer is now communicating with the irrigation authorities to convince them to change their water release schedule. Biological research workers have more fully understood the constraints facing the farmers. The need for research in water management has became obvious. These accomplishments and not the modest increase in production are the most important lessons of the operations research project in this area.

Farmer incentives

The disincentives for farm production are many. Often noted are land fragmentation, small size of farms, lack of credit, high cost of inputs, and lack of knowledge on how to use inputs. Land reform and land consolidation programmes are being implemented at an extremely slow rate. Lack of community leadership is another important problem which prevents successful implementation of programmes 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, even the choice of the contact farmers becomes a critical issue.

Research/Extension can also provide another important incentive to farmers in terms of a more cost efficient package of inputs. The recommended doses of chemical inputs are in general very high (such as to serve the objectives of the chemical dealers and the government, but not the farmer). There is far too little effort to teach farmers how to use fertilizers and chemicals efficiently. For example, despite excellent research demonstrating that fertilizer requirement can be significantly

reduced by proper timing and placement, this knowledge is not yet available to farmers.

There are also problems in getting the fertilizer and other chemical inputs delivered in time. Part of the problem, according to a recent World Bank report, stems from the low profit margins to fertilizer dealers. 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 very 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 approximately $150 per ton. This compares with $235 per ton charged to Indian farmer. A ton of ordinary rice in the international market is currently $190 which is approximately the price received by Indian farmers allowing for normal milling and transportation charges. It might be argued that in the subsistence oriented rainfed villages, farmers are not responsive to price. However, in most of these villages we surveyed, a significant portion of the farmers were selling rice to purchase other consumption goods. If a more suitable technology can be placed in the hands of farmers, more favourable fertilizer price would stimulate the adoption of the new technology.

Indian farmers today face one of the least favourable nitrogen to paddy price ratios in all of Asia. The nitrogen to paddy price ratio should be 3 to 1 or less to stimulate fertilizer consumption. It is now between 5 and 6 to 1 in this area.

Summary and Conclusions

- There has been essentially no upward trend in rice yields in three states of Eastern India - Bihar, West Bengal and Orissa - over the past two decades. Only a small portion of the rice area is irrigated, 29% of the gross rice cropped area of which 11% is rabi (dry) season. Of the total of 15 million hectares, 2.5 million or 17 percent is planted to HYV, nearly half of this during the dry season. Modern rice varieties and inputs are not widely adopted in the kharif. Half of the rice area is transplanted to local photoperiod sensitive varieties and another 25 percent broadcast to local varieties.

- The rice growing environment is extremely heterogenous ranging from upland areas that experience frequent drought to lowland areas of chronic flooding and stagnant water. The monsoon rains are of fairly short duration, beginning in mid-June and ending in late September or early October It would appear that in about 1/2 of the 7.5 million hectares transplanted to photoperiod sensitive varieties, there is a need for suitable short duration, non-photoperiod sensitive varieties. In another 1/4 of the area, longer duration non-photoperiod sensitive varieties similar to Pankaj or

Mahsuri might be suitable. In the remaining 1/4, where water is of intermediate depth, photoperiod sensitive varieties are needed.

- Unfortunately, we know all too little about the potential yield of much of the material in experiment stations, because it has not been tested in farmers fields under the wide diversity of environments existing in this area. There is much talk about yield potential and the "gap" between potential and farm yields, but no evidence to verify the existence and magnitude of the gap for each of these environments.

- Due to the high risks of farming, the technology for the rainfed compared to the irrigated areas should be yield stabilizing and low cost. High stability varieties (HSV) are more appropriate for these rainfed areas than HYVs.

- The current price structure also discourages the use of modern inputs. The nitrogen to paddy rice price ratio (kg paddy to buy one kg N) is about 6. At current world price for urea and paddy, the ratio is about 3.5.

- 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 particular attention should be given to ways to shorten 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 a 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, needs to be strengthened. Ultimately the strengthening of farmer incentives requires the strengthening of community leadership and organization. This provides perhaps the greatest challenge for social science research.

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FOOTNOTES

1/ Edward J. Clay, Agricultural Development Council, Bangladesh, makes the following useful comments on the discussion of cropping patterns in personal correspondence with the author:

> "One problem is that in addition to the distinctions between cropping patterns based on elevation of land in moving from Orissa to northern Bihar, one also has to take account of climatic changes which affect production possibilities. The orissa coastal area and the southern parts of West Bengal are tropical-subtropical regions in which it is possible to grow rice crops in any of the three seasons: Aus, Aman, Boro. However, in the districts of North Bengal and Northern Bihar, the dry season temperatures fall as low as 40-45°F. and inhibit the growth of all the locally available rice varieties during the Boro season. For this reason one really requires a double classification: first of all similar to that of Table 4 for the predominantly rice growing areas, and a second classification for the northernmost districts where one finds the low land rice and rice/jute cultivation and on slightly higher, better drained land the rice, wheat and complex of alternative cropping patterns including maize which you identify and also millets which in my experience are far more important in these northern districts than is generally realized.
>
> Rabi season usually refers to the non-rice crops whilst the winter rice crop is normally referred to as Boro. The substitution possibilities between jute and rice are also more complex than indicated in paragraph 3 on page 2. For example, on very low land, the choice is between the low land variety of jute (Corchus Capsularis, locally known as Dacca or Deshi jute) and broadcast Aman (deep water rice). This substitution is reflected in the intercropping of jute and rice by some farmers on this land. As one proceeds from east to west, the duration of the monsoon and rainfall also affect the choices for the farmer. Thus, in the north and central districts of Bangladesh, farmers grow an early maturing jute crop, usually the supposedly lower land capsularis variety, followed by a transplanted Aman crop. However, further west where the monsoon begins later and ends earlier in the important jute area of northeastern Bihar, farmers grow either a higher value later maturing crop of Tossa jute (Corchus Olitorius) <u>or</u> a rainfed transplanted Aman crop which is transplanted from mid July to early August and on even higher land a Broadcast Aus crop."

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Table 1. Statistics for selected states of India, 1974

	Northern India	Southern India	Eastern India
Percent of total rice area	2	21	40
Percent of total rice production	3	33	34
Percent rice irrigated (1970)	89	84	29
Percent area in HYV	71	62	12
Fertilizer (Kg NPK/ha)	28	28	10
Yield paddy (7 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

Northern India - Punjab, Haryana, Jammu, Kashmir

Southern India - Andhra Pradesh, Karnataka, Kerala, Tamil Nadu

Eastern India - Bihar, West Bengal, Orissa

TABLE 2. Rice Areas in Bihar, West Bengal and Orissa States, India by Specified Characteristics in Millions of Hectares, September 1977. 1/

Type of Culture topographic position and water depths	Transplanted		Broadcast		TOTAL
	Photo-Sensitive	Non-photo Sensitive 2/	Photo-Sensitive	Non-photo Sensitive 3/	
Irrigated (mostly on soils from alluvium)					
Kharif, medium, 0-15 cm	2	1 (HYV)	-	-	3
Rabi, Medium, 0-15 cm		1 (HYV)	-	-	1
Uplands (all Kharif wet season)					
Upland unbunded		-		1.5	1.5
Rainfed, medium and high bunded	1.5	1.0	-	0.5	3.0
Lowlands subject to submergence, 15-30 cm	0.5	-	-	-	0.5
Lowlands (all kharif wet season)					
Shallow rainfed, medium lands, 0-15 cm	0.5	0.5	-	-	1
Intermediate rainfed, medium low and lowlands, subject to submergence, 15-30 cm	1.0	-	-	-	1
Semi-deep stagnant water water remains until Nov. subject to submergence 30-50cm	1.5	-	0.5	-	2
Deep, stagnant water remains until late Nov. to early Dec. subject to submergence, 50-150 cm	0.5	-	0.5	-	1
Deep, stagnant water remains until end of Dec., 150-300cm	-	-	1.0	-	1
TOTAL	7.5	3.5	2.0	2.0	15

1/ Tentative classification by R. Feuer and R. Barker, September 1977.

2/ In 1976, there were an overall total of 2.5 million hectares of non-photosensitive HYV's grown representing 17% of the total area.

3/ Of the lowlands, perhaps 0.5 million hectares, along the costs are saline.

Table 3. Classification of percent of photoperiod sensitive rice areas and production in Bihar, West Bengal and Orissa by water regime, September 1977.

	Water depth (cm)	Area (%)	Production (%)
Irrigated	0-15	27	29
Rainfed			
Upland bunded and shallow bunded	0-15	27	30
Intermediate depth	15-30	20	23
Semi-deep and deep	more than 30	26	18

Table 4. Land category and rice culture in Orissa.

Group	Land Category	% Rice Area	Duration	Sowing	Panicle Initiation	Flowering	Ripening
I	Highland (att)	15	85–105	June 10 to June 25	July 15 to July 25	August 10 to August 25	September 10 to September 30
II	Medium High	20	105–120	June 10 to June 25	July 25 to August 10	August 25 to September 10	September 22 to October 10
III	Medium	27	120–135	June 8 to June 20	August 10 to August 25	September 10 to Sept. 25	October 10 to October 25
IV	Low Medium	23	135–150	June 6 to June 14	Sept. 10 to Sept. 25	October 20 to November 5	November 10 to November 20
V	Low (Gahir-Pat)	12	150–165	June 4 to June 14	Sept. 20 to October 5	October 20 to November 5	November 20 to December 5
VI	Very low (Pat)	3	> 165	June 4 to June 12	Sept. 30 to October 15	October 30 to November 15	November 30 to December 20

Deviation 7 - 10 days

Broadcasting - Mid-June

Transplanting - July-August, 1st week

Source: D. Lenka, Department of Agronomy, Orissa College of Agriculture, 1977.

TABLE 5. Rice Yield (t/ha) in Bihar, West Bengal and Orissa States, India by Specified Characteristics, September 1977. 1/

Type of Culture topographic position and water depths	Transplanted		Broadcast		Total
	Photo-Sensitive	Non-photo Sensitive 2/	Photo-Sensitive	Non-photo Sensitive 3/	
Irrigated (mostly on soils from alluvium)					
Kharif, medium, 0-15 cm	1.5	2.0	-	-	1.7
Rabi, medium, 0-15 cm		2.5			2.5
Uplands (all Kharif wet season)					
Upland unbunded		-	-	0.6	0.6
Rainfed, medium and high bunded	1.5	1.5		1.0	1.4
Lowlands subject to submergence, 15-30 cm	1.5	-	-	-	1.5
Lowlands (all kharif wet season)					
Shallow rainfed, medium lands, 0-15 cm	1.5	1.5	-	-	1.5
Intermediate rainfed, medium low and lowlands, subject to submergence, 15-30cm	1.5	-	-	-	1.5
Semi-deep stagnant water remains until November subject to submergence 30-50 cm	1.0		1.0	-	1.0
Deep, stagnant water remains until later November to early December subject to submergence 50-150 cm	0.8	-	0.8	-	0.8
Deep, stagnant water remains until end of December, 150-300 cm	-	-	0.6	-	0.6
Average	1.4	1.9	0.8	0.7	1.4

1/ Tentative classification by R. Feuer and R. Barker, September 1977.

2/ In 1976, there were an overall total of 2.5 million hectares of non-photosensitive HYV's grown representing 17% of the total area.

3/ Of the lowlands, perhaps 0.5 million hectares, along the costs are saline.

Table 6. Selected factors from survey of seven villages in Bihar, West Bengal and Orissa, September 1977.

	Upland rainfed		Lowland rainfed			Irrigated Kharif[1/]	
	Ranchi Bihar	Purulla West Bengal	Muzaffar pur, Bihar (Vill. 1)	(Vill.2)	24 Para-ganas West	Cuttack Orissa Vill. 1	Cuttack Orissa Vill. 2
Population	1175	354	3500	1698	350	1400	-
Cultivated ha.	205	42	333	180	75	229	-
People/ Cultivated ha	6	8	10	9	5	6	-
Landless	2	17	35	20	30	40	25
Size of farm (ha)	0.6	0.4	0.8	1.0	0.4	1.2	1.5
Average yield (quintals/ha)	12	8	10	10	14	15	16
Years in 5 yield loss over 20%	2	2	2	3	2	0	2
Trend in yield over 10 years	up	up	same	down	down	down	down
Percent of farmers selling	10	100	5	50	50	100	100
Paddy (Rs./kg)	0.65	0.85	0.75	0.75	0.92	0.75	0.75
Nitrogen (Rs./kg)	4.50	4.10	4.50	4.50	4.10	4.50	4.50
Kg N/kg paddy	6.9	4.80	6.0	6.0	4.5	6.0	6.0
Wage rate (male day)	3.00	-	3.00	3.00	3.00	3.50	3.50

1/ In neither case was the irrigation ideal. In the first village the land was low lying and not very suited to HYV in Kharif. The second village was located at the end of the canal and subject to drought.

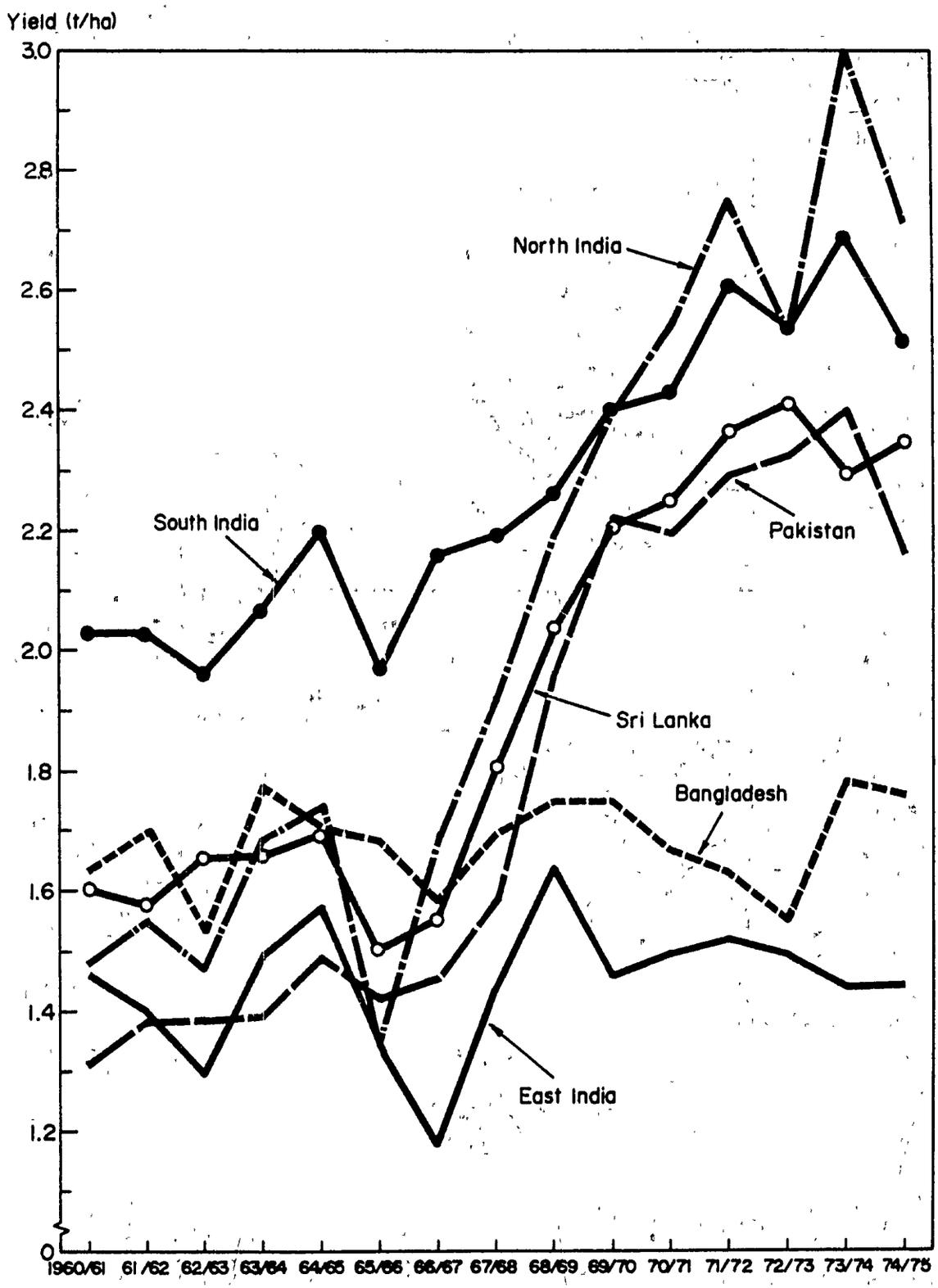

Fig. 1. Rice yield trends in 3 regions of India, Bangladesh, Pakistan, and Sri Lanka, 1960/61 to 1974/75.

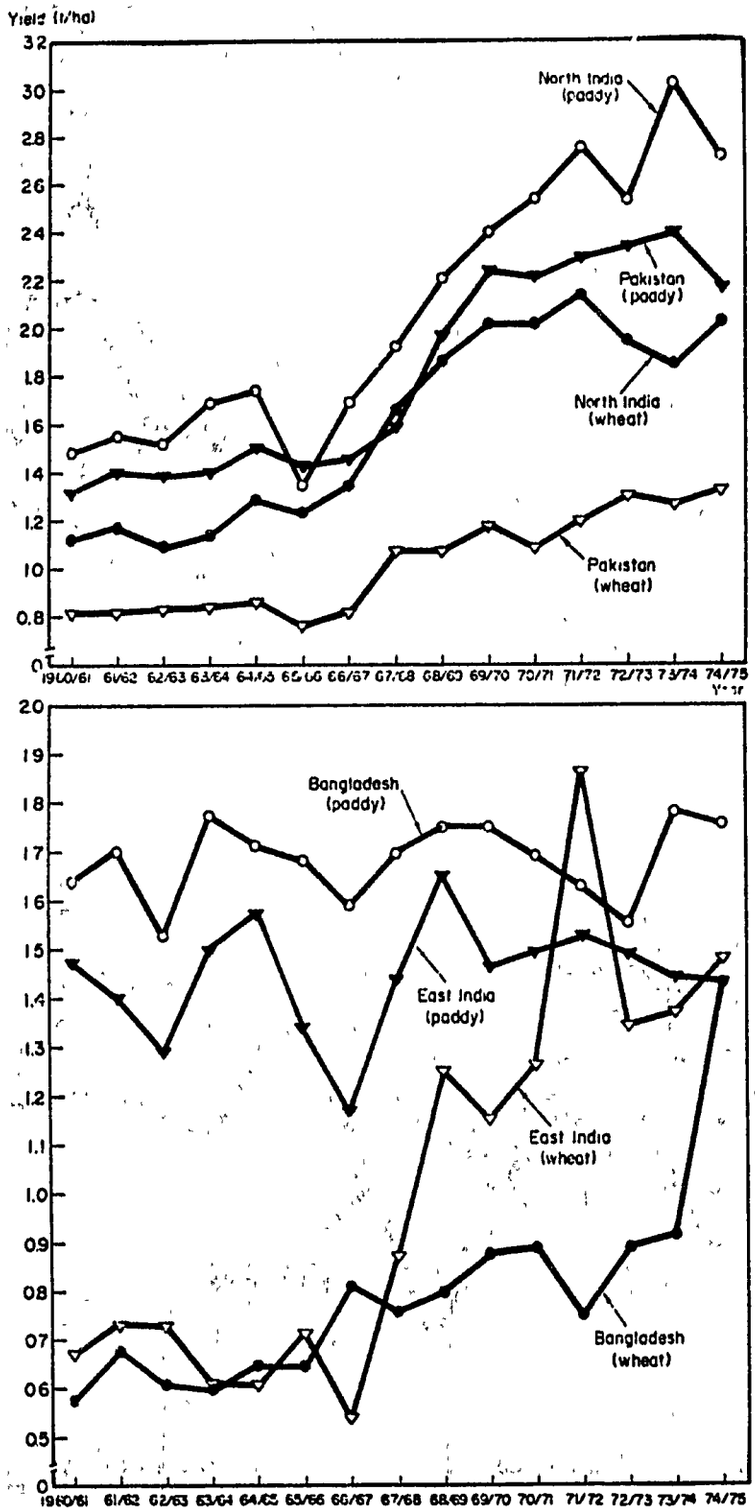

Fig. 2. Yield trends of rice and wheat in North India and Pakistan (top) and East India and Bangladesh (bottom), 1960/61 to 1974/75.

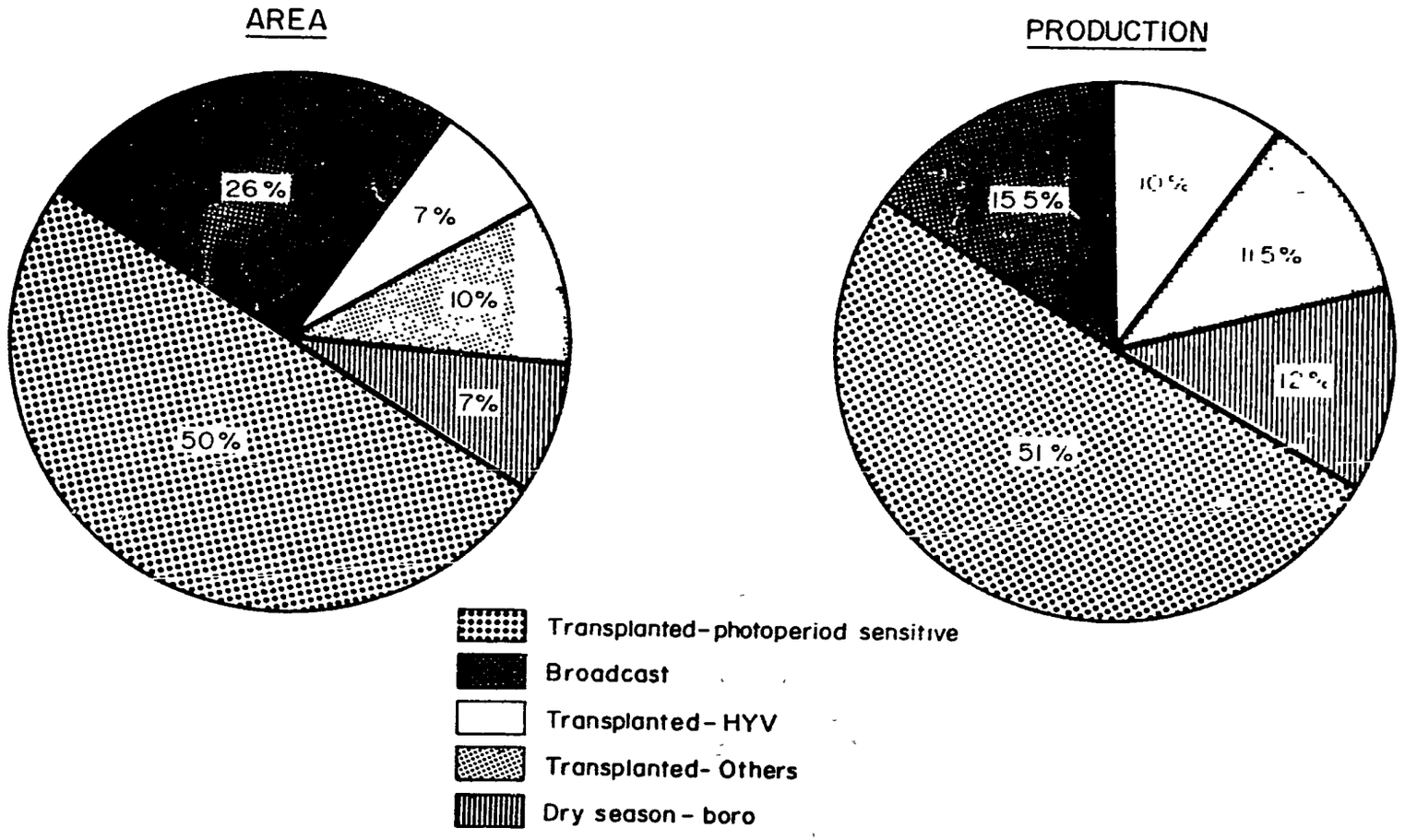

Fig. 3. Contribution of varietal types to total rice area and production, Bihar, West Bengal and Orissa, 1977.

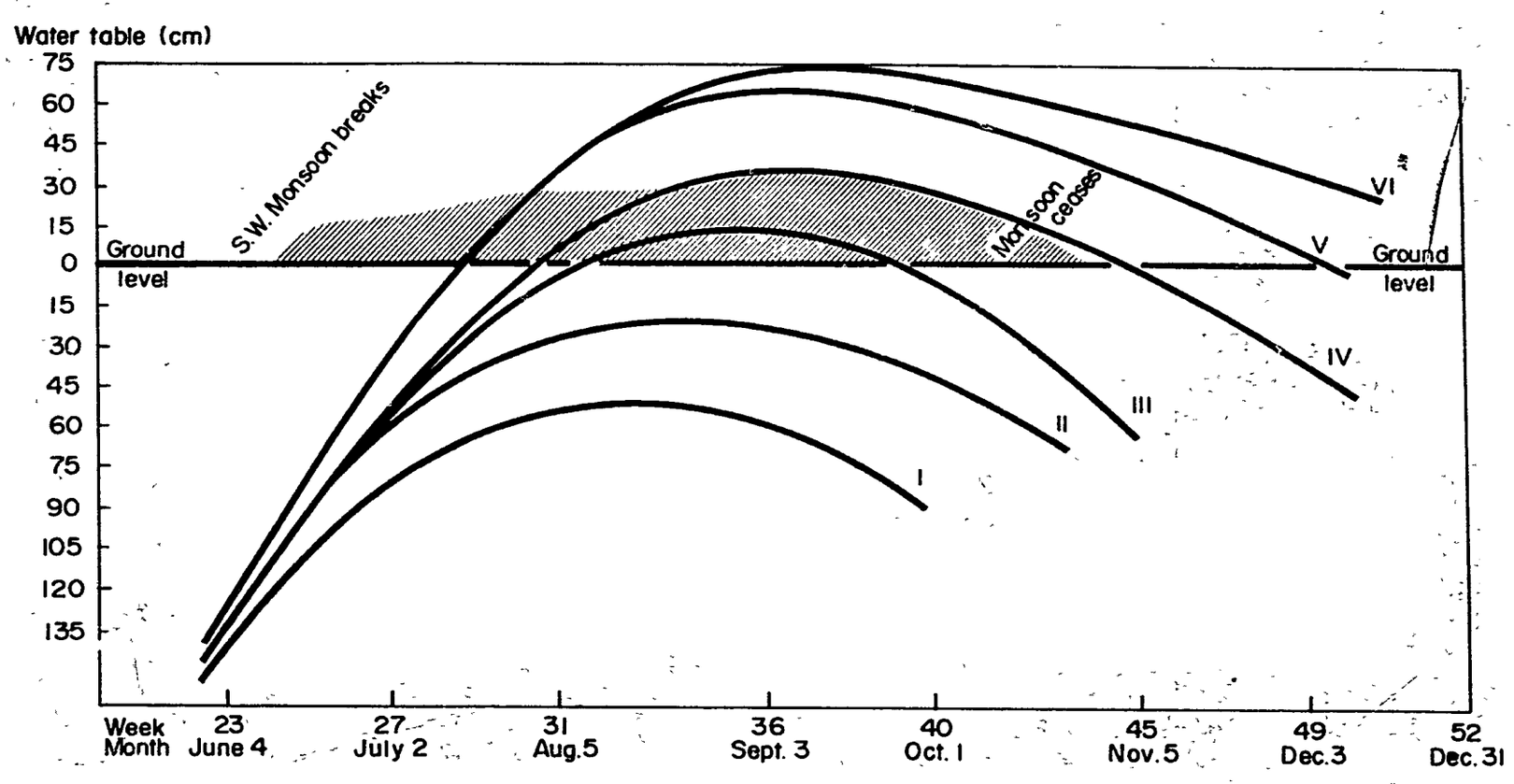

Fig. 4. Variation of water table in ricefield of Orissa.

Source: D. Lenka, Dept. of Agronomy, Orissa College of Agriculture, 1977.