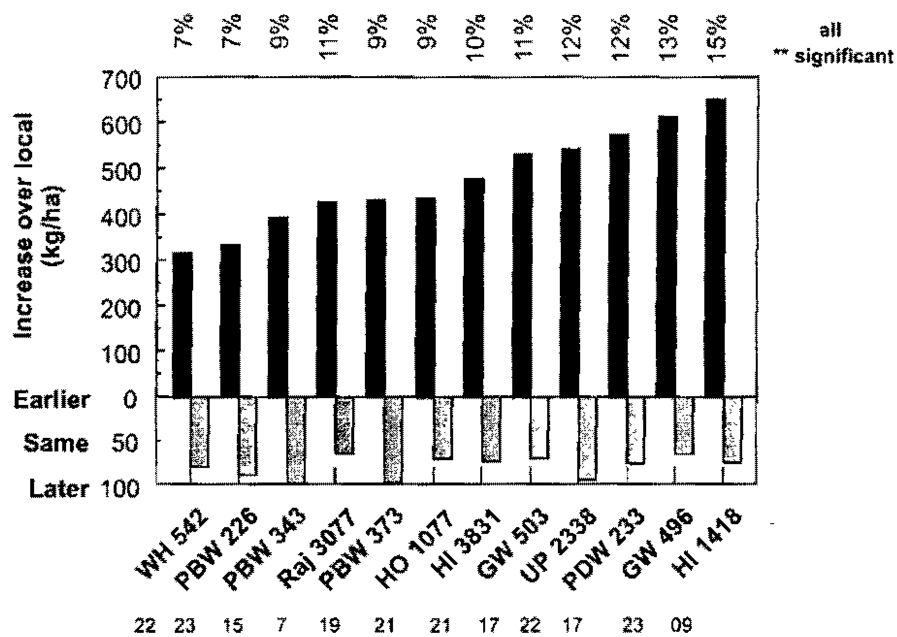

Note: All results are significant at $p < .01$.
Flowering characteristics are calculated as an average of the scores given by farmers, where 0 = earlier than Lok 1, 50 = same as Lok 1, and 100 = later than Lok 1.
GW 496 and GW 503 are the only varieties recommended in Gujarat.
The number of farmers that grew each cultivar is shown below the cultivar name.
The base for percent increase for the yield of the new variety varied because the yield of the check variety varied in each trial.

Figure 3. Results of participatory trials on 13 wheat varieties in Lunawada, Gujarat, 1996–97 (Raj 3765 not shown)

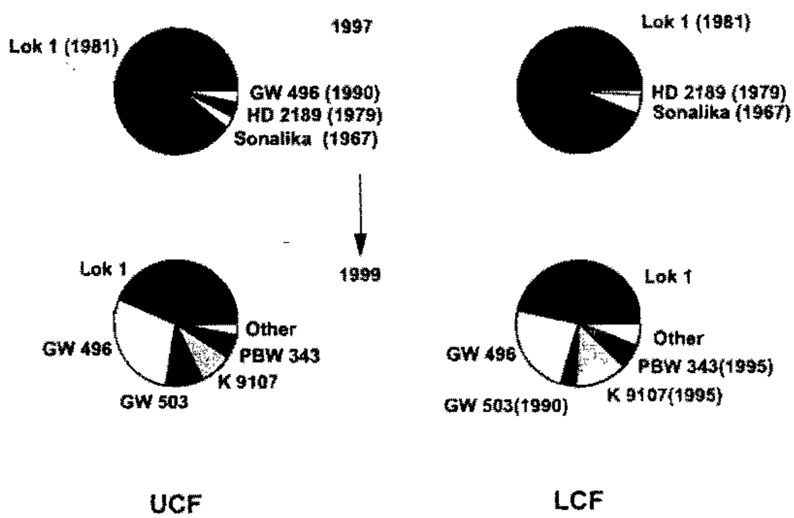

Figure 4. Comparison of percent area of varieties before PVS in 1997 and three seasons later in 1999 after introduction of new varieties in three villages: Kothamba, Ladvel, Thanasavli (Other varieties for UCF were 2% UP2338 [1995] and 1% Sonalika [1967]; and for LCF, 3% WH147 [1979], 2% Raj 3077 [1989] and 1% GW173 [1993].)

- Farmers adopt many cultivars and thus increase on-farm biodiversity. In three seasons, the number of varieties grown by the upper-category farmers increased from four to eight, and for the lower category, from three to nine. There was significant replacement of Lok 1 by more than one variety.
- The proportion of land planted to new varieties increased significantly, with both upper- and lower-category farmers (figure 5). Thus, lower-category farmers benefitted from the increased yields of new varieties as much as the better-off farmers.
- Out-of-state, nonrecommended varieties that meet farmers' selection criteria exist in the country. However, the recommendation domains determined by the formal system for these varieties are too narrow.
- PVS is a potent tool for popularizing recommended cultivars. Variety GW 496 had been released in Gujarat but its area increased substantially after the PVS program.

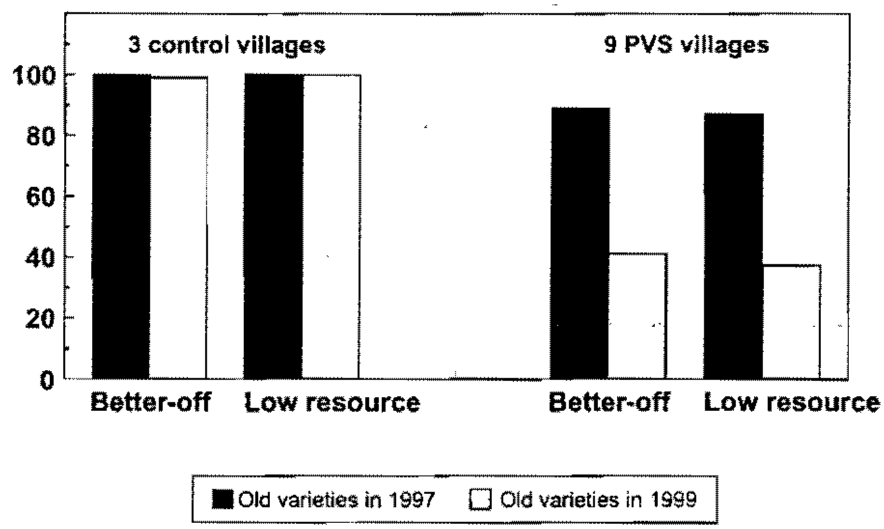

Figure 5. Change in proportion of old varieties (released before 1985) grown by farmers in three control villages and nine PVS villages (using FAMPAR and IRD approaches) (Note that farmers in the lower category benefitted as much from new varieties as those in the upper category.)

Participatory on-farm seed priming. Seed priming is a simple, cheap agronomic intervention to improve germination and ensure better emergence and proper plant stand, particularly in rainfed agriculture: seeds are soaked in water overnight followed by surface drying before sowing. We extended the approach to the HPPS area of Lunawada to compensate for the late sowing of wheat because seed priming has been reported to stimulate earlier maturity (Harris et al. 1999).

Participatory experiments on wheat seed priming in HPPS of Lunawada showed a number of useful effects (figure 6). Almost all participating farmers felt that seed priming induced earlier maturity and that they would use the practice again in the next year. Seed priming also increased yield significantly by about 5%, since the crop had more tillers per plant and larger spikes from more vigorously growing plants than the control.

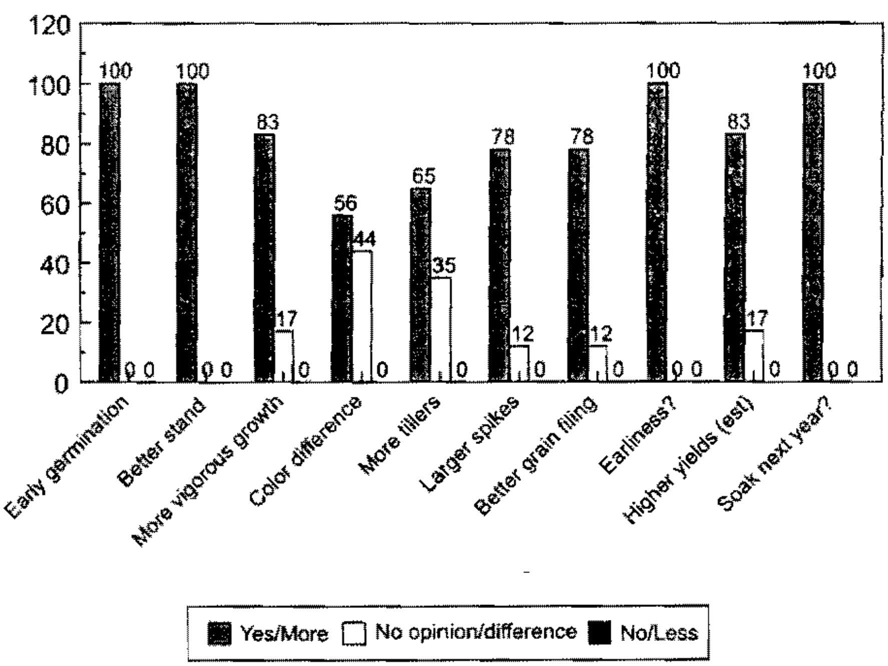

Figure 6. Opinions of 23 participating farmers in seed-priming trials of wheat in *rabi* 1997–1998 in Kothamba and Dalvai Savli villages in Lunawada

Conclusions

Participatory crop improvement should be based on a holistic approach to the farming system. Baseline surveys are needed to understand farmers' practices, and following participatory interventions, follow-up surveys are required to quantify changes in the farming system. This study has shown that participatory approaches to crop improvement can lead to improved livelihoods and can increase on-farm biodiversity.

The study also shows that farmer-participatory approaches are effective in HPPSs (Witcombe 1999), where farmers are benefitting only partially from modern varieties in the period following the Green Revolution. The single intervention of growing a new variety can result in large yield gains. The findings raise questions concerning breeding and extension policies for HPPS, as well as for assuring food security in developing countries.

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Participatory Varietal Selection in Rice in the Punjab

S.S. Malhi, J.R. Witcombe, D.S. Virk, and K.B. Singh

Abstract

Participatory varietal selection (PVS) was used to try to identify an alternative to the most popular rice variety, Pusa 44, in the Patiala district of the Punjab. Pusa 44 (released in 1993 in India but not recommended for the Punjab) is grown in over 50% of the rice area in Patiala. It is highly susceptible to bacterial leaf blight (BLB) but is preferred by farmers because of its high yield and resistance to lodging. Pusa 44 is late maturing and needs to be transplanted very early in the season—as early as the first week in May, when temperatures are very high. This greatly increases demand for irrigation water and accelerates the lowering of the water table, a serious problem in Patiala and the Punjab. It also causes an increase in humidity in the hot season, contributing to the build-up of insect populations on the rice, which is a continuous host after the harvest of sunflower. Because of the lack of a suitable alternative, no recommended variety has replaced Pusa 44 so far.

In the program described here, 12 Indian state-released varieties were provided to farmers to test. Among these 12 varieties, only two were recommended for the Punjab (PR 111 and PR 114). We tested out-of-state varieties since formal multilocational trials do not always determine the precise adaptation of a variety. Three varieties, IR64, IR36, and PR 114, were identified as better performing than Pusa 44, and of these, the best option was IR64. This variety yielded more than Pusa 44, even when transplanted three to four weeks later. This has several additional benefits: it can reduce the need for irrigation water by 20% to 30% and allow green manuring, to improve soil fertility, between the wheat and rice crops. IR64 is resistant to BLB and has better grain quality than Pusa 44. Further testing of IR64 for release in Punjab is being undertaken.

Introduction

Rice is the most important monsoon-season crop grown in the Punjab. The area under rice has increased progressively over the last 20 years, reaching 2.5 million hectares in 1998–99. The average yield of 3.5 t ha^{-1} in 1997–98 (the highest for any state in the country) decreased to 3.2 t ha^{-1} in 1998–99 due to the attack of *tungro* virus disease. Although there has been an increase in the area and total production in the state, there has not been any appreciable increase in productivity over the past decade.

The increasing area planted to rice is the result of a decrease in the area planted to cotton and other less profitable crops. The increasing area under rice presents a number of problems:

- increased water use
- problems of soil health arising from a continuous rice-wheat rotation
- environmental problems, such as the effects on human health of chemicals used to control pests and diseases
- seasonal use of labor
- increased mechanization, with reduced labor opportunities for the poor

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Two features of the large-scale cultivation of rice are relevant to the present study:

1. the widespread transplanting of rice early in the season, contrary to extension recommendations
2. trends in varietal adoption, such as the widespread cultivation of a single variety

We discuss these issues here and present evidence in support of an alternative approach to that of conventional extension: participatory varietal selection for new varieties.

Issues related to rice cultivation in the Punjab

Early transplanting

Time of transplanting is a major factor that substantially influences rice yield. A transplanting schedule has been recommended by the Punjab Agricultural University (PAU) to get the highest yield and prepare the fields in time for the following wheat crop. It is recommended that varieties Jaya, IR8, and all Punjab rice (PR series) varieties should be transplanted from 10–20 June, with the exception of the early-maturing variety PR103, which should be transplanted from 20–30 June. PAU has issued a general guideline stating that where the rice area is large, the transplanting period should extend equally around 20 June (PAU 1996).

Surveys conducted in the Punjab (Singh 1998, 1999) over four years (1996–1999) revealed that transplanting in the Punjab starts from 1 May (figure 1). By the end of May, about 22% of the rice crop is transplanted, and by the middle of June, about 65% of the crop is already in the field. This early planting is more conspicuous in the Patiala district, where about 50% of the rice is transplanted by the end of May and 89% by mid-June.

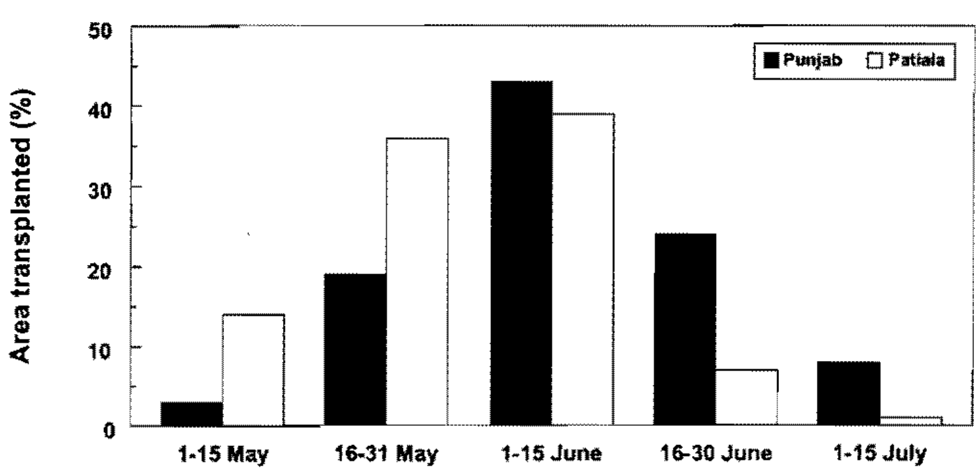

Figure 1. Rice area transplanted from 1 May to 15 July in Punjab and the project area of the Patiala district
(The averages are over four years (1996–1999), based, for Punjab, on a sample of 1076 farmers in 11 districts in 1996 and 1997, and 855 farmers in 1998 and 1999; in Patiala, based on a sample of 105 farmers in 1996 and 1997, and 100 farmers in 1998 and 1999.)

Why farmers practice early transplanting contrary to extension recommendations is an interesting question. Participatory rural appraisals (PRAs) done with farmers reveal some of the reasons farmers transplant late:

- the availability of tube-well irrigation and a cheap, flat rate for electricity
- the continued employment of labor after the wheat harvest
- the limited choice of early-maturing varieties, since high-yielding cultivars tend to have longer maturation periods and need earlier transplanting

Early transplanting of rice has led to multiple problems such as the following:

- a lowering of the water table from greater exploitation of ground-water resources (During May and June, the water requirements for crops are at their peak. The early transplanted crop requires 20% to 30% more water [PAU 1996].)
- the loss of nutrients from evaporation in the extremely hot months, resulting in increased use of chemicals and degradation of the environment
- an increase in diseases and insect pests
- less opportunity for green manuring

Specific varietal adoption patterns

Old varieties are cultivated on a large area. PAU has recommended a number of varieties of rice; however, farmers still prefer to grow old varieties. The varietal surveys conducted by PAU's senior extension specialist (farm management) showed that 36% of the area in the state during 1999 was occupied by varieties released 15 years ago, e.g., PR 106, IR8, Jaya, PR 103, and Govind (Singh 1999).

Weighted average age of varieties is high. The average age of varieties, weighted by the area grown to them in the Punjab, was 12 years in 1996, 11 years in 1997, and 10 years in 1998 and 1999. This average is very close to the 12 years reported by Witcombe et al. (1988) for the whole of India. More recently, farmers have replaced their varieties more rapidly, but the average age remains higher than what could be expected of an agriculturally advanced state. Varieties of wheat and barley grown in the UK in 1999 had an average age of only five years (analysis of data from the National Institute of Agricultural Botany by A.G. Bhasker Raj, *personal communication*).

Nonrecommended varieties occupy large areas. Despite many recommendations by PAU, there is significant adoption of nonrecommended varieties in the state. In fact, the area under non-PAU varieties increased in 1998 and 1999 (table 1).

In Patiala, the adoption of nonrecommended varieties was higher than in the Punjab as a whole (average of 53% over four years). Among nonrecommended varieties, Pusa 44 has the highest adoption. It occupied nearly 50% of the area in the Patiala district in 1996 to 1999. Pusa 44 is highly susceptible to bacterial leaf blight (BLB), and the large-scale cultivation of Pusa 44 has helped to build up the BLB pathogen, which causes losses in other varieties. However, farmers prefer Pusa 44 for its high yield and resistance to lodging.

Table 1. Area of Nonrecommended Varieties in the Punjab and Patiala District from 1996 to 1999

	Area of nonrecommended varieties (% of total rice area)		Area of Pusa 44 (% of total rice area)	
Year	Punjab	Patiala	Punjab	Patiala
1996	31	43	24	43
1997	33	47	28	47
1998	35	60	30	56
1999	38	60	28	54
Mean	34	53	28	50

Note: See figure 1 for information on sample sizes.

Methods and materials

Participatory approaches

Three participatory approaches were used in this study:

1. farmer-managed participatory-research (FAMPAR) varietal trials, in which farmers grow new varieties alongside their local variety under farmer management, with evaluation of many cultivar traits by both scientists and farmers
2. informal research and development (IRD), in which farmers evaluate new varieties with little intervention from scientists; evaluation is mainly from the examination of adoption trends
3. single-replicate design (mother trials), with all varieties grown together as demonstration plots to assess the relative performance of varieties (researcher-designed but farmer-managed trials)

Selection of farmers and villages

Eleven villages (Kalifewala, Chalaila, Kalwa, Barsat, Bhedpura, Gajjumajra, Kaidopur, Dhengera, Partapgarh, Kartarpur, and Jauramajra) were selected to represent agroclimatic situations in the Patiala district. Three villages (Gajjumajra, Bhedpura, and Barsat) represented salt-affected areas with soils having a pH between 9.0 and 9.5. Of these 11 villages, FAMPAR trials were conducted in six and IRD in the rest. All villages have either metaled or good earthen approach roads. All of the agricultural land is irrigated from canals or tube wells.

Farmers were selected to represent small, medium, and large landholdings. Willingness to experiment with new varieties was the key factor in selecting farmers. A total of 497 farmers were involved in participatory research in the *kharif* (monsoon season) of 1999.

Farmer-managed trials

Twelve varieties were tested in participatory trials: IR36, IR64, HKR 120, HKR 126, Pant Dhan 4, Pant Dhan 10, Gurjari, Kalinga III, Govind, Pusa 834, PR 111, and PR 114. Of these, varieties, PR 111 and PR 114 are recommended for the Punjab. All other varieties are out-of-state released varieties. Small bags (2–5 kg) of seed (varying according to the demand of farmers) were given to farmers with the understanding that they would grow the new variety alongside their local variety under the same management and that they would participate in the evaluation.

The plot area for FAMPAR trials varied from 40–5000 m^2. Most trials had an area of more than 1000 m^2 under any variety. Some farmers, particularly in IRD villages, pooled the seed to grow a larger area.

Researchers and farmers jointly evaluated the trials. Frequent farm walks, focus-group discussions, and household-level questionnaires were used for recording farmers' perceptions. Grain yield data were recorded jointly; researchers measured the plot size and farmers weighed the plot yield.

Demonstration plots of all varieties grown in the same field in a single-replicate trial were grown in all villages as mother trials.

Results and discussion

Of the 12 varieties tested with farmers, three (IR64, IR36, and PR 114) were preferred but IR64 was the most preferred. We shall restrict the description of trials to IR64 only. Variety IR64 was tested with 43 farmers (26 in FAMPAR villages and 17 in IRD villages) and compared to Pusa 44.

Farmer trials over several dates of sowing

The greatest power of participatory trials was experienced in this study when IR64 was tested over a span of time representing the whole of the transplanting period in the Punjab. This was not deliberately designed but was a result of the reasonably large sample size that represented the normal practices of farmers. This was not possible in earlier on-station trials that were invariably sown over a restricted, usually late, period. These on-station trials, done in 1985, 1986, and 1987, did not identify IR64 because it yielded less than the check varieties in trials that were transplanted in July.

Performance of IR64

IR64 had a significant yield superiority of 5% over Pusa 44 in 43 trials, giving an extra 300 kg of grain ha^{-1} over a base of 6550 kg (figure 2). IR64 showed the best performance (a 12% yield increase over Pusa 44) when transplanted from 21–24 June. The yield advantage decreased when IR64 was transplanted earlier or later in June, which fits very well with the extension recommendation to spread transplanting equally around 20 June.

An important feature of IR64 is that it matures 26 days earlier than Pusa 44. This trait, along with high yield, favors its adoption in various situations (figure 3).

Farmers' perceptions for traits other than grain yield (figure 4) identified IR64 to be superior to Pusa 44 for number of tillers per plant and resistance to BLB, stem borer, and leaf folder. IR64 is shorter so it is resistant to lodging, which allows it to be responsive to inputs.

Advantages of IR64 over Pusa 44

IR64 had the following advantages over Pusa 44:

- superior grain quality and higher yields
- earlier maturity, leading to a saving of irrigation water
- resistance to BLB and tolerance to white-backed plant hoppers
- resistance to lodging

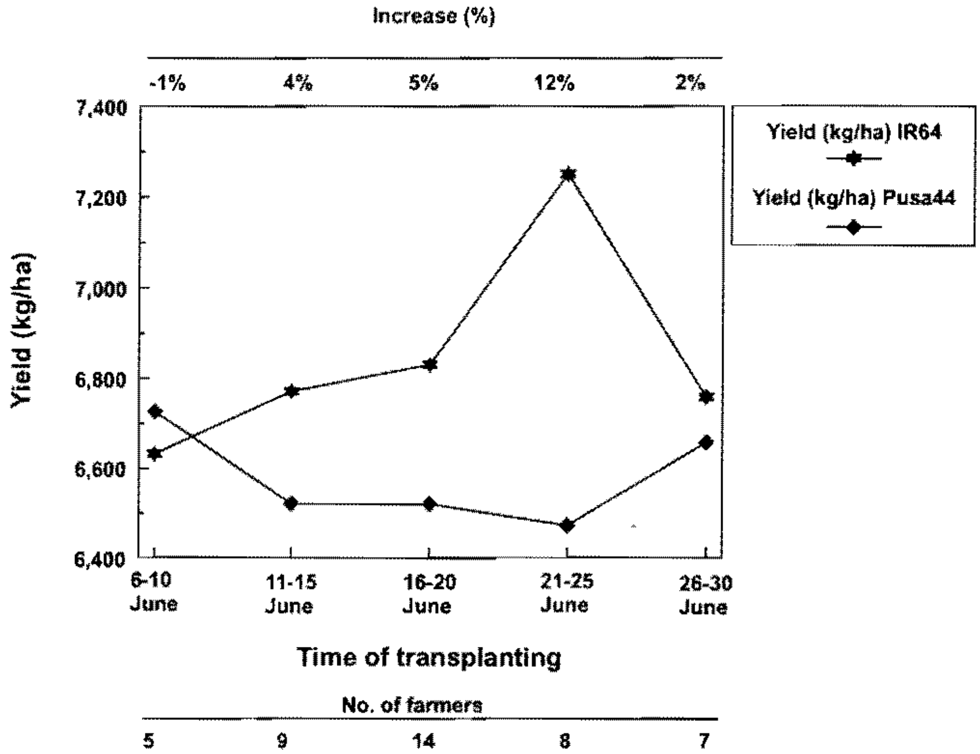

Figure 2. Yield (kg ha^{-1}) of IR64 and Pusa 44 in 43 farmers' field trials (26 FAMPAR and 17 IRD) in the Patiala district during the monsoon season of 1999 (The overall mean yield of 6860 kg ha^{-1} of IR64 was significantly higher [at the 1% level] than the 6550 kg ha^{-1} yield of Pusa 44 with a *t*-value of 4.1 over 43 sites.)

- allowing a green-manure crop or summer mung (*Vigna radiata* [L.] Wilczek) to be grown between the wheat harvest and rice transplanting

Adoption and further testing of IR64

All participating farmers saved IR64 seed in 1999 for growing in *kharif* 2000. There was considerable seed exchange from farmer-to-farmer. Seed demand in *kharif* 2000, from farmers who had seen the trials was considerable, but only five tones of seed could be procured and supplied to farmers. Some entrepreneurial farmers and farmers' groups in the state have already become active in producing and procuring IR64 seed.

As a consequence of the participatory trials in Patiala, PAU is retesting IR64 at a number of research stations under appropriate management. The Krishi Vigyan Kendra (KVK), Patiala, has undertaken large-scale testing on farmers' fields in Patiala and other districts of the Punjab in *kharif* 2000.

To exploit the advantage of IR64's early maturity, new agronomic practices and cropping patterns are being tested by the KVK Patiala in more than 40 trials with farmers. These are on growing summer mung and green manuring with sesbania in *kharif* 2000.

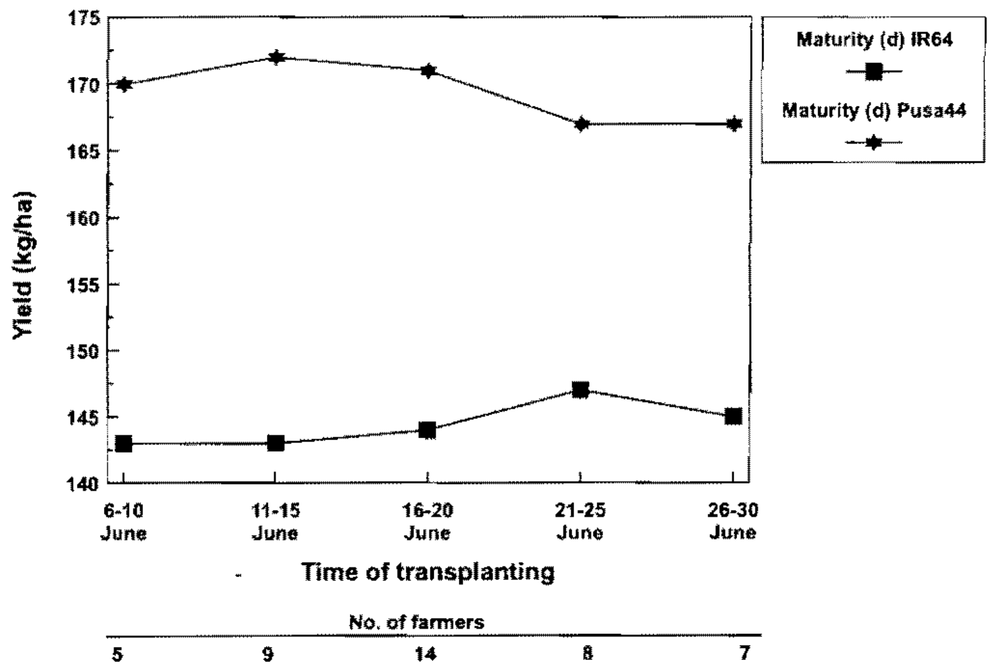

Figure 3. Days to maturity of IR64 and Pusa 44 in 43 farmers' field trials (26 FAMPAR and 17 IRD) in the Patiala district during the monsoon season of 1999 (Over 43 trials, IR64 matured significantly earlier [144 days] compared to Pusa 44 [170 days].)

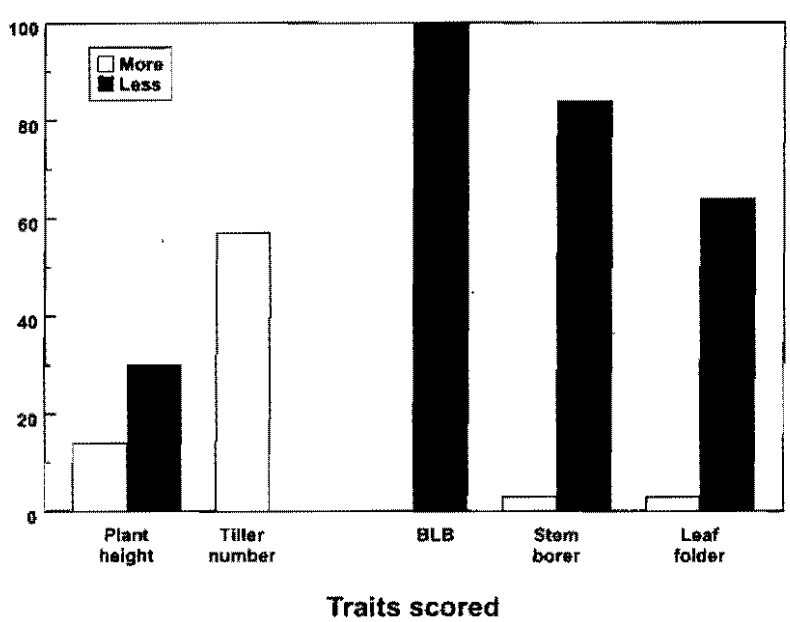

Figure 4. Farmers' perceptions (%) for IR64 in comparison to Pusa 44 for plant height, tiller number per plant, and resistance to bacterial leaf blight (BLB), stem borer, and leaf folder over 48 farmers (Like Pusa 44, IR64 was found to be 100% lodging resistant.)