LOWLAND RICE AGRONOMY IN LAOS
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Lowland rice agronomy research in Laos

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Abstract
Systematic research aimed at the development of technologies for improving yields in the lowland environments of the Lao PDR commenced in 1992. The paper describes some of the achievement of agronomic studies in recent years. For rainfed lowland transplanted rice, sowing high yielding varieties in late May — early June and transplanting 25 days old seedlings are important for achieving high yields. Early seeding (early June) is also important for direct seeded rainfed lowland rice. When weed control is optimal and crop establishment is good, yields from direct seeding have been shown to equal that from transplanted crops. The results of studies in the dry season irrigated environment have demonstrated the need to ensure high plant population through closer hill spacing, to maximize yield potential. It is believed the same requirement exists for transplanted rice in the rainfed lowland environment. The potential yield improvement achievable from improved agronomic practices in both the rainfed lowland and irrigated environments depends on appropriate management of soil fertility. Technology packages have been developed for both transplanted and direct seeded rainfed lowland rice in the wet season.

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1 Introduction

The area under rice cultivation in Laos is about 717,000 ha, representing more than 80% of the area under cultivation (Lao-IRRI, 1999). The rainfed lowland ecosystem occupies the largest area (> 60%) among all the rice ecosystems. A single wet season rice crop is the basic production system in Laos. Rice yields are generally reported in the range of 2.5 to 3.5 t/ha but lower yields are common particularly in the rainfed lowland environment. Under non-fertilised conditions, individual farmer's yield can be as low as 1 t/ha (Lao-IRRI, 1999). Drought problems consistently feature in rainfed lowland rice in Laos. Early-season drought can cause delays in the time of sowing and transplanting, while late season drought reduces yield of particularly late maturing traditional varieties. Farmers generally fail to perceive soil fertility management as an important yield constraint, although research has demonstrated potential yield improvement through improved NPK nutrition (Linguist et al. 1998). Key management options to minimize adverse effects of drought and infertile soil conditions are the use of appropriate varieties, fertiliser application, time of planting and the use of seedlings of appropriate age for transplanting. These topics have been the focus of recent agronomic research in the lowland environment of Laos. Direct seeding technologies have also been a research focus, reflecting an increasing labor shortage for transplanting near the larger provincial towns, and a relatively high labor cost at the time of transplanting. It is anticipated that there will be a gradual change from transplanting to direct seeding in Laos, similar to that which has occurred in Northeast Thailand (Naklang 1997).

Over the past decade, the dry-season irrigated rice area has expanded rapidly in Laos. In 1995 the area irrigated in the dry-season was 13,000, while in 2000 it had expanded to approximately 100,000 ha. Traditional photoperiod sensitive varieties cannot be grown in the dry-season irrigated environment. The development of appropriate varieties for this environment, and studies on appropriate planting time to maximize crop yield, have been a recent focus of Lao research program.

Much of the recent agronomic research in the lowland rice ecosystems (both irrigated and rainfed lowland) of Laos conducted by the Lao National Rice Research Program within the National Agriculture and Forestry Research Institute (NAFRI), has been in collaboration with the Lao-IRRI Project and ACIAR supported projects. The research has been undertaken under both on-station and on-farm conditions. The purpose of this paper is to summarise the more salient research output from these studies. Some results on research on direct seeding has already been published by Sipaseuth et al 2000.
2 Materials and methods

2.1 Rainfed lowland rice-transplanted

2.1.1 Effect of planting date on the performance of selected varieties

Studies were undertaken in the 1994 and 1995 wet seasons at the National Agricultural Research Center (NARC) of the effect of sowing date on the performance of Nang-nuan, Dok tiou and RD8; 1995- TDK2, L161, Niaw Ubon1, and Pongseng. Seeds were sown at approximately 15 day intervals between 25 May and 10 July in both years. In 1995 there were two additional sowing dates after July 10, however, the crops were destroyed by flooding at the end of the growing season. In all cases transplanting took place approximately 25 to 35 days after sowing.

2.1.2 Effect of sowing time and seedling age at transplanting

Experiments were conducted at NARC, Vientiane Municipality during the 1997 wet season, and at two provincial sites in the 1998 wet season (Vientiane and Savannakhet). In the 1997 study, the performance of three improved glutinous varieties was evaluated. PN1, TDK1 and RD6. Five sowing dates at 15 day intervals were compared using 25 or 45 days old seedlings (Table 1).

2.2 Rainfed lowland rice-Direct seeded

2.2.1 Effect of time of seeding

In 1996, studies of the effect of time of seeding were conducted at three locations Vientiane Municipality, and the provinces of Savannakhet and Champassak. At each location, lines in three phenology groups, early, medium and late flowering lines (PN1, TDK1 and RD6) were direct seeded by dibbling (three replicates) at two-week intervals, commencing on 5 May and finishing at 5 July.

2.2.2 Genotype requirement for direct seeding

In the 1997 wet season, 18 genotypes were evaluated for direct seeding at two sites at the NARC in Vientiane Municipality (VTN) and at Phone Ngam Research Station in Champassak province (CPK). All 18 genotypes were planted at VTN on 4 July 1997 whereas only 11 genotypes were planted at CPK on 12 July 1997.

Two further experiments were conducted in the 1998 wet season to investigate genotype requirement for direct seeding and weed competition. The experiments were conducted under on-farm conditions at two sites, one in each of Vientiane municipality and Champassak province. Twelve genotypes were evaluated (including seven genotypes used in 1997) under weeded and
unweeded conditions. Sowing took place on 26 June 1998 and 2 July 1998 in VTN and CPK respectively. The same genotypes were also grown from transplanting and yields of different genotypes were compared for crop established from direct seeding and from transplanting.

2.3 Methods of weed control in direct-seeded rice.

During the 1997 wet season a weed control experiment was conducted at three sites over three provinces (Vientiane, Savanakhet and Champassak). Comparisons were made of the degree of land preparation (2 and 3 cultivations with 15 days between successive cultivations) and weeding treatment. During land preparation, the field was left without standing water. The five weeding treatments were (i) one hand weeding 15 days after dibbling (DAD), (ii) two hand weedings at 15 and 30 DAD, (iii) rotary weeding at 15 DAD, (iv) two rotary weedings at 15 and 30 DAD and (v) unweeded control treatment.

2.4 Optimum spacing for direct seeding.

A study was conducted at three locations (VTN, SVK and CPK) in the 1998 wet season to investigate the effects of plant density on grain yield for direct seeded crop. Two levels of weed control were compared (weeded and unweeded), with two genotypes being compared (IR57514-PMI-5-B-1-2-2 and IR66368-CPA-P1-3R-0-1). The plant density treatments were 25 x 25 cm, 25 x 10 cm and continuous rows with 25 cm between rows. Seed was dibbled at a rate of 80 kg/ha, on 26 June in Vientiane municipality, 30 May in Savannakhet and 4 July in Champassak.
3 Irrigated dry season rice.

3.1 Effect on hill spacing and the number of seedlings per hill on grain yield

Two studies were undertaken at the NARC in Vientiane Municipality to investigate the relationship of yield to plant density for a number of selected varieties. The studies were conducted during the 1994 and 1995 dry seasons. In each study, three hill spacings (25 x 25 cm, 20 x 20 cm and 15 x 15 cm, corresponding to 16, 25 and 44 hills/m\(^2\), respectively) and two seedling densities (3 and 6 seedlings/hill) were compared. In 1994, two popular varieties, TDK1 and RD10, were used, and in 1995, the varieties TDK1, RD10 and RD23 were used. A split-plot design was applied with varieties as main plots and plant densities as subplots. Fertilizer was applied at a rate of 90, 30 and 20 kg/ha of N, P\(_2\)O\(_5\) and K\(_2\)O, respectively. The N was applied in three equal splits at transplanting, active tillering and panicle initiation.

3.2 Effect of hill spacing and N regime on grain yield

In 1996 and 1997, a study was undertaken, to examine the effect of N regime (0, 45 and 90 kg N/ha) and hill spacing (25 x 25 cm, 20 x 20 cm and 15 x 15 cm, corresponding to 16, 25 and 44 hills/m\(^2\), respectively) on rice productivity. Both studies were conducted under research station conditions at NARC. In 1996, the variety TDK1 was used, while in 1997 NTN1 was used. In all cases 6 seedlings per hill were transplanted. P and K were applied to all treatments.
4 Results and discussion

*Rainfed lowland rice-transplanted.*

4.1 Effect of planting date on the performance of selected varieties.

During the 1994 wet season rainfall was generally favorably distributed throughout the season. However, in 1995, early season drought and late season flooding adversely affected yields and these are probably the main factors responsible for the lower grain yield in 1995 (< 3 t/ha) relative to 1994 (> 4.5 t/ha)(Fig1). Despite these differences, the effect of delayed sowing was similar in both years, and yield generally declined when the crop was sown after June 10. Yields from sowing on June 24 and July 10 were reduced by 22% and 39%, respectively, relative to the first two sowings. The lower yields associated with delayed sowing was probably due to late season drought or pest damage (rice bug, birds and rats).

In 1994, yield decline associated with delayed sowing appeared to be influenced by maturity time. TDK1 (a photoperiod non-sensitive variety) was the most affected by delayed sowing and yield declined by 45% between the first and last sowing dates. RD8 (a highly photoperiod sensitive variety) experienced a 33% decline, while the other two local varieties (moderately photoperiod sensitive) experienced yield decline between these. However, despite the large effect of sowing date on TDK1, the yield was the highest over all sowing dates. In 1995 this effect of maturity time on grain yield was not observed. The photoperiod sensitive varieties (Niaw Ubon 1 and Pongseng) gave a similar performance to the photoperiod non-sensitive varieties. Reduced yields associated with delayed sowing in 1995 may have been due to flooding (the last two sowing dates were completely destroyed by flooding).

4.2 Effect of sowing time and seedling age at transplanting.

Yield data in the 1997 experiment showed consistent differences among varieties (Figure 2). Yield of TDK 1 was 30 % higher than PN1 and RD6. Later sowing of 25 June, 10 July, and 25 July produced significantly reduced yields. The two earliest sowing dates of 25 May and 10 June, generally favored all 3 varieties and both seedling ages (25 and 45 days). However, yield from 25 days old seedlings was on average 460 kg/ha (22%) higher than that from 45 days old seedlings and the difference was consistent across sowing dates. The number of days to flowering varied between seeding dates particularly for photoperiod insensitive varieties. In early seeding, time to flowering was longer and with late seeding the number of days to flowering was less.

A similar effect of plant time was also obtained at Vientiane in 1998. However, planting an early maturing cultivar (SK12-47-2-1) in May and early June resulted in low yield at Champassak in 1998 (Figure 3) as flowering of this cultivars in August and early September corresponded with the period of peak wet season rainfall. It is recommended that cultivars and planting dates should
be used that allow flowering to take place after mid-September. In areas of favourable soils and rainfall, early planted and early harvested rice might allow second cropping.
5 Rainfed lowland rice-direct seeded.

5.1 Time of direct seeding.

In general, seeding in late May to early June produced highest yields (Figure 4). However, seeding in late May for short and medium maturing varieties may result in the crop flowering during the period of peak wet-season rainfall (with subsequent detrimental effects on yield). However, for longer maturing, photoperiod nonsensitive varieties, early seeding would allow harvesting to take place shortly after the end of the wet season rains, thereby possibly avoiding the potential effects of late-season drought and potential rice bug damage.

These results on direct seeding are similar to those of transplanting mentioned earlier. Thus generally early seeding of late May-June is advantageous to avoid adverse growing conditions later in the wet season. These results confirm earlier reported findings (Inthapanya et al. 1997) that late-season varieties do not produce high yields due to the effects of late season drought.

5.2 Genotype requirement for direct seeding.

In both 1997 and 1998 seasons, there were some interactions between genotype and crop establishment method. In the Vientiane 1997 experiment, tall genotypes, Eak-hao had much lower yield under direct seeding than under transplanting because of a high tendency of lodging (data not shown). An advanced line IR 46343-CPA-5-2-1-1, performed better under transplanting than under direct seeding. In Champassak, Ea-khao and IR 46343-CPA-5-2-1-1 did not perform well in direct seeding. Hom Nang nuan, a local variety, performed better under direct seeding in Champassak. In the 1998 study, the weed problem was severe in direct seeded rice, and there was a resulting significant variety and planting method (direct seeding, transplanting) interaction (Figure 5). Some tall genotypes, IRUBN-8-4-TDK-1-1 (5) and NSG 19 (8), had much lower yield under direct seeding because of a high tendency of lodging. Lodging is a major problem with direct seeding because higher plant density, commonly used in direct seeding, causes excessive stem elongation. Some flowered rather late, and did not lodge even though they are tall genotypes. Flowering was delayed for several days in the unweeded treatment. Varieties responded differently to weeding, and the reduction in yield due to weeds was rather small in some varieties but was large in others (Table 2).

Fukai (2000) suggested several genotypic characters that are required for direct seeding in rainfed lowland rice. Some of the characters are required for rainfed lowland rice in general and are common for both transplanting and direct seeding; for example appropriate phenology to avoid drought, general adaptation to low soil fertility of rainfed lowlands. Characters that need to be emphasized more strongly for direct seeding conditions are short-intermediate plant height to prevent lodging, ability to compete against weeds, and ability to establish under adverse soil
conditions. Yield of direct seeded rice can be as high as that of transplanted rice provided better crop establishment and weed free conditions prevail.

5.3 Methods of weed control in direct-seeded rice.

Results of 1997 experiments showed that grain yields among three sites were different, partly because of weed competition. Savanakhet gave the highest yield, followed by Champasack in this weed competition experiment. The land preparation twice or three times did not produce any difference in yield. (Table 3a). Weed growth was small at 15 days after seeding and there was no effect of weed management at this stage on fresh weed weight in all 3 locations. However, there was an effect of weed management methods (two times weeding) in Vientiane and Champasack (Table 3b). Second weeding at 30 days after dibbling was effective in reducing grass weed weight at Champasack. In Vientiane, there was an effect of weed competition on grain yield. It was estimated that 47% yield reduction could be caused by weed competition when the control treatment was compared to one time hand weeding in Vientiane.

5.4 Optimum spacing for direct seeding.

Results suggest that the conventional spacing of 25 x 25 cm used in transplanting is unlikely to be the optimum spacing for direct seeding (Table 4). Dibbling at 25 x 10 cm is effective for achieving high yield and weed control, but this requires a large amount of labour resources. Therefore, it is advisable to establish a sound method for continuous row planting where a simple tool can be utilized.

In all 3 locations, the 25 x 25 cm spacing of rice resulted in having the largest amount of weeds and produced the lowest yields. The spacing of 25x10 cm was better than the continuous rows in Savannakhet, as too many rice seeds were planted for the continuous rows at this location. In the Champassak province experiment, yields in 25 x 10 cm and the continuous rows were similar under both weeded and non-weeded conditions.

Broadcasting, as commonly practiced, is a problem for weed control, whereas regular row planting pattern is advantageous for manual and mechanical weed control. Continuous row system where seeds are dropped in to shallow furrows that are 25 cm apart may facilitate weed control. It also requires reduced amount of labor for planting compared to dibbling. Wide spacing between hills, on the other hand, is likely to be more of a problem with weeds. The yield was higher in the row planting than 25 x 25 cm and 25 x 10 cm under weeded conditions, except in Savannakhet for the reason mentioned earlier.
6 Dry season irrigated rice

6.1 Effect of hill spacing and seedlings per hill on rice yield.

Average yields in both years were similar at 3.3 t/ha but yield of individual treatments ranged from 2.3 to 4.9 t/ha (Figure 6). In 1994 TDK1 yields were 26% greater than for RD10, while in 1995, RD10 yields were 20% higher than for TDK1. Yields of RD23 were similar to that of TDK1. The effect of hill spacing and seedling number per hill on grain yield for each variety is shown in Figure 1. Yields were consistently higher when hill densities were high. On average across all treatments and years, increasing hill density from 16 hills/m$^2$ (25 x 25 cm) to 25 and 44 hills/m$^2$ increased yields by 13 and 31%, respectively. Doubling the number of seedlings per hill from 3 to 6 also resulted in a consistent increase in yield, averaging 9%. Increasing plant density either by using closer spaced hills or more seedlings per hill increased panicle density (data not shown), resulting in higher yields.

6.2 Effect of hill spacing and N regime on rice yield.

Responses to hill spacing and N treatment were similar in both years, with yield increasing linearly with the amount of N applied at each hill spacing (Figure 7). TDK1 yields in 1996 were higher than the NTN1 yields in 1997. This may be due to seasonal or varietal effects. When no N was applied, increasing plant densities from 16 (25x25 cm) to 44 hills/m$^2$ (15x15 cm) increased yields by 0.8 t/ha (a 63% increase), averaged across years. This suggests that that at higher plant densities the crop is better able to exploit native soil N. Furthermore, applied N fertilizer was utilized more efficiently at high plant density than at the lower plant densities in both years. With 44 hills/m$^2$ the yield increase per kg N applied was 24 kg compared to 18 and 12 kg for densities of 25 and 16 hills/m$^2$.

Results from the spacing studies discussed above are consistent with other reports. For example, Nguu and De Datta (1979) found that under low N conditions, rice yields increased progressively with increased plant density because high plant density tends to compensate for the adverse affects on yield of low tiller number with low soil fertility. In our studies, even at the highest N rates applied (90 kg/ha) N was limiting.

These data and the data from Figure 6 illustrate the benefits of closer plant spacing under less than optimal soil N conditions. Farmers typically space their hills about 20 cm apart during the dry season and up to 25 cm apart during the wet season. This may be a reflection of labor availability which is typically less during the wet season with more area being under cultivation. The benefits of higher densities need to be weighed against the additional cost of seed, extra labor required for a larger seedbed and more transplanting. Furthermore, in the wet season, high plant densities may predispose the crop to drought.
7 Technology packages

Technology packages have been developed for rainfed lowland rice for both transplanting and direct seeding. Further work is required before a technology package is developed for irrigated rice in dry season.

7.1 Rainfed lowland rice – transplanted.

7.1.1 Improved varieties.

Since 1993, nine improved glutinous varieties have been released for the wet-season lowland environment (Lao-IRRI 2000). When combined with appropriate fertilizer management and appropriate cultural practices, these varieties have been demonstrated to have the potential for raising average yields by at least 100% in much of the Mekong River Valley. The choice of varieties also depends on time-of-sowing (see below).

7.1.2 Appropriate time of sowing.

The time of sowing depends on seasonal rainfall conditions. Sowing of seed in nursery should wait until the main fields are sufficiently wet. It is likely that sowing in late May to June is optimum for high yield in most conditions. Unless main fields are located in low toposequence positions, sowing in July is likely to result in reduced yield with crop maturing too late. When quick maturing varieties are used early sowing in late May-early June should be avoided, as the crop is likely to flower too early during the peak of wet season.

7.1.3 Transplanting with young seedlings.

Time of transplanting depends on the condition of the main fields, and it may be necessary to wait for the field to become sufficiently wet for success of transplanting. If water is available transplanting should be conducted when seedlings are still young. Transplanting with 25 days old seedlings is likely to produce the highest yield.

7.1.4 Moderate rate of fertilizer application.

The rate and timing of fertiliser application depends on many factors, including socio-economical factors and risk. General recommendations are to apply nitrogen with 3 splits (transplanting, active tillering and panicle initiation), (depends on irrigated (90 kg) vs rainfed (60 kg)). Phosphorus is required in many locations, and use of 20-30 kg/ha P₂O₅ is recommended for sandy to sandy loam soils in the first season of application. (Linguist et al. 1998). In subsequent seasons an application of the amount removed by the previous crop is sufficient (Linguist et al (2000). Potassium is limiting on fewer soils, but a moderate amount of K (20 -30 K₂O/ha) is recommended as part of a sustainable management practice (Linguist et al. 1998).

7.2 Rainfed lowland rice-direct seeding.

This new technology of direct seeding may be applicable under two conditions; one is that the cost and availability of labour is such that it is difficult to use the traditional transplanting method. The other condition is that rainfall is rather low at the beginning of wet season, so that transplanting at appropriate time may be difficult and crop is likely to fail or produce low yield. The two key factors for success of direct seeding are good crop establishment and control of weeds. The technology package for direct seeding for Laos is detailed in Sipaseuth et al. (2000), and is summarized below.
7.2.1 Suitable location.
Lowland fields with heavy soils, poor drainage or in low toposequence positions are generally not suitable for direct seeding as the fields are likely to be too wet for successful crop establishment. Fields with weed problem should not be used as it is likely that the problem is worse under direct seeding.

7.2.2 Thorough land preparation.
Since establishment is more difficult and weeds are a major problem in direct seeding, fields need to be prepared more thoroughly for establishment of adequate seedbed. Early land preparation at the beginning of the wet season is recommended. Land levelling with a lowland field may be necessary for even establishment of the crop.

7.2.3 High yielding varieties.
Varieties with appropriate maturity group that are high yielding under transplanting are generally also suitable for direct seeding. With earlier seeding improved photoperiod-insensitive varieties are likely to be suitable for direct seeding. On the other hand tall traditional varieties are often not suitable because of their tendency to lodge under direct seeding.

7.2.4 Appropriate time of sowing.
Time of sowing depends largely on water availability. General recommendation is that the seed should be sown when soil is moist but the field is not flooded. Seed may be soaked for a day before sowing for rapid germination and establishment. If soil conditions are favourable, early seeding in late May-early June is the optimum time under most conditions. As for transplanted crop, sowing time also depends on the variety to be used.

7.2.5 Planting pattern.
If water conditions are favourable and weed problems are not envisaged, broadcasting may be adopted. Otherwise row planting with 25cm row width is recommended, and seed may be placed in shallow furrows. Row planting allows one to do weeding more readily.
8 Conclusion

The agronomic research results presented in this paper here have provided some basic understanding of lowland rice management for Laos. The rainfed lowland ecosystem is likely to remain the most important rice production system in Laos, and efforts need to be continued for development of sound technology packages appropriate for their ecosystems. Understanding of drought development patterns and water movement in rainfed lowland ecosystem is an aspect of new research conducted by the joint NAFRI-ACIAR-IRRI group. This may lead to understanding of risk of planting upland crop after rice harvesting.

Another area of agronomy research where NAFRI scientists in association with ACIAR project are going to work is irrigated rice in dry season. This system has expanded rapidly in different Provinces, and variety requirement and optimum time of planting need to be found for each Province. This needs to be considered in relation to wet season rice planting and harvesting so that the combined yield from wet and dry seasons is maximized. One of key elements of the work is to identify effect of low temperature at the time of sowing particularly for Northern Laos. Integrated direct seeding technology packages that are being developed for the rainfed lowland rice in the wet season may need to be modified for the dry season; in fact it may be that direct seeding is adopted more readily for the irrigated conditions because of ease of water control in the dry season.

Acknowledgements

Much of agronomy research currently being undertaken within the Lao national rice research program, is financed by the Australian Center for International Agricultural Research (ACIAR) and the Swiss Development Cooperation (SDC), through the Lao-IRRI Project.
9 References


Figure 1. Grain yield of rice varieties at different sowing date at National Agricultural Research Center, Vientiane Municipality in the wet season 1994 and 1995.
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Figure 3. Effects of sowing date on grain yield at Champassak during wet season 1998.
Figure 4. Effect of sowing dates on grain yield of direct seeded rice in Vientiane Municipality and Savannakhet in the Wet season 1996.
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Figure 7. Effect of hill spacing N fertilizer regime on rice yields of TDK1 and NTN1.
Table 1. Sowing dates and transplanting dates for 25 and 45 days old seedlings in 1997 wet season at Vientiane.

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<thead>
<tr>
<th>Sowing date</th>
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Table 2. Mean yield of 12 genotypes (kg ha\(^{-1}\)) established from direct seeding and grown under weeded and non-weeded conditions in 1998 Wet Season at Vientiane and Champassak

<table>
<thead>
<tr>
<th>No</th>
<th>Genotypes</th>
<th>Vientiane Weeded</th>
<th>Vientiane Non-weeded</th>
<th>Champassak Weeded</th>
<th>Champassak Non-weeded</th>
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<td>TDK 1</td>
<td>2660 a</td>
<td>1683 abc</td>
<td>1959a</td>
<td>809d</td>
</tr>
<tr>
<td>4</td>
<td>IR57514-PMI-5-B-2-1</td>
<td>2514 a</td>
<td>1642 ab</td>
<td>1914ab</td>
<td>940bcd</td>
</tr>
<tr>
<td>5</td>
<td>IRUBN8-TDK-1-1</td>
<td>2217 a</td>
<td>978 bc</td>
<td>1707bc</td>
<td>917bcd</td>
</tr>
<tr>
<td>6</td>
<td>DOKMAY</td>
<td>2621 a</td>
<td>1200 abc</td>
<td>1924ab</td>
<td>1082b</td>
</tr>
<tr>
<td>7</td>
<td>RD 6</td>
<td>2227 a</td>
<td>1198 abc</td>
<td>2123a</td>
<td>1299a</td>
</tr>
<tr>
<td>8</td>
<td>NSG 19</td>
<td>2014 ab</td>
<td>975 bc</td>
<td>1318e</td>
<td>1008bcd</td>
</tr>
<tr>
<td>9</td>
<td>IR58821/IR58821/CA-7</td>
<td>1313 b</td>
<td>639 c</td>
<td>1629cd</td>
<td>814cd</td>
</tr>
<tr>
<td>10</td>
<td>MAHSURI</td>
<td>2129 a</td>
<td>1423 abc</td>
<td>2007a</td>
<td>1062b</td>
</tr>
<tr>
<td>11</td>
<td>IR49766-KKN-52-B-23</td>
<td>1851 ab</td>
<td>1060 abc</td>
<td>1971a</td>
<td>1028bcd</td>
</tr>
<tr>
<td>12</td>
<td>HOM NANG NUAN</td>
<td>1858 ab</td>
<td>1230 abc</td>
<td>1478de</td>
<td>1054bc</td>
</tr>
</tbody>
</table>

Means with the same letters are not significantly different at 5% significance level.
### Table 3. Grain yield (kg/ha) of direct seeded rice under 2 or 3 times of land preparation before seeding at three locations in Laos. 1997.

<table>
<thead>
<tr>
<th>Land preparation</th>
<th>VTN</th>
<th>SVK</th>
<th>CPK</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 times</td>
<td>2090</td>
<td>3671</td>
<td>2936</td>
</tr>
<tr>
<td>3 times</td>
<td>2175</td>
<td>4013</td>
<td>2640</td>
</tr>
<tr>
<td>Significance (5%)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

### Table 4. Yield (kg ha⁻¹) of direct seeded rainfed lowland rice under different weed control measures, obtained at 3 locations in Laos. 1997.

<table>
<thead>
<tr>
<th>Weed control treatment</th>
<th>VTN</th>
<th>SVK</th>
<th>CPK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>1121</td>
<td>3823</td>
<td>2419</td>
</tr>
<tr>
<td>Hand weeding once</td>
<td>2131</td>
<td>3654</td>
<td>2795</td>
</tr>
<tr>
<td>Hand weeding twice</td>
<td>2280</td>
<td>3895</td>
<td>2917</td>
</tr>
<tr>
<td>Rotary weeding once</td>
<td>2457</td>
<td>3969</td>
<td>2857</td>
</tr>
<tr>
<td>Rotary and hand weeding</td>
<td>2670</td>
<td>3853</td>
<td>2948</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>294</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Table 5. Grain yield (kg/ha) of two lines of rice grown in three different spacing in direct seeding at 3 locations (VTN, SVK, CPK) in wet season 1998.

<table>
<thead>
<tr>
<th>Location</th>
<th>Spacing</th>
<th>Weeded IR57514-PMI-5-B-1-2</th>
<th>Non weeded IR57514-PMI-5-B-1-2</th>
<th>Weeded IR66368-CPA-3R-0</th>
<th>Non weeded IR66368-CPA-3R-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTN</td>
<td>25*25</td>
<td>2235</td>
<td>2083</td>
<td>1754</td>
<td>1152</td>
</tr>
<tr>
<td></td>
<td>25*10</td>
<td>1741</td>
<td>2114</td>
<td>2356</td>
<td>2147</td>
</tr>
<tr>
<td></td>
<td>25*row</td>
<td>2594</td>
<td>2053</td>
<td>3623</td>
<td>1796</td>
</tr>
<tr>
<td>SVK</td>
<td>25*25</td>
<td>1775</td>
<td>1591</td>
<td>1928</td>
<td>1476</td>
</tr>
<tr>
<td></td>
<td>25*10</td>
<td>2207</td>
<td>2375</td>
<td>3120</td>
<td>2175</td>
</tr>
<tr>
<td></td>
<td>25*row</td>
<td>2095</td>
<td>1764</td>
<td>1835</td>
<td>1262</td>
</tr>
<tr>
<td>CPK</td>
<td>20*10</td>
<td>1446</td>
<td>854</td>
<td>1551</td>
<td>942</td>
</tr>
<tr>
<td></td>
<td>25*row</td>
<td>2097</td>
<td>947</td>
<td>1909</td>
<td>1054</td>
</tr>
</tbody>
</table>