ADOPTION OF WATER SAVING TECHNOLOGIES IN RICE PRODUCTION IN THE PHILIPPINES


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ABSTRACT

Traditional lowland rice production in Asia requires much water: it consumes more than 50% of all irrigation water used in the region. Water resources are, however, increasingly getting scarce and expensive. There is a need to develop alternative rice production systems that require less water and increase water productivity. In the last decade(s), researchers have studied and developed a number of water-saving irrigation technologies. Although these technologies have been demonstrated to save water and increase water productivity, their adoption by farmers is low because of a lack of extension. Compared with the heavy investments needed to develop new water resources, the adoption of water-saving technologies by farmers is low-cost and has great potential to save water. Therefore, in 2001, a project was initiated to transfer and promote water-saving technologies among farmers in the Philippines called the “Technology Transfer for Water Savings (TTWS)” project. The first two years of the project were designed as a participatory learning phase with project partners. Controlled irrigation or alternate wetting and drying was the first matured water-saving technology included in the first phase of the project while the aerobic rice trials-cum-research were also integrated in the project. This paper documents the activities of the TTWS project, describes the results and implications of the first two-year implementation, and explores a future course of action including widespread training and extension of water-saving technologies in the Philippines.

INTRODUCTION

Rice is the most important food crop in Asia (IRRI 1997), however, it requires most water. In fact, the majority of the world’s rice is being produced under flooded, so-called lowland conditions. Of the roughly 147 million ha rice land, 79 million ha is classified as irrigated lowland, 36 million ha as rainfed lowland, and 13 million ha as flood prone (IRRI 2002). In these ecosystems, rice is mostly grown in bunded, puddled fields under flooded conditions or so-called anaerobic conditions.

Fresh water for agriculture is becoming increasingly scarce. In many Asian countries, per capita availability declined by 40-60% between 1955 and 1990, and is expected to decline further by 15-54% over the next 35 years (Gleick 1993). The main reasons are diverse and location specific, but include increasing population growth, increasing urban and industrial demand, and decreasing availability because of pollution (chemicals, salts, silts) and resource depletion. In agriculture, the situation is aggravated by the dramatically increasing costs for irrigation development over the past decades. Because of the combined increasing demand for food with increasing scarcity of water, rice producers face three major challenges: (1) to save water; (2) to

Keywords: water-saving technologies, controlled irrigation, participatory R&D and extension, process documentation
increase productivity; and (3) to produce more rice with less water (Bouman and Tuong 2001). In the Philippines, some 61% of the 3.4 million ha of rice land is under irrigation, with the majority of the production coming from the rice bowl in central Luzon (IRRI 1997). Irrigation is provided by gravity systems and shallow and deep tubewells. However, the availability of water for irrigation has declined in the last decade(s). Water from the Angat reservoir in Bulacan Province is increasingly diverted toward the Greater Manila Area (Pingali et al. 1997), water in the Agno River Irrigation System in Pangasinan Province is polluted with sediments and chemicals from mining activities upstream (Castañeda and Bhuiyan 1993), and many irrigation systems were destroyed and clogged by the earthquakes of 1990 and the Mount Pinatubo eruption in 1991 (NIA 1996). Because of its dense population and close proximity to the capital Manila, rice production in central Luzon is of strategic importance to food security and poverty alleviation. The government of the Philippines, through its National Irrigation Administration (NIA), is dedicated to maintaining and enhancing irrigation water availability by infrastructure development and maintenance and by the propagation of water-saving irrigation technologies (NIA 1996).

The decreasing availability of water for irrigated rice threatens food security in Asia in general and the livelihood of farmers in particular. Also, the increasing scarcity of water means that the costs of its use and resource development are increasing dramatically (Postel 1997, Rosegrant 1997). Therefore, researchers have been looking for ways to decrease water use in rice production and increase its use efficiency. Though water use can be optimized at scale levels from field to farm, irrigation system, watershed and entire river basins, a fundamental approach is to save water at the field level where water and the rice crop interact. This is also the scale level that concerns rice farmers most. During the past decades, much research has been done at the field level and various technologies have been proposed that save water and increase its productivity while maintaining high yields (Sandhu et al. 1980, Mishra et al. 1990, Li 2001). In the Philippines, pioneering research has been done by the International Rice Research Institute (IRRI; Bhuiyan et al. 1995, Tabbal et al. 2002, Tuong 1999, Bouman and Tuong 2001) and PhilRice (de Dios et al. 2000). Despite the good results obtained in research, however, very little attention has been paid to the dissemination, extension and adoption of the developed technologies among farmers in the Philippines. At the moment, it is not well known how farmers actually manage their water and to what extent they are aware of water-saving technologies. It is generally assumed that rice farmers in Asia have gotten used to the idea of continuously flooding their fields for much of the growing period. This practice is tied up with weed control, ease for transplanting and on the belief that reducing the amount of water will be harmful to the plant. To bridge the gap between research on water-saving technologies and adoption by farmers, IRRI, PhilRice and NIA initiated in 2001 a special project called “Technology Transfer for Water Savings (TTWS)” in rice production.

The TTWS project is part of the international Irrigated Rice Research Consortium (see IRRC page at the IRRI website www.cgiar.org/irri) through the Water Workgroup and has counterpart activities in China and India. TTWS was conceived to develop and implement a framework for transfer, adaptation, and adoption of knowledge on water-saving technologies through the interagency collaboration of the National Irrigation Administration, Philippine Rice Research Institute and IRRI. The first two years of the project are designed as a participatory learning phase with farmers who are using irrigation water from deepwell and shallow tubewell groundwater systems in Tarlac and Nueva Ecija, respectively. Project site selection, baseline characterization and needs and opportunities assessment were conducted in 2001. The actual implementation of the
project started in the 2002 at 21 farmers’ fields with controlled irrigation (CI) as the first water-saving technology in dry season, and aerobic rice in the wet season at nine farmers’ fields. In the 2003 dry season, intensive farmer-participatory aerobic rice trials were added after successful trials in the 2002 wet season with promising varieties. Controlled irrigation or alternate wetting and drying entails an irrigation schedule where water is applied to the field a number of days after disappearance of ponded water. This technology is a departure from continuously flooding the fields and introduces period of dry (aerobic) soil conditions. Aerobic rice, on the other hand, refers to high-yielding rice grown in non-puddled, aerobic soil (Bouman et al. 2002, Wang Huaqi et al. 2002, Yang Xiaguang et al. 2002). It entails the growing of rice in aerobic soil, with the use of external inputs such as supplementary irrigation and fertilizers, and aiming at high yields. It has characteristics of both upland and lowland varieties.

This paper reports on the first two-year results of implementation of the CI and the aerobic rice in the TTWS pilot sites. This paper also attempts to sketch a possible future direction for adaptation and adoption of water-saving technologies in rice production in the Philippines.

**METHODOLOGY**

**Project partners and the pilot sites**

The project is truly a collaborative one involving a national rice research institution mandated to undertake rice research and development (PhilRice); the National Irrigation Administration that administers various water resource systems (NIA), and the International Rice Research Institute (IRRI). Considered as part of the project team are farmer-cooperators who are themselves members of Farmer Irrigator Associations or Cooperatives.

The project’s study area is central Luzon (Fig. 1). An important (reservoir-backed) gravity irrigation system here is the Upper Pampanga River Integrated Irrigation System (UPRIIS), covering some 100,000 ha but scheduled to be increased to some 130,000 ha in the coming years. Beside UPRIIS, shallow tubewell and deepwell pumps owned and operated by farmers’ groups and individuals are commonly

![Fig. 1. Location of pilot sites (asterixes) in central Luzon, Philippines.](image-url)
found in Bulacan, Pampanga, Tarlac and Nueva Ecija. For the initial implementation in the 2002 dry season, farmers getting irrigation water from deepwells and shallow tubewells were selected for two reasons. First, since these farmers directly face the costs of water that they use, they are considered most susceptible to use technologies that help save water and reduce costs. Second, it is easier to manage and control water in small-scale deepwell and private shallow tubewell systems than in large gravity irrigation systems such as UPRIIS. If the practice of water saving will be accepted by pump users, the next territory to conquer will be those covered by the gravity systems.

**Controlled irrigation or alternate wetting and drying**

Table 1 shows the number of farmer-cooperators of controlled irrigation and aerobic rice from Tarlac and Nueva Ecija pilot sites. Controlled irrigation was only carried out during the dry seasons (DS 2002 and 2003), while aerobic rice was tested for the 2002 wet season and the 2003 dry season. A total of 21 farmers volunteered to participate in CI during 2002 dry season, and about 26 farmers in the following 2003 dry season. The selection of farmers was based on motivation and willingness to participate in the field trials, and on site criteria like accessibility, spread of farmers across the site, position on the toposquence, and nearness to pump. A special effort was made to select farmers on different toposquence positions (high, middle, low elevation) to capture differences in groundwater status and soil type since these are expected to affect the actual number of days the crop can be without standing water.

Each farmer-cooperator participated with two fields: one managed using his standard farmer’s practice (FP), and the other managed as controlled irrigation (CI). Each field size was about 500-1000 m², with an internal farm ditch. Wetland preparation was done using the standard hand tractor driven disc plow, followed by two harrowings and one leveling for better water control and weed management. In Canarem and Gabaldon, crops were transplanted, spaced at 20 cm × 20 cm. Farmer-cooperators in Dolores established their crop by wet seeding. Production inputs were the same for both CI and FP plots. Rice crops were transplanted between the last week of December to the middle of January for both 2002 and 2003 dry seasons in Canarem, while a much later crop establishment (from first to third week of January) was done for Dolores and Gabaldon sites because the farmer-cooperators were still busy planting onions and other upland crops during the middle to last week of December.

In the P-38 deepwell irrigation system in Canarem, water is distributed to the service area rotationally, where each farmer received irrigation water once a week, and usually maintained 6-8 cm of ponded water after irrigation. Irrigation schedules for CI and FP plots followed the rotational irrigation schedule of the sectors. However, to differentiate the water management of the CI and FP plots, the

<table>
<thead>
<tr>
<th>Table 1. Number of farmer-cooperators in the TTWS project</th>
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<tbody>
<tr>
<td><strong>Location</strong></td>
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<tr>
<td>(deepwell)</td>
</tr>
<tr>
<td>A. Tarlac sites (deepwell)</td>
</tr>
<tr>
<td>Canarem (P-38)</td>
</tr>
<tr>
<td>Dapdap (TG-04)</td>
</tr>
<tr>
<td>Pansi (GP-125)</td>
</tr>
<tr>
<td>B. Nueva Ecija sites (shallow tubewell)</td>
</tr>
<tr>
<td>Dolores</td>
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<tr>
<td>Gabaldon</td>
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<td>Total</td>
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amount of irrigation water supplied at the CI plots was made to be about 30-40% lower than that supplied to the FP plots at each irrigation. In the shallow tubewell systems in Nueva Ecija, FP plots were almost continuously flooded, while irrigation in the CI plots was done only after 4-5 days of no standing water in the field. Irrigation water was measured using trapezoidal weirs. Staff gauges were also installed to measure daily ponded water depth in the plots.

Perched water table and groundwater levels in the CI and FP plots were monitored using PVC tubes. Divers (groundwater level data loggers) were also installed in the pilot sites to continuously monitor groundwater level fluctuations. Rainfall and evaporation data in Canarem were obtained from the agro-meteorological station installed in the area, which consists of Class A evaporation pan and true-check rain gage. Rainfall and evaporation for the Nueva Ecija sites were taken from the agro-meteorological station in PhilRice, Muñoz. Calendar-type monitoring sheets were given to the farmer-cooperators in all pilot sites to record all their field operations, labor used, and all inputs applied in the CI and FP plots. Yields were taken from crop-cut samples collected from two 2 × 2.5 m² sampling area in the FP and CI plots. The actual yields from the whole plots were also taken for comparison.

**Aerobic rice participatory R&D**

Initially, nine farmer-cooperators were identified and selected during the 2002 wet season (WS) in Tarlac and Nueva Ecija to participate in the first exploratory trials of aerobic rice under farmer field conditions. In the 2003 dry season (DS), the number of farmer-cooperators was increased to 29. The farmer-cooperators were selected based on representativeness of their fields and their willingness to participate in the R&D process. For both seasons, each farmer-cooperator was requested to test one of the three promising aerobic varieties (APO, UPLRI-5 and Magat). Farmers who volunteered or selected to test these varieties were either at the edge of the pump area or situated on the higher sites, with relatively large water losses and dry soil conditions. Fields were prepared dry using either animal or tractor, and rice seeds were dry seeded (in rows) in relatively dry soil with a seeding rate of about 80-100 kg ha⁻¹. In the 2002 WS, the establishment was done using a lithao, a wooden implement to open the furrows (low tech); the seeds were hand-sown; and basal fertilizer was broadcast. However, in the 2003 DS, a mechanical seeder (high tech) was also used in seed establishment, which is pulled by big tractor for direct seeding and direct placement of basal fertilizer. Most of the farmer-participants tried both the low technology (low tech) and the high technology (high tech) level of seeding by either contributing two plots, or splitting one big plot into two subplots. Both “low tech” and “high tech” areas were laser-leveled before seeding. For uniformity in the technology adaptation, cultural management practices and inputs such as rice seeds, fertilizers and chemicals calculated for the area of the participating fields, as well as technical support were provided by the project. The farmers provided the day-to-day management of the fields, as well as the labor and power for land preparation, crop establishment, weeding, spraying, harvesting and threshing. Supplementary irrigation was given to the crop for crop growth, although the amount of water was not measured.

Farmers were asked to conscientiously record all their operations such as labor and other inputs (seeds, fertilizer, pesticides, etc.) in the forms provided. Long tubes were installed to monitor daily groundwater table at each farmer’s field. Emergence, flowering and harvesting dates were recorded. For the estimate of grain yields, two sources of data were utilized: (1) crop cut samples were obtained from two 10-m² sampling spots, and (2) the yield of the whole field per record of the farmers obtained during the interview. The cut crop samples were threshed, sun-dried, and weighed and the moisture content determined. Other observations such as pest and disease occurrence, rodent infestation, lodging, weed pressures, etc. were noted.

**Within season extension**

Field school type activities were done to demonstrate the controlled irrigation and aerobic rice concept to other (nonparticipating) farmers and to broadly discuss the progress.
and results at harvest. The field school concept was agreed upon to emphasize the learning objective. These field schools consist of visits to the research-extension sites and briefings conducted by the farmer-cooperators with the assistance of the project team members. After the field visits, the different tour groups meet in plenary for summary, integration and question and answer sessions.

**Process documentation**

Throughout the first year, the whole process of developing the technology transfer framework was documented through reports, pictures and video footage. These materials will later be used to develop training and extension materials and to formalize the developed procedure for transfer and adaptation of knowledge for water savings.

**RESULTS AND DISCUSSIONS**

**Controlled irrigation**

*Perched water table and groundwater level fluctuation.* In Canarem, perched water table and groundwater level dynamics in both CI and FP plots were affected by the timing of irrigation delivery and toposequence positions. As shown in the sample graphs for 2002 DS (Fig. 2), the periodic water table rise in CI and FP plots was caused by the irrigation water applications. However, the degree of fluctuations vary across the toposequence positions. As summarized in Fig. 3, the seasonal average perched water table depth of plots located in the high positions was about 40 cm lower than in the low positions. The shallow water table in the low areas was attributed to the collected seepage from the high and middle portions of the service area. To compare CI and FP plots, perched water table and groundwater table depths in CI plots were relatively deeper (but not significantly different) than in FP plots caused by higher initial ponding depths of the latter. However, in the low toposequence, no noticeable differences in depths between CI and FP plots were observed and both had water tables that were already very close to the ground surface.

Groundwater depths in Gabaldon were more than 3 m below the ground surface (Fig. 4). Previous studies by Igbokwe (1992) showed that during dry season in Gabaldon, the deepest groundwater depth was recorded at 8.4 m below the ground surface and the dry season average is 7.4 m. In fact during the peak season of crop growth (February-March), some farmers had to lower their pumps to draw groundwater. On the other hand, perched water table dynamics (Fig. 4) were shallower, and only fluctuated from 0-60 cm below the ground surface. On the average, FP plots had a shallower perched water table depth than CI plots (Fig. 3).

Perched water table depths in Dolores (Fig. 5) were shallower (but not significantly different) than in Gabaldon, ranging from 0-50 cm below the ground surface throughout the dry season. In both FP and CI plots, perched water table depths did not drop below the rootzone (30-40 cm depth) throughout the season.

Based on the above results, the differences of the average perched water table depths between CI and FP in all sites in Tarlac and Nueva Ecija were not really significant which showed that the farmers who were drawing water from deepwells and shallow tubewells were already practicing controlled irrigation to a certain extent, and their current water management practices only require minor refinement to optimize the benefits of controlled irrigation.

*Irrigation water use.* Irrigation water use in this paper is defined as the water input (rainfall and irrigation) from transplanting (or direct seeding) until harvest. Total rainfall (from December 1 to April 30) in Tarlac sites was very low, about 55 mm and 80 mm for 2002 and 2003 dry seasons, respectively. However, a much lower total rainfall was recorded in Nueva Ecija sites with 2002 dry season total of 34 mm and 2003 dry season total of 10 mm.

In Canarem, mean total water use (Fig. 6) was highest in high elevations in both CI and FP plots in both years. This was attributed to its lighter soil texture (fine silty loam) and lateral seepage towards the lower toposequence positions. During its first season of implementation (dry season), the difference of the total water used between CI and FP plots was also highest in high elevations (24%), compared to 20% and 5% in middle and low toposequences, respectively. The following
Fig. 2. Typical perched water table and groundwater depths at three toposequence positions in Canarem during 2002 dry season.
Fig. 3. Seasonal average perched water table depths in Tarlac and Nueva Ecija sites for 2002 and 2003 dry seasons.

Fig. 4. Typical perched water table and groundwater depths in Gabaldon in dry season 2002.

Fig. 5. Typical perched water table and groundwater depths in Dolores in 2002 dry season.
year, farmers became more confident on the technology and as a result, a much higher savings was achieved especially in high elevation (33%). The average savings for all elevations (Fig. 7) was about 16% in 2002 and 24% in 2003.

In Gabaldon, the average percent difference in water used between CI and FP practices was relatively low (11%) in 2002 DS as shown in Fig. 6. In fact, three out of five farmer-cooperators had only savings of 2-8%, while only one farmer was able to achieve a saving of 31%. The small difference can be explained by the difficulty of water pumping due to the lowering of groundwater table. Because of this situation, these farmers decided to irrigated their FP plots almost like CI plots. In Dolores, CI plots used about 727 mm while the FP plots used 853 mm in 2002 DS, and the difference of 15% water used was not significant. A similar trend of water used was also observed in 2003 DS under the shallow tubewell systems as shown in Fig. 6. On the average, number of irrigations was slightly higher in Dolores than in Gabaldon for both CI (13.2 vs 12.6) and FP (14 vs 15.8) plots. This was because farmers in Dolores established their crops through direct wet seeding while the Gabaldon farmers transplanted their crops. Thus in Dolores, extra irrigations were needed to grow the seed to the seedling stage in direct-seeded rice crop establishment.

**Grain yield.** In Canarem, the average grain yields did not vary significantly between CI and FP plots for the two dry season cropping (Fig. 8). In the 2002 DS, yields did not also vary across toposequence and ranged from 5.3 to 5.5 t ha\(^{-1}\), with middle plots getting slightly higher yields. In DS 2003, the lower elevation plots got the highest average yield of about 7.5 t ha\(^{-1}\), and was the only group that had significant increase in yield between seasons. This was maybe because most of the farmer-cooperators in lower portion during the 2003 dry season used APO that yielded higher than the other variety (PSBRC-28) used by most of the farmers in the high and middle elevations. In the 2002 DS, all farmer-cooperators used PSBRC-98 in their fields.

In Gabaldon, the yield differences between CI and FP plots were also not significantly different, although CI average yields are slightly higher than in FP plots in both years. There was also no significant difference of yields between the cropping seasons (Fig. 8). Average yields of CI and FP plots in the wet-seeded rice in Dolores was about one ton lower than in Gabaldon during the 2003 DS (4.6 vs 5.8 t ha\(^{-1}\)), however, no significant yield difference was observed between the CI and FP plots in both years.

**Water productivity.** Water productivity is computed as the grain yield in kilograms divided by the mean total irrigation plus rainfall in cubic meters. In Canarem, the average water productivity (Fig. 9) in the CI plots was higher than in the FP plots at all three toposequence positions. Plots at low toposequence had the highest productivity values of 1.7 and 1.6 kg m\(^{-3}\) in the 2002 dry season and 1.9 and 1.6 kg m\(^{-3}\) in the 2003 dry season for CI and FP plots, respectively. Since yields were the same (Fig. 8), the relatively high water productivity in low toposequence was caused by the lower water inputs (Fig. 6). In Gabaldon and Dolores, water productivity in the CI plots was higher than in the FP plots, but the difference was not statistically significant.

**Cost and returns.** Table 2 shows the average cost and returns under the two water management practices. The gross returns were calculated as the total harvest (kg ha\(^{-1}\)) multiplied by prevailing market price of paddy (US$ kg\(^{-1}\)). Total production cost includes material costs (seeds, fertilizers, herbicides, pesticides, fuel and oil) and labor costs (land preparation, crop establishment, crop care and maintenance, and post-harvest labor). Noncash and imputed costs were also added to the total production cost.

On the average, there was no significant difference of the gross returns between FP and CI plots in Canarem for the two years of dry season cropping. During the first dry season implementation of the project, the average total production cost per hectare under FP was higher than CI (441 versus 397 US$) which was attributed to higher fuel and oil consumption in FP plots. As a result, the 2002 dry season net profit in CI was slightly higher than in FP plots by almost US$45 ha\(^{-1}\). However, during the next dry season (2003), the disparity of the amount (Fig. 6) and cost of irrigation had reduced that resulted to almost the same net profits of CI and FP. This was probably because the farmers gained more confidence on CI during the past dry season and they tried to copy the irrigation scheme of...
Fig. 6. Total water used (mm) in CI and FP plots for 2002 and 2003 dry seasons.

Fig. 7. Average water savings (%) in the pilot sites for 2002 and 2003 dry seasons.

Fig. 8. Average yield in CI and FP plots in the pilot sites for 2002 and 2003 dry seasons.
CI to their FP plots. The average two-year net profit-cost ratio was slightly higher in CI plots (1.31) than in FP plots (1.16), which showed the slight economic advantage of CI over FP.

In Gabaldon, only the data from the 2002 DS is presented in this paper. The average total gross return (in US dollars per hectare) under CI was higher than under FP by about US$110 (Table 2). However, the total production cost was lower in CI than in FP by about US$46, which was attributed to lower pumping cost (fuel and oil) and fertilizer cost. Total number of irrigations in CI plots was less than in FP plots (12.6 vs 14 irrigations). Due to higher total gross returns and lower total production costs, the difference of the net profit per ha between CI and FP was about US$127.

In Dolores, total gross return was slightly higher in FP plots than in CI plots, although the difference was not significant. Total production cost was not also significantly different between the two water management practices (Table 2), although CI plots received

Table 2. Average yields, cost and returns of rice crop grown under two water management practices for 2002 and 2003 DS

<table>
<thead>
<tr>
<th>Item</th>
<th>Canarem (Deepwell)</th>
<th>Gabaldon* (Shallow tubewells)</th>
<th>Dolores* (Shallow tubewells)</th>
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<tr>
<td></td>
<td>FP</td>
<td>CI</td>
<td>FP</td>
</tr>
<tr>
<td><strong>2002 dry season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross return (US$/ha)</td>
<td>932.7</td>
<td>932.7</td>
<td>1182.6</td>
</tr>
<tr>
<td>Total Production cost (US$/ha)</td>
<td>441.2</td>
<td>397.3</td>
<td>897.6</td>
</tr>
<tr>
<td>Net profit (US$/ha)</td>
<td>491.5</td>
<td>535.5</td>
<td>297.0</td>
</tr>
<tr>
<td>Net profit-cost ratio</td>
<td>1.14</td>
<td>1.37</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>2003 dry season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross return (US$/ha)</td>
<td>1133.6</td>
<td>1105.2</td>
<td>N/A</td>
</tr>
<tr>
<td>Total Production cost (US$/ha)</td>
<td>519.0</td>
<td>491.3</td>
<td>N/A</td>
</tr>
<tr>
<td>Net profit (US$/ha)</td>
<td>614.6</td>
<td>613.9</td>
<td>N/A</td>
</tr>
<tr>
<td>Net profit-cost ratio</td>
<td>1.18</td>
<td>1.25</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* N/A: data are still not available (analysis in progress for 2003 DS).
a slightly higher production costs. This was due to the fact that some of the farmers were not able to follow the irrigation protocol for the CI plots. Some of them put extra irrigation without the prior knowledge of the researchers.

On the average, the net profits obtained in Dolores for the CI and FP plots were higher than in Gabaldon because of the lower cost of crop establishment (direct seeding) in Dolores. Moreover, the groundwater table in Dolores was shallower and the farmer-cooperators’ fields were located in a contiguous area, where one field can receive seepage water from the neighboring fields that resulted to lower pumping cost.

**Aerobic rice**

About 1500 mm of rain fell in Tarlac and Nueva Ecija sites from seeding to harvest during the 2002 WS, of which more than 50% occurred from the last week of June to middle of July. However, in 2003 DS, almost no rainfall was recorded in the pilot sites.

During the 2002 WS in Tarlac, APO yielded the highest among the three varieties with an average yield of 5.5 t ha⁻¹, while Magat and UPLRI-5 yielded 5.0 and 4.5 t ha⁻¹, respectively (Fig. 10). In the Nueva Ecija sites, APO only yielded an average of 4.1 t ha⁻¹, while the UPLRI-5 yielded about 4.5 t ha⁻¹. The low yield of APO in Nueva Ecija site was caused by severe lodging during the flowering stage. Unfortunately, the number of sample farmers was only 9, compared to 29 farmers during the 2003 DS, and results may be inconclusive due to the limited samples if we try to compare the aerobic rice results with the farmers’ varieties. Nonetheless, the yield advantage during the 2002 DS of the three aerobic rice varieties in Dapdap (GP-04) was evaluated by comparing them with the yields sampled from the 25 neighboring farmers’ fields in the area. Most of these farmers grew rice by dry seeding in hills along the rows using different lowland varieties. As shown in Figure 11, yields at the neighboring fields in Dapdap ranged from 2.1 to 4.8 t ha⁻¹ or an average of 4 t ha⁻¹. This average yield was about 1.5 and 1.3 t ha⁻¹ lower than the average yield of APO and Magat, respectively. However, UPLRI-5 yield was not significantly different from the average yield of the neighboring farmers.

With more farmer-cooperators participating in the development of the aerobic rice technology during the 2003 dry season, a wide range of yield results was observed. The yield range for all varieties in 2002 was 4-5 t ha⁻¹, while in 2003, the yield was 2-6.6 t ha⁻¹. In terms of varietal performance, APO was better...
than UPLRI-5 in Tarlac for 2003 DS. The average yields were 4.0 and 3.4 t ha\(^{-1}\) from the crop cut estimate. The differences in yields between the two varieties, however, were not significant using the paired t-test. In terms of technology level of crop establishment, the level of technology imposed on aerobic rice did not have a consistent and significant effect on the yield performance. The crop cut estimates at the low-tech level had relatively higher values compared to the high-tech level for the two varieties, however, the differences were not significant. It was difficult to establish the relationship of yield and seeding dates because the range of the seeding date was limited (aerobic rice was established from December 5-20 only).

**CONCLUSIONS**

The results of the first season CI trial in Canarem, Gabaldon and Dolores have provided a good indication that controlled irrigation is a viable alternative in improving water productivity in deepwell irrigation system and shallow tubewell irrigation systems. A significant water saving of about 20% was attained in deepwell systems and about 11-15% in shallow tubewells. Although it could go up to 40% as demonstrated by some farmers. In terms of yield penalty, there was no significant reduction in yield between CI and FP plots. In Canarem, for two dry seasons, CI plots obtained higher profit of US$ 575 ha\(^{-1}\) as against US$ 553 ha\(^{-1}\) in FP plots. In Gabaldon, a net profit per ha of US$ 425 was attained in the CI and US$297 in the FP plots, while in Dolores, the net profit per ha in CI plots was slightly lower (US$ 444) compared to FP plots (US$ 474).

The two-season trials of the promising ‘aerobic’ rice varieties in Tarlac and Nueva Ecija sites showed remarkable yield performance. Higher yields were attained compared to the conventional lowland varieties where soils were very light, and farmers were practicing dry seeding for decades. A yield level of about 6 t ha\(^{-1}\) is achievable under farmer field conditions for both wet and dry seasons. Although farmers were very enthusiastic about adopting these varieties, there are still various issues that need to be understood and researched before a full-scale adoption of this technology can take place. Many problems were experienced in aerobic rice system especially during the dry season.

Fig. 11. Scatter plot of grain yields (t ha\(^{-1}\)) of the three aerobic rice and farmers’ varieties in Dapdap, Tarlac during the 2002 WS.
trials, including water stress, weed pressure, possible yield reduction due to continuous monoculture (nematode), nutrient management and others. These problems still need to be researched before moving to a wide scale adoption of the technology.

**FUTURE DIRECTIONS**

After two seasons, the project is now ready to enter into its second phase. The second phase will have the following components:

1. Formalizing the framework for participatory transfer and adaptation of water-saving technologies. The lessons learned through the farmer-participatory research and development of controlled irrigation will be translated into a kind of blueprint on how to set up pilot sites that can have a lighthouse function for a wider farmer community.

2. Develop training and extension program to further spread water-saving technologies in the Philippines, still using controlled irrigation as a model technology. Two activities may be required. First, a mode of knowledge transfer and adaptation that is suitable to reach a large audience needs to be developed. One mechanism can be the establishment of a number of lighthouse pilot sites in strategic areas for water saving, from which the knowledge can diffuse to surrounding farmers. Another mechanism can be distant learning via internet or radio and television media. Second, training needs to be organized for extension agents to disseminate the technology among farmers. These extension agents can be NIA personnel involved in irrigation system operation, local extension officers, local NGOs, or heads of farmer irrigator associations, farmer cooperatives or other local farmer organizations. The training of such extension agents involves a technological component on water-saving technologies and a “training-the-trainer” component in which the techniques of knowledge extension and adaptation are taught. Training materials need to be prepared that the extension agents can use in the field (e.g., leaflets, brochures, radio broadcasts, video etc.), and that are required at the training of the extension agents themselves (course curriculum).

3. Inclusion of other water-saving technologies beside controlled irrigation. A number of options have been researched to reduce water use in irrigated rice production and each has specific advantages and disadvantages and specific target domains in time and space. As the mechanism for transfer and adaptation of technology becomes clear in the course of the project, other water-saving technologies can be tested in farmer-participatory approaches and added to the training curriculum.

The speed, scope and duration of the second phase of the project will depend very much on the long-term commitments of the project partners and their (financially) supporting governments.

**REFERENCES**


