Adoption of Basmati-385: Implications for Time Conflicts in the Rice-wheat Cropping System of Pakistan's Punjab

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PARC/CIMMYT Paper No. 89-1

Agricultural Economics Research Unit (PARC)
Ayub Agricultural Research Institute
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Foreword

The rice-wheat cropping system of Pakistan, indeed of all South Asia, is important for agricultural development in our region. However, the rice-wheat system faces a number of constraints in the main rice-growing areas. A major one in the Punjab of Pakistan has been the late harvesting of basmati rice, which reduces productivity of the following wheat crop. The system has also been constrained by the low yield potential of Basmati-370, an old and well-proven variety. In 1985, the Rice Research Institute, Kala Shah Kaku, released the variety, Basmati-385, which has proved to be very popular amongst farmers.

The present study has been conducted to provide a timely assessment of the implications of the very rapid adoption of Basmati-385. It gives an interesting example of the type of research that social scientists can, and should, do on agricultural research developments in Pakistan. We should do more on understanding why certain technologies are rapidly taken up by farmers, and others are not.

I am sure that both biological and social scientists, having a keen interest in agricultural development, will find this study useful. The findings of this study deserve to be widely disseminated amongst researchers, agriculturalists and policy makers.

I commend the Agricultural Economics Research Unit (PARC), at Ayub Agricultural Research Institute, Faisalabad and CIMMYT, Islamabad for completing this fine piece of interesting and relevant work.

Amir Muhammad

Dr. Amir Muhammad,
Chairman,
Pakistan Agricultural Research Council,
Islamabad.

Preface

In 1985, the Pakistan Agricultural Research Council established an Agricultural Economics Research Unit (AERU) at Ayub Agricultural Research Institute, Faisalabad, with the following objectives:

- o to conduct farm-level agricultural economics research in collaboration with biological scientists on important issues for researchers and policy makers
- o to use this research to help establish priorities for research
- o to provide support to biological scientists in the conduct of their research.

This study is part of the series of studies conducted by the AERU, in close collaboration with biological scientists with the support of CIMMYT. In this case, the collaboration was with the Rice Research Institute, Kala Shah Kaku, Lahore. The objective was to examine the economic implications of the very rapid adoption of Basmati-385 in recent years in the northern Punjab.

Basmati-385 is significantly more profitable than the other basmati varieties, as well as IRRI varieties. Therefore, a strong substitution in favour of Basmati-385 occurred. The main factors contributing to higher profitability of Basmati-385 compared to Basmati-370 are the significantly higher yields of Basmati-385 and shorter maturity. This translates into improved timeliness and better land preparation for wheat in the following rabi cycle.

One way that Pakistan can increase further agricultural production is by increasing cropping intensity. Shortening maturity and quickening turnaround time between crops can help achieve this. The current study is focussed on this issue in the rice-wheat cropping system. Basically, it demonstrates the need to do useful research on ways of reducing turnaround time, including zero tillage, land preparation and weed control.

I hope that the study will prove to be useful for agricultural planners, researchers, extension workers and policy makers. It can also provide a sound basis for carrying out similar work on cropping systems in different agro-ecological zones of Pakistan. I really appreciate the efforts of the research staff who conducted this study.

Dr. Agha Sajjad Haider,
Member, Social Sciences,
PARC.

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Abbreviations

AARI	Ayub Agricultural Research Institute
AERU	Agricultural Economics Research Unit
CIMMYT	International Maize and Wheat Improvement Centre
IRRI	International Rice Research Institute
PARC	Pakistan Agricultural Research Council
RRI	Rice Research Institute, Kala Shah Kaku

Local Terminology

basmati	high-quality long-grained aromatic rice
kalar tract	saline area suited to rice cultivation in northern Punjab
rauni	irrigating after rice harvest for land preparation for wheat
tehsil	a sub-district
wadwatter	using late irrigation of rice for land preparation for wheat

For this study, $US 1.00 equals approximately 18 Rupees

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Executive Summary

- The traditional basmati rice-wheat cropping system of Pakistan's Punjab involves major time conflicts between the harvesting date of rice and the planting date of wheat. The lengthy maturity period of traditional basmati has led to wheat often being planted late in the crop rotation, with consequent losses of wheat yield. It has been estimated that wheat yields decline on average at 1 percent/ha/day as a result of late planting.

- In this report the implications of widespread adoption of the new input-responsive and shorter maturity rice variety, Basmati-385, are analyzed. There has been a very rapid adoption of this variety which was first made available to farmers in 1985. Since then it has been adopted extremely rapidly to cover almost three quarters of the rice area planted in the main rice zone of the Punjab by 1988. The rate of adoption has been higher than that observed during Pakistan's green revolution with semi-dwarf wheats and IRRI rices in the late 1960s.

- A survey of 144 farmers in the rice zone of the Punjab was undertaken in March, 1988 to assess the implications of this widespread adoption on timeliness of wheat plantings. The survey covered three main rice-growing Districts, Gujranwala, Sheikhupura and Sialkot. Where farmers had more than one variety, data on Basmati-385 and the other main variety were obtained.

- Farmers were asked about their initial sources of awareness of Basmati-385 and their sources of seed of the new variety. By far the majority of farmers (68%) became aware of the new variety from other farmers and 56% obtained their seed from other farmers.

- Yields of Basmati-385 and of other main rice varieties in 1987 were obtained from the farmers. The mean yield of Basmati-385 was 3 t/ha, some 48% higher than that of Basmati-370. The mean yield of IRRI varieties was also about 3 t/ha. Data on use of key inputs were also obtained. Generally, Basmati-385 received higher levels of fertilizer and pesticides than Basmati-370 but less than applied to IRRI varieties.

- The prices received by farmers for the main rice varieties were analyzed. The average price of Basmati-385 was 135 Rs/40 kgs, only 4 Rs/40 kgs below the average price of the high-quality Basmati-370. IRRI prices were just over half those of the basmati varieties.

- Maturity periods were estimated as the number of days from transplanting of rice to completion of rice harvest. In 1987, Basmati-385 matured 14 days earlier than Basmati-370 on average. IRRI varieties matured only a few days earlier than the new basmati variety.

- Factors affecting the date of rice harvesting and turnaround time from rice to wheat were analyzed. The date of completion of rice harvest largely was influenced by the date of transplanting of rice and by variety planted.

- On average, turnaround time from rice to wheat was about 7 days longer following earlier maturing varieties (Basmati-385 and IRRI varieties) than the later maturing one (Basmati-370). With longer turnaround time, farmers undertook more ploughings and spent more time in seedbed preparation, in anticipation of better weed control and higher wheat yields. Thus wheat after Basmati-385 was planted only 6 days earlier than wheat after Basmati-370 on average.

- The differences in profitability of the main rice-wheat rotations were calculated. Generally, gross returns (net of harvesting and marketing costs) were almost 3300 Rs/ha higher for Basmati-385 than with Basmati-370. Additional benefits from improved timeliness of wheat were estimated to be around 540 Rs/ha. With a slightly higher use of inputs of Basmati-385, overall profitability was over 3,000 Rs/ha higher for this variety in rotation with wheat, compared with Basmati-370 in the cropping system. The profitability for the Basmati-385 rotation was estimated to be more than 4500 Rs/ha above that involving IRRI varieties.

- The above differences in profitability (including improved timeliness of wheat planting) explain why farmers have so rapidly adopted Basmati-385. However, this adoption has not led to the gains in improved timeliness that were expected. In part this stems from substitution of Basmati-385 for the earlier-maturing IRRI varieties. It also stems from farmers not taking full advantage of improved timeliness resulting from substituting Basmati-385 for

Basmati-370. This emphasizes the need to continue to place high priority on research to shorten turnaround time from rice to wheat, especially with zero tillage technology, mechanical harvesting and alternative weed and water management strategies.

- Finally, concern has been expressed about declining productivity of the rice-wheat cropping system in Pakistan's Punjab. The results of this study imply that a significant increase in productivity in basmati rice has recently occurred. Other implications of the adoption of Basmati-385 need to be further studied.

ADOPTION OF BASMATI-385: IMPLICATIONS FOR TIME CONFLICTS IN THE RICE-WHEAT CROPPING SYSTEM OF PAKISTAN'S PUNJAB

INTRODUCTION

The rice-wheat cropping system of the irrigated Punjab is a major cropping system in Pakistan. However, wheat yields in rice-growing areas are lower than in neighbouring irrigated areas of the Punjab (Byerlee et al., 1984). One of the major factors limiting wheat yields is late planting of wheat after rice, particularly after the late-maturing basmati rice. Such delays in wheat planting reduce wheat yields considerably. This conflict between rice and wheat can be resolved in several ways, including development of early-maturing rice and wheat varieties, mechanical harvesting of rice, wheat planting through direct drilling or changes in cropping patterns. Until recently the predominant variety grown was Basmati-370, an old tall variety with limited yield potential and relatively in late-maturing. In 1985, the Rice Research Institute, Kala Shah Kaku, released a new high-yielding Basmati variety, Basmati-385, which is also significantly earlier than Basmati-370. In this study we are concerned with the implications of the adoption of Basmati-385 on time conflicts in the rice-wheat cropping system. The specific objectives are:

i) To examine farmers' adoption of Basmati-385 and factors associated with adoption.

ii) To assess the differences in production practices and output of Basmati-385 compared with Basmati-370 in the rice-wheat area.

iii) To assess the turnaround time from Basmati-385 to wheat compared with Basmati-370 in the rice zone.

iv) To analyze the economic implications of adoption of Basmati-385 for both rice and wheat in the cropping system.

v) To suggest some implications for research and extension.

RESEARCH METHODS

Surveys

The main issues and key factors in adoption of Basmati-385 were reviewed initially with key scientists, notably of the Rice Research Institute, Kala Shah Kaku, Lahore. Prior to this, considerable information about the rice-based cropping system (Byerlee et al., 1984) and about Basmati-385 (Chaudhry and Rehman, 1986) was reviewed in detail.

Informal and formal surveys were then carried out for data collection in the rice-wheat area of the irrigated Punjab. First, the Agricultural Economics Research Unit, AARI, Faisalabad, in collaboration with CIMMYT, conducted an exploratory, or informal, survey in the major rice-growing area. The survey was conducted in Gujranwala, Sheikhupura and Sialkot district in February 1988. The survey was carried out to assess the extent and implications of adoption of Basmati-385 in the study area and to develop a questionnaire for a later formal survey. The draft questionnaire was discussed with staff of the Rice Research Institute, Kala Shah Kaku and his comments were incorporated in the final questionnaire.

The formal survey was designed to collect data from the rice growers on adoption of Basmati-385 and its impact on timing in the rice-wheat rotation. The questionnaire contained detailed questions on the production practices of Basmati-385 compared with other rice varieties, on timing of rice harvesting and timing of wheat planting after Basmati-385 and other varieties. Questions on yields of Basmati-385 and of the other main rice varieties were also included, along with other key input variables. Before the start of the survey, the questionnaire was pre-tested and some modifications were made. A copy of the questionnaire is included in Appendix A.

The "Kalar" tract (Gujranwala, Sialkot and Sheikhupura Districts) of the irrigated Punjab was chosen for the formal survey (Figure 1). From these districts, three contiguous tehsils were selected: Gujranwala, Daska and Ferozewala. Twenty four villages from these adjacent tehsils were randomly selected with the probability of selection of the village proportional to the population of the village and the overall population of the three tehsils. Six farmers growing wheat after rice were selected from each sample village to examine the impact of adoption of Basmati-385 on wheat planting and interviewed from each village to give a total sample size of 144 farmers. This sample was a sub-sample of farmers interviewed for a study of area planted to major rice varieties in the rice zone (Sharif et al., 1988a).

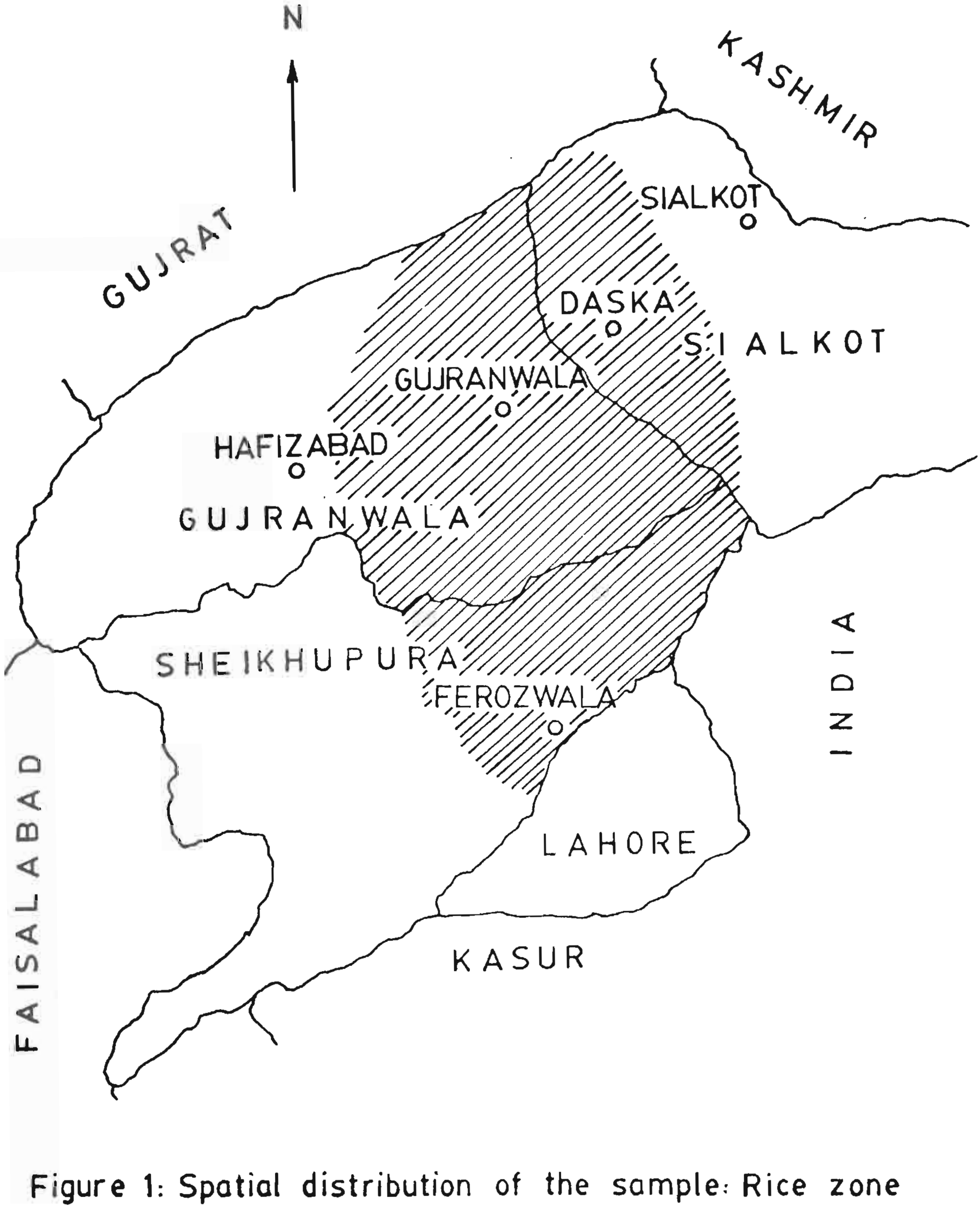

Figure 1: Spatial distribution of the sample: Rice zone

The distribution of sampled growers by variety of rice grown is shown in Table 1. Fifty six of the farms surveyed grew only one variety, and 88 grew more than one variety. One hundred and eight of the sampled growers had planted Basmati-385 and, of these, 74 were also growing another rice variety.

Table 1. The distribution of sampled growers by variety of rice grown, 1987

First Variety	Farmers Growing only one Variety	Second Variety			
		Basmati-370	IRRI Varieties	Others	Total
Basmati-385	34	38	16	20	108
Basmati-370	19	-	4	8	31
IRRI varieties	1	-	-	-	1
Other varieties	2	-	1	1	4
Total sample	56	38	21	29	144

[a] IRRI varieties were IR-6 and IR-9.

The survey was conducted by a team of agricultural economists, from Agricultural Economics Research Unit (PARC), Faisalabad, in the second week of March, 1988. To ensure the quality of data collected, evening sessions were held in the field where cross-checking of data in the questionnaire was done. In order to make comparisons on the same farms between yields, timing and input use of the main rice varieties, data were collected on the two main rice varieties grown by farmers. Data were pre-coded and analyzed using the SPSS package. Additionally, the probit analysis reported was undertaken usthe LIMDEP package.

CHARACTERISTICS OF SAMPLE RICE GROWERS

Characteristics of the sampled farmers are similar to those reported from other surveys of the area (Byerlee et al., 1984, and Sharif et al., 1987). Almost half of the sampled farmers had a farm size of less than 5 hectares (Table 2) and the majority of sample rice growers was owner operators (72%). A high proportion of the farmers were using tractors, either their own or rented in. The major sources of irrigation on sample farms were own tubewell and canal plus tubewell. When farmers have access to tubewells, they generally have better water availability.

Table 2. Characteristics of sample rice growers in in study area

Characteristic		Percentage of Sample
Farm size		
Small	(< 5 ha)	44
Medium	(5-10 ha)	27
Large	(> 10 ha)	29
Land Tenure		
Owner		72
Owner-cum-tenant		22
Tenant		6
Power Source		
Own tractor		48
Rented in Tractor		37
Bullock		6
Rented tractor & Bullock		9
Source of Irrigation		
Canal		3
Own tubewell		44
Rented tubewell		12
Canal plus tubewell		41

ADOPTION OF BASMATI-385 DURING 1985-1988

For the survey year, 1987, the major rice varieties planted were Basmati-385 (51%), Basmati-370 (22%) and IRRI(14%) (Table 3). An additional year's data on area planted to the main rice varieties became available during the final stages of completing this report and are included in Table 3. A comparison with previous years indicates that the area under Basmati-385 has increased very rapidly while the area under Basmati-370 declined rapidly. The percentage of the area under IRRI rice varieties decreased similarly. Farmers have rapidly substituted Basmati-385 for Basmati-370, IRRI varieties, and other important rice varieties in the short space of three years (Figure 2).

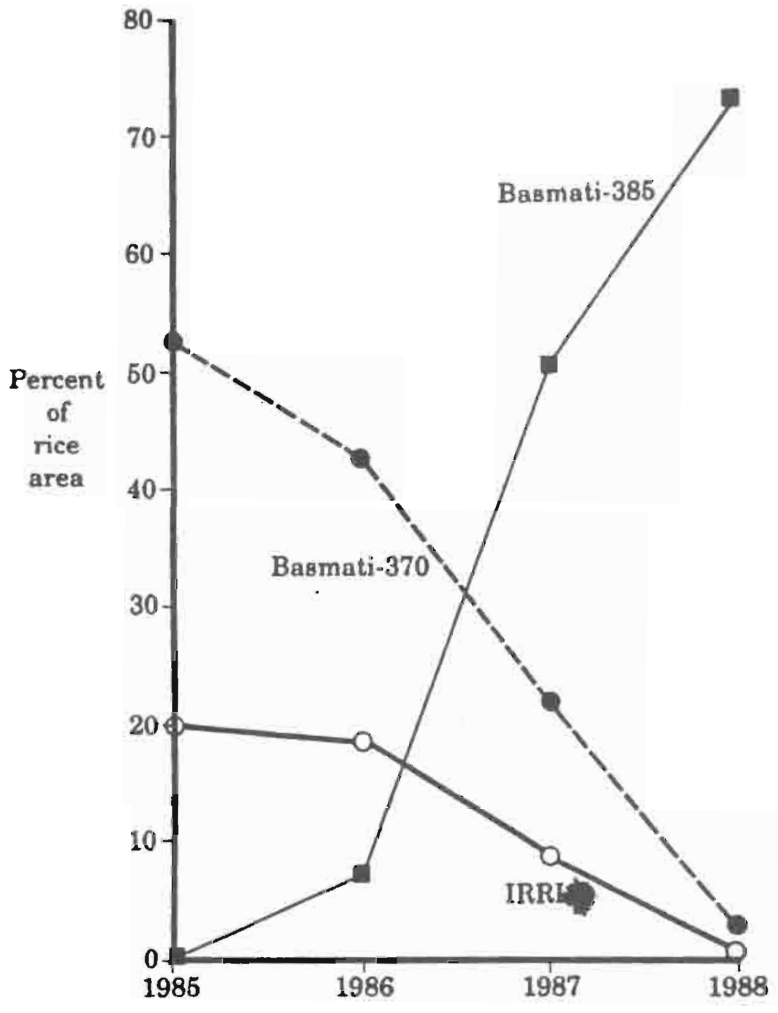

Figure 2. Percent Area Under Main Rice Varieties, Punjab, 1985-88.

Table 3. Area under different rice varieties planted by sample rice growers in the study area during 1985-88

Varietal Group	Year			
	1985	1986	1987	1988[a]
	(Percent Area)			
Basmati-385	0.2	7.3	50.7	73.6
Basmati-370	52.7	42.7	22.3	3.1
IR-6	20.1	18.8	8.8	0.8
Other Basmati	13.0	19.6	13.4	18.6
Other IRRI varieties	14.0	11.6	4.8	3.9

[a] For more details, see Sharif et al., 1988b.

Basmati-385 was most rapidly adopted by the sample farmers in 1987 going from 7.2% of area in 1986 to 51% in one year. This means that the adoption of Basmati-385 has been more rapid than that of semi-dwarf wheats and IRRI rice varieties in the Green Revolution in the late 1960s. A basmati rice revolution has recently occurred in Pakistan.

Farmers were asked about how they first became aware of Basmati-385. The majority of sample rice growers (68%) obtained their first information about the variety from other farmers. The extension department and commission agents (Arthis) were the second and third most important sources of awareness of Basmati-385 in the study area. A small proportion of sample farmers (4%) learnt about Basmati-385 directly from the Rice Research Institute, Kala Shah Kaku, Lahore, where the variety was developed.

The majority of sample farmers (56%) obtained seed of Basmati-385 from other farmers in the rice-wheat area. Another quarter of them obtained seed from arthis, who sell commercial seed on behalf of the Punjab Seed Corporation. The Rice Research Institute and government depots were also important sources of Basmati-385 seed for about 10% of farmers.

Probit Analysis on Adoption of Basmati-385

Adoption of technologies can be influenced by a number of factors, but profitability is an important one (Byerlee and Hesse, 1986). For this study, the main characteristics of sampled farmers were gathered. These are summarised in Table 4.

Table 4. Characteristics of sample rice growers with Basmati-385 and without Basmati-385, 1987

Characteristic	With Basmati-385 in 1987	Without Basmati-385 in 1987
	(Percent farmers)	
Farm Size		
- Small (< 5 ha)	30.6	86.1
- Medium (5-10 ha)	33.3	5.6
- Large (> 10 ha)	36.1	8.3
Land Tenure		
- Owner	75	61.1
- Owner-cum Tenant	21.3	25
- Tenant	3.7	13.9
Source of Irrigation		
- Canal	1.9	8.3
- Own Tubewell	44.4	41.5
- Rented Tubewell	11.1	16.8
- Canal plus Tubewell	42.6	33.4
Extension		
- Extension Contact	48.1	19.4
- No Extension Contact	51.9	80.6

To obtain a better understanding of the main factors underlying adoption, multivariate analysis of farmers' adoption behaviour of new technology is needed (Feder, Just and Zilberman, 1985). To quantify the effect on individual variables, probit analysis was used. This correctly estimates the adoption when the variable measured is either yes or no. Variables considered in the analysis are shown below:

Dependent Variables

ADOPT	0	Not adopted Basmati-385
	1	Adopted Basmati-385

Independent Variables

EDU		Education in years
FSIZ		Farm size in acres
EXT	0	No contact with extension
	1	Contact with extension
TEN	0	Tenant
	1	Owner/owner-cum-tenant

Results of the analysis are presented in Table 5. Farm size explained adoption of Basmati-385 significantly in the rice-wheat system. As well, education was a factor significantly related to adoption of the new variety. These two variables are obviously closely related to each other. Larger farmers were more likely to be better educated, as observed in this study and in earlier ones (Sharif et al., 1986). Interestingly, farm tenure status had little impact on adoption of Basmati-385. As well, no statistical effect of contact with extension on adoption could be found. This latter point may be due to the fact that information on the new variety spread very rapidly from farmer-to-farmer. The majority of the sample farmers obtained their first information about Basmati-385 and its seed from other farmers (Sharif et al., 1988b).

Table 5. Probit analysis of adoption of Basmati-385, 1987

Dependent Variable	ADOPT	0 Not adopted Basmati-385 1 Adopted Basmati-385
Variables	**Coefficient**	**Asymptotic t-values**
CONSTANT	-.823	-1.646
EDU	.071	2.10F*
FSIZ	.033	2.93**
EXT	.234	0.797
n = 144		

**Significant at 5 percent level.
* Significant at 10 percent level.

COMPARISON OF YIELDS, INPUTS AND PRICES OF MAJOR RICE VARIETIES

Key factors underlying the choice of different rice varieties by farmers are yields, inputs and prices. In this section, differences in yield levels, input use and prices are presented for the main rice varieties grown. In Appendix B, pairwise t-tests for differences in yields, inputs and prices are presented for those farmers growing two major varieties of rice. The table that follows in this section includes overall means as well as means for Basmati-385 growers only.

Yields

Yields of rice were obtained by interviewing farmers, on the basis that farmers' yield estimates in the area previously have closely matched those of crop cuts (Byerlee et al., 1984, p.22). Basmati-385 significantly out-yielded Basmati-370, and almost equalled the mean yield of IRRI varieties (Table 6). It should be noted that the year of survey, 1987, was exceptionally dry and some very low yields of IRRI rice varieties were reported by farmers due to shortage of water. Overall, the coefficients of variation in yields were similar for the main varieties, suggesting that the yield of Basmati-385 carried about the same risk as other varieties.

Table 6. Average yields of major rice varieties grown on sample farms in the study area, 1987

Variety	Average Yield (t/ha)	C.V. (%)	Number of Cases
<u>Total Sample</u>			
Basmati-385	2.99[a]	32.4	108
Basmati-370	1.98***	37.9	69
IRRI varieties	3.01[ns]	42.3	22
<u>For Basmati-385 Growers</u>			
Basmati-385	2.99[a]	32.4	108
Basmati-370	2.04***	39.7	38
IRRI varieties	2.91*	49.8	16

Note: Two-tailed t-tests were undertaken to compare differences between mean yields of Basmati-385 against those of Basmati-370 and IRRI varieties for the total sample of each variety. Pairwise t-tests are reported in Appendix B.
*** Significant at 1% level, ** Significant at 5% level,
* Significant at 10 % level, [ns] Not significant at 10% level.
[a] Level of significance for comparing means reported against with other varieties.
[b] For IRRI varieties, two very low yield cases were deleted from the sample.

A comparison of this study's estimates for farmers' yields of Basmati-385 with yield performance from experimental station trials and from trials conducted on farmers' fields is interesting. From this study, farmers yields of Basmati-385 and Basmati-370 averaged 3.0 and almost 2.0 t/ha respectively (Table 6). Thus Basmati-385 out-yielded Basmati-370 by 50 percent. The difference from earlier trials on farmers' fields was even greater. Chaudhry and Rehman (1986) reported average yields of Basmati-385 of 3.6 t/ha., compared with 2.3 t/ha for Basmati-370, a 57 percent difference.

Fertilizer

Since the advent of the green revolution, chemical fertilizers have been regarded as the most important input for increasing IRRI rice output (Sharif et al., 1986). However, traditional basmati varieties have been less responsive to fertilizers. Basmati-385, is the first variety of basmati rice to be released in Pakistan to have high responsiveness to fertilizer. The data presented in Table 7 reveal that for IRRI rice, virtually all farmers applied nitrogenous fertilizers. In contrast, only 71 percent of Basmati-370 growers applied nitrogenous fertilizers. For Basmati-385, a higher proportion of farmers was applying nitrogenous fertilizers than for Basmati-370. In the same way, sample rice growers applied more phosphatic fertilizers to IRRI varieties than basmati varieties. These data suggest that farmers are aware of the greater responsiveness to fertilizer of the new Basmati-385, as compared with Basmati-370.

Table 7. Average dose of fertilizer applied by sample farmers to main varieties of rice

Variety	Nitrogen		Phosphorous	
	Farmers Applying (%)	Average Dose (Kgs/ha)	Farmers Applying (%)	Average Dose (Kgs/ha)
Total Sample				
Basmati-385	89	54^{a}	57	32^{a}
Basmati-370	71	36^{***}	42	21^{***}
IRRI varieties	100	66^{ns}	61	35^{ns}
For Basmati-385 Growers				
Basmati-385	89	54^{a}	57	32^{a}
Basmati-370	76	39^{***}	50	26^{ns}
IRRI varieties	100	66^{*}	64	37^{ns}

Note: These average doses are calculated for all farmers, whether applying fertilizer or not.
a,*,**,*** and ns See for detail note of Table 6.

Insecticides

A higher percentage of farmers was applying insecticides to Basmati-385 than to Basmati-370 and IRRI (Table 8). Insecticide expenditure per treated hectare was higher for Basmati-385 as well. This greater use of insecticides by farmers on Basmati-385 was surprising given the apparently greater insect resistance of the variety (Chaudhry and Rehman, 1986).

Table 8. Average cost of insecticides applied to main rice varieties on sample farms, 1987

Variety	Percentage of Farmers Applying	Average Cost (Rs/ha)
Total Sample		
Basmati-385	29	122[a]
Basmati-370	23	64[*]
IRRI varieties	18	51[ns]
For Basmati-385 Growers		
Basmati-385	29	122[a]
Basmati-370	26	82[ns]
IRRI varieties	25	70[ns]

Note: Average cost is calculated for all farmers, whether applying insecticides or not.
Note: [a,*,ns] See for detail note of Table 6.

Prices

Information on prices received in local markets by farmers in 1987 by varieties of rice are presented in Table 9. Farmers obtained slightly lower prices for Basmati-385 than for Basmati-370. The mean price of Basmati-385 averaged 4 rupees per 40 kg less than that of Basmati-370. The prices of IRRI varieties were just over half of those of basmati varieties and displayed considerably greater price variability across farmers.

Table 9. Average prices of major rice varieties received by sample farmers, 1987

Variety	Price (Rs/40 kgs)	Coefficient of Variation (%)
Basmati-385	135	4.00
Basmati-370	139	8.00
IRRI varieties	68	30.00

Note: Prices are those received by farmers at local markets

The guaranteed prices were set equal for both varieties, so this price difference may be due to a higher proportion of Basmati-385 growers using combine harvesting, than for other rice varieties (Table 10). The use of combines leads to more broken grains and higher price discounts (Smale, 1987). This price difference may also reflect other quality differences between the two Basmati varieties.

Table 10. Proportion of sample growers reporting rice harvesting methods by major rice varieties

Variety	Farm Size Group								Prob.
	< 5 ha		5-10 ha		> 10 ha		All		
	Man	Com	Man	Com	Man	Com	Man	Com	
	(Percent Farmers)								
Basmati-385	91	9	81	19	69	31	80	20	.07
Basmati-370	100	0	94	6	93	7	97	3	.26
IRRI varieties	100	0	100	0	77	23	86	14	.30
All	97	3	87	13	76	14	88	12	.00

IMPLICATIONS FOR TIME CONFLICTS

At the individual farm level, the substitution of Basmati-385 is expected to have important implications for time conflicts, and wheat yields, in the rice-wheat cropping system. This is due to the shorter duration of Basmati-385 compared to Basmati-370 and the improved timeliness of wheat planting as a consequence. Hobbs (1985) reported that 40 kgs/ha/day are lost from late planting of wheat after rice under experimental conditions. Under farmer conditions, the yield loss is estimated to be 30 kg/ha/day, or slightly more than 1%/ha/day, (Aslam et al., 1988).

The key factors influencing timeliness of wheat planting are presented in Figure 3. In the rice-wheat cropping system, the time of wheat planting will be influenced by two key factors, the harvesting date of rice and the turnaround time from wheat to rice. In this section these two key factors influencing wheat planting dates are analyzed by main variety of rice grown. In Appendix B, pair-wise t-tests for differences in rice transplanting dates, harvesting dates, turnaround time, number of ploughings for wheat, wheat planting dates and expected wheat yields are presented.

Maturity Periods of Main Rice Varieties

The data presented in Figure 4 indicate that rice transplanting began in the second week of June and continued until the first week of August. The mean transplanting dates of Basmati-385, Basmati-370 and IRRI varieties were very close, within a spread of five days (Table 11). However, the mean harvesting dates of Basmati-385, Basmati-370 and IRRI varieties were 23rd October, 6th November, 16th October respectively. Thus in 1987, Basmati-385 matured 12 days earlier than Basmati-370 and only a few days later than IRRI varieties (Figure 4). The mean difference in maturity between Basmati-385 and Basmati-370 from this was therefore close to that reported by Chaudhry and Rehman (1986).

Table 11. Mean transplanting, harvesting dates and maturity period for major rice varieties

Variety	Transplanting Date	C.V.[a] (%)	Harvesting Date	C.V.[a] (%)	Maturity Period (days)
Basmati-385	27th June[a]	6	23rd October[a]	4	118
Basmati-370	29th June[ns]	6	8th November[***]	4	132
IRRI varieties	24th June[ns]	6	17th October[ns]	6	115

[a] Coefficient of variation.
[a,***,ns] See for detail note of Table 6.

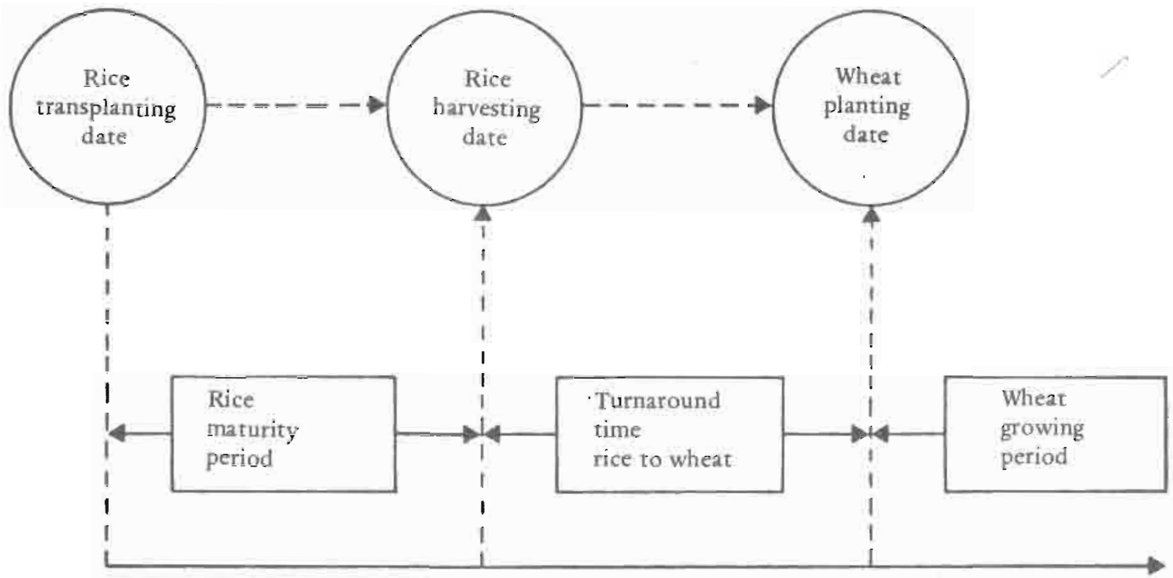

Figure 3. Factors influencing timeliness of wheat planting in Rice-Wheat Pattern.

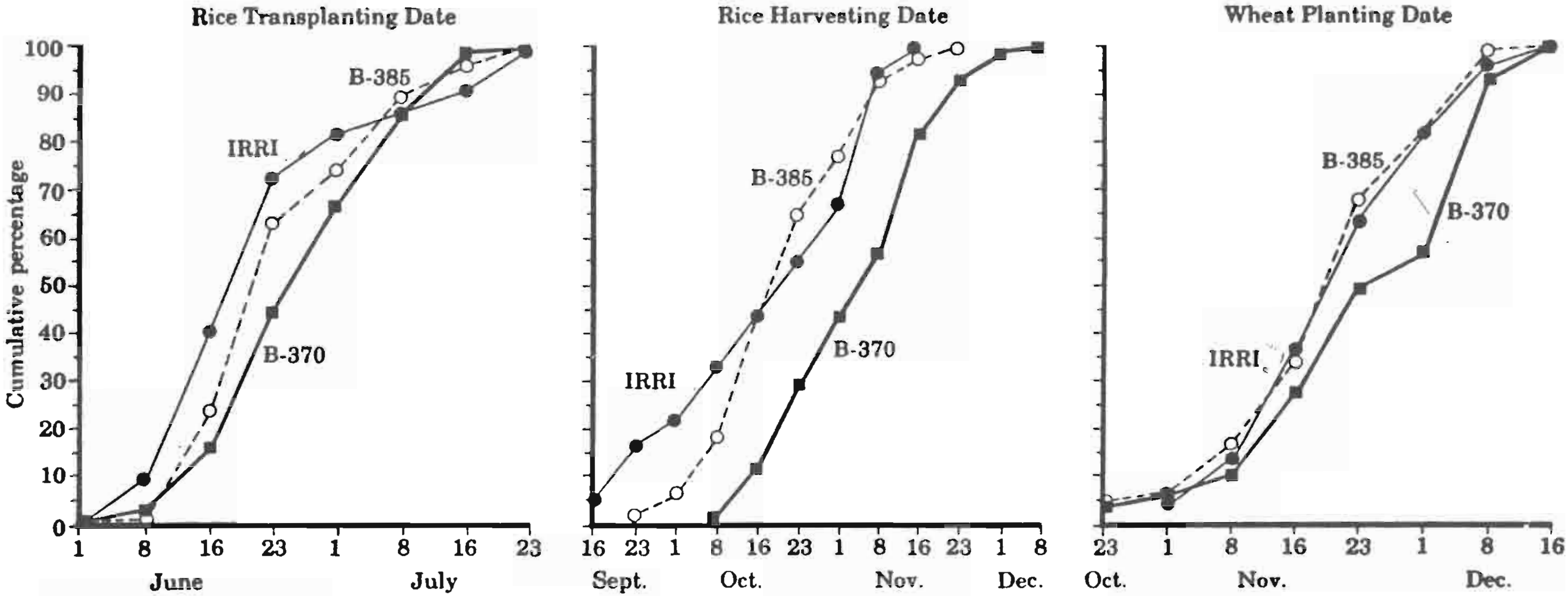

Figure 4. Cumulative frequencies of rice trasplanting and harvesting dates and wheat planting date, 1987.

Regression analysis of factors affecting the date of harvesting of rice varieties was undertaken. The variables hypothesized to affect harvesting date (DHR) were:

DHR = date of rice harvesting (specified in days of calendar year)

DTR = date of rice transplanting (specified in days of calendar year)

DUMB385= dummy variable for variety Basmati-385, (1= if B385, 0= otherwise)

DUMIRRI= dummy variable for IRRI rice varieties (1= if IRRI, 0= otherwise)

IRS = dummy variable for irrigation source (1= tubewell, 0= otherwise).

The best equation, based on statistical and agronomic criteria, was:

$$
\begin{aligned}
DHR = 30.7 &+ \underset{(3.38)^{***}}{0.301\ DTR} - \underset{(-6.45)^{***}}{14.0\ DUMB385} - \underset{(-5.64)^{***}}{19.0\ DUMIRRI} \\
&+ \underset{(1.40)}{1.29\ IRS} \qquad \ldots(1)
\end{aligned}
$$

Adjusted $R^2 = 0.25$ $n = 200$

where t-statistics are in parentheses and ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

The date of transplanting significantly affected the date of rice harvest. The estimated coefficient implies that every three days' delay in transplanting of rice adds an extra day to the date of completing rice harvest, additional to the varietal effect. The coefficient of the dummy variable for Basmati-385 was significant at the 1 percent level. A 14 day difference in maturity period between Basmati-385 and Basmati-370 was thus estimated. The coefficient of the dummy variable for IRRI varieties suggested a 19 day difference between harvesting of IRRI varieties and Basmati-370.

Rice Harvesting Method and Wheat Planting Date

Analysis of the effect of harvesting method for rice on the timeliness of wheat planting was undertaken. No statistically significant difference could be ascertained between harvest completion dates for manual and combine harvesting, respectively, for the major rice varieties. This supports the simple fact that harvesting time for combines extends over about the same period as for manual harvesting (Smale, 1987).

Turnaround Time From Rice to Wheat

The mean turnaround time for shorter-duration varieties (IRRI and Basmati-385) was longer than for Basmati-370 (Table 12). This suggests that the full timeliness advantage of the shorter duration rice varieties was not reflected in wheat planting dates. More farmers growing shorter-duration rice varieties were using the rauni method of irrigation (watering just after rice and before ploughing). This method helps increase the weed kills by cultivation and offers better seedbed preparation compared with the other main method used (wadwatter - watering rice late and preparing the seedbeds with no extra water). With extra turnaround time after earlier-harvested rice varieties, farmers also undertake more ploughings for improved seedbed preparation and weed management. Farmers place a high priority on land preparation for improving wheat yields in the rice-wheat rotation (Tetlay et al., 1988).

Table 12. Mean turnaround from major rice varieties to wheat, average number of ploughings for wheat and percentage of farmers using rauni

Variety	Mean Turnaround Time (days)	Average Number of Ploughings	Percent Farmers Using Rauni
Basmati-385	26^{a}	6.1^{a}	65
Basmati-370	19^{***}	5.1^{***}	48
IRRI varieties	31^{ns}	6.8^{ns}	61

$^{a,\ ***,\ ns}$ See for details, note of Table 6.

Correlation analysis of Basmati-385, Basmati-370, and IRRI harvest dates, turnaround time to wheat after these varieties and wheat planting dates showed some interesting relationships (Table 13).

There were highly significant but negative relationships between harvest dates and turnaround time from rice to wheat for all rice varieties. This implies that when Basmati-385, for example, is harvested early some additional time is available for land preparation for wheat and turnaround time is longer. Similarly late Basmati-385 harvest reduces the turnaround period. There is a significant positive correlation between Basmati-385 harvest date and wheat planting dates. Similar trends were observed for Basmati-370 but turnaround time was shorter than for Basmati-385.

Table 13. Correlation matrix of rice harvesting date, turnaround time from wheat to rice, and wheat planting date

Basmati-385

	HARV	TURN	WPD
HARV	1.00		
TURN	-0.546***	1.00	
WPD	0.569***	0.255***	1.00

Basmati-370

	HARV	TURN	WPD
HARV	1.00		
TURN	-0.433***	1.00	
WPD	0.650***	0.192	1.00

IRRI Varieties

	HARV	TURN	WPD
HARV	1.00		
TURN	-0.697***	1.00	
WPD	0.416	0.228	1.00

HARV = Harvest completion date, TURN = Turnaround time, and WPD = Wheat planting date.
*** Significant at 1% level.

Regression analysis was also undertaken of the main factors affecting turnaround time from rice harvesting completion to wheat planting date. The main factors expected to determine turnaround time (TURN) were:

- Date rice harvesting is completed
- Number of ploughings
- Method and timing of watering before ploughing
- Soil type
- Expectation of use of herbicides in wheat
- Degree of waterlogging.

The best equation, on statistical and agronomic criteria, was:

$$\underset{}{TURN} = 157.6 - \underset{(8.91)^{***}}{0.42\ DHR} + \underset{(2.76)^{**}}{4.24\ DUMWMETH} + \underset{(1.05)}{0.408\ NOP} \quad \ldots(2)$$

Adjusted R^2 = 0.39 n = 200

Where:

TURN	=	Turnaround time (in days)
DHR	=	Date of completion of harvesting of rice (in days of calendar year)
DUMWMET	=	Dummy variable for watering method before ploughing (1=Rauni, 0=otherwise)
NOP	=	Number of ploughings.

The results imply that for every additional week's delay in harvesting, turnaround time was shortened by just over 3 days. Use of wadwatter (irrigation of the soil before rice harvesting) shortened turnaround time by over four days on average. Each additional ploughing was estimated to increase turnaround time by 0.4 days, on average. With earlier harvesting of rice, farmers tended to have more ploughings, ($r = -0.183^{***}$), which improved seedbed preparation, weed kill and wheat yields. Byerlee et al. (1984) reported that every additional ploughing increased wheat yields by 40 kg/ha in the rice zone.

Wheat Planting After Main Rice Varieties

The mean planting dates of wheat in 1987-88 after main rice varieties in the study area are given in Table 14. On average, wheat after Basmati-385 was planted 6 days earlier than wheat after Basmati-370. Similarly wheat after IRRI rice varieties was planted a week earlier than wheat after Basmati-370. By planting wheat 6 days earlier on average, after Basmati-385 than after Basmati-370, farmers could be gaining higher wheat yields of the order of 6 percent, resulting from improved timeliness. However, if they were to take full advantage of the earlier maturity of Basmati-385 (about 15 days), this gain could be of the order of 15 percent, or about 370 kg/ha.

The cumulative planting dates of wheat after the main rice varieties are shown in Figure 4. There are two key features of these results. Firstly, timeliness of wheat planting after Basmati-385 closely matched that of wheat after IRRI varieties and it was clearly better than after Basmati-370. Secondly, a high proportion of the wheat was planted later than recommended. Only a third of the wheat was planted by mid-November, the date for maximising wheat yield. One reason for this might have been the delays caused by local-government elections. However, a more likely reason is that farmers deliberately delay planting for better land preparation and weed kill.

Table 14. Mean wheat planting dates after major rice varieties

Variety	Mean Planting Date
Basmati-385	22nd November[a]
Basmati-370	28th November[***]
IRRI varieties	21st November[ns]

a, *** and ns See for detail note of Table 6.

Regression analysis was also undertaken of the main factors affecting wheat planting date. Since, by definition, wheat planting date (WPD) equals date of harvesting of rice (DHR) plus turnaround time from rice to wheat (TURN), the dependent variable of this equation is a linear combination of the dependent variables of the two previous equations. This is why the results are very similar to those of the previous equation. The main factors expected to determine wheat plating date (WPD) were:

- Date rice harvesting is completed
- Number of ploughings
- Method and timing of watering before ploughing
- Soil type.

The best equation, on statistical and agronomic criteria, was:

$$WPD = 22.05 + \underset{(1.05)}{0.444}\ NOP + \underset{(10.5)^{***}}{0.542}\ DHR + \underset{(2.76)^{**}}{4.58}\ DUMWMET \qquad \ldots(3)$$

$$\text{Adjusted-}R^2 = 0.35 \qquad n = 200$$

where:

WPD = Wheat planting dates (in days)

NOP = Number of ploughings

DHR = Date of completion of harvesting of rice (in days of calendar year)

DUMWMET = Dummy variable for watering method before ploughings (1 = rauni, 0 = others).

This implies that every additional ploughing delayed wheat planting by about half a day. Similarly, every day's delay in harvesting led to about a half day's additional delay in wheat planting. The use of wadwatter significantly reduced the delay in wheat planting (by 4-5 days).

Expected Wheat Yield of Sample Farms

At the time of the survey, the wheat crop was close to harvest. Therefore, farmers were asked to provide their estimated wheat yields for 1987-88 for wheat following main rice varieties. The mean yield of wheat planted after Basmati-385 rice was some 350 kgs/ha higher than for wheat after Basmati-370 (Table 15). Some of this difference would be due to improved timeliness of wheat planting and part would be due to improved land preparation for wheat after Basmati-385.

Table 15. Expected wheat yields and number of ploughings following major rice varieties in study area

Variety	Expected Wheat Yield (t/ha)	Number of Ploughings
Basmati-385	2.46[a]	6.1[a]
Basmati-370	2.11***	5.1***
IRRI varieties	2.32[ns]	6.8[ns]

a, *** and ns See for detail note of Table 6.

Differences in Profitability Between Basmati-385 and Other Main Rice Varieties

Differences in profitability between Basmati-385 and other main rice varieties (Basmati-370 and IRRI varieties) have been calculated using data drawn from the survey. The calculations involved three components: differences in gross revenues from rice grain and straw per hectare, differences in wheat returns from improved timeliness, and differences in costs of main inputs. These were factors assessed as most likely to affect the comparative profitability between varieties.

The field price of rice, yields and input use levels were used to estimate differences in revenues from rice grain and straw between Basmati-385 and other main rice varieties.

Field Prices of Rice by Variety

The field prices of rice by variety were calculated by deducting the costs of harvesting, threshing, transport and marketing from the prices received by farmers at local markets (Table 16).

Table 16. Calculation of field price of rice by main varieties

Item	B-385	B-370	IRRI Varieties
Price Received By Farmers at Market (Rs/40Kg)	135	139	68
Transport and Marketing Cost	4	4	4
Price Received by Farmers at Farm (Rs/40 Kg).	131	135	64
Cost of the Harvest (cutting and threshing) (% of grain)	13	13	13
Field Price of Rice	114	117	56

Gross Field Revenues From Rice Grain and Straw by Main Varieties

Gross field revenues from rice grain and straw for main rice varieties were estimated by multiplying rice grain and straw yields with the field prices of rice grain and straw (Table 17). The gross field revenue from Basmati-385 was 43 and 93 percent higher than that of Basmati-370 and IRRI, respectively. The higher gross revenues from Basmati-385 seem to be the most important factor responsible for its very rapid adoption in the rice-wheat area of the irrigated Punjab.

Table 17. Gross field revenues from rice grain and straw by main varieties

Item	Variety		
	Basmati-385	Basmati-370	IRRI
Rice yield (Kgs/ha)	2990	1980	3010
Field Price Rice (Rs/40 Kgs)	114	117	56
Revenues from Rice Grain at Field Price (Rs/ha)	8522	5792	4214
Revenues from Rice Straw (Rs/ha)[a]	664	636	540
Gross Revenues (Rs/ha)	9186	6428	4754

[a] A brief survey and small crop cut at 20 sites was conducted in early November, 1988, to measure the straw yield of main rice varieties and straw value as assessed by farmers.

In addition to the effects on revenues, the indirect effects on wheat yields were estimated. The average of the farmers' estimates of additional wheat yield after Basmati-385, compared with that after Basmati-370, is 350 kg/ha. At a field price of wheat of Rs 1.54/kg, the additional revenue from wheat after Basmati-385 amounts to about 540 Rs/ha (Table 18). This is mainly attributed to extra ploughings and applying the rauni method applied to wheat after Basmati-385. It should be noted that the indirect revenue effects are comparatively small in relation to the direct revenue differences (Table 19).

Table 18. Assessment of wheat yield and revenue implications for wheat after Basmati-385 compared with wheat after Basmati-370 and IRRI

Item	Wheat after Basmati-385 compared with wheat after Basmati-370	Wheat after Basmati-385 compared with wheat after IRRI varieties
Additional Wheat(Kgs/ha)	350	140
Field Price Wheat (Rs/kg)	1.54	1.54
Wheat Revenue Difference(Rs./ha)	539	216

Profitability Differences

Profitability differences between Basmati-385 and other main rice varieties are presented in Table 19. Total revenue differences between Basmati-385 and Basmati-370 were 2758 Rs/ha, about 43 percent higher for the new basmati variety. An even higher difference in returns is estimated for Basmati-385 compared with IRRI. Overall profitability of Basmati-385 compared with IRRI rice varieties was just over 4500 Rs/ha higher. This clearly reflects the superiority of Basmati-385 cultivation as compared with other main rice varieties in the "Kalar" Tract of Pakistan's Punjab.

Table 19. Differences in profitability between Basmati-385 and other main rice varieties

Item	Basmati-385 Compared with Basmati-370	Basmati-385 Compared with IRRI Varieties
	(Rs./ha)	(Rs./ha)
Rice Grain and Straw Revenue Difference (at Field Price)	2758	4432
Wheat Revenue Difference (at Field Price)	539	216
Total Grain Revenue Differences	3297	4648
Major Input Cost Differences		
- Ploughings	75	0
- Fertilizer	121	12
- Insecticides	54	71
- Irrigations	-16	0
- Total cost differences	234	83
Profitability Differences	3063	4565

Timeliness Effects in Aggregate

So far in this report, we have considered the implications of adoption of Basmati-385 for improved timeliness from the individual farmer perspective. It is also of interest to consider the implications for improved timeliness for the rice zone in the aggregate. As indicated in Table 3 and Sharif et al. (1988b), Basmati-385 has substituted for IRRI varieties as well as Basmati-370. However, IRRI varieties are of shorter duration than Basmati-385. Thus not all of the adoption of the Basmati-385 has led to a gain in timeliness. Only that area in which Basmati-385 has substituted for longer maturity varieties represents a gain in timeliness.

In order to estimate the potential impact in aggregate on timeliness from adoption of Basmati-385, the weighted-average maturity period for the three main rice varieties was calculated from 1985 to 1988, the period of rapid varietal change. The weighted-average maturity was calculated as:

$$M_t = \Sigma W_{it} m_t$$

Where

M_t = weighted-average maturity (days from transplanting to completion of harvest) for rice in year t.

W_{it} = share of rice variety i in total area planted to major varieties in year t.

m_t = maturity period of the ith rice variety.

The weighted-average maturity of Basmati-385, Basmati-370 and IRRI varieties were estimated to be 126 days in 1985, but 118 in 1988 (Table 20). Thus the adoption of Basmati-385 implies an overall gain in maturity of about 8 days. Note that this is well below the maturity difference of Basmati-385 and Basmati-370, which is 14 days.

Table 20. Calculating the weighted-average maturity of the main rice varieties, 1985 to 1988

Share of Rice Variety in Total Area (%)	Year			
	1985	1986	1987	1988[a]
Basmati-385	0.2	9.1	58.5	90.4
Basmati-370	60.6	53.1	25.8	3.8
IRRI	39.2	37.8	15.7	5.8
Weighted Average Maturity(days)	126.3	125.1	121.2	118.5

Note: Assumed maturity periods are Basmati-385, 118 days Basmati-370, 133 days, and IRRI varieties, 116 days. The percentages differ from those in Table 3 because only major varieties were included in this analysis.

[a] Based on Sharif et al. (1988b).

The gain in maturity from substitution of the new basmati variety for the old one are somewhat offset by the losses in maturity from substitution of Basmati-385 for the shorter duration IRRI varieties. In this latter case, farmers have opted to lose a little in timeliness of wheat planting but to gain the extra returns from Basmati-385 when compared to IRRI varieties.

CONCLUSIONS

A major change has occurred recently in basmati rice production in the irrigated Punjab. This is the rapid adoption of Basmati-385, a recently-released variety which is more responsive to major inputs than traditional basmati varieties. Because it is an earlier maturing variety, this change has implications for rice production and for wheat production in the rice-wheat cropping systems of the area.

Basmati-385 is significantly more profitable than the other basmati varieties, so strong substitution for them has been occurring. Basmati-385 is even more profitable compared IRRI rice varieties, at current prices, so Basmati-385 is substituting for them as well. Overall, a significant increase in production of Basmati rice has resulted from the uptake of Basmati-385, but production IRRI varieties has probably declined somewhat.

The main factors contributing to the higher profitability of Basmati-385 compared to Basmati-370 (the main traditional variety) were:

- significantly higher yield of Basmati-385 (about 50 percent on farmers fields).

- shorter maturity (by 14 days), which translates partially into improved timeliness of plantings wheat fields in the rice-wheat cropping system.

Although Basmati-385 prices were slightly lower than Basmati-370 (by 3 percent), and use of purchased inputs higher, this was somewhat offset by the saving in rice irrigations with the shorter maturity variety.

Compared to IRRI varieties, the higher profitability of Basmati-385 is due mainly to the price differences favouring the basmati variety. Yields of Basmati-385 were not much below those of IRRI varieties on farmers' fields, although water shortages may have led to yields of IRRI varieties being reduced in the year of the survey.

With the introduction of the more input-responsive variety, farmers have applied more fertilizer to Basmati-385 compared to traditional varieties. However, use of fertilizer on IRRI varieties was higher than on Basmati-385. The higher use of insecticides on Basmati-385 by farmers is of interest and warrants further field research.

Another factor that warrants further research on Basmati-385 is its acceptability on a quality basis, in domestic and export markets. With the growth in availability of rice of this variety, domestic consumers could now be surveyed to assess this quality factor. However the large yield advantage of Basmati-385 should offset any disadvantage in quality. Assessment of effects on export quality would require a more complex study of export marketing behavior.

The earlier maturity of Basmati-385 has also helped reduce conflicts between rice and wheat due to late rice harvesting. However, even for wheat planted after Basmati-385, almost 70 percent of the wheat is planted after mid-November. Since experimental data indicate declining wheat yields after 15 November, there is a need to intensify research on other ways of reducing turnaround time, including zero tillage, on watering practices before ploughing and on weed management of wheat (especially herbicide use). However, extension agents now could play a very important role in emphasizing the value of more timely planting of wheat.

Finally, concerns have been expressed about declining productivity in the rice-wheat cropping systems of Pakistan and of South Asia more generally. The findings of this study suggest that a significant increase in productivity has occurred because of Basmati-385 entering the irrigated rice lands of the Northern Punjab of Pakistan.

REFERENCES

Aslam, M., A. Majid, N.I. Hashmi, P.R. Hobbs and D. Byerlee. 1988. "On-Farm Research in the Rice-Wheat System of the Punjab: A Synthesis of Results from 1984 to 1988". PARC/CIMMYT (draft research report).

Byerlee, D., A.D. Sheikh, M.Aslam and P.R Hobbs. 1984. "Wheat in the Rice-Based Farming System of the Punjab Implications for Research and Extension". National Agricultural Research Centre, Islamabad.

Chaudhry, A. Majid., and Habib-Ur-Rehman. 1986. "Basmati-385: A New Rice Variety for Punjab", Progressive Farming Vol.6, No.1 Jan/Feb, 1986 PARC.

Feder, G., R. Just and D. Zilberman. 1985. "Adoption of Agricultural Innovations in the Developing Countries". Economic Development and Cultural Change. Vol. 33, 255-298.

Hobbs, P.R. 1985. "Agronomic Practices and Problems for Wheat Following Cotton and Rice In Pakistan" in Wheat for More Tropical Environments, A Proceedings of the International Symposium, CIMMYT, Mexico, 273-277.

Sharif, M., M. Jameel and M. Sarwar. 1986. "Constraints Facing Small Farmers in Punjab". PERI, Publication No. 224, Lahore.

Sharif, M., Z.Ahmad, A.M. Chaudhry, K.A. Tetlay and M.S. Bajwa. (1987). "Conflicts and Challenges in the Rice-Wheat Cropping System of the Irrigated Punjab", AERU, (PARC), Faisalabad. Staff Paper No. 87-9.

Sharif, M, M. Shafique. Z. Ahmad, M.A. Maqbool and J. Longmire. 1988a. "Monitoring Rice Varieties Grown in the Rice Zone of the Punjab: Results from 1985-87", AERU, (PARC), Faisalabad, Staff Paper No. 88-6.

Sharif, M. M. Shafique, Z. Ahmad, J. Longmire and M. Azeem, 1988b. "Rice varietal Adoption in the Rice zone of the Punjab: Results from 1988", AERU, (PARC), Faisalabad. Staff Paper No.88-7.

Smale, M. 1987. "Wheat Harvest Technology in Punjab's Rice Wheat Zone: Combines, Laborers and the Cost of Harvest Delay". PARC/CIMMYT Paper No. 87-23, Islamabad.

Tetlay K.A., P.W. Heisey and Z. Ahmad. 1988. "Issues in the Diffusion of Improve Wheat Varieties in the Irrigated Punjab", PARC/CIMMYT, collaborative Programme, Islamabad.

APPENDIX-A
Questionnaire For the Study

Tehsil ________ Village __________ Enumerator __________

Rice varieties planted (ac)

	B385	B370	Kash	Russ	IRRI-6	IRRI-9	Other(Sp)
1987	_____	_____	_____	_____	____	_____	_______
1986	_____	_____	_____	_____	____	_____	_______
1985	_____	_____	_____	_____	____	_____	_______

Comparison of Rice Varieties

Name of variety		Code		Code
Area of field	______ acre	______	________ acre	______
Date transplanted	______ 1 2 3 4	______	______ 1 2 3 4	_____
Date harvest completed	______ 1 2 3 4	______	______ 1 2 3 4	_____
Total fertilizer applied	Urea _____ DAP	______	Urea___ DAP	_____
Cost of insecticide applied	_____ ____	______	_____ _____	_____
Cost of transplanting	___ ____	______	_____ _____	_____
Yield	______/___	______	______/ _____	_____
Price received	______/ md	______	______/ _____	_____
Method harvest rice	Man___Com ___	______	Mn____Com____	_____
Wheat planting date	____1 2 3 4	______	____1 2 3 4	_____
Turnaround time	____ days	______	____ days	_____
No. of ploughings (wheat)	______	______	___________	_____
Wheat planted on	Wad/Rauni	______	Wad/Rauni	_____
Expected wheat yield, 1988	__________	______	___________	______
Soil type	__________	______	___________	______
Degree waterlogging in wheat field	0 1 2	______	0 1 2	______

For adopters of Basmati 385 Code

First year tried: ____________

Expected area of B385, 1988 ______________acres ______

o Source of awareness Ext ___ Radio ___ Farmer ____ ______
RRI ___ Other (Sp) __________
o Source of initial seed: Depot ___ Farmer ____ RRI _____ ______
Arthi ___ Other (sP) _____

Weedicide Adoption

Area of wheat treated
with herbicide, 1988: __________ acre _____

Product applied: __________ _____

Year first used herbicide on wheat: _____

Combine adoption

Area harvested by combine,
1987: Wheat ___ ac Rice _____ ac ______

(If combine used) Straw burnt __ not burnt ____ ______

(If combine used) Year first used combine ___________ ______

General Farm Information

Power sources: Own Tract __ Rent Tract ___ Bullock ____ ______
RT + B _____

Tenancy: owner ___ Own/Ten ___ Ten ___ ______

Irrigation sources: Canal___ Own TW___ Rent TW___ ______
Pub TW___ Private TW ___ ___

Extension contact, 1987 Y ____ N ____ _____

(If yes) Nature of
information received: Y__F__H__I__ Other (sp) ____ _____

Visited demonstration, 1987 Y ____ N ____ _____

(If yes) Nature of
information received: Y__F__H__I__ Other (sp) _____ ______

Farm size (acres) _____ Rabi crop area: Wheat _____
Berseem ____ Sunflower ___ Veg _____
Other (sp) ______ Fallow ______

Thank the farmer for his cooperation.

Appendix B. Results of pairwise t-tests on different inputs and out puts among main rice varieties on the same farms

Categories	B-385 B-370	B-385 IRRI
Transplanting Dates	-1.65	0.82
Nitrogen	8.15***	-1.24
Phosphorous	8.02*	-1.46
Insecticide Costs	0.39	3.29**
Harvesting Dates	-7.99***	1.61
Yields	8.15***	-1.24
Price/40 kgs	-2.15*	11.98***
Turnaround Time	4.80***	-1.64
Number of Ploughing for Wheat	2.94**	0.32
Wheat Planting Dates	-4.53***	-0.44
Expected Wheat Yields	3.87***	-1.58

Note: Pairwise sample sizes:
Basmati-385 with Basmati-370, n = 38
Basmati-385 with IRRI, n = 16

***, **, * significance level at 1%, 5% and 10% respectively.

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